DREXEL UNIVERSITY
College of
Engineering

# CATALOG
## 2020-2021

**UNDERGRADUATE**


catalog.drexel.edu

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# The College of Engineering

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.

## Majors

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- ***NEW:*** Architectural Engineering - Structural Concentration BSAE / Civil Engineering - Structural Track MS
- ***NEW:*** Chemical Engineering (BSCHE) / Chemical Engineering (MSCHE)
- ***NEW:*** Civil Engineering (BSCIV) / Civil Engineering (MSCIV)
- ***NEW:*** Civil Engineering BSCIV / Environmental Engineering MSENE
- ***NEW:*** Computer Engineering BSCE / Computer Engineering MSCE
- ***NEW:*** Computer Engineering BSCE / Project Management MS
- ***NEW:*** Electrical Engineering BS / Electrical Engineering MS
- ***NEW:*** Environmental Engineering (BSENE) / Environmental Engineering (MSENE)
- ***NEW:*** Materials Science & Engineering (BS) / Materials Science & Engineering (MS)
- ***NEW:*** Mechanical Engineering & Mechanics (BSME) / Mechanical Engineering & Mechanics (MSME)

## Minors

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## Certificates

- Construction Management Concepts (p. 115)
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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.

The College of Engineering offers students a diverse academic learning and research environment embodying the highest standards of knowledge and preparing them to impact society's greatest challenges. Through entrepreneurial risk-taking and exploration, students are encouraged to find innovative solutions that promote economic development and improve life

In addition to the traditional engineering curriculum, the college offers Engineering Technology (p. 42) and Construction Management (p. 28).

## Objectives of the traditional 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 and entrepreneurship*
- *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.

## Cooperative Education

In five-year cooperative 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 cooperative 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 Traditional Engineering Curriculum

### Degree Requirements

The degree of Bachelor of Science in the engineering specialities is comprised 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 cooperative engineering degree accredited by ABET (http://www.abet.org).

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 to students in their second year and beyond. 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. To learn more about the Bachelor of Science in Engineering program, please visit the (http://drexel.edu/engineering/areas-of-study/engineering/BSE/)Program Overview webpage (http://drexel.edu/engineering/areas-of-study/engineering/BSE/). (http://drexel.edu/engineering/areas-of-study/engineering/BSE/)

### Curricular Organization

Students in the traditional engineering programs study many of the same subjects during the three terms in the first year. During the two terms of the sophomore year, students begin taking much more 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, advanced placement and/or transfer credit, and placement exams administered during the summer before Fall enrollment.

Engineering students will take placement exams which will determine their readiness in calculus, physics, and chemistry. Students who demonstrate the preparation and skills to succeed in our core math and science courses will immediately be placed into the courses starting in the fall term. Students that may need additional preparation are strongly encouraged to participate in the online prep courses the summer before the fall term.

In the second year, 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 (http://drexel.edu/engineering/resources/undergraduate-advising/current-students/electives/general-ed-electives/).

### The Common Curriculum

While some programs vary in detail, the following courses are common to most engineering curricula. See each program for specifics.

| | | |
|---|---|---|
| **University Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| UNIV E101 | The Drexel Experience | 2.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 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 |
| 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 |

In addition, engineering students complete a minimum of 30.0 General Education Credits (p. 5).

### 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. PHYS 100 may be counted as a Free Elective.

## 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 thirty (30.0) credits. Nine (9.0) of the thirty credits are designated as follows and must be completed by all majors:

| | | |
|---|---|---|
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |

General Education requirements for specific majors can be found in the degree requirements for each major. The remaining credits can be chosen from the disciplines listed below.

## 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), Chinese (CHIN), Communication (COM), Criminology & Justice Studies (CJS), Culinary Arts (CULA), Dance (DANC), Economics (ECON), Education (EDUC), English (ENGL, except ENGL 101, ENGL 102, ENGL 103 & ENGL 105), Entertainment & Arts Management (EAM), Entrepreneurship (ENTP), Environmental Studies & Sustainability (ENSS), Film Studies (FMST), Finance (FIN), French (FREN), General Business (BUSN), German (GER), Global Studies (GST), Hebrew (HBRW), History (HIST), Hotel & Restaurant Management (HRM), Humanities (HUM, except HUM 107 & HUM 108), Interior Design (INTR), International Business (INTB), Italian (ITAL), Japanese (JAPN), Jewish Studies (JWST), Korean (KOR), Language (LANG), Leadership (LEAD), Management (MGMT), Marketing (MKTG), Military Science (MLSC), Music (MUSC), Music Industry Program (MIP), Operations Management (OPM), Operations Research (OPR), Organizational Behavior (ORGB), Philosophy (PHIL), Photography (PHTO), Product Design (PROD) Project Management (PROJ), Political Science (PSCI), Psychology (PSY), Public Health (PBHL), Real Estate (REAL), Science Technology & Society (SCTS), Screenwriting & Playwriting (SCRP), Sociology (SOC), Spanish (SPAN), Special Education (EDEX), Sports Management (SMT), STEM Teacher Education (ESTM), Taxation (TAX), Theatre (THTR), Visual Studies (VSST), WEST Studies (WEST), Women's and Gender Studies (WGST), and Writing (WRIT).

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

## 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 Programs (http://drexel.edu/engineering/programs/undergraduate/accelerated-programs/) web page.

## Facilities

### Core Engineering Facilities

The Freshman Engineering Design Laboratories are located in the Innovation Studio. The Studio hosts activities for all class levels from Freshman Design at one end through Senior Design at the other. It includes 3D printers, multiple sensor suites and the college machine shop representing the flow of freshman initial ideas through complex fabrication.

Freshman Design courses taken by all new freshmen are held exclusively in the Innovation Studio which was completed in the fall of 2015. A team of Drexel faculty and staff designed the studio to allow activities of many scales as well as to promote open communication within and across groups of students. The lab tables accommodate work in small and larger groups.

The Innovation Studios are an example of Drexel's commitment to undergraduate education, but 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

*Major: Architectural Engineering*
*Degree Awarded: Bachelor of Science in Architectural Engineering (BSAE)*
*Calendar Type: Quarter*
*Total Credit Hours: 190.0*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.0401*
*Standard Occupational Classification (SOC) code: 17-2199*

## About the Program

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 responsible professionals who analyze, design, construct, manage, or operate various types of buildings and their systems, and/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:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of the engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

## 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

## Additional Information

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

For more information about this major, contact the program director:
Michael Waring, PhD
Associate Professor
Civil, Architectural & Environmental Engineering
msw59@drexel.edu

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education requirements * | | 12.0 |
| Free elective | | 3.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |

| | | |
|---|---|---|
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **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-AE | 3.0 |
| ARCH 192 | Studio 2-AE | 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 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| 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 |
| **Concentration Courses** | | **29.0-34.0** |
| **Students select one of the following concentrations for a total of 29.0-34.0 credits:** | | |
| **Building Systems Concentration** | | |
| AE 430 | Control Systems for HVAC | |
| CIVE 302 | Structural Analysis I | |
| CIVE 303 | Structural Design I | |
| MEM 345 | Heat Transfer | |
| MEM 413 | HVAC Loads | |
| MEM 414 | HVAC Equipment | |
| Three professional electives | | |
| **Structural Concentration** | | |
| CIVE 302 | Structural Analysis I | |
| CIVE 303 | Structural Design I | |
| CIVE 312 | Soil Mechanics I | |
| CIVE 315 | Soil Mechanics II | |
| CIVE 400 | First Principles of Structural Design | |
| CIVE 401 | Structural Design II | |
| CIVE 402 | Structural Design III | |
| MEM 238 | Dynamics | |
| Two professional electives | | |
| **Digital Building Concentration** | | |
| AE 510 | Intelligent Buildings | |
| CIVE 302 | Structural Analysis I | |
| CIVE 303 | Structural Design I | |
| CMGT 361 | Contracts And Specifications I | |
| CMGT 467 | Techniques of Project Control | |
| INFO 210 | Database Management Systems | |
| INFO 203 | Information Technology for Engineers | |
| Three professional electives | | |
| **Total Credits** | | **190.0-195.0** |

* General Education Requirements. (p. 5)

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

## BS Architectural Engineering, Building Systems Concentration

## 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101 | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | ARCH 191 | 3.0 | AE 340 | 3.0 | AE 220 | 3.5 |
| ENGL 103 or 113 | 3.0 | CAEE 203 | 3.0 | ARCH 141 | 3.0 | ARCH 142 | 3.0 |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | ARCH 192 | 3.0 | CIVE 250 | 4.0 |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | CAEE 212 | 4.0 | CIVE 330 | 4.0 |
| PHYS 201 | 4.0 | ENGR 232 | 3.0 | CIVE 320 | 3.0 | MEM 230 | 4.0 |
| | | MEM 202 | 3.0 | | | | |
| | **17** | | **18** | | **16** | | **18.5** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 143 | 3.0 | CIVE 303 | 3.0 | | | | |
| CIVE 302 | 4.0 | General Education elective* | 3.0 | | | | |
| MEM 345 | 4.0 | Professiona elective* | 3.0 | | | | |
| Free elective | 3.0 | | | | | | |
| | **18** | | **13** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 544 | 3.0 | CAE 492 | 3.0 | AE 430 | 3.0 |
| CAE 491 | 3.0 | MEM 414 | 3.0 | CAE 493 | 3.0 |
| CAEE 361 | 3.0 | Professional elective* | 3.0 | Professional elective* | 3.0 |
| MEM 413 | 3.0 | General Education elective* | 3.0 | General Education elective* | 3.0 |
| General Education elective* | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 190**

## BS Architectural Engineering, Building Systems Concentration

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101 | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | ARCH 191 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGL 103 or 113 | 3.0 | CAEE 203 | 3.0 | | | | |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | | | | |
| PHYS 201 | 4.0 | ENGR 232 | 3.0 | | | | |
| | | MEM 202 | 3.0 | | | | |
| | **17** | | **18** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 340 | 3.0 | AE 220 | 3.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 141 | 3.0 | ARCH 142 | 3.0 | | | | |
| ARCH 192 | 3.0 | CIVE 250 | 4.0 | | | | |
| CAEE 212 | 4.0 | CIVE 330 | 4.0 | | | | |
| CIVE 320 | 3.0 | MEM 230 | 4.0 | | | | |
| | **16** | | **18.5** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 143 | 3.0 | CIVE 303 | 3.0 | | | | |
| CIVE 302 | 4.0 | General Education elective* | 3.0 | | | | |
| MEM 345 | 4.0 | Professiona elective* | 3.0 | | | | |
| Free elective | 3.0 | | | | | | |
| | **18** | | **13** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 544 | 3.0 | CAE 492 | 3.0 | AE 430 | 3.0 |
| CAE 491 | 3.0 | MEM 414 | 3.0 | CAE 493 | 3.0 |
| CAEE 361 | 3.0 | Professional elective* | 3.0 | Professional elective* | 3.0 |
| MEM 413 | 3.0 | General Education elective* | 3.0 | General Education elective* | 3.0 |
| General Education elective* | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 190**

* See degree requirements (p. 6).

## BS Architectural Engineering, Structural Concentration

## 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101 | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | ARCH 191 | 3.0 | AE 340 | 3.0 | AE 220 | 3.5 |
| ENGL 103 or 113 | 3.0 | CAEE 203 | 3.0 | ARCH 141 | 3.0 | ARCH 142 | 3.0 |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | ARCH 192 | 3.0 | CIVE 250 | 4.0 |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | CAEE 212 | 4.0 | CIVE 330 | 4.0 |
| PHYS 201 | 4.0 | ENGR 232 | 3.0 | CIVE 320 | 3.0 | MEM 230 | 4.0 |
| | | MEM 202 | 3.0 | | | | |
| | **17** | | **18** | | **16** | | **18.5** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 143 | 3.0 | CIVE 303 | 3.0 | | | | |
| CIVE 302 | 4.0 | General Education elective* | 3.0 | | | | |

| | | | | |
|---|---|---|---|---|
| MEM 345 | 4.0 | Professiona elective* | 3.0 | |
| Free elective | 3.0 | | | |
| | **18** | **13** | **0** | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 544 | 3.0 | CAE 492 | 3.0 | AE 430 | 3.0 |
| CAE 491 | 3.0 | MEM 414 | 3.0 | CAE 493 | 3.0 |
| CAEE 361 | 3.0 | Professional elective* | 3.0 | Professional elective* | 3.0 |
| MEM 413 | 3.0 | General Education elective* | 3.0 | General Education elective* | 3.0 |
| General Education elective* | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 190**

## BS Architectural Engineering, Structural Concentration

## 5 year, 3 co-ops

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101 | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | ARCH 191 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGL 103 or 113 | 3.0 | CAEE 203 | 3.0 | | | | |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 220 | 4.0 | | | | |
| PHYS 201 | 4.0 | ENGR 231 | 3.0 | | | | |
| | | MEM 202 | 3.0 | | | | |
| | **17** | | **19** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 340 | 3.0 | AE 220 | 3.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 141 | 3.0 | ARCH 142 | 3.0 | | | | |
| ARCH 192 | 3.0 | CIVE 250 | 4.0 | | | | |
| CAEE 212 | 4.0 | CIVE 330 | 4.0 | | | | |
| CIVE 320 | 3.0 | MEM 230 | 4.0 | | | | |
| | **16** | | **18.5** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 143 | 3.0 | CIVE 303 | 3.0 | | | | |
| CIVE 302 | 4.0 | Professional elective | 3.0 | | | | |
| CIVE 312 | 4.0 | General Education elective | 3.0 | | | | |
| MEM 238 | 4.0 | Free elective | 3.0 | | | | |
| | **19** | | **16** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 544 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| CAE 491 | 3.0 | CIVE 315 | 4.0 | CIVE 402 | 3.0 |
| CAEE 361 | 3.0 | CIVE 401 | 3.0 | Professional elective | |
| CIVE 400 | 3.0 | General Education elective | 3.0 | General Education elective | |
| General Education elective | 3.0 | | | | |
| | **15** | | **13** | | **6** |

**Total Credits 190**

* See degree requirements (p. 6).

## BS Architectural Engineering, Digital Building Concentration

4 year, one co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101 | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | ARCH 191 | 3.0 | AE 340 | 3.0 | AE 220 | 3.5 |
| ENGL 103 or 113 | 3.0 | CAEE 203 | 3.0 | ARCH 141 | 3.0 | ARCH 142 | 3.0 |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | ARCH 192 | 3.0 | CIVE 250 | 4.0 |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | CIVE 320 | 3.0 | CIVE 330 | 4.0 |
| PHYS 201 | 4.0 | ENGR 232 | 3.0 | CAEE 212 | 4.0 | MEM 230 | 4.0 |
| | | MEM 202 | 3.0 | | | | |
| | **17** | | **18** | | **16** | | **18.5** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 143 | 3.0 | INFO 210 | 3.0 | | | | |
| CIVE 302 | 4.0 | CIVE 303 | 3.0 | | | | |
| Free elective | 3.0 | General Education Elective* | 3.0 | | | | |
| Professional elective | 3.0 | Professional Elective | 3.0 | | | | |
| | **17** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 544 | 3.0 | AE 510 | 3.0 | CAE 493 | 3.0 |
| CAE 491 | 3.0 | CAE 492 | 3.0 | CMGT 361 | 3.0 |

| | | | | | |
|---|---|---|---|---|---|
| CAEE 361 | 3.0 | CMGT 467 | 4.0 | General Education elective* | 3.0 |
| INFO 203** | 3.0 | General Education elective* | 3.0 | Professional elective | 3.0 |
| General Education elective | 3.0 | | | | |
| | **15** | | **13** | | **12** |

**Total Credits 193**

## 5 YR UG Co-op Digital Building Concentration 5 year, 3 co-ops

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101 | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | ARCH 191 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGL 103 or 113 | 3.0 | CAEE 203 | 3.0 | | | | |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | | | | |
| PHYS 201 | 4.0 | ENGR 232 | 3.0 | | | | |
| | | MEM 202 | 3.0 | | | | |
| | **17** | | **18** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 340 | 3.0 | AE 220 | 3.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 141 | 3.0 | ARCH 142 | 3.0 | | | | |
| ARCH 192 | 3.0 | CIVE 250 | 4.0 | | | | |
| CIVE 320 | 3.0 | CIVE 330 | 4.0 | | | | |
| CAEE 212 | 4.0 | MEM 230 | 4.0 | | | | |
| | **16** | | **18.5** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 143 | 3.0 | INFO 210 | 3.0 | | | | |
| CIVE 302 | 4.0 | CIVE 303 | 3.0 | | | | |
| Free elective | 3.0 | General Education elective* | 3.0 | | | | |
| Professional elective | 3.0 | Professional elective | 3.0 | | | | |
| | **17** | | **16** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 544 | 3.0 | AE 510 | 3.0 | CAE 493 | 3.0 |
| CAE 491 | 3.0 | CAE 492 | 3.0 | CMGT 361 | 3.0 |
| CAEE 361 | 3.0 | CMGT 467 | 4.0 | General Education elective* | 3.0 |
| INFO 203** | 3.0 | General Education elective* | 3.0 | Professional Elective | 3.0 |
| General Education elective* | 3.0 | | | | |
| | **15** | | **13** | | **12** |

**Total Credits 193**

* See degree requirements (p. 6).

** 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 Programs 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. Programs include: Architectural Engineering BS - Building Systems Concentration / Architectural Engineering MS (p. 69) and Architectural Engineering BS - Structural Concentration / Civil Engineering MS -Structural Track (p. 73).

### 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.)

## 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.

# 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.

# Civil, Architectural and Environmental Engineering Faculty

Abieyuwa Aghayere, PhD *(University of Alberta)*. Professor. Structural design - concrete, steel and wood; structural failure analysis; retrofitting of existing structures; new structural systems and materials; engineering education.

Ivan Bartoli, PhD *(University of California, San Diego)*. Associate Professor. Non-destructive evaluation and structural health monitoring; dynamic identification, stress wave propagation modeling.

Robert Brehm, PhD *(Drexel University)*. Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

Shannon Capps, PhD *(Georgia Institute of Technology)*. Assistant Professor. Atmospheric chemistry; data assimilation; advanced sensitivity analysis; inverse modeling.

S.C. Jonathan Cheng, PhD *(West Virginia University)*. Associate Professor. Soil mechanics; geosynthetics; geotechnical engineering; probabilistic design; landfill containments; engineering education.

Eugenia Ellis, PhD, AIA *(Virginia Polytechnic Institute and State University)*. Professor. Natural and electric light sources and effects on biological rhythms and health outcomes; ecological strategies for smart, sustainable buildings of the nexus of health, energy and technology.

Yaghoob (Amir) Farnam, PhD *(Purdue University)*. Assistant Professor. Advanced and sustainable infrastructure materials; multifunctional, self-responsive and bioinspired construction materials; advanced multiscale manufacturing; characterization, and evaluation of construction materials; durability of cement-based materials.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute and State University)*. Professor. Geotechnical and geoenvironmental engineering; soil improvement; soil improvement; recycled materials in geotechnics.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Professor. Risk analysis of environmental and infrastructure systems; novel adsorbent materials; environmental standard setting; Bayesian statistical modeling; community outreach and environmental health.

Charles N. Haas, PhD *(University of Illinois-Urbana) L. D. Betz Chair Professor of Environmental Engineering and Department Head, Civil, Architectural and Environmental Engineering*. Water treatment; risk assessment; bioterrorism; environmental modeling and statistics; microbiology; environmental health.

Ahmad Hamid, PhD *(McMaster University)*. Professor. Engineered masonry; seismic behavior, design and retrofit of masonry structures; development of new materials and building systems.

Simi Hoque, PhD *(University of California - Berkeley)*. Associate Professor. Computational methods to reduce building energy and environmental impacts, urban metabolism, thermal comfort, climate resilience.

Y. Grace Hsuan, PhD *(Imperial College)*. Professor. Durability of polymeric construction materials; advanced construction materials; and performance of geosynthetics.

Joseph B. Hughes, PhD *(University of Iowa)*. Distinguished University Professor. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Architectural fluid mechanics; building automation and autonomy; implementation of natural and hybrid ventilation in buildings; airflow distribution in buildings; large-scale air movement in an urban built environment; building and urban informatics; data-enhanced sensing and control for optimal building operation and management; novel data gathering methods for building/urban problem solving; interdisciplinary research on occupant behaviors in the built environment.

Joseph P. Martin, PhD *(Colorado State University)*. Professor. Geotechnical and geoenvironmental engineering; hydrology; transportation; waste management.

James E. Mitchell, MArch *(University of Pennsylvania)*. Professor. Architectural engineering design; building systems; engineering education.

Franco Montalto, PhD *(Cornell University)*. Professor. Effects of built infrastructure on societal water needs, ecohydrologic patterns and processes, ecological restoration, green design, and water interventions.

Nariman Mostafavi, PhD *(University of Massachusetts - Amherst)*. Assistant Teaching Professor. Simulation tools for analyzing urban metabolism; environmentally responsive design; urban resilience; engineering economics; industrial ecology.

Joseph V. Mullin, PhD *(Pennsylvania State University) Associate Department Head*. Teaching Professor. Structural engineering; failure analysis; experimental stress analysis; construction materials; marine structures.

Mira S. Olson, PhD *(University of Virginia)*. Associate Professor. Peace engineering; source water quality protection and management; contaminant and bacterial fate and transport; community engagement.

Miguel A. Pando, PhD *(Virginia Polytechnic Institute and State University)*. Assistant Professor. Laboratory testing of geomaterials; geotechnical aspects of natural hazards; soil-structure-interaction; geotechnical engineering.

Michael Ryan, PhD *(Drexel University) Associate Department Head of Graduate Studies*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); dynamic engineering systems modeling; molecular microbial biology; phylogenetics; metagenomics; bioinformatics; environmental statistics; engineering economics; microbiology; potable and waste water quality; environmental management systems.

Christopher Sales, PhD *(University of California, Berkeley)*. Associate Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste; application of molecular biology, analytical chemistry and bioinformatic techniques to study environmental biological systems.

Yared Shifferaw, PhD *(Johns Hopkins University)*. Assistant Professor. Computational and experimental mechanics; structural stability; optimization; health monitoring and hazard mitigation; sustainable structures; emerging materials; thin-walled structures and metallic structures.

Kurt Sjoblom, PhD *(Massachusetts Institute of Technology)*. Assistant Professor. Laboratory testing of geomaterials, geotechnical engineering, foundation engineering.

Sabrina Spatari, PhD *(University of Toronto)*. Associate Professor. Industrial ecology; development and application of life cycle assessment (LCA) and material flow analysis (MFA) methods for guiding engineering and policy decisions; specific interest in biomass and bioenergy, biofuels, and urban infrastructure.

Robert Swan Associate Teaching Professor. Geotechnical and Geosynthetic Engineering; soil/geosynthetic interaction and performance; laboratory and field geotechnical/geosynthetic testing.

Michael Waring, PhD *(University of Texas-Austin) Associate Department Head for Undergraduate Programs; Director of Architectural Engineering Program*. Associate Professor. Indoor air quality and building sustainability; indoor particulate matter fate and transport; indoor chemistry and particle formation; secondary impacts of control technologies and strategies.

Jin Wen, PhD *(University of Iowa)*. Associate Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

Aspasia Zerva, PhD *(University of Illinois)*. Professor. Earthquake engineering; mechanics; seismology; structural reliability; system identification; advanced computational computational methods in structural analysis.

## Emeritus Faculty

Harry G. Harris, PhD *(Cornell University)*. Professor Emeritus. Structural models; dynamics of structures, plates and shells; industrialized building construction.

Richard Weggel, PhD *(University of Illinois) Samuel S. Baxter Professor Emeritus; Civil and Environmental Engineering*. Professor Emeritus. Coastal engineering; hydraulics engineering; hydrology.

Richard Woodring, PhD *(University of Illinois) Dean of Engineering Emeritus*. Professor Emeritus. Structural engineering, reinforced concrete.

# Chemical Engineering

*Major: Chemical Engineering*
*Degree Awarded: Bachelor of Science in Chemical Engineering (BSCHE)*
*Calendar Type: Quarter*
*Total Credit Hours: 181.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.0701*
*Standard Occupational Classification (SOC) code: 17-2041*

## About the Program

The department of Chemical and Biological Engineering's chemical engineering curriculum progresses through sequences in the fundamental physical sciences, humanities, engineering sciences, and engineering design.

Chemical engineers are dedicated to designing devices and processes that convert input materials into more valuable products and often to designing those products themselves. Such end products include petrochemical derivatives, fine chemicals, pharmaceuticals, plastics, and other materials, integrated circuits, electrical energy, biologically derived fuels, and much more. Chemical engineering often begins with small laboratory scale processes that must be scaled up to production levels through carefully integrated design, optimization, economic, environmental and safety analyses.

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 group of students in the chemical engineering major 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 Department of Chemical and Biological Engineering has four goals pertaining to student outcomes within a few years of graduation:

- Our graduates will succeed in careers requiring strong skills in engineering, science, creative problem solving, communication, teamwork, and appropriate leadership.
- Our graduates will continue their professional development through life-long learning involving self- or group-study and on-the-job training.
- Our graduates will hold paramount the safety, health, and welfare of the public. They will conduct their work ethically and understand its global impact and sustainability.
- Our graduates will be thought leaders in their area of expertise who are prepared to contribute to research, development, and industrial innovation at the forefront of chemical engineering and related fields.

## Student Outcomes

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of the engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

## Additional Information

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

For more information about this program, visit Drexel University's Department of Chemical and Biological Engineering (https://drexel.edu/engineering/academics/departments/chemical-biological-engineering/) web page.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Requirements * | | 18.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 220 | Fundamentals of Materials | 4.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| MATH 201 | Linear Algebra | 4.0 |
| MATH 210 | Differential Equations | 4.0 |
| PHYS 101 | Fundamentals of Physics I | 4.0 |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| Bio Elective | | 3.0 |
| **Professional Requirements** | | |
| CHE 211 | Material and Energy Balances I | 4.0 |
| CHE 212 | Material and Energy Balances II | 4.0 |
| CHE 220 | Computational Methods in Chemical Engineering I | 3.0 |
| CHE 230 | Chemical Engineering Thermodynamics I | 4.0 |
| CHE 320 | Computational Methods in Chemical Engineering II | 3.0 |
| CHE 330 | Chemical Engineering Thermodynamics II | 4.0 |
| CHE 331 | Separation Processes | 3.0 |
| CHE 341 | Fluid Mechanics | 4.0 |
| CHE 342 | Heat Transfer | 4.0 |
| CHE 343 | Mass Transfer | 4.0 |
| CHE 350 | Statistics and Design of Experiments | 3.0 |
| CHE 351 [WI] | Chemical Engineering Laboratory I | 2.5 |
| CHE 352 [WI] | Chemical Engineering Laboratory II | 2.5 |
| CHE 362 | Chemical Kinetics and Reactor Design | 4.0 |
| CHE 371 | Engineering Economics and Professional Practice | 3.0 |
| CHE 372 | Integrated Case Studies in Chemical Engineering | 3.0 |
| CHE 453 [WI] | Chemical Engineering Laboratory III | 2.5 |
| CHE 464 | Process Dynamics and Control | 3.0 |
| CHE 466 | Chemical Process Safety | 3.0 |
| CHE 471 | Process Design I | 4.0 |
| CHE 472 [WI] | Process Design II | 3.0 |
| CHE 473 [WI] | Process Design III | 3.0 |
| 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 |
| Technical Electives | | 12.0 |
| **Total Credits** | | **181.5** |

* General Education Requirements (p. 5).

## Graduate-Level Electives

| | | |
|---|---|---|
| CHE 502 | Mathematical Methods in Chemical Engineering | 3.0 |
| CHE 513 | Chemical Engineering Thermodynamics I | 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

### 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | ENGL 102 or 112 | 3.0 | VACATION | |
| COOP 101* | 1.0 | CIVC 101 | 1.0 | ENGR 113 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | General Education elective** | 3.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **17** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHE 211 | 4.0 | CHE 212 | 4.0 | CHE 330 | 4.0 | CHE 320 | 3.0 |
| CHE 220 | 3.0 | CHE 230 | 4.0 | CHE 341 | 4.0 | CHE 342 | 4.0 |
| CHEM 241 | 4.0 | CHEM 242 | 4.0 | CHE 350 | 3.0 | CHE 343 | 4.0 |
| MATH 201 | 4.0 | MATH 210 | 4.0 | ENGR 220 | 4.0 | CHE 351 | 2.5 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | ENGL 103 or 113 | | 3.0 |
| | **15** | | **16** | | **15** | | **16.5** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHE 331 | 3.0 | CHE 352 | 2.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 362 | 4.0 | CHE 371 | 3.0 | | | | |
| CHEC 353 | 4.0 | CHE 372 | 3.0 | | | | |
| CHEM 356 | 2.0 | CHE Technical elective | 3.0 | | | | |
| Bio elective*** | 3.0 | General Education elective** | 3.0 | | | | |
| | **16** | | **14.5** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CHE 453 | 2.5 | CHE 472 | 3.0 | CHE 466 | 3.0 |
| CHE 464 | 3.0 | General Education elective** | 6.0 | CHE 473 | 3.0 |
| CHE 471 | 4.0 | CHE Technical elective | 3.0 | CHE Technical elective | 3.0 |
| CHE Technical elective | 3.0 | | | General Education elective** | 3.0 |
| General Education elective** | 3.0 | | | | |
| | **15.5** | | **12** | | **12** |

**Total Credits 181.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 13).

*** Pick from BIO 100, BIO 101, BIO 122, or BIO 141

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | ENGL 102 or 112 | 3.0 | VACATION | |
| COOP 101* | 1.0 | CIVC 101 | 1.0 | ENGR 113 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | General Education elective** | 3.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **17** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHE 211 | 4.0 | CHE 212 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 220 | 3.0 | CHE 230 | 4.0 | | | | |
| CHEM 241 | 4.0 | CHEM 242 | 4.0 | | | | |
| MATH 201 | 4.0 | MATH 210 | 4.0 | | | | |
| | **15** | | **16** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHE 330 | 4.0 | CHE 320 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 341 | 4.0 | CHE 342 | 4.0 | | | | |
| CHE 350 | 3.0 | CHE 343 | 4.0 | | | | |
| ENGR 220 | 4.0 | CHE 351 | 2.5 | | | | |
| | | ENGL 103 or 113 | 3.0 | | | | |
| | **15** | | **16.5** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHE 331 | 3.0 | CHE 352 | 2.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 362 | 4.0 | CHE 371 | 3.0 | | | | |
| CHEC 353 | 4.0 | CHE 372 | 3.0 | | | | |
| CHEM 356 | 2.0 | CHE Technical elective | 3.0 | | | | |
| Bio elective*** | 3.0 | General Education elective** | 3.0 | | | | |
| | **16** | | **14.5** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CHE 453 | 2.5 | CHE 472 | 3.0 | CHE 466 | 3.0 |
| CHE 464 | 3.0 | General Education elective** | 6.0 | CHE 473 | 3.0 |
| CHE 471 | 4.0 | CHE Technical elective | 3.0 | CHE Technical elective | 3.0 |
| CHE Technical elective | 3.0 | | | General Education elective** | 3.0 |
| General Education elective** | 3.0 | | | | |
| | **15.5** | | **12** | | **12** |

**Total Credits 181.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 13).

*** Pick from BIO 100, BIO 101, BIO 122, or BIO 141

## 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, Dow Chemical, 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.

## Facilities

The Department of Chemical and Biological Engineering occupies the 2nd, 3rd, and 4th floors of the Center for Automation Technology. Approximately 35,000 square feet (gross) are available for the department.

Two thousand square feet of laboratory facilities are designed for the pre-junior and junior year laboratory courses. Experiments in these laboratory courses focus on applying concepts in thermodynamics, fluid mechanics, heat and mass transfer, separations, and reaction engineering. Laboratory courses are run with class sizes of 18 students or less.

The department has two computer laboratories:

- The senior design laboratory features nine booths designed for team projects. Each booth contains a work station loaded with the latest process simulation software produced by Aspen, Simulation Sciences and HYSIS. Seniors use the room heavily during their Capstone design experience, although pre-junior courses in separations and transport also include projects requiring use of the process simulation software.
- A second computer lab contains over 30 individual work stations with general and engineering-specific software.

Many undergraduate students participate in research projects in faculty laboratories as part of independent study coursework or BS/MS thesis work. Chemical engineering faculty are engaged in a wide range of research activities in areas including energy and the environment, polymer science and engineering, biological engineering, and multi-scale modeling and process systems engineering. Further details can be found on the Department of Chemical and Biological Engineering's Research Group (https://drexel.edu/engineering/academics/departments/chemical-biological-engineering/department-research/research-groups/) web page.

# 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 BS/MS 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 BS/MS students involves additional graduate courses and electives.

# Chemical Engineering Faculty

Cameron F. Abrams, PhD *(University of California, Berkeley)*. Professor. Molecular simulations in biophysics and materials; receptors for insulin and growth factors; and HIV-1 envelope structure and function.

Nicolas Alvarez, PhD *(Carnegie Mellon University)*. Assistant Professor. Phototonic crystal defect chromatography; extensional rheology of polymer/polymer composites; surfactant/polymer transport to fluid and solid interfaces; aqueous lubrication; interfacial instabilities.

Jason Baxter, PhD *(University of California, Santa Barbara)*. Professor. Solar cells, semiconductor nanomaterials, ultrafast spectroscopy.

Richard A. Cairncross, PhD *(University of Minnesota)*. Associate Professor. Effects of microstructure on transport and properties of polymers; moisture transport and degradation on biodegradation on biodegradable polymers; production of biofuel.

Aaron Fafarman, PhD *(Stanford University)*. Associate Professor. Photovoltaic energy conversion; solution-based synthesis of semiconductor thin films; colloidal nanocrystals; electromodulation and photomodulation spectroscopy.

Vibha Kalra, PhD *(Cornell University)*. Associate Professor. Electrodes for energy storage and conversion; supercapacitors; Li-S batteries; fuel cells; flow batteries; electrospinning for nanofibers; molecular dynamics simulations; Nanotechnology, polymer nanocomposites.

Kenneth K.S. Lau, PhD *(Massachusetts Institute of Technology) Associate Department Head*. Professor. Surface science; nanotechnology; polymer thin films and coatings; chemical vapor deposition.

Raj Mutharasan, PhD *(Drexel University) Frank A, Fletcher Professor*. Biochemical engineering; cellular metabolism in bioreactors; biosensors.

Giuseppe R. Palmese, PhD *(University of Delaware)*. George B Francis Professor. Reacting polymer systems; nanostructured polymers; radiation processing of materials; composites and interfaces.

Joshua Snyder, PhD *(Johns Hopkins University)*. Assistant Professor. Electrocatalysis (energy conversion/storage); hetergeneous catalysis corrosion (dealloying nanoporous metals); interfacial electrochemical phenomena in nanostructured materials; colloidal synthesis.

Masoud Soroush, PhD *(University of Michigan)*. Professor. Process systems engineering; polymer engineering.

John H. Speidel, BSHE, MCHE *(University of Delaware; Illinois Institute of Technology)*. Teaching Professor. Chemical process safety; process design engineering.

Maureen Tang, PhD *(University of California, Berkeley)*. Assistant Professor. Batteries and fuel cells; nonaqueous electrochemistry; charge transport at interfaces.

Michael Walters, PhD *(Drexel University)*. Assistant Teaching Professor. Undergraduate laboratory.

Stephen P. Wrenn, PhD *(University of Delaware)*. Professor. Biomedical engineering; biological colloids; membrane phase behavior and cholesterol transport.

## Emeritus Faculty

Charles B. Weinberger, PhD *(University of Michigan)*. Professor Emeritus. Suspension rheology; fluid mechanics of multi-phase systems.

# Civil Engineering

*Major: Civil Engineering*
*Degree Awarded: Bachelor of Science in Civil Engineering (BSCIV)*
*Calendar Type: Quarter*
*Total Credit Hours: 189.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.0801*
*Standard Occupational Classification (SOC) code: 17-2051*

## 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 responsible professionals who analyze, design, construct, manage or operate built and natural infrastructure and systems, and/or will have 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:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of the engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

## Additional Information

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

For more information about this major, contact the Department of Civil, Architectural and Environmental Engineering. (https://drexel.edu/engineering/academics/areas-of-study-programs/cvil-engineering/)

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |

| | | |
|---|---|---|
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Requirements [*] | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 210 | Introduction to Thermodynamics | 3.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| ENGR 220 | Fundamentals of Materials | 4.0 |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| 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 |
| **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 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 302 | Structural Analysis I | 4.0 |
| CIVE 303 | Structural Design I | 3.0 |
| CIVE 312 | Soil Mechanics I | 4.0 |
| CIVE 315 | Soil Mechanics II | 4.0 |
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| CIVE 375 | Structural Material Behavior | 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 | Statics | 3.0 |
| MEM 238 | Dynamics | 4.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| Senior Professional Electives [**] | | 18.0 |
| **Total Credits** | | **189.5** |

* General Education Requirements (p. 5).

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

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

### 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101[*] | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | CAEE 212 | 4.0 | CIVE 250 | 4.0 |
| ENGL 103 or 113 | 3.0 | CIVE 240 | 3.0 | CIVE 320 | 3.0 | CIVE 330 | 4.0 |
| ENGR 220 | 4.0 | ENGR 210 | 3.0 | ENVE 300 | 3.0 | MEM 238 | 4.0 |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | MEM 230 | 4.0 | Free elective | 3.0 |
| PHYS 201 | 4.0 | MEM 202 | 3.0 | General Education elective[**] | 3.0 | General Education elective[**] | 3.0 |
| | **17** | | **15** | | **17** | | **18** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 361 | 3.0 | CIVE 303 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CIVE 302 | 4.0 | CIVE 315 | 4.0 | | | | |
| CIVE 312 | 4.0 | CIVE 375 | 3.0 | | | | |
| CIVE 430 | 3.0 | General Education elective[**] | 3.0 | | | | |
| General Education elective[**] | 3.0 | | | | | | |
| | **17** | | **13** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CAE 491 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| CIVE 477 | 2.0 | CIVE 478 | 1.0 | Free elective | 3.0 |
| Professional elective** | 6.0 | Professional elective** | 6.0 | Professional elective** | 6.0 |
| General Education elective** | 3.0 | General Education elective** | 3.0 | General Education elective** | 3.0 |
| | **14** | | **13** | | **15** |

**Total Credits 189.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 16).

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101* | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGL 103 or 113 | 3.0 | CIVE 240 | 3.0 | | | | |
| ENGR 220 | 4.0 | ENGR 210 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | MEM 202 | 3.0 | | | | |
| | **17** | | **15** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 | 4.0 | CIVE 250 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CIVE 320 | 3.0 | CIVE 330 | 4.0 | | | | |
| ENVE 300 | 3.0 | MEM 238 | 4.0 | | | | |
| MEM 230 | 4.0 | Free elective | 3.0 | | | | |
| General Education elective** | 3.0 | General Education elective** | 3.0 | | | | |
| | **17** | | **18** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 361 | 3.0 | CIVE 303 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CIVE 302 | 4.0 | CIVE 315 | 4.0 | | | | |
| CIVE 312 | 4.0 | CIVE 375 | 3.0 | | | | |
| CIVE 430 | 3.0 | General Education elective** | 3.0 | | | | |
| General Education elective** | 3.0 | | | | | | |
| | **17** | | **13** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CAE 491 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| CIVE 477 | 2.0 | CIVE 478 | 1.0 | Free elective | 3.0 |
| Professional elective** | 6.0 | Professional elective** | 6.0 | Professional elective** | 6.0 |
| General Education elective** | 3.0 | General Education elective** | 3.0 | General Education elective** | 3.0 |
| | **14** | | **13** | | **15** |

**Total Credits 189.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 16).

## 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.

# Facilities

The Civil, Architectural, and Environmental Engineering Department laboratories provide students with fully equipped space for education and research opportunities.

## Structural and Geotechnical Research Laboratory Facilities and Equipment

The geotechnical and structural engineering research labs at Drexel University provide a forum to perform large-scale experimentation across a broad range of areas including infrastructure preservation and renewal, structural health monitoring, geosynthetics, nondestructive evaluation, earthquake engineering, and novel ground modification approaches among others.

The laboratory is equipped with different data acquisition systems (MTS, Campbell Scientific, and National Instruments) capable of recording strain, displacement, tilt, load and acceleration time histories. An array of sensors including LVDTs, wire potentiometers, linear and rotational accelerometers, and load cells are also available. Structural testing capabilities include two 220kips capacity loading frames (MTS 311 and Tinius Olsen), in addition to several medium capacity testing frames (Instron 1331 and 567 and MTS 370 testing frames), two 5-kips MTS actuators for dynamic testing and one degree of freedom 22kips ANCO shake table. The laboratory also features a phenomenological physical model which resembles the dynamic features of common highway bridges and is used for field testing preparation and for testing different measurement devices.

The **Woodring Laboratory** hosts a wide variety of geotechnical, geosynthetics, and materials engineering testing equipment. The geotechnical engineering testing equipment includes Geotac unconfined compression and a triaxial compression testing device, ring shear apparatus, constant rate of strain consolidometer, an automated incremental consolidometer, an automated Geotac direct shear device and a large-scale consolidometer (12” by 12” sample size). Other equipment includes a Fisher pH and conductivity meter as well as a Brookfield rotating viscometer. Electronic and digital equipment include FLIR SC 325 infrared camera for thermal measurements, NI Function generators, acoustic emission sensors and ultrasonic transducers, signal conditioners, and impulse hammers for nondestructive testing.

The geosynthetics testing equipment in the Woodring lab includes pressure cells for incubation and a new differential scanning calorimetry device including the standard-OIT. Materials testing equipment that is available through the materials and chemical engineering departments includes a scanning electron microscope, liquid chromatography, and Fourier transform infrared spectroscopy.

**The Building Science and Engineering Group (BSEG)** research space is also located in the Woodring Laboratory. This is a collaborative research unit working at Drexel University with the objective of achieving more comprehensive and innovative approaches to sustainable building design and operation through the promotion of greater collaboration between diverse sets of research expertise. Much of the BSEG work is simulation or model based. Researchers in this lab also share some instrumentation with the DARRL lab (see below).

## Environmental Engineering Laboratory Facilities and Equipment

The environmental engineering laboratories at Drexel University allow faculty and student researchers access to state-of-the-art equipment needed to execute a variety of experiments. These facilities are located in the Alumni Engineering Laboratory Building and includes approximately 2000 SF shared laboratory space, and a 400 SF clean room for cell culture and PCR.

The major equipment used in this laboratory space consists of: Roche Applied Science LightCyclerÔ 480 Real-time PCR System, Leica fluorescence microscope with phase contrast and video camera, Spectrophotometer, Zeiss stereo microscope with heavy duty boom stand, fluorescence capability, and a SPOT cooled color camera, BIORAD iCycler thermocycler for PCR, gel readers, transilluminator and electrophoresis setups, temperature controlled circulator with immersion stirrers suitable for inactivation studies at volumes up to 2 L per reactor, BSL level 2 fume hood, laminar hood, soil sampling equipment, Percival Scientific environmental chamber (model 1-35LLVL), custom-built rainfall simulator.

The **Drexel Air Resources Research Laboratory (DARRL)** is located in the Alumni Engineering Laboratory Building and contains state-of-the-art aerosol measurement instrumentation including a Soot Particle Aerosol Mass Spectrometer (Aerodyne Research Inc.), mini-Aerosol Mass Spectrometer, (Aerodyne Research Inc.), Scanning Electrical Mobility Sizer (Brechtel Manufacturing), Scanning Mobility Particle Sizer (TSI Inc.), Fast Mobility Particle Sizer (TSI Inc.), Centrifugal Particle Mass Analyzer (Cambustion Ltd.), GC-FID, ozone monitors, and other instrumentation. These instruments are used for the detailed characterization of the properties of particles less than 1 micrometer in diameter including: chemical composition, size, density, and shape or morphology.

In addition to the analytical instrumentation in DARRL, the laboratory houses several reaction chambers. These chambers are used for controlled experiments meant to simulate chemical reactions that occur in the indoor and outdoor environments. The reaction chambers vary in size from 15 L to 1 m3, and allow for a range of experimental conditions to be conducted in the laboratory.

## Computer Equipment and Software

The Civil, Architectural, and Environmental Engineering (CAEE) Department at Drexel University has hardware and software capabilities for students to conduct research. The CAEE department operates a computer lab that is divided into two sections; one open access room, and a section dedicated to teaching. The current computer lab has 25 desktop computers that are recently updated to handle resource intensive GIS (Geographic Information Systems) and image processing software. There are a sufficient number of B&W and color laser printers that can be utilized for basic printing purposes.

Drexel University has site-licenses for a number of software, such as ESRITM ArcGIS 10, Visual Studio, SAP 2000, STAAD, Abaqus and MathworksTM Matlab. The Information Resources & Technology (IRT) department at Drexel University provides support (e.g., installation, maintenance and troubleshooting) to the above-mentioned software. It is currently supporting the lab by hosting a software image configuration that provides a series of commonly used software packages, such as MS Office and ADOBE Acrobat among others. As a part of ESRI campus license (the primary maker of GIS applications, i.e. ArcGIS) the department has access to a suite of seated licenses for GIS software with necessary extensions (e.g., LIDAR Analyst) required for conducting research.

# Civil, Architectural and Environmental Engineering Faculty

Abieyuwa Aghayere, PhD *(University of Alberta)*. Professor. Structural design - concrete, steel and wood; structural failure analysis; retrofitting of existing structures; new structural systems and materials; engineering education.

Ivan Bartoli, PhD *(University of California, San Diego)*. Associate Professor. Non-destructive evaluation and structural health monitoring; dynamic identification, stress wave propagation modeling.

Robert Brehm, PhD *(Drexel University)*. Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

Shannon Capps, PhD *(Georgia Institute of Technology)*. Assistant Professor. Atmospheric chemistry; data assimilation; advanced sensitivity analysis; inverse modeling.

S.C. Jonathan Cheng, PhD *(West Virginia University)*. Associate Professor. Soil mechanics; geosynthetics; geotechnical engineering; probabilistic design; landfill containments; engineering education.

Eugenia Ellis, PhD, AIA *(Virginia Polytechnic Institute and State University)*. Professor. Natural and electric light sources and effects on biological rhythms and health outcomes; ecological strategies for smart, sustainable buildings of the nexus of health, energy and technology.

Yaghoob (Amir) Farnam, PhD *(Purdue University)*. Assistant Professor. Advanced and sustainable infrastructure materials; multifunctional, self-responsive and bioinspired construction materials; advanced multiscale manufacturing; characterization, and evaluation of construction materials; durability of cement-based materials.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute and State University)*. Professor. Geotechnical and geoenvironmental engineering; soil improvement; soil improvement; recycled materials in geotechnics.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Professor. Risk analysis of environmental and infrastructure systems; novel adsorbent materials; environmental standard setting; Bayesian statistical modeling; community outreach and environmental health.

Charles N. Haas, PhD *(University of Illinois-Urbana) L. D. Betz Chair Professor of Environmental Engineering and Department Head, Civil, Architectural and Environmental Engineering*. Water treatment; risk assessment; bioterrorism; environmental modeling and statistics; microbiology; environmental health.

Ahmad Hamid, PhD *(McMaster University)*. Professor. Engineered masonry; seismic behavior, design and retrofit of masonry structures; development of new materials and building systems.

Simi Hoque, PhD *(University of California - Berkeley)*. Associate Professor. Computational methods to reduce building energy and environmental impacts, urban metabolism, thermal comfort, climate resilience.

Y. Grace Hsuan, PhD *(Imperial College)*. Professor. Durability of polymeric construction materials; advanced construction materials; and performance of geosynthetics.

Joseph B. Hughes, PhD *(University of Iowa)*. Distinguished University Professor. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Architectural fluid mechanics; building automation and autonomy; implementation of natural and hybrid ventilation in buildings; airflow distribution in buildings; large-scale air movement in an urban built environment; building and urban informatics; data-enhanced sensing and control for optimal building operation and management; novel data gathering methods for building/urban problem solving; interdisciplinary research on occupant behaviors in the built environment.

Joseph P. Martin, PhD *(Colorado State University)*. Professor. Geotechnical and geoenvironmental engineering; hydrology; transportation; waste management.

James E. Mitchell, MArch *(University of Pennsylvania)*. Professor. Architectural engineering design; building systems; engineering education.

Franco Montalto, PhD *(Cornell University)*. Professor. Effects of built infrastructure on societal water needs, ecohydrologic patterns and processes, ecological restoration, green design, and water interventions.

Nariman Mostafavi, PhD *(University of Massachusetts - Amherst)*. Assistant Teaching Professor. Simulation tools for analyzing urban metabolism; environmentally responsive design; urban resilience; engineering economics; industrial ecology.

Joseph V. Mullin, PhD *(Pennsylvania State University) Associate Department Head*. Teaching Professor. Structural engineering; failure analysis; experimental stress analysis; construction materials; marine structures.

Mira S. Olson, PhD *(University of Virginia)*. Associate Professor. Peace engineering; source water quality protection and management; contaminant and bacterial fate and transport; community engagement.

Miguel A. Pando, PhD *(Virginia Polytechnic Institute and State University)*. Assistant Professor. Laboratory testing of geomaterials; geotechnical aspects of natural hazards; soil-structure-interaction; geotechnical engineering.

Michael Ryan, PhD *(Drexel University) Associate Department Head of Graduate Studies*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); dynamic engineering systems modeling; molecular microbial biology; phylogenetics; metagenomics; bioinformatics; environmental statistics; engineering economics; microbiology; potable and waste water quality; environmental management systems.

Christopher Sales, PhD *(University of California, Berkeley)*. Associate Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste; application of molecular biology, analytical chemistry and bioinformatic techniques to study environmental biological systems.

Yared Shifferaw, PhD *(Johns Hopkins University)*. Assistant Professor. Computational and experimental mechanics; structural stability; optimization; health monitoring and hazard mitigation; sustainable structures; emerging materials; thin-walled structures and metallic structures.

Kurt Sjoblom, PhD *(Massachusetts Institute of Technology)*. Assistant Professor. Laboratory testing of geomaterials, geotechnical engineering, foundation engineering.

Sabrina Spatari, PhD *(University of Toronto)*. Associate Professor. Industrial ecology; development and application of life cycle assessment (LCA) and material flow analysis (MFA) methods for guiding engineering and policy decisions; specific interest in biomass and bioenergy, biofuels, and urban infrastructure.

Robert Swan Associate Teaching Professor. Geotechnical and Geosynthetic Engineering; soil/geosynthetic interaction and performance; laboratory and field geotechnical/geosynthetic testing.

Michael Waring, PhD *(University of Texas-Austin) Associate Department Head for Undergraduate Programs; Director of Architectural Engineering Program*. Associate Professor. Indoor air quality and building sustainability; indoor particulate matter fate and transport; indoor chemistry and particle formation; secondary impacts of control technologies and strategies.

Jin Wen, PhD *(University of Iowa)*. Associate Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

Aspasia Zerva, PhD *(University of Illinois)*. Professor. Earthquake engineering; mechanics; seismology; structural reliability; system identification; advanced computational computational methods in structural analysis.

## Emeritus Faculty

Harry G. Harris, PhD *(Cornell University)*. Professor Emeritus. Structural models; dynamics of structures, plates and shells; industrialized building construction.

Richard Weggel, PhD *(University of Illinois) Samuel S. Baxter Professor Emeritus; Civil and Environmental Engineering*. Professor Emeritus. Coastal engineering; hydraulics engineering; hydrology.

Richard Woodring, PhD *(University of Illinois) Dean of Engineering Emeritus*. Professor Emeritus. Structural engineering, reinforced concrete.

# Computer Engineering

*Major: Computer Engineering*
*Degree Awarded: Bachelor of Science in Computer Engineering (BSCE)*
*Calendar Type: Quarter*
*Total Credit Hours: 183.0*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.0901*
*Standard Occupational Classification (SOC) code: 15-1132; 15-1133; 15-1143; 17-2031*

## About the Program

The major provides a broad focus on electronic circuits and systems, computer architecture, computer networking, embedded systems, programming and system software, algorithms, and computer security.

Computer engineers design smaller, faster, and more reliable computers and digital systems, build computer networks to transfer data, embed microprocessors in larger physical systems such as cars and planes, work on theoretical issues in computing, and design large-scale software systems. 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 (http://drexel.edu/ece/) 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 such that its alumni, in their early years after graduation can:

- Secure positions and continue as valued, creative, dependable, and proficient employees in a wide variety of fields and industries, in particular as computer engineers.
- Succeed in graduate and professional studies if pursued, such as engineering, science, law, medicine and business.
- Embrace and pursue lifelong learning for a successful and rewarding career.
- Act as an ambassador for the field of engineering through clear, professional communication with technical and non-technical audiences, including the general public.
- Accept responsibility for leadership roles in their profession, in their communities, and in the global society.
- Contribute to their professional discipline's body of knowledge.
- Function as responsible members of society with an awareness of the social and ethical ramifications of their work.

## Student Outcomes

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of the engineering solutions in global, economic, environmental, and societal contexts

5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

## Additional Information

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

Additional information about the major is available on the ECE Department website (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/).

For advising questions, please contact the ECE advisor (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/resources/current-undergrad/).

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| COOP 101 | Career Management and Professional Development | 1.0 |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| **COM Elective** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| or COM 310 | Technical Communication | |
| General Education Requirements * | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CS 265 | Advanced Programming Tools and Techniques | 3.0 |
| CS 260 | Data Structures | 3.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| MATH 221 | Discrete Mathematics | 3.0 |
| MATH 291 | Complex and Vector Analysis for Engineers | 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 |
| **Science Elective** | | **3.0** |
| Choose any BIO, CHEM, or PHYS | | |
| **Professional Requirements** | | |
| ECE 101 | Electrical and Computer Engineering in the Real World | 1.0 |
| ECE 105 | Programming for Engineers II | 3.0 |
| ECE 200 | Digital Logic Design | 4.0 |
| ECE 201 | Foundations of Electric Circuits I | 4.0 |
| ECE 301 | Foundations of Electric Circuits II | 4.0 |
| ECE 303 | ECE Laboratory | 3.0 |
| ECE 350 | Introduction to Computer Organization | 3.0 |
| ECE 361 | Probability and Data Analytics for Engineers | 4.0 |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 | Senior Design Project III | 3.0 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| **ECE Electives** ** | | **15.0** |
| **CE Core Elective** *** | | **3.0** |
| **Free Electives** | | **27.0** |
| **Total Credits** | | **181.5** |

* General Education Requirements (p. 5)

** At least 9 credits must be in the major at the 400 level. At least 12 credits must be in the subject codes ECE or ECEC.

*** Must choose one course from approved list

Note: Students majoring in Computer Engineering must have a 2.0 cumulative overall GPA and a 2.0 cumulative GPA in their Professional Requirements courses.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

### 4 year, 1 co-op

| First Year | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Fall** | **Credits** | **Winter** | **Credits** | **Spring** | **Credits** | **Summer** | **Credits** |
| CHEM 101 | 3.5 | COOP 101* | 1.0 | CIVC 101 | 1.0 | VACATION | |
| ECE 101 | 1.0 | ECE 200 | 4.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **16** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 201 | 4.0 | COM 230 or 310 | 3.0 | ECE 301 | 4.0 | ECE 361 | 4.0 |
| ECEC 201 | 3.0 | CS 265 | 3.0 | CS 260 | 3.0 | PHIL 315 | 3.0 |
| ENGL 103 | 3.0 | ECEC 204 | 3.0 | ECE 350 | 3.0 | CE Core elective | 3.0 |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | ECES 301 | 4.0 | Science elective | 3.0 |
| MATH 221 | 3.0 | PHYS 201 | 4.0 | | | Free elective | 3.0 |
| | **16** | | **16** | | **14** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ECE 303 | 3.0 | General Education elective | 3.0 |
| | | | | MATH 291 | 4.0 | ECE elective | 3.0 |
| | | | | General Education elective** | 3.0 | Free electives | 9.0 |
| | | | | Free electives | 6.0 | | |
| | **0** | | **0** | | **16** | | **15** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| ECEC elective (400-level or higher) | 3.0 | ECEC elective (400+ level or higher) | 3.0 | ECEC elective (400+ level or higher) | 3.0 |
| ECE elective | 3.0 | General Education elective | 3.0 | General Education elective | 3.0 |
| General Education elective | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 181.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (p. 5)

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | COOP 101 | 1.0 | CIVC 101 | 1.0 | VACATION | |
| ECE 101 | 1.0 | ECE 200 | 4.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **16** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ECEC 201 | 3.0 | ECEC 204 | 3.0 |
| | | | | ENGR 231 | 3.0 | ENGR 232 | 3.0 |
| | | | | ECE 201 | 4.0 | CS 265 | 3.0 |
| | | | | MATH 221 | 3.0 | PHYS 201 | 4.0 |
| | | | | ENGL 103 or 113 | 3.0 | COM 230 or 310 | 3.0 |
| | **0** | | **0** | | **16** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | CS 260 | 3.0 | ECE 361 | 4.0 |
| | | | | ECE 301 | 4.0 | PHIL 315 | 3.0 |
| | | | | ECE 350 | 3.0 | CE Core elective | 3.0 |
| | | | | ECES 301 | 4.0 | Science elective | 3.0 |
| | | | | | | Free elective | 3.0 |
| | **0** | | **0** | | **14** | | **16** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ECE 303 | 3.0 | General Education elective | 3.0 |
| | | | | MATH 291 | 4.0 | ECE elective | 3.0 |
| | | | | General Education elective* | 3.0 | Free electives | 9.0 |
| | | | | Free electives | 6.0 | | |
| | **0** | | **0** | | **16** | | **15** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| ECEC elective (400+ level or higher) | 3.0 | ECEC elective (400+ level or higher) | 3.0 | ECEC elective (400+ level or higher) | 3.0 |
| ECE elective | 3.0 | General Education elective | 3.0 | Free elective | 3.0 |
| General Education elective | 3.0 | Free elective | 3.0 | General Education elective | 3.0 |
| Free elective | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 181.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (p. 5)

Students majoring in Computer Engineering must have a 2.0 cumulative overall GPA and a 2.0 cumulative GPA in their professional requirements courses.

## Co-op/Career Opportunities

Drexel University's co-op program has an 80 year history and is one of the oldest and largest co-op programs in the world. Students graduate with 6-18 months of full time employment experience, depending on their choice of a 4-year or 5-year program. The majority of Computer Engineering students in ECE choose the 5-year program and graduate with 18 months of full-time work experience, and often receive a job offer from their third co-op employer or from a connection made from one of their co-op experiences.

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.

The Steinbright Career Development Center had a co-op placement rate of approximately 99% for electrical and computer engineering majors.

Co-op employers for computer engineering majors include:

- Lockheed Martin
- Comcast Corporation
- SAP America
- Susquehanna International Group LLC
- PJM Interconnection, LLC
- Dell
- National Board of Medical Examiners
- UNISYS Corporation
- Woodward McCoach, Inc.
- NAVSEA
- ClarivateAnalytics (Thomson Reuters)
- NVIDIA
- Excelon Corporation

For more information about the co-op process, please contact the Steinbright Career Development Center (http://drexel.edu/scdc/).

## Dual Degree Bachelor's Program

With careful planning, students can complete both a Computer Engineering and an Electrical Engineering degree in the time usually required to complete one degree. For detailed information the student should contact the ECE advisor (http://drexel.edu/ece/academics/undergrad/advising/).

## 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://drexel.edu/ece/academics/undergrad/bs-ms/) 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**

The Adaptive Signal Processing and Information Theory Research Group (http://www.ece.drexel.edu/walsh/aspitrg/home.html) conducts research in the area of signal processing and information theory. Our main interests are belief/expectation propagation, turbo decoding and composite adaptive system theory. We are currently doing projects on the following topics:
i) Delay mitigating codes for network coded systems,
ii) Distributed estimation in sensor networks via expectation propagation,
iii) Turbo speaker identification,
iv) Performance and convergence of expectation propagation,
v) Investigating bounds for SINR performance of autocorrelation based channel shorteners.

**Bioimage Laboratory**

Uses computer gaming hardware for enhanced and affordable 3-D visualization, along with techniques from information theory and machine learning to combine the exquisite capabilities of the human visual system with computational sensing techniques for analyzing vast quantities of image sequence data.

**Data Fusion Laboratory**

The Data Fusion Laboratory investigates problems in multisensory detection and estimation, with applications in robotics, digital communications, radar, and target tracking. Among the projects in progress: computationally efficient parallel distributed detection architectures, data fusion for robot navigation, modulation recognition and RF scene analysis in time-varying environments, pattern recognition in biological data sequences and large arrays, and hardware realizations of data fusion architectures for target detection and target tracking.

**Drexel Network Modeling Laboratory**

The Drexel Network Modeling Laboratory investigates problems in the mathematical modeling of communication networks, with specific focus on wireless ad hoc networks, wireless sensor networks, and supporting guaranteed delivery service models on best effort and multipath routed networks. Typical methodologies employed in our research include mathematical modeling, computer simulation, and performance optimization, often with the end goal of obtaining meaningful insights into network design principles and fundamental performance tradeoffs.

**Drexel Power-Aware Computing Laboratory**

The Power-Aware Computing Lab (http://dpac.ece.drexel.edu/) investigates methods to increase energy efficiency across the boundaries of circuits, architecture, and systems. Our recent accomplishments include the Sigil profiling tool, scalable modeling infrastructure for

accelerator implementations, microarchitecture-aware VDD gating algorithms, an accelerator architecture for ultrasound imaging, evaluation of hardware reference counting, hardware and operating system support for power-agile computing, and memory systems for accelerator-based architectures.

**Drexel University Nuclear Engineering Education Laboratory**

The field of nuclear engineering encompasses a wide spectrum of occupations, including nuclear reactor design, medical imaging, homeland security, and oil exploration.The Drexel University Nuclear Engineering Education Laboratory (DUNEEL) provides fundamental hands on understanding for power plant design and radiation detection and analysis.Software based study for power plant design, as well as physical laboratory equipment for radiation detection, strengthen the underlying concepts used in nuclear engineering such that the student will comprehend and appreciate the basic concepts and terminology used in various nuclear engineering professions. Additionally, students use the laboratory to develop methods for delivering remote, live time radiation detection and analysis. The goal of DUNEEL is to prepare students for potential employment in the nuclear engineering arena.

**Drexel VLSI Laboratory**

The Drexel VLSI Laboratory investigates problems in the design, analysis, optimization and manufacturing of high performance (low power, high throughput) integrated circuits in contemporary CMOS and emerging technologies. Suited with industrial design tools for integrated circuits, simulation tools and measurement beds, the VLSI group is involved with digital and mixed-signal circuit design to verify the functionality of the discovered novel circuit and physical design principles. The Drexel VLSI laboratory develops design methodologies and automation tools in these areas, particularly in novel clocking techniques, featuring resonant clocking, and interconnects, featuring wireless interconnects.

**Drexel Wireless Systems Laboratory**

The Drexel Wireless Systems Laboratory (DWSL) contains an extensive suite of equipment for constructing, debugging, and testing prototype wireless communications systems. Major equipment within DWSL includes:

- three software defined radio network testbeds (HYDRA, USRP, and WARP) for rapidly prototyping radio, optical and ultrasonic communications systems,
- a TDK RF anechoic chamber and EMSCAN desktop antenna pattern measurement system,
- a materials printer and printed circuit board milling machine for fabricating conformal antennas and
- wireless protocol conformance testing equipment from Aeroflex.

The lab is also equipped with network analyzers, high speed signal generators, oscilloscopes, and spectrum analyzers as well as several Zigbee development platforms for rapidly prototyping sensor networks.

DWSL personnel also collaborate to create wearable, fabric based transceivers through collaboration with the Shima Seiki Haute Laboratory in the Drexel ExCITe Center.The knitting equipment at Drexel includes sixteen SDS-ONE APEX3 workstations and four state-of-the-art knitting machines. The workstations accurately simulate fabric construction and provide researchers and designers the opportunity to program, create and simulate textile prototypes, import CAD specifications of final products, and produce made-to-measure or mass-produced pieces on Shima Seiki knitting machines.For testing smart textiles for biomedical, DWSL personnel also have collaborators in the Center for Interdisciplinary Clinical Simulation and Practice (CICSP) in the Drexel College of Medicine which provides access to medical mannequin simulators.

**Ecological and Evolutionary Signal-processing and Informatics Laboratory**

The Ecological and Evolutionary Signal-processing and Informatics Laboratory (EESI) seeks to solve problems in high-throughput genomics and engineer better solutions for biochemical applications. The lab's primary thrust is to enhance the use of high-throughput DNA sequencing technologies with pattern recognition and signal processing techniques. Applications include assessing the organism content of an environmental sample, recognizing/classifying potential and functional genes, inferring environmental factors and inter-species relationships, and inferring microbial evolutionary relationships from short-read DNA/RNA fragments. The lab also investigates higher-level biological systems such as modeling and controlling chemotaxis, the movement of cells.

**Electric Power Engineering Center**

This newly established facility makes possible state-of-the-art research in a wide variety of areas, ranging from detailed theoretical model study to experimental investigation in its high voltage laboratories. The mission is to advance and apply scientific and engineering knowledge associated with the generation, transmission, distribution, use, and conservation of electric power. In pursuing these goals, this center works with electric utilities, state and federal agencies, private industries, nonprofit organizations and other universities on a wide spectrum of projects. Research efforts, both theoretical and experimental, focus on the solution of those problems currently faced by the electric power industry. Advanced concepts for electric power generation are also under investigation to ensure that electric power needs will be met at the present and in the future.

**Electronic Design Automation Facility**

Industrial-grade electronic design automation software suite and intergrated design environment for digital, analog and mixed-signal systems development. Field Programmable Gate Array (FPGA) development hardware. Most up-to-date FPGA/embedded system development hardware kits. Printed circuit board production facility. Also see Drexel VLSI Laboratory.

**Microwave-Photonics Device Laboratories**

The laboratory is equipped with test and measurement equipment for high-speed analog and digital electronics and fiber optic systems. The test equipment includes network analyzers from Agilent (100kHz- 1.3 GHz and 45 Mhz-40 GHz), and Anritsu (45 MHz-6 GHz); spectrum analyzers from Tektronix, HP, and Agilent with measurement capability of DC to 40 GHz and up to 90 GHz using external mixers; signal generators and communication channel modulators from HP, Rhode-Schwartz, Systron Donner, and Agilent; microwave power meter and sensor heads, assortment of passive and active microwave components up to 40 GHz ; data pattern generator and BER tester up to 3Gb/s; optical spectrum analyzer from Anritsu and power meters from HP; single and multimode fiber optic based optical transmitter and receiver boards covering ITU channels at data rates up to 10Gb/s; passive optical components such as isolator, filter, couplers, optical connectors and fusion splicer; LPKF milling machine for fabrication of printed circuit boards; wire-bonding and Cascade probe stations; Intercontinental test fixtures for testing of MMIC circuits and solid-state transistors; state-of-the-art microwave and

electromagnetic CAD packages such as Agilent ADS, ANSYS HFSS, and COMSOL multi-physics module.

**Music and Entertainment Technology Laboratory**

The Music and Entertainment Technology Laboratory (MET-lab) is devoted to research in digital media technologies that will shape the future of entertainment, especially in the areas of sound and music. We employ digital signal processing and machine learning to pursue novel applications in music information retrieval, music production and processing technology, and new music interfaces. The MET-lab is also heavily involved in outreach programs for K-12 students and hosts the Summer Music Technology program, a one-week learning experience for high school students. Lab facilities include a sound isolation booth for audio and music recording, a digital audio workstation running ProTools, two large multi-touch display interfaces of our own design, and a small computing cluster for distributed processing.

## NanoPhotonics+ Lab

Our research is primarily in the area of nanophotonics with a focus on the nanoscale interaction of light with matter. Interests include: liquid crystal/polymer composites for gratings, lenses and HOEs; liquid crystal interactions with surfaces and in confined nanospaces; alternative energy generation through novel photon interactions; ink-jet printed conducting materials for RF and photonic applications; and the creation and development of smart textiles technologies including soft interconnects, sensors, and wireless implementations.

**Opto-Electro-Mechanical Laboratory**

This lab concentrates on the system integration on optics, electronics, and mechanical components and systems, for applications in imaging, communication, and biomedical research. Research areas include: Programmable Imaging with Optical Micro-electrical-mechanical systems (MEMS), in which microscopic mirrors are used to image light into a single photodetector; Pre-Cancerous Detection using White Light Spectroscopy, which performs a cellular size analysis of nuclei in tissue; Free-space Optical Communication using Space Time Coding, which consists of diffused light for computer-to-computer communications, and also tiny lasers and detectors for chip-to-chip communication; Magnetic Particle Locomotion, which showed that particles could swim in a uniform field; and Transparent Antennas using Polymer, which enables antennas to be printed through an ink-jet printer.

**Plasma and Magnetics Laboratory**

Research is focused on applications of electrical and magnetic technologies to biology and medicine. This includes the subjects of non-thermal atmospheric pressure plasma for medicine, magnetic manipulation of particles for drug delivery and bio-separation, development of miniature NMR sensors for cellular imaging and carbon nanotube cellular probes.

**Power Electronics Research Laboratory**

The Power Electronics Research Laboratory (PERL) is involved in circuit and design simulation, device modeling and simulation, and experimental testing and fabrication of power electronic circuits. The research and development activities include electrical terminations, power quality, solar photovoltaic systems, GTO modeling, protection and relay coordination, and solid-state circuit breakers. The analysis tools include EMPT, SPICE, and others, which have been modified to incorporate models of such controllable solid-state switches as SCRs, GTOs, and MOSFETs. These programs have a wide variety and range of modeling capabilities used to model electromagnetics and electromechanical transients ranging from microseconds to seconds in duration. The PERL is a fully equipped laboratory with 42 kVA AC and 70 kVA DC power sources and data acquisition systems, which have the ability to display and store data for detailed analysis. Some of the equipment available is a distribution and HV transformer and three phase rectifiers for power sources and digital oscilloscopes for data measuring and experimental analysis. Some of the recent studies performed by the PERL include static VAR compensators, power quality of motor controllers, solid-state circuit breakers, and power device modeling which have been supported by PECO, GE, Gould, and EPRI.

**Testbed for Power-Performance Management of Enterprise Computing Systems**

This computing testbed is used to validate techniques and algorithms aimed at managing the performance and power consumption of enterprise computing systems. The testbed comprises a rack of Dell 2950 and Dell 1950 PowerEdge servers, as well as assorted desktop machines, networked via a gigabit switch. Virtualization of this cluster is enabled by VMWare's ESX Server running the Linux RedHat kernel. It also comprises of a rack of ten Apple Xserve machines networked via a gigabit switch. These servers run the OS X Leopard operating systems and have access to a RAID with TBs of total disk capacity.

# Computer Engineering Faculty

Tom Chmielewski, PhD *(Drexel University)*. Teaching Professor. Modeling and simulation of electro-mechanical systems; optimal, adaptive and non-linear control; DC motor control; system identification; kalman filters (smoothing algorithms, tracking); image processing; robot design; biometric technology and design of embedded systems for control applications utilizing MATLAB and SIMULINK

Fernand Cohen, PhD *(Brown University)*. Professor. Surface modeling; tissue characterization and modeling; face modeling; recognition and tracking.

Andrew Cohen, PhD *(Rensselaer Polytechnic Institute)*. Associate Professor. Image processing; multi-target tracking; statistical pattern recognition and machine learning; algorithmic information theory; 5-D visualization

Kapil Dandekar, PhD *(University of Texas-Austin) Director of the Drexel Wireless Systems Laboratory (DWSL); Associate Dean of Research, College of Engineering*. Professor. Cellular/mobile communications and wireless LAN; smart antenna/MIMO for wireless communications; applied computational electromagnetics; microwave antenna and receiver development; free space optical communication; ultrasonic communication; sensor networks for homeland security; ultrawideband communication.

Afshin Daryoush, ScD *(Drexel University)*. Professor. Digital and microwave photonics; nonlinear microwave circuits; RFIC; medical imaging.

Anup Das, PhD *(Universit of Singapore)*. Assistant Professor. Design of algorithms for neuromorphic computing, particularly using spiking neural networks, dataflow-based design of neuromorphic computing system, design of scalable computing system; hardware-software co-design and management, and thermal and power management of many-core embedded systems

Bruce A. Eisenstein, PhD *(University of Pennsylvania)*. Arthur J. Rowland Professor of Electrical and Computer Engineering. Pattern recognition; estimation; decision theory.

Adam K. Fontecchio, PhD *(Brown University) Director, Center for the Advancement of STEM Teaching and Learning Excellence (CASTLE)*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

Gary Friedman, PhD *(University of Maryland-College Park) Associate Department Head for Graduate Affairs*. Professor. Biological and biomedical applications of nanoscale magnetic systems.

Allon Guez, PhD *(University of Florida)*. Professor. Intelligent control systems; robotics, biomedical, automation and manufacturing; business systems engineering.

Peter R. Herczfeld, PhD *(University of Minnesota)*. Professor. Lightwave technology; microwaves; millimeter waves; fiberoptic and integrated optic devices.

Leonid Hrebien, PhD *(Drexel University)*. Professor. Tissue excitability; acceleration effects on physiology; bioinformatics.

Nagarajan Kandasamy, PhD *(University of Michigan) Associate Department Head for Undergraduate Affairs*. Associate Professor. Embedded systems, self-managing systems, reliable and fault-tolerant computing, distributed systems, computer architecture, and testing and verification of digital systems.

Youngmoo Kim, PhD *(MIT) Director, Expressive and Creative Interactive Technologies (ExCITe) Center*. Professor. Audio and music signal processing, voice analysis and synthesis, music information retrieval, machine learning.

Fei Lu, PhD *(University of Michigan)*. Assistant Professor. Power electronics; wireless power transfer technology for the high-power electric vehicles and the low-power electronic devices.

Karen Miu, PhD *(Cornell University)*. Professor. Power systems; distribution networks; distribution automation; optimization; system analysis.

Bahram Nabet, PhD *(University of Washington)*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Prawat Nagvajara, PhD *(Boston University)*. Associate Professor. System on a chip; embedded systems; power grid computation; testing of computer hardware; fault-tolerant computing; VLSI systems; error control coding.

Dagmar Niebur, PhD *(Swiss Federal Institute of Technology)*. Associate Professor. Intelligent systems; dynamical systems; power system monitoring and control.

Christopher Peters, PhD *(University of Michigan)*. Teaching Professor. Nuclear reactor design; ionizing radiation detection; nuclear forensics; power plant reliability and risk analysis; naval/marine power and propulsion; directed energy/high power microwaves; nonstationary signal processing; radar; electronic survivability/susceptibility to harsh environments; electronic warfare

Karkal Prabhu, PhD *(Harvard University)*. Teaching Professor. Computer engineering education; computer architecture; embedded systems

Gail L. Rosen, PhD *(Georgia Institute of Technology)*. Associate Professor. Signal processing, signal processing for biological analysis and modeling, bio-inspired designs, source localization and tracking.

Ioannis Savidis, PhD *(University of Rochester)*. Associate Professor. Analysis, modeling, and design methodologies for high performance digital and mixed-signal integrated circuits; Emerging integrated circuit technologies; Electrical and thermal modeling and characterization, signal and power integrity, and power and clock delivery for 3-D IC technologies

Kevin J. Scoles, PhD *(Dartmouth College) Associate Dean for Undergraduate Affairs*. Associate Professor. Microelectronics; electric vehicles; solar energy; biomedical electronics.

Harish Sethu, PhD *(Lehigh University)*. Associate Professor. Protocols, architectures and algorithms in computer networks; computer security; mobile ad hoc networks; large-scale complex adaptive networks and systems.

James Shackleford, PhD *(Drexel University)*. Associate Professor. Medical image processing, high performance computing, embedded systems, computer vision, machine learning

P. Mohana Shankar, PhD *(Indian Institute of Technology) Allen Rothwarf Professor of Electrical and Computer Engineering*. Professor. Wireless communications; biomedical ultrasonics; fiberoptic bio-sensors.

Matthew Stamm, PhD *(University of Maryland, College Park)*. Associate Professor. Information Security; multimedia forensics and anti-forensics; information verification; adversarial dynamics; signal processing

Baris Taskin, PhD *(University of Pittsburgh)*. Professor. Very large-scal integration (VLSI) systems, computer architecture, circuits and systems, electronic design automation (EDA), energy efficient computing.

John Walsh, PhD *(Cornell University)*. Associate Professor. Bounding the region of entropic vectors and its implications for the limits of communication networks, big data distributed storage systems, and graphical model based machine learning; efficient computation and analysis of rate regions for network coding and distributed storage; code construction, polyhedral computation, hierarchy, and symmetry

Steven Weber, PhD *(University of Texas-Austin) Department Head*. Professor. Mathematical modeling of computer and communication networks, specifically streaming multimedia and ad hoc networks.

Jaudelice de Oliveira, PhD *(Georgia Institute of Technology)*. Associate Professor. Software-defined networking; social and economic networks; network security; design and analysis of protocols, algorithms and architectures in computer networks, particularly solutions for the Internet of Things

## Emeritus Faculty

Suryadevara Basavaiah, PhD *(University of Pennsylvania)*. Professor Emeritus. Computer engineering; computer engineering education; custom circuit design; VLSI technology; process and silicon fabrication

Eli Fromm, PhD *(Jefferson Medical College)*. Professor Emeritus. Engineering education; academic research policy; bioinstrumentation; physiologic systems.

Edwin L. Gerber, PhD *(University of Pennsylvania)*. Professor Emeritus. Computerized instruments and measurements; undergraduate engineering education.

# Construction Management

*Major: Construction Management*
*Degree Awarded: Bachelor of Science in Construction Management (BSCMGT)*
*Calendar Type: Quarter*
*Total Credit Hours: 186.0*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 52.2001*
*Standard Occupational Classification (SOC) code: 11-9021*

## About the Program

Construction management is a dynamic profession that is a combination of art and science. While an understanding of the technical aspects of construction is extremely important, it is also essential that construction professionals have knowledge of the business and management aspects of the profession. While construction has traditionally been a very conservative industry, the increasing rate of technological development and competition in the industry serves to accelerate the development of new construction methods, equipment, materials, and management techniques. As a result of these forces, there is an increasing need for innovative and professionally competent construction professionals.

The Construction Management major prepares students for all phases of operation and management of the construction organization including cost estimating, project scheduling, and planning, in addition to technology courses, sustainability, BIM and Virtual Design and Construction. Students are able to choose from a wide range of subjects in the social sciences and humanities to satisfy electives in the liberal arts and free elective requirements. Pursuing part-time, degree completion on average takes six years.

Students in Drexel's Construction Management program receive broad academic, technical, business, and construction management courses that are designed to produce well-rounded construction professionals. Students interested in extending their construction management studies into real estate development should consider the concentration in real estate. This concentration in real estate is designed for students to attain the knowledge and skills required to create and maintain built environments for living, working and entertainment purposes, as well as to explore issues in the real estate development process and the industry as a whole.

## Program Delivery Options

Program delivery options for the Construction Management program include:

- A traditional 5-year with co-op
- 4-year with one co-op
- A part-time study option

## Additional Information

For additional information, visit the Construction Management (https://drexel.edu/engineering/academics/departments/construction-engineering-project-management-systems-engineering/) website or contact:

Jessica Cruz
215.895.5943
jc635@drexel.edu

## Degree Requirements

| | | |
|---|---|---|
| **English/Communication** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| **Mathematics** | | |
| MATH 110 | Precalculus | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| **Science** | | |
| GEO 101 | Physical Geology | 4.0 |
| PHYS 151 | Applied Physics | 3.0 |
| One Physical Science Elective | | 3.0 |
| **Business** | | |
| ACCT 110 | Accounting for Professionals | 4.0 |
| ECON 201 | Principles of Microeconomics | 4.0 |
| ECON 202 | Principles of Macroeconomics | 4.0 |
| FIN 301 | Introduction to Finance | 4.0 |
| STAT 201 | Introduction to Business Statistics | 4.0 |
| One Business Elective | | 4.0 |
| **Humanities and Social Science** | | |
| PHIL 315 | Engineering Ethics | 3.0 |
| Three Humanities and Social Science Electives | | 9.0 |
| **Engineering Core** | | |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| **Professional Core - Construction Science** | | |
| CMGT 161 | Building Materials and Construction Methods I | 3.0 |
| CMGT 162 | Building Materials and Construction Methods II | 3.0 |
| CMGT 163 | Building Materials and Construction Methods III | 3.0 |
| CMGT 251 | Construction Surveying | 3.0 |
| CMGT 265 | Information Technologies in Construction | 3.0 |
| CMGT 266 | Building Systems I | 3.0 |
| CMGT 267 | Building Systems II | 3.0 |
| CMGT 270 | Principles of Statics for Construction Management | 3.0 |
| CMGT 365 | Soil Mechanics in Construction | 4.0 |
| CMGT 371 | Structural Aspects in Construction I | 3.0 |
| CMGT 372 | Structural Aspects in Construction II | 3.0 |
| **Professional Core - Construction** | | |
| CMGT 101 | Introduction to Construction Management | 3.0 |
| CMGT 240 [WI] | Economic Planning for Construction | 3.0 |
| CMGT 261 | Construction Safety | 3.0 |
| CMGT 263 | Understanding Construction Drawings | 3.0 |
| CMGT 355 | Introduction to Sustainability in Construction | 3.0 |
| CMGT 361 | Contracts And Specifications I | 3.0 |
| CMGT 362 | Contracts and Specifications II | 3.0 |
| CMGT 363 | Estimating I | 3.0 |
| CMGT 364 | Estimating II | 3.0 |
| CMGT 375 | Building Information Modeling in Construction | 3.0 |
| CMGT 450 | Management of Field Operations | 3.0 |
| CMGT 461 | Construction Project & Company Management | 3.0 |
| CMGT 463 | Value Engineering | 3.0 |
| CMGT 467 | Techniques of Project Control | 4.0 |
| **Professional Core - Professional Techniques** | | |
| CMGT 385 [WI] | Selling and Negotiation Techniques in Construction | 3.0 |
| CMGT 485 | Habits of Successful Design and Build Construction | 3.0 |
| CMGT 486 | Leading in the Construction Industry | 3.0 |

| | | |
|---|---|---|
| **Construction Electives** | | |
| Select three of the following: | | 9.0 |
| CMGT 262 | Building Codes | |
| CMGT 451 | Heavy Construction Principles & Practices | |
| CMGT 468 | Real Estate | |
| CMGT 469 | Construction Seminar: Contemporary Issues | |
| CMGT 470 | Productivity in Construction | |
| CMGT I499 | Independent Study in CMGT | |
| Other Approved CMGT Elective * | | |
| **Construction Capstone** | | |
| CMGT 491 | Senior Capstone I | 3.0 |
| CMGT 492 | Senior Capstone II | 3.0 |
| CMGT 493 | Senior Capstone III | 3.0 |
| **University Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| UNIV G101 | The Drexel Experience | 1.0 |
| **Free Electives** | | **9.0** |
| **Total Credits** | | **187.0** |

* Students may choose another construction elective but the permission of the Program is required.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

## 4 year, one co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 161 | 3.0 | CIVC 101 | 1.0 | ACCT 110 | 4.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CMGT 101 | 3.0 | CMGT 163 | 3.0 | | |
| ENGR 111 | 3.0 | CMGT 162 | 3.0 | CMGT 263 | 3.0 | | |
| MATH 110 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| UNIV E101 | 1.0 | MATH 121 | 4.0 | ENGR 113 | 3.0 | | |
| | | PHYS 151 | 3.0 | | | | |
| | **13** | | **17** | | **16** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 251 | 3.0 | CMGT 240 | 3.0 | CMGT 266 | 3.0 | CMGT 265 | 3.0 |
| CMGT 261 | 3.0 | CMGT 270 | 3.0 | CMGT 363 | 3.0 | CMGT 267 | 3.0 |
| ECON 201 | 4.0 | COM 230 | 3.0 | CMGT 371 | 3.0 | CMGT 364 | 3.0 |
| GEO 101 | 4.0 | ECON 202 | 4.0 | COOP 101* | 1.0 | CMGT 372 | 3.0 |
| Free elective | 3.0 | Physical Science elective | 3.0 | PHIL 315 | 3.0 | CMGT 385 | 3.0 |
| | | | | STAT 201 | 4.0 | | |
| | **17** | | **16** | | **17** | | **15** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 355 | 3.0 | CMGT 362 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 361 | 3.0 | CMGT 365 | 4.0 | | | | |
| CMGT 375 | 3.0 | CMGT 485 | 3.0 | | | | |
| FIN 301 | 4.0 | Business elective | 4.0 | | | | |
| Humanities/ Social Science elective | 3.0 | Construction Management elective | 3.0 | | | | |
| | **16** | | **17** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CMGT 463 | 3.0 | CMGT 450 | 3.0 | CMGT 493 | 3.0 |
| CMGT 467 | 4.0 | CMGT 461 | 3.0 | Construction Management elective | 3.0 |
| CMGT 491 | 3.0 | CMGT 486 | 3.0 | Free electives | 6.0 |
| Construction Management elective | 3.0 | CMGT 492 | 3.0 | | |
| Humanities/ Social Science elective | 3.0 | Humanities/ Social Science elective | 3.0 | | |
| | **16** | | **15** | | **12** |

**Total Credits 187**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 161 | 3.0 | CIVC 101 | 1.0 | ACCT 110 | 4.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CMGT 101 | 3.0 | CMGT 163 | 3.0 | | |
| ENGR 111 | 3.0 | CMGT 162 | 3.0 | CMGT 263 | 3.0 | | |
| MATH 110 | 3.0 | ENGL 102 or 112 | 3.0 | COOP 101* | 1.0 | | |
| UNIV E101 | 1.0 | MATH 121 | 4.0 | ENGL 103 or 113 | 3.0 | | |
| | | PHYS 151 | 3.0 | ENGR 113 | 3.0 | | |
| | **13** | | **17** | | **17** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 251 | 3.0 | CMGT 240 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 261 | 3.0 | CMGT 270 | 3.0 | | | | |
| ECON 201 | 4.0 | COM 230 | 3.0 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| GEO 101 | 4.0 | ECON 202 | 4.0 | | | | |
| Free elective | 3.0 | Physical Science elective | 3.0 | | | | |
| | **17** | | **16** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 266 | 3.0 | CMGT 265 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 363 | 3.0 | CMGT 267 | 3.0 | | | | |
| CMGT 371 | 3.0 | CMGT 364 | 3.0 | | | | |
| PHIL 315 | 3.0 | CMGT 372 | 3.0 | | | | |
| STAT 201 | 4.0 | CMGT 385 | 3.0 | | | | |
| | **16** | | **15** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 355 | 3.0 | CMGT 362 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 361 | 3.0 | CMGT 365 | 4.0 | | | | |
| CMGT 375 | 3.0 | CMGT 485 | 3.0 | | | | |
| FIN 301 | 4.0 | Business elective | 4.0 | | | | |
| Humanities/ Social Science elective | 3.0 | Construction Management elective | 3.0 | | | | |
| | **16** | | **17** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CMGT 463 | 3.0 | CMGT 450 | 3.0 | CMGT 493 | 3.0 |
| CMGT 467 | 4.0 | CMGT 461 | 3.0 | Construction Management elective | 3.0 |
| CMGT 491 | 3.0 | CMGT 486 | 3.0 | Free electives | 6.0 |
| Construction Management elective | 3.0 | CMGT 492 | 3.0 | | |
| Humanities/ Social Science elective | 3.0 | Humanities/ Social Science elective | 3.0 | | |
| | **16** | | **15** | | **12** |

**Total Credits 187**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## Real Estate Concentration

The concentration in real estate provides students with training in issues such as project finance, real estate as investment, design and construction, operations, development law, environmental remediation, public policy, market analysis, and architecture. For this specialization, students take the same Construction Management (CMGT) core requirements, replacing some electives with the concentration-specific courses.

## Program Requirements

| | | |
|---|---|---|
| **English/Communication** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| **Mathematics** | | |
| MATH 110 | Precalculus | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| **Science** | | |
| GEO 101 | Physical Geology | 4.0 |
| PHYS 151 | Applied Physics | 3.0 |
| One Physical Science Elective | | 3.0 |
| **Business** | | |
| ACCT 110 | Accounting for Professionals | 4.0 |
| ECON 201 | Principles of Microeconomics | 4.0 |
| ECON 202 | Principles of Macroeconomics | 4.0 |
| FIN 301 | Introduction to Finance | 4.0 |
| STAT 201 | Introduction to Business Statistics | 4.0 |
| One Business Elective | | 4.0 |
| **Humanities and Social Science** | | |
| PHIL 315 | Engineering Ethics | 3.0 |
| Two Humanities and Social Science Electives | | 6.0 |
| **Engineering Core** | | |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| **Professional Core - Construction Science** | | |
| CMGT 161 | Building Materials and Construction Methods I | 3.0 |
| CMGT 162 | Building Materials and Construction Methods II | 3.0 |
| CMGT 163 | Building Materials and Construction Methods III | 3.0 |
| CMGT 251 | Construction Surveying | 3.0 |
| CMGT 265 | Information Technologies in Construction | 3.0 |
| CMGT 266 | Building Systems I | 3.0 |
| CMGT 267 | Building Systems II | 3.0 |
| CMGT 270 | Principles of Statics for Construction Management | 3.0 |
| CMGT 365 | Soil Mechanics in Construction | 4.0 |
| CMGT 371 | Structural Aspects in Construction I | 3.0 |
| CMGT 372 | Structural Aspects in Construction II | 3.0 |
| **Professional Core - Construction** | | |
| CMGT 101 | Introduction to Construction Management | 3.0 |
| CMGT 240 [WI] | Economic Planning for Construction | 3.0 |
| CMGT 261 | Construction Safety | 3.0 |
| CMGT 263 | Understanding Construction Drawings | 3.0 |
| CMGT 355 | Introduction to Sustainability in Construction | 3.0 |
| CMGT 361 | Contracts And Specifications I | 3.0 |
| CMGT 362 | Contracts and Specifications II | 3.0 |
| CMGT 363 | Estimating I | 3.0 |
| CMGT 364 | Estimating II | 3.0 |
| CMGT 375 | Building Information Modeling in Construction | 3.0 |
| CMGT 450 | Management of Field Operations | 3.0 |
| CMGT 461 | Construction Project & Company Management | 3.0 |
| CMGT 463 | Value Engineering | 3.0 |
| CMGT 467 | Techniques of Project Control | 4.0 |
| **Professional Core - Professional Techniques** | | |
| CMGT 385 [WI] | Selling and Negotiation Techniques in Construction | 3.0 |
| CMGT 485 | Habits of Successful Design and Build Construction | 3.0 |
| CMGT 486 | Leading in the Construction Industry | 3.0 |
| **Construction Capstone** | | |
| CMGT 491 | Senior Capstone I | 3.0 |
| CMGT 492 | Senior Capstone II | 3.0 |
| CMGT 493 | Senior Capstone III | 3.0 |
| **Concentration in Real Estate** | | |
| ARCH 432 | The Development Process | 3.0 |

| | | |
|---|---|---|
| CMGT 468 | Real Estate | 3.0 |
| REAL 310 | Introduction to Real Estate | 3.0 |
| REAL 320 | Real Estate Law - Principle & Practice | 3.0 |
| REAL 330 | Facilities Management | 3.0 |
| REAL 470 | Real Estate Investments - Market & Feasibility Analysis | 3.0 |
| **University Requirements** | | |
| **Free Electives** | | **3.0** |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| **Total Credits** | | **187.0** |

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

## 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 101 | 3.0 | CIVC 101 | 1.0 | ACCT 110 | 4.0 | VACATION | |
| CMGT 161 | 3.0 | CMGT 162 | 3.0 | CMGT 163 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | CMGT 263 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 121 | 4.0 | COOP 101* | 1.0 | | |
| MATH 110 | 3.0 | PHYS 151 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| UNIV E101 | 1.0 | | | ENGR 113 | 3.0 | | |
| | **16** | | **14** | | **17** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 251 | 3.0 | CMGT 240 | 3.0 | CMGT 266 | 3.0 | CMGT 265 | 3.0 |
| CMGT 261 | 3.0 | CMGT 270 | 3.0 | CMGT 363 | 3.0 | CMGT 267 | 3.0 |
| ECON 201 | 4.0 | COM 230 | 3.0 | CMGT 371 | 3.0 | CMGT 364 | 3.0 |
| GEO 101 | 4.0 | ECON 202 | 4.0 | PHIL 315 | 3.0 | CMGT 372 | 3.0 |
| REAL 310 | 3.0 | Physical Science elective | 3.0 | STAT 201 | 4.0 | CMGT 385 | 3.0 |
| | **17** | | **16** | | **16** | | **15** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 355 | 3.0 | CMGT 362 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 361 | 3.0 | CMGT 365 | 4.0 | | | | |
| CMGT 375 | 3.0 | CMGT 485 | 3.0 | | | | |
| FIN 301 | 4.0 | REAL 330 | 3.0 | | | | |
| REAL 320 | 3.0 | Business elective | 4.0 | | | | |
| | **16** | | **17** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ARCH 432 | 3.0 | CMGT 450 | 3.0 | CMGT 493 | 3.0 |
| CMGT 463 | 3.0 | CMGT 461 | 3.0 | REAL 470 | 3.0 |
| CMGT 467 | 4.0 | CMGT 468 | 3.0 | Free elective | 3.0 |
| CMGT 491 | 3.0 | CMGT 486 | 3.0 | Humanities/ Social Science elective | 3.0 |
| Humanities/ Social Science elective | 3.0 | CMGT 492 | 3.0 | | |
| | **16** | | **15** | | **12** |

**Total Credits 187**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 101 | 3.0 | CIVC 101 | 1.0 | ACCT 110 | 4.0 | VACATION | |
| CMGT 161 | 3.0 | CMGT 162 | 3.0 | CMGT 163 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | CMGT 263 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 121 | 4.0 | COOP 101* | 1.0 | | |
| MATH 110 | 3.0 | PHYS 151 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| UNIV E101 | 1.0 | | | ENGR 113 | 3.0 | | |
| | **16** | | **14** | | **17** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 251 | 3.0 | CMGT 240 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 261 | 3.0 | CMGT 270 | 3.0 | | | | |
| ECON 201 | 4.0 | COM 230 | 3.0 | | | | |
| GEO 101 | 4.0 | ECON 202 | 4.0 | | | | |
| REAL 310 | 3.0 | Physical Science elective | 3.0 | | | | |
| | **17** | | **16** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 266 | 3.0 | CMGT 265 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 363 | 3.0 | CMGT 267 | 3.0 | | | | |
| CMGT 371 | 3.0 | CMGT 364 | 3.0 | | | | |
| PHIL 315 | 3.0 | CMGT 372 | 3.0 | | | | |
| STAT 201 | 4.0 | CMGT 385 | 3.0 | | | | |
| | **16** | | **15** | | **0** | | **0** |

| Fourth Year | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Fall** | **Credits** | **Winter** | **Credits** | **Spring** | **Credits** | **Summer** | **Credits** |
| CMGT 355 | 3.0 | CMGT 362 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 361 | 3.0 | CMGT 365 | 4.0 | | | | |
| CMGT 375 | 3.0 | CMGT 485 | 3.0 | | | | |
| FIN 301 | 4.0 | REAL 330 | 3.0 | | | | |
| REAL 320 | 3.0 | Business elective | 4.0 | | | | |
| | **16** | | **17** | | **0** | | **0** |
| **Fifth Year** | | | | | | | |
| **Fall** | **Credits** | **Winter** | **Credits** | **Spring** | **Credits** | | |
| ARCH 432 | 3.0 | CMGT 450 | 3.0 | CMGT 493 | 3.0 | | |
| CMGT 463 | 3.0 | CMGT 461 | 3.0 | REAL 470 | 3.0 | | |
| CMGT 467 | 4.0 | CMGT 468 | 3.0 | Free elective | 3.0 | | |
| CMGT 491 | 3.0 | CMGT 486 | 3.0 | Humanities/ Social Science elective | 3.0 | | |
| Humanities/ Social Science elective | 3.0 | CMGT 492 | 3.0 | | | | |
| | **16** | | **15** | | **12** | | |

**Total Credits 187**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## Career Opportunities

The graduates of the construction management program have secured positions as project managers, estimators, schedulers, and field superintendents for general contractors, subcontractors, and construction managers. Many are employed as owner representatives working for architectural firms, consulting engineering firms, commercial companies and institutions that have needs for building or other construction projects. Some have risen to executive positions within companies while others own their own firms. Graduates have also returned to the program after obtaining positions in the field to teach and share expertise.

The College of Engineering offers a Bachelor of Science in Construction Management as well as a Certificate Program in Construction Management. Depending on student goals, each option provides a strong educational foundation for successful performance and/or entrance into the construction industry.

## Employers

Some of the companies that have hired Drexel students as co-op or full-time employees:

- Gilbane Building Company
- L.F. Driscoll Construction Company
- Allan Myers
- Pennoni Associates
- Brandywine Realty Trust
- Turner Construction Company
- Intech Construction Managers
- Urban Engineers, Inc.

## Potential Careers

*Construction Manager*: Coordinates a venture from its initial development through final construction. Develops a schedule and ensures the project is completed on time and within budget. Obtains necessary licenses and permits and oversees the progress of the project.

*Cost Estimator*: Prepares information about costs that are necessary for a business to bid on a contract or to determine the profitability of a proposed product. Assembles information about factors that can influence costs such as materials, labor, location, and special machinery requirements, including computer hardware and software.

*Project Manager*: Develops requirements, budgets, and timetables for a firm's construction plans to ensure that the projects are successful. Determines the tasks to complete, assigns responsibilities to team members, and sees the project through from conception to completion.

Visit the Drexel Steinbright Career Development Center (http://www.drexel.edu/scdc/) page for more information on career opportunities.

## Construction Management Faculty

Jeffrey Beard, PhD *(Georgia Institute of Technology)*. Associate Clinical Professor. Project and Program Management; Entrepreneurship in design and construction; Integrated project delivery systems; History of engineering and construction; Sustainable design and construction.

Douglas Carney, MBA, AIA *(Eastern University)*. Clinical Professor. Architecture; Contract management; Master planning; Site analysis; Feasibility and zoning issues; Space needs and program development; Code analysis and compliance studies; project scheduling.

Johanna Casale, PhD *(Rutgers University)*. Assistant Teaching Professor. Engineering education, first year design, structural aspects of construction.

Charles Cook, PhD *(New York University)*. Assistant Clinical Professor. Construction management; project management; leadership and teambuilding; oral and written communication.

Christine M. Fiori, PhD *(Drexel University) Program Director*. Clinical Professor. Improving the delivery of safety education in construction curriculum; Ancient construction techniques; Design and construction in developing countries; Leadership in construction; Workforce development

Kathleen M. Short, PhD *(Virginia Tech)*. Assistant Teaching Professor. Workforce development and women in construction; transformative safety leadership; construction education.

# Electrical Engineering

*Major: Electrical Engineering*
*Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE)*
*Calendar Type: Quarter*
*Total Credit Hours: 181.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.1001*
*Standard Occupational Classification (SOC) code: 17-2071*

## About the Program

Electrical engineers contribute to industry and research in diverse areas such as electronic circuits, lasers and photonics, semiconductor devices, computer and communication networks, wireless networks,

biomedical engineering, bioinformatics, machine learning, automation and control, and power and energy systems. 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, automation, and power and systems and 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:

- Secure positions and continue as valued, creative, dependable, and proficient employees in a wide variety of fields and industries, in particular as electrical engineers.
- Succeed in graduate and professional studies if pursued, such as engineering, science, law, medicine, and business.
- Embrace and pursue lifelong learning for a successful and rewarding career.
- Act as an ambassador for the field of engineering through clear, professional communication with technical and non-technical audiences, including the general public.
- Accept responsibility for leadership roles in their profession, in their communities, and in the global society.
- Contribute to their professional discipline's body of knowledge.
- 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:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of the engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

## Areas of Study

**Telecommunications and Digital Signal Processing (DSP)**

Telecommunications and digital signal processing (DSP) are two of the fastest-growing fields of electrical engineering. The telecommunications and DSP areas of study prepare 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, www.abet.org (http://www.abet.org).

Additional information about the major is available on the ECE Department website (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/).

For advising questions, please contact the ECE advisor (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/resources/current-undergrad/).

# Degree Requirements

In addition to completing 181.5 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** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| COM Elective * | | 3.0 |
| General Education Courses ** | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| MATH 221 | Discrete Mathematics | 3.0 |
| MATH 291 | Complex and Vector Analysis for Engineers | 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 |
| Science Elective † | | 3.0 |
| **Professional Requirements** | | |
| ECE 101 | Electrical and Computer Engineering in the Real World | 1.0 |
| ECE 105 | Programming for Engineers II | 3.0 |
| ECE 200 | Digital Logic Design | 4.0 |
| ECE 201 | Foundations of Electric Circuits I | 4.0 |
| ECE 301 | Foundations of Electric Circuits II | 4.0 |
| ECE 303 | ECE Laboratory | 3.0 |
| ECE 361 | Probability and Data Analytics for Engineers | 4.0 |
| ECE 370 | Electronic Devices | 3.0 |
| ECE 371 | Foundations of Electromagnetics for Computing & Wireless Systems | 3.0 |
| ECE 380 | Fundamentals of Power and Energy | 3.0 |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 | Senior Design Project III | 3.0 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| **EE Core Elective** *** | | **3.0** |
| **ECE Electives** †† | | **15.0** |
| **Free Electives** | | **27.0** |
| **Total Credits** | | **181.5** |

* COM Elective: Choose one of the following: COM 230 or COM 310 [WI]

** General Education Courses (p. 5)

*** Must choose one course from approved list

† Science elective: choose any BIO, CHEM, or PHYS

†† At least 9.0 credits must be in the major at the 400#level. Up to 12.0 credits must be in subject codes ECE, ECEE, ECES, or ECEP.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

## 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | COOP 101* | 1.0 | CIVC 101 | 1.0 | VACATION | |
| ECE 101 | 1.0 | ECE 200 | 4.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **16** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 201 | 4.0 | ECEC 204 | 3.0 | ECE 301 | 4.0 | ECE 361 | 4.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ECEC 201 | 3.0 | ENGR 232 | 3.0 | ECE 370 | 3.0 | ECE 371 | 3.0 |
| ENGL 103 or 113 | 3.0 | PHIL 315 | 3.0 | ECES 301 | 4.0 | ECE 380 | 3.0 |
| ENGR 231 | 3.0 | PHYS 201 | 4.0 | EE Core elective | 3.0 | Science elective | 3.0 |
| MATH 291 | 4.0 | COM elective | 3.0 | | | Free elective | 3.0 |
| | **17** | | **16** | | **14** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ECE 303 | 3.0 | ECE elective | 3.0 |
| | | | | MATH 221 | 3.0 | General Education elective | 3.0 |
| | | | | General Education elective | 3.0 | Free electives | 9.0 |
| | | | | Free electives | 6.0 | | |
| | **0** | | **0** | | **15** | | **15** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| ECE elective | 3.0 | ECEP, ECES, ECEE 400+ level elective | 3.0 | ECEP, ECES, ECEE 400+ level elective | 3.0 |
| ECEP, ECES, ECEE 400+ level elective | 3.0 | General Education elective | 3.0 | General Education elective | 3.0 |
| General Education elective | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 181.5**

Note: An ECE student must have a 2.0 cumulative overall GPA and a 2.0 cumulative GPA in their ECE Professional Requirements.

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | COOP 101* | 1.0 | CIVC 101 | 1.0 | VACATION | |
| ECE 101 | 1.0 | ECE 200 | 4.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **16** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ECE 201 | 4.0 | ECEC 204 | 3.0 |
| | | | | ECEC 201 | 3.0 | ENGR 232 | 3.0 |
| | | | | ENGL 103 or 113 | 3.0 | PHIL 315 | 3.0 |
| | | | | ENGR 231 | 3.0 | PHYS 201 | 4.0 |
| | | | | MATH 291 | 4.0 | COM elective | 3.0 |
| | **0** | | **0** | | **17** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ECE 301 | 4.0 | ECE 361 | 4.0 |
| | | | | ECE 370 | 3.0 | ECE 371 | 3.0 |
| | | | | ECES 301 | 4.0 | ECE 380 | 3.0 |
| | | | | EE Core elective | 3.0 | Science elective | 3.0 |
| | | | | | | Free elective | 3.0 |
| | **0** | | **0** | | **14** | | **16** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ECE 303 | 3.0 | General Education elective | 3.0 |
| | | | | MATH 221 | 3.0 | ECE elective | 3.0 |
| | | | | Free electives | 6.0 | Free electives | 9.0 |
| | | | | General Education elective | 3.0 | | |
| | **0** | | **0** | | **15** | | **15** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| ECE elective | 3.0 | ECEP, ECES, ECEE 400+ elective | 3.0 | ECEP, ECES, ECEE 400+ elective | 3.0 |
| ECEP, ECES, ECEE 400+ elective | 3.0 | General education elective | 3.0 | General Education elective | 3.0 |
| General Education elective | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 181.5**

Note: An ECE student must have a 2.0 cumulative overall GPA and a 2.0 cumulative GPA in their ECE Professional Requirements.

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## Co-op/Career Opportunities

Top co-op employers for electrical engineering majors include:

- PJM Interconnection LLC
- Exelon Corporation (PECO)
- Lockheed Martin
- Woodward McCoach, Inc.
- NAVSEA
- EwingCole
- Schweitzer Engineering Laboratories Inc.
- Ametek, Inc.
- SAP America
- Comcast Corporation
- Susquehanna Int'l Group LLP
- L-3 Communications
- Philadelphia Department of Commerce
- Philadelphia Water Department

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

Drexel University's co-op program has an 80 year history and is one of the oldest and largest co-op programs in the world. Students graduate with 6-18 months of full time employment experience, depending on their choice of a 4-year or 5-year program. The majority of Computer Engineering students in ECE choose the 5-year program and graduate with 18 months of full-time work experience, and often receive a job offer from their third co-op employer or from a connection made from one of their co-op experiences.

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.
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.

The Steinbright Career Development Center had a co-op placement rate of approximately 99% for electrical and computer engineering majors.

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

## Dual Degrees

**Dual Degree Bachelor's Program**

With careful planning, students can complete both an Electrical Engineering degree and a Computer Engineering degree in the time usually required to complete one degree. For detailed information the student should contact the ECE advisor (http://drexel.edu/ece/academics/undergrad/advising/).

**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://drexel.edu/ece/academics/undergrad/bs-ms/) 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**

The Adaptive Signal Processing and Information Theory Research Group (http://www.ece.drexel.edu/walsh/aspitrg/home.html) conducts research in the area of signal processing and information theory. Our main interests are belief/expectation propagation, turbo decoding and composite adaptive system theory. We are currently doing projects on the following topics:
i) Delay mitigating codes for network coded systems,
ii) Distributed estimation in sensor networks via expectation propagation,
iii) Turbo speaker identification,
iv) Performance and convergence of expectation propagation,
v) Investigating bounds for SINR performance of autocorrelation based channel shorteners.

**Bioimage Laboratory**

Uses computer gaming hardware for enhanced and affordable 3-D visualization, along with techniques from information theory and machine learning to combine the exquisite capabilities of the human visual system with computational sensing techniques for analyzing vast quantities of image sequence data.

**Data Fusion Laboratory**

The Data Fusion Laboratory investigates problems in multisensory detection and estimation, with applications in robotics, digital communications, radar, and target tracking. Among the projects in progress: computationally efficient parallel distributed detection architectures, data fusion for robot navigation, modulation recognition and RF scene analysis in time-varying environments, pattern recognition in biological data sequences and large arrays, and hardware realizations of data fusion architectures for target detection and target tracking.

**Drexel Network Modeling Laboratory**

The Drexel Network Modeling Laboratory investigates problems in the mathematical modeling of communication networks, with specific focus on wireless ad hoc networks, wireless sensor networks, and supporting

guaranteed delivery service models on best effort and multipath routed networks. Typical methodologies employed in our research include mathematical modeling, computer simulation, and performance optimization, often with the end goal of obtaining meaningful insights into network design principles and fundamental performance tradeoffs.

**Drexel Power-Aware Computing Laboratory**

The Power-Aware Computing Lab (http://dpac.ece.drexel.edu/) investigates methods to increase energy efficiency across the boundaries of circuits, architecture, and systems. Our recent accomplishments include the Sigil profiling tool, scalable modeling infrastructure for accelerator implementations, microarchitecture-aware VDD gating algorithms, an accelerator architecture for ultrasound imaging, evaluation of hardware reference counting, hardware and operating system support for power-agile computing, and memory systems for accelerator-based architectures.

**Drexel University Nuclear Engineering Education Laboratory**

The field of nuclear engineering encompasses a wide spectrum of occupations, including nuclear reactor design, medical imaging, homeland security, and oil exploration. The Drexel University Nuclear Engineering Education Laboratory (DUNEEL) provides fundamental hands on understanding for power plant design and radiation detection and analysis. Software based study for power plant design, as well as physical laboratory equipment for radiation detection, strengthen the underlying concepts used in nuclear engineering such that the student will comprehend and appreciate the basic concepts and terminology used in various nuclear engineering professions. Additionally, students use the laboratory to develop methods for delivering remote, live time radiation detection and analysis. The goal of DUNEEL is to prepare students for potential employment in the nuclear engineering arena.

**Drexel VLSI Laboratory**

The Drexel VLSI Laboratory (http://vlsi.ece.drexel.edu/?title=Main_Page) investigates problems in the design, analysis, optimization and manufacturing of high performance (low power, high throughput) integrated circuits in contemporary CMOS and emerging technologies. Suited with industrial design tools for integrated circuits, simulation tools and measurement beds, the VLSI group is involved with digital and mixed-signal circuit design to verify the functionality of the discovered novel circuit and physical design principles. The Drexel VLSI laboratory develops design methodologies and automation tools in these areas, particularly in novel clocking techniques, featuring resonant clocking, and interconnects, featuring wireless interconnects.

**Drexel Wireless Systems Laboratory**

The Drexel Wireless Systems Laboratory (DWSL) contains an extensive suite of equipment for constructing, debugging, and testing prototype wireless communications systems. Major equipment within DWSL includes:

- three software defined radio network testbeds (HYDRA, USRP, and WARP) for rapidly prototyping radio, optical and ultrasonic communications systems,
- a TDK RF anechoic chamber and EMSCAN desktop antenna pattern measurement system,
- a materials printer and printed circuit board milling machine for fabricating conformal antennas and
- wireless protocol conformance testing equipment from Aeroflex.

The lab is also equipped with network analyzers, high speed signal generators, oscilloscopes, and spectrum analyzers as well as several Zigbee development platforms for rapidly prototyping sensor networks.

DWSL personnel also collaborate to create wearable, fabric based transceivers through collaboration with the Shima Seiki Haute Laboratory in the Drexel ExCITe Center.The knitting equipment at Drexel includes sixteen SDS-ONE APEX3 workstations and four state-of-the-art knitting machines. The workstations accurately simulate fabric construction and provide researchers and designers the opportunity to program, create and simulate textile prototypes, import CAD specifications of final products, and produce made-to-measure or mass-produced pieces on Shima Seiki knitting machines.For testing smart textiles for biomedical, DWSL personnel also have collaborators in the Center for Interdisciplinary Clinical Simulation and Practice (CICSP) in the Drexel College of Medicine which provides access to medical mannequin simulators.

**Ecological and Evolutionary Signal-processing and Informatics Laboratory**

The Ecological and Evolutionary Signal-processing and Informatics Laboratory (EESI) seeks to solve problems in high-throughput genomics and engineer better solutions for biochemical applications. The lab's primary thrust is to enhance the use of high-throughput DNA sequencing technologies with pattern recognition and signal processing techniques. Applications include assessing the organism content of an environmental sample, recognizing/classifying potential and functional genes, inferring environmental factors and inter-species relationships, and inferring microbial evolutionary relationships from short-read DNA/RNA fragments. The lab also investigates higher-level biological systems such as modeling and controlling chemotaxis, the movement of cells.

**Electric Power Engineering Center**

This newly established facility makes possible state-of-the-art research in a wide variety of areas, ranging from detailed theoretical model study to experimental investigation in its high voltage laboratories. The mission is to advance and apply scientific and engineering knowledge associated with the generation, transmission, distribution, use, and conservation of electric power. In pursuing these goals, this center works with electric utilities, state and federal agencies, private industries, nonprofit organizations and other universities on a wide spectrum of projects. Research efforts, both theoretical and experimental, focus on the solution of those problems currently faced by the electric power industry. Advanced concepts for electric power generation are also under investigation to ensure that electric power needs will be met at the present and in the future.

**Electronic Design Automation Facility**

Industrial-grade electronic design automation software suite and integrated design environment for digital, analog and mixed-signal systems development. Field Programmable Gate Array (FPGA) development hardware. Most up-to-date FPGA/embedded system development hardware kits. Printed circuit board production facility. Also see Drexel VLSI Laboratory.

**Microwave-Photonics Device Laboratories**

The laboratory is equipped with test and measurement equipment for high-speed analog and digital electronics and fiber optic systems. The test equipment includes network analyzers from Agilent (100kHz- 1.3 GHz and 45 Mhz-40 GHz), and Anritsu (45 MHz-6 GHz); spectrum analyzers from Tektronix, HP, and Agilent with measurement capability of DC

to 40 GHz and up to 90 GHz using external mixers; signal generators and communication channel modulators from HP, Rhode-Schwartz, Systron Donner, and Agilent; microwave power meter and sensor heads, assortment of passive and active microwave components up to 40 GHz ; data pattern generator and BER tester up to 3Gb/s; optical spectrum analyzer from Anritsu and power meters from HP; single and multimode fiber optic based optical transmitter and receiver boards covering ITU channels at data rates up to 10Gb/s; passive optical components such as isolator, filter, couplers, optical connectors and fusion splicer; LPKF milling machine for fabrication of printed circuit boards; wire-bonding and Cascade probe stations; Intercontinental test fixtures for testing of MMIC circuits and solid-state transistors; state-of-the-art microwave and electromagnetic CAD packages such as Agilent ADS, ANSYS HFSS, and COMSOL multi-physics module.

**Music and Entertainment Technology Laboratory**

The Music and Entertainment Technology Laboratory (MET-lab) is devoted to research in digital media technologies that will shape the future of entertainment, especially in the areas of sound and music. We employ digital signal processing and machine learning to pursue novel applications in music information retrieval, music production and processing technology, and new music interfaces. The MET-lab is also heavily involved in outreach programs for K-12 students and hosts the Summer Music Technology program, a one-week learning experience for high school students. Lab facilities include a sound isolation booth for audio and music recording, a digital audio workstation running ProTools, two large multi-touch display interfaces of our own design, and a small computing cluster for distributed processing.

## NanoPhotonics Laboratory

Our research is primarily in the area of nanophotonics with a focus on the nanoscale interaction of light with matter. Interests include: liquid crystal/polymer composites for gratings, lenses and HOEs; liquid crystal interactions with surfaces and in confined nanospaces; alternative energy generation through novel photon interactions; ink-jet printed conducting materials for RF and photonic applications; and the creation and development of smart textiles technologies including soft interconnects, sensors, and wireless implementations.

**Opto-Electro-Mechanical Laboratory**

This lab concentrates on the system integration on optics, electronics, and mechanical components and systems, for applications in imaging, communication, and biomedical research. Research areas include: Programmable Imaging with Optical Micro-electrical-mechanical systems (MEMS), in which microscopic mirrors are used to image light into a single photodetector; Pre-Cancerous Detection using White Light Spectroscopy, which performs a cellular size analysis of nuclei in tissue; Free-space Optical Communication using Space Time Coding, which consists of diffused light for computer-to-computer communications, and also tiny lasers and detectors for chip-to-chip communication; Magnetic Particle Locomotion, which showed that particles could swim in a uniform field; and Transparent Antennas using Polymer, which enables antennas to be printed through an ink-jet printer.

**Plasma and Magnetics Laboratory**

Research is focused on applications of electrical and magnetic technologies to biology and medicine. This includes the subjects of non-thermal atmospheric pressure plasma for medicine, magnetic manipulation of particles for drug delivery and bio-separation, development of miniature NMR sensors for cellular imaging and carbon nanotube cellular probes.

**Power Electronics Research Laboratory**

The Power Electronics Research Laboratory (PERL) is involved in circuit and design simulation, device modeling and simulation, and experimental testing and fabrication of power electronic circuits. The research and development activities include electrical terminations, power quality, solar photovoltaic systems, GTO modeling, protection and relay coordination, and solid-state circuit breakers. The analysis tools include EMPT, SPICE, and others, which have been modified to incorporate models of such controllable solid-state switches as SCRs, GTOs, and MOSFETs. These programs have a wide variety and range of modeling capabilities used to model electromagnetics and electromechanical transients ranging from microseconds to seconds in duration. The PERL is a fully equipped laboratory with 42 kVA AC and 70 kVA DC power sources and data acquisition systems, which have the ability to display and store data for detailed analysis. Some of the equipment available is a distribution and HV transformer and three phase rectifiers for power sources and digital oscilloscopes for data measuring and experimental analysis. Some of the recent studies performed by the PERL include static VAR compensators, power quality of motor controllers, solid-state circuit breakers, and power device modeling which have been supported by PECO, GE, Gould, and EPRI.

**Testbed for Power-Performance Management of Enterprise Computing Systems**

This computing testbed is used to validate techniques and algorithms aimed at managing the performance and power consumption of enterprise computing systems. The testbed comprises a rack of Dell 2950 and Dell 1950 PowerEdge servers, as well as assorted desktop machines, networked via a gigabit switch. Virtualization of this cluster is enabled by VMWare's ESX Server running the Linux RedHat kernel. It also comprises of a rack of ten Apple Xserve machines networked via a gigabit switch. These servers run the OS X Leopard operating systems and have access to a RAID with TBs of total disk capacity.

# Electrical Engineering Faculty

Tom Chmielewski, PhD *(Drexel University)*. Teaching Professor. Modeling and simulation of electro-mechanical systems; optimal, adaptive and non-linear control; DC motor control; system identification; kalman filters (smoothing algorithms, tracking); image processing; robot design; biometric technology and design of embedded systems for control applications utilizing MATLAB and SIMULINK

Fernand Cohen, PhD *(Brown University)*. Professor. Surface modeling; tissue characterization and modeling; face modeling; recognition and tracking.

Andrew Cohen, PhD *(Rensselaer Polytechnic Institute)*. Associate Professor. Image processing; multi-target tracking; statistical pattern recognition and machine learning; algorithmic information theory; 5-D visualization

Kapil Dandekar, PhD *(University of Texas-Austin) Director of the Drexel Wireless Systems Laboratory (DWSL); Associate Dean of Research, College of Engineering*. Professor. Cellular/mobile communications and wireless LAN; smart antenna/MIMO for wireless communications; applied computational electromagnetics; microwave antenna and receiver development; free space optical communication; ultrasonic

communication; sensor networks for homeland security; ultrawideband communication.

Afshin Daryoush, ScD *(Drexel University)*. Professor. Digital and microwave photonics; nonlinear microwave circuits; RFIC; medical imaging.

Anup Das, PhD *(Universit of Singapore)*. Assistant Professor. Design of algorithms for neuromorphic computing, particularly using spiking neural networks, dataflow-based design of neuromorphic computing system, design of scalable computing system; hardware-software co-design and management, and thermal and power management of many-core embedded systems

Bruce A. Eisenstein, PhD *(University of Pennsylvania)*. Arthur J. Rowland Professor of Electrical and Computer Engineering. Pattern recognition; estimation; decision theory.

Adam K. Fontecchio, PhD *(Brown University) Director, Center for the Advancement of STEM Teaching and Learning Excellence (CASTLE)*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

Gary Friedman, PhD *(University of Maryland-College Park) Associate Department Head for Graduate Affairs*. Professor. Biological and biomedical applications of nanoscale magnetic systems.

Allon Guez, PhD *(University of Florida)*. Professor. Intelligent control systems; robotics, biomedical, automation and manufacturing; business systems engineering.

Leonid Hrebien, PhD *(Drexel University)*. Professor. Tissue excitability; acceleration effects on physiology; bioinformatics.

Nagarajan Kandasamy, PhD *(University of Michigan) Associate Department Head for Undergraduate Affairs*. Associate Professor. Embedded systems, self-managing systems, reliable and fault-tolerant computing, distributed systems, computer architecture, and testing and verification of digital systems.

Youngmoo Kim, PhD *(MIT) Director, Expressive and Creative Interactive Technologies (ExCITe) Center*. Professor. Audio and music signal processing, voice analysis and synthesis, music information retrieval, machine learning.

Fei Lu, PhD *(University of Michigan)*. Assistant Professor. Power electronics; wireless power transfer technology for the high-power electric vehicles and the low-power electronic devices.

Karen Miu, PhD *(Cornell University)*. Professor. Power systems; distribution networks; distribution automation; optimization; system analysis.

Bahram Nabet, PhD *(University of Washington)*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Prawat Nagvajara, PhD *(Boston University)*. Associate Professor. System on a chip; embedded systems; power grid computation; testing of computer hardware; fault-tolerant computing; VLSI systems; error control coding.

Dagmar Niebur, PhD *(Swiss Federal Institute of Technology)*. Associate Professor. Intelligent systems; dynamical systems; power system monitoring and control.

Christopher Peters, PhD *(University of Michigan)*. Teaching Professor. Nuclear reactor design; ionizing radiation detection; nuclear forensics; power plant reliability and risk analysis; naval/marine power and propulsion; directed energy/high power microwaves; nonstationary signal processing; radar; electronic survivability/susceptibility to harsh environments; electronic warfare

Gail L. Rosen, PhD *(Georgia Institute of Technology)*. Associate Professor. Signal processing, signal processing for biological analysis and modeling, bio-inspired designs, source localization and tracking.

Ioannis Savidis, PhD *(University of Rochester)*. Associate Professor. Analysis, modeling, and design methodologies for high performance digital and mixed-signal integrated circuits; Emerging integrated circuit technologies; Electrical and thermal modeling and characterization, signal and power integrity, and power and clock delivery for 3-D IC technologies

Kevin J. Scoles, PhD *(Dartmouth College) Associate Dean for Undergraduate Affairs*. Associate Professor. Microelectronics; electric vehicles; solar energy; biomedical electronics.

Harish Sethu, PhD *(Lehigh University)*. Associate Professor. Protocols, architectures and algorithms in computer networks; computer security; mobile ad hoc networks; large-scale complex adaptive networks and systems.

James Shackleford, PhD *(Drexel University)*. Associate Professor. Medical image processing, high performance computing, embedded systems, computer vision, machine learning

P. Mohana Shankar, PhD *(Indian Institute of Technology) Allen Rothwarf Professor of Electrical and Computer Engineering*. Professor. Wireless communications; biomedical ultrasonics; fiberoptic bio-sensors.

Jonathan E. Spanier, PhD *(Columbia University) Department Head, Mechanical Engineering and Mechanics*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laser spectroscopy, including Raman scattering.

Matthew Stamm, PhD *(University of Maryland, College Park)*. Associate Professor. Information Security; multimedia forensics and anti-forensics; information verification; adversarial dynamics; signal processing

Baris Taskin, PhD *(University of Pittsburgh)*. Professor. Very large-scal integration (VLSI) systems, computer architecture, circuits and systems, electronic design automation (EDA), energy efficient computing.

John Walsh, PhD *(Cornell University)*. Associate Professor. Bounding the region of entropic vectors and its implications for the limits of communication networks, big data distributed storage systems, and graphical model based machine learning; efficient computation and analysis of rate regions for network coding and distributed storage; code construction, polyhedral computation, hierarchy, and symmetry

Steven Weber, PhD *(University of Texas-Austin) Department Head*. Professor. Mathematical modeling of computer and communication networks, specifically streaming multimedia and ad hoc networks.

Jaudelice de Oliveira, PhD *(Georgia Institute of Technology)*. Associate Professor. Software-defined networking; social and economic networks; network security; design and analysis of protocols, algorithms and architectures in computer networks, particularly solutions for the Internet of Things

## Emeritus Faculty

Eli Fromm, PhD *(Jefferson Medical College)*. Professor Emeritus. Engineering education; academic research policy; bioinstrumentation; physiologic systems.

Edwin L. Gerber, PhD *(University of Pennsylvania)*. Professor Emeritus. Computerized instruments and measurements; undergraduate engineering education.

# Engineering

*Major: Engineering*
*Degree Awarded: Bachelor of Science in Engineering (BSE)*
*Calendar Type: Quarter*
*Total Credit Hours: 181.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years); No Co-op (Four years)*
*Classification of Instructional (CIP) code: 14.0101*
*Standard Occupational Classification (SOC) code: 17-2199*

## About the Program

The Bachelor of Science in Engineering major is an interdisciplinary engineering major for students who do not intend to be practicing engineers. Students in the Bachelor of Science in Engineering major combine a rigorous engineering education in the College of Engineering with interdisciplinary studies in fields outside of engineering such as law, medicine, business, entrepreneurship, teaching, international studies, public policy, music, art, environmental studies, and more. The Bachelor of Science in Engineering major 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.

Drexel's Bachelor of Science in Engineering major 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 science 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 their 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

More information is available on the College of Engineering academics (https://drexel.edu/engineering/academics/overview/) website.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| 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** | | |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| **Engineering Requirements** | | |
| Senior Design Sequence or Research Project | | 8.0 |
| 200+ Level Courses ** | | 22.0 |
| 300+ Level Courses ** | | 22.0 |
| **Technical Electives** | | |
| 200+ Level Courses *** | | 18.0 |
| **Total Credits** | | **181.5** |

* General Education Requirements. (p. 5)

** Students may choose between AE, BMES, CHE, CAE, CS, ECE, ENGR, ENVE, MATE or MEM.

*** Students may choose between BMES, CS, MATH, CHEM, PHYS, BIO or approved College of Engineering courses. Advisor approval is required for technical electives.

## Sample Plan of Study

4 year, no co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | CHEM 102 | 4.5 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| | **14.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ENGL 103 or 113 | 3.0 | ENGR 232 | 3.0 | Two Engineering courses** | 6.0 | VACATION | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ENGR 231 | 3.0 | Two Engineering courses** | 7.0 | General Education elective** | 3.0 | | |
| PHYS 201 | 4.0 | General Education elective** | 3.0 | Free elective | 3.0 | | |
| Two Engineering courses** | 7.0 | Free elective* | 4.0 | | | | |
| | **17** | | **17** | | **12** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| Two Engineering courses** | 6.0 | Two Engineering courses** | 6.0 | Two Engineering courses** | 6.0 | VACATION | |
| Technical elective | 3.0 | Technical elective | 3.0 | Technical elective | 3.0 | | |
| General Education elective** | 3.0 | General Education elective** | 3.0 | General Education elective** | 3.0 | | |
| Free elective | 3.0 | Free elective | 3.0 | Free elective | 3.0 | | |
| | **15** | | **15** | | **15** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| Senior Design Project I or Capstone course** | 2.0 | Senior Design Project II or Capstone course** | 2.0 | Senior Design Project III or Capstone course** | 4.0 |
| Engineering course** | 3.0 | Engineering course** | 3.0 | Technical elective | 3.0 |
| Technical elective | 3.0 | Technical elective | 3.0 | General Education elective** | 3.0 |
| General Education elective** | 3.0 | General Education elective** | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | Free elective | 3.0 | | |
| | **14** | | **14** | | **13** |

**Total Credits 181.5**

* Students not participating in co-op will not take COOP 101; 1 credit of Free Elective will be added in place of COOP 101.

** See degree requirements (p. 40).

## 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | CHEM 102 | 4.5 | COOP 101* | 1.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 or 112 | 3.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| | | | | PHYS 102 | 4.0 | | |
| | **14.5** | | **16.5** | | **19.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ENGL 103 or 113 | 3.0 | ENGR 232 | 3.0 | Two Engineering courses** | 6.0 | Two Engineering courses** | 6.0 |
| ENGR 231 | 3.0 | Two Engineering courses** | 7.0 | General Education elective** | 3.0 | Technical elective | 3.0 |
| PHYS 201 | 4.0 | General Education elective** | 3.0 | Free elective | 3.0 | General Education elective** | 3.0 |
| Two Engineering courses** | 7.0 | Free elective | 3.0 | | | Free elective | 3.0 |
| | **17** | | **16** | | **12** | | **15** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| Two Engineering courses** | 6.0 | Two Engineering courses** | 6.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| Technical elective | 3.0 | Technical elective | 3.0 | | | | |
| General Education elective** | 3.0 | General Education elective** | 3.0 | | | | |
| Free elective | 3.0 | Free elective | 3.0 | | | | |
| | **15** | | **15** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| Senior Design Project I or Capstone course** | 2.0 | Senior Design Project II or Capstone course** | 2.0 | Senior Design Project III or Capstone course** | 4.0 |
| Engineering course** | 3.0 | Engineering course** | 3.0 | Technical elective | 3.0 |
| Technical elective | 3.0 | Technical elective | 3.0 | General Education elective** | 3.0 |
| General Education elective** | 3.0 | General Education elective** | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | Free elective | 3.0 | | |
| | **14** | | **14** | | **13** |

**Total Credits 181.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place ofCOOP 101

** See degree requirements (p. 40).

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | CHEM 102 | 4.5 | COOP 101* | 1.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 or 112 | 3.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| | | | | PHYS 102 | 4.0 | | |
| | **14.5** | | **16.5** | | **19.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ENGL 103 or 113 | 3.0 | ENGR 232 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGR 231 | 3.0 | Two Engineering courses** | 7.0 | | | | |
| PHYS 201 | 4.0 | General Education elective** | 3.0 | | | | |
| Two Engineering courses** | 7.0 | Free elective | 3.0 | | | | |
| | **17** | | **16** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| Two Engineering courses** | 6.0 | Two Engineering courses** | 6.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| General Education elective** | 3.0 | Technical elective | 3.0 | | | | |
| Free elective | 3.0 | General Education elective** | 3.0 | | | | |
| | | Free elective | 3.0 | | | | |
| | **12** | | **15** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| Two Engineering courses** | 6.0 | Two Engineering courses** | 6.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| Technical elective | 3.0 | Technical elective | 3.0 | | | | |
| General Education elective** | 3.0 | General Education elective** | 3.0 | | | | |
| Free elective | 3.0 | Free elective | 3.0 | | | | |
| | **15** | | **15** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| Senior Design Project I or Capstone course** | 2.0 | Senior Design Project II or Capstone course** | 2.0 | Senior Design Project III or Capstone course** | 4.0 |
| Engineering course** | 3.0 | Engineering course** | 3.0 | Technical elective | 3.0 |
| Technical elective | 3.0 | Technical elective | 3.0 | General Education elective** | 3.0 |
| General Education elective** | 3.0 | General Education elective** | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | Free elective | 3.0 | | |
| | **14** | | **14** | | **13** |

**Total Credits 181.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place ofCOOP 101

** See degree requirements (p. 40).

## 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.

## 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 will be vital in today's work environment.

# Engineering Technology

*Major: Engineering Technology*
*Degree Awarded: Bachelor of Science in Engineering Technology (BSET)*
*Calendar Type: Quarter*
*Total Credit Hours: 186.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years); No Co-op (Four years)*
*Classification of Instructional (CIP) code: 15.0401; 15.9999; 15.1299; 15.0699; 15.0805*
*Standard Occupational Classification (SOC) code: 17-3029; 17-3027*

## About the Program

### The degree is *Engineering Technology*, the career is *Engineering*.™

The BS in Engineering Technology (ET) program at Drexel University is organized around a multidisciplinary, practice- and systems-based learning with extensive use of hands-on laboratory exercises in a majority of the classes. The program prepares graduates for success as future technology innovators and industry leaders, bringing designs from theory into reality. The ET program stresses a multidisciplinary, systems-based approach in solving real-world problems. It promotes student-focused teaching and career-focused education, emphasizing a practical application of theory.

Due to its application-oriented, broad focus in different engineering disciplines, the program is suited for students who learn best by seeing concepts put into practice, "Learn by doing." The program is ideal for students who want to pursue careers as engineers and leaders in advanced technology fields. The multidisciplinary nature of ET allows graduates to excel in a range of disciplines, from robotics and smart manufacturing to electronics and renewable energy, and have an immediate impact on the engineering field.

Engineering Technology graduates integrate electrical, mechanical, manufacturing, and industrial engineering disciplines to solve problems

and meet opportunities and technical challenges in robotics, healthcare, energy, transportation, communications, environmental protection, defense and homeland security, and buildings and infrastructure.

The state-of-the-art technology at the heart of the practice-based laboratories allows students to be well-versed in the application of modern technology to production-level engineering problems. Through real world industry-sponsored capstone projects and internships with local and international companies, students in the Engineering Technology program frequently become closely connected to the regional industry and often end up employed with those local industries.

The following concentrations are available under the Engineering Technology degree:

- ***NEW:*** Robotics and Automation Engineering Technology
- Mechanical and Manufacturing Engineering Technology (p. 48)
- Electrical Engineering Technology (p. 45)

All students enrolled in the program are required to take general education courses, including mathematics, sciences, and general education electives. All concentrations consist of core fundamental courses, technical electives, free electives, and a three-term senior design project. The senior design project reflects industrial practices and requires working prototype. During pre-junior year, students need to choose one of the four available concentrations.

Full-time students can opt for a four-year program with a six-month co-op or a five-year program with three, six-month co-op cycles.

Engineering Technology graduates are uniquely qualified to serve in a variety of functions requiring traditional and nontraditional technological skills. The program also prepares students for graduate study in a variety of fields, including engineering technology, engineering management, business administration, and healthcare.

## Mission

The Bachelor of Science in Engineering Technology (ET) educates future engineers to become the next generation of innovators and industry leaders, giving graduates the tools to meet the technological and applied engineering challenges of industry and society for the 21st century.

## Engineering Technology Program Educational Objectives

Produces graduates who:

- Apply discipline-specific theory, experiments, and real-world experience to interpret, analyze, and solve current and emerging technical problems
- Communicate clearly and persuasively with technical and non-technical people in oral, written, and graphical forms
- Function individually or as a member of a team, or as a leader on teams to design quality systems, components, or processes in a timely, responsible, and creative manner
- Demonstrate behavior consistent with professional ethics and are cognizant of social concerns as they relate to the practice of engineering technology
- Strive for professional growth and engage in lifelong learning

## Engineering Technology Student Outcomes

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

- An ability to apply knowledge, techniques, skills, and modern tools of mathematics, science, engineering, and technology to solve broadly defined engineering problems appropriate to the discipline
- An ability to design systems, components, or processes meeting specified needs for broadly defined engineering problems appropriate to the discipline
- An ability to apply written, oral, and graphical communication in broadly defined technical and non-technical environments, and an ability to identify and use appropriate technical literature
- An ability to conduct standard tests, measurements, and experiments to analyze and interpret the results to improve processes
- An ability to function effectively as a member or leader on a technical team

## Additional Information

The Engineering Technology program is accredited by the Engineering Technology Accreditation Commission of ABET. (http://www.abet.org)

For additional information, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253 or visit the Engineering Technology (https://drexel.edu/engineering/academics/departments/engineering-technology/) web page.

## Career Opportunities

The Engineering Technology program is designed to meet employers' growing needs for college-educated problem solvers created by the technology revolution. Career opportunities in engineering technology are virtually limitless with at least 5,500 companies in the region offering jobs for engineering technologists. As a leading urban university in the Greater Philadelphia region, Drexel's location offers access to a vast number of industries including:

- Defense
- Aerospace
- Power generation
- Public utilities
- Shipbuilding
- Railroad
- Manufacturing
- Environmental
- Chemical
- Pharmaceutical
- Medical care

With the skills developed in this program, students will be able to integrate academic theory and professional practice in order to communicate effectively with engineers from different fields, scientists, the production workforce, marketing professionals, company management, and ultimately the customer. Students may participate in the design, development, testing, and manufacturing of industrial machinery, electric and electronic equipment, medical devices, consumer products, and other equipment.

Engineering technologists can serve in industry in many capacities. Some fields include:

- Automation design and process engineering
- Mechanical/production engineering
- Electrical engineering and electronics
- Field engineering
- Systems engineering and management
- Environmental engineering
- Quality control
- Sales and customer service
- Systems/programming
- Testing engineering

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

## Engineering Technology Faculty

M. Eric Carr, MsCpE *(Drexel University)*. Instructor. Computer Engineering, Digital Design, Programmable Devices, Genetic Algorithms, Programming, Additive Manufacturing, Maker Movement.

Richard Chiou, PhD *(Georgia Institute of Technology)*. Associate Professor. Green manufacturing, mechatronics, Internet-based robotics and automation, and remote sensors and monitoring.

Yalcin Ertekin, PhD *(University of Missouri-Rolla)*. Associate Clinical Professor. High speed machining with micromachining applications, machining process optimization and condition monitoring using multiple sensors, FEA simulation with 3D solid modeling applications, rapid prototyping and reverse engineering, quality and reliability improvement through statistically designed experiments, neural networks and data mining and Taguchi methods, CNC machine tool calibration characterization of cold fastening, clinching and self-pierced riveting processes, non-invasive surgical tool design, student learning enhancement using online simulation tools.

Vladimir Genis, PhD *(Kiev State University, Ukraine) Department Head, Engineering Technology*. Professor. Ultrasound wave propagation and scattering, ultrasound imaging, electronic instrumentation, piezoelectric transducers, and engineering education. Designed and developed diagnostic and therapeutic equipment for medical applications and electronic systems and techniques for defense-related and industrial applications.

Irina Ciobanescu Husanu, PhD *(Drexel University)*. Assistant Clinical Professor. Microgravity combustion, thermal-fluid science with applications in micro-combustion, fuel cells and research of alternative and green fuels, energy conversion and renewable energy, industrial experience in aerospace engineering areas (theoretical analysis, numerical simulations and experimental investigations), design and testing of propulsion systems, mechanical instrumentation, and developing industrial applications of aircraft engines.

Lunal Khuon, PhD *(Massachusetts Institute of Technology)*. Clinical Associate Professor. Radio frequency, analog, and biomedical integrated circuits, biomedical instrumentation, neural interfaces, wireless systems, and engineering education. Research topics include area-efficient and power-efficient integrated circuits, plasmonics, adiabatic circuits, rotary clocks, and medical cyber-physical systems.

Michael Mauk, PhD, PE *(University of Delaware)*. Assistant Clinical Professor. Rapid prototyping, microfluidics, alternative energy including solar energy and photovoltaics, semiconductor materials science, nanotechnology.

# Engineering Technology

## Computer Engineering Technology Concentration

**Effective March 15, 2020, new students are no longer being accepted into this concentration, however similar options are available. Contact Gerry Willis at** gtm23@drexel.edu **or 215-895-6253 for additional information.**

The Computer Engineering Technology concentration provides in-depth knowledge of hardware and software design, development, and maintenance. Through our solid, laboratory-centric curriculum, students gain a strong background in software and hardware development with programming languages and HDLs currently used in industry. In addition, students learn state-of-the-art techniques for developing robust technological solutions, including network- and web-based applications and Internet of Things (IoT) considerations.

The focus of the curriculum is on embedded systems design and development. From low-level, gate-based design to the use of high-end microprocessors and current bus standards, students gain a thorough architectural understanding of computer systems. The curriculum includes in-depth design and analysis of combinational logic, sequential logic and state machines, microcontroller systems, microprocessor systems, and state-of-the-art computer technology.

## Additional Information

For more information on the Computer Engineering Technology concentration, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

Degree Requirements

| | | |
|---|---|---|
| **General Education Requirements** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| HIST 285 | Technology in Historical Perspective | 4.0 |
| PHIL 315 | Engineering Ethics | 3.0 |
| General Educational Electives | | 10.0 |
| **Basic Science Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| PHYS 152 | Introductory Physics I | 4.0 |
| PHYS 153 | Introductory Physics II | 4.0 |
| PHYS 154 | Introductory Physics III | 4.0 |
| **Mathematics Requirements** | | |
| MATH 110 | Precalculus | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| STAT 201 | Introduction to Business Statistics | 4.0 |
| **Computer Technology Core** | | |

| | | |
|---|---|---|
| EET 102 | Introduction to Engineering Technology | 3.0 |
| EET 201 | Circuit Analysis I | 4.0 |
| EET 202 | Circuit Analysis II | 4.0 |
| EET 205 | Digital Electronics | 4.0 |
| EET 206 | Analog Electronics I | 4.0 |
| EET 208 | Introduction to Programming for Embedded Systems | 3.0 |
| EET 209 | Fundamentals of Virtual Instrumentation | 3.0 |
| EET 319 | PLC Fundamentals | 4.0 |
| EET 325 | Microprocessors | 3.0 |
| EET 401 | Applied Microcontrollers | 4.0 |
| INDE 240 | Technology Economics | 3.0 |
| INDE 370 | Industrial Project Management | 3.0 |
| MET 100 | Graphical Communication | 3.0 |
| **Computer Technology Concentration Requirements** | | |
| CET 201 | Microcomputer Hardware | 3.0 |
| CET 301 | Advanced Digital Electronics | 4.0 |
| CET 303 | Computer Architecture with Verilog HDL | 4.0 |
| CET 401 | Real-Time Operating Systems | 4.0 |
| CET 402 | Applied Embedded Systems | 4.0 |
| CET 403 | Computer Networking Technologies | 4.0 |
| CET 405 | Electronic Device Design | 4.0 |
| 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 |
| CT 201 | Information Technology Security I | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECEC 302 | Digital Systems Projects | 3.0 |
| INFO 151 | Web Systems and Services I | 3.0 |
| INFO 152 | Web Systems and Services II | 3.0 |
| CET Technical Electives | | 6.0 |
| **Capstone Course Requirements** | | |
| CET 421 | Senior Design Project I | 3.0 |
| CET 422 | Senior Design Project II | 3.0 |
| CET 423 | Senior Design Project III | 3.0 |
| **Miscellaneous** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 0.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| Free Electives | | 10.0 |
| **Total Credits** | | **185.5** |

# Engineering Technology

## Electrical Engineering Technology Concentration

The Electrical Engineering Technology (EET) concentration prepares graduates that can design, develop, test, and supervise the manufacturing, installation, and maintenance of electrical and electronic equipment, components, or systems for commercial, industrial, military, or medical use. EET graduates are experienced, accomplished, and self-motivated problem solvers who can work through technical challenges and present practical solutions to maintain and support industry-leading products and systems. The program prepares students to work across a variety of functional groups that are directly involved in engineering, product development, implementation, and international contract manufacturing.

The EET concentration provides an extensive background in electric circuit analysis and electronics. Students are required to study digital and analog electronics, digital computer design, analysis of electric power systems, and renewable energy.

During the first three years, students in engineering technology take electrical, mechanical, computer, and industrial courses to get a solid, multidisciplinary, systematic background in different engineering fields. Students are required to complete general and concentration engineering technology courses, technical electives, and free elective courses that permit students great latitude in tailoring the program of study to match their career goals.

## Additional Information

For more information, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

## Degree Requirements

| | | |
|---|---|---|
| **Humanites and Social Sciences Requirements** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| HIST 285 | Technology in Historical Perspective | 4.0 |
| PHIL 315 | Engineering Ethics | 3.0 |
| General Educational Electives | | 9.0 |
| **Basic Science Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| PHYS 152 | Introductory Physics I | 4.0 |
| PHYS 153 | Introductory Physics II | 4.0 |
| PHYS 154 | Introductory Physics III | 4.0 |
| **Mathematics Requirements** | | |
| MATH 110 | Precalculus | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| STAT 201 | Introduction to Business Statistics | 4.0 |
| **Engineering Technology Core** | | |
| EET 102 | Introduction to Engineering Technology | 3.0 |
| EET 201 | Circuit Analysis I | 4.0 |
| EET 202 | Circuit Analysis II | 4.0 |

| | | |
|---|---|---|
| EET 204 | Introduction to Nanotechnology | 3.0 |
| EET 205 | Digital Electronics | 4.0 |
| EET 208 | Introduction to Programming for Embedded Systems | 3.0 |
| EET 209 | Fundamentals of Virtual Instrumentation | 3.0 |
| EET 311 | Modeling of Engineering Systems | 4.0 |
| EET 319 | PLC Fundamentals | 4.0 |
| EET 320 | Renewable Energy Systems | 3.0 |
| EET 333 [WI] | Non-Destructive Evaluation of Materials | 4.0 |
| EET 401 | Applied Microcontrollers | 4.0 |
| INDE 240 | Technology Economics | 3.0 |
| INDE 370 | Industrial Project Management | 3.0 |
| MET 100 | Graphical Communication | 3.0 |
| MET 101 | Engineering Materials | 3.0 |
| MET 204 | Applied Quality Control | 3.0 |
| MET 205 | Robotics and Mechatronics | 3.0 |
| MET 209 | Fluid Power | 4.0 |
| MET 213 | Applied Mechanics | 4.0 |
| MHT 205 | Thermodynamics I | 3.0 |
| MHT 226 | Measurement Techniques and Instrumentation | 3.0 |
| **Electrical Engineering Technology Concentration Requirements** | | |
| EET 206 | Analog Electronics I | 4.0 |
| EET 313 | Signals and Systems I | 4.0 |
| EET 317 | Analog Electronics II | 4.0 |
| EET 322 | Energy Conversion | 4.0 |
| EET 323 | Electrical Systems Design | 3.0 |
| EET 324 | Power Electronics | 4.0 |
| EET 325 | Microprocessors | 3.0 |
| **Electrical Engineering Technology (EET) Electives** | | **6.0** |
| Select 6.0 additional credits from any BET, EET, MET, MHT or INDE courses not already required. See advisor for specific courses. | | |
| **Capstone Course Requirements** | | |
| MET 421 [WI] | Senior Design Project I | 3.0 |
| MET 422 | Senior Design Project II | 3.0 |
| MET 423 [WI] | Senior Design Project III | 3.0 |
| **Miscellaneous** | | |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| Free electives | | 9.0 |
| **Total Credits** | | **186.5** |

* Students not participating in co-op will not take COOP 101; 1 credit of Free Elective will be added in place of COOP 101.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

## 4 year, no co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | EET 209 | 3.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | EET 208 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| EET 102 | 3.0 | ENGL 102 or 112 | 3.0 | MATH 122 | 4.0 | | |
| MATH 110 | 3.0 | MATH 121 | 4.0 | MET 101 | 3.0 | | |
| PHYS 152 | 4.0 | MET 100 | 3.0 | PHYS 154 | 4.0 | | |
| UNIV E101 | 1.0 | PHYS 153 | 4.0 | | | | |
| | **17.5** | | **18** | | **17** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 201 | 4.0 | EET 202 | 4.0 | COM 230 | 3.0 | VACATION | |
| EET 333 | 4.0 | EET 204 | 3.0 | EET 311 | 4.0 | | |
| MET 209 | 4.0 | EET 205 | 4.0 | EET 319 | 4.0 | | |
| STAT 201 | 4.0 | MET 205 | 3.0 | MET 213 | 4.0 | | |
| | | MHT 205 | 3.0 | | | | |
| | **16** | | **17** | | **15** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 320 | 3.0 | EET 206 | 4.0 | EET 313 | 4.0 | VACATION | |
| EET 401 | 4.0 | EET 322 | 4.0 | EET 317 | 4.0 | | |
| INDE 240 | 3.0 | EET 324 | 4.0 | EET 323 | 3.0 | | |
| MET 204 | 3.0 | PHIL 315 | 3.0 | INDE 370 | 3.0 | | |
| MHT 226 | 3.0 | | | Free elective | 3.0 | | |
| | **16** | | **15** | | **17** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| HIST 285 | 4.0 | MET 422 | 3.0 | EET 325 | 3.0 |
| MET 421 | 3.0 | Free elective | 4.0 | MET 423 | 3.0 |
| General Education elective | 3.0 | General Education elective | 3.0 | Free elective | 3.0 |
| Technical elective | 3.0 | Technical elective | 3.0 | General Education elective | 3.0 |
| | **13** | | **13** | | **12** |

**Total Credits 186.5**

## 4 year, one co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | COOP 101* | 1.0 | VACATION | |
| EET 102 | 3.0 | EET 208 | 3.0 | EET 209 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 110 | 3.0 | MATH 121 | 4.0 | MATH 122 | 4.0 | | |
| PHYS 152 | 4.0 | MET 100 | 3.0 | MET 101 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 153 | 4.0 | PHYS 154 | 4.0 | | |
| | **17.5** | | **18** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 201 | 4.0 | EET 202 | 4.0 | COM 230 | 3.0 | EET 320 | 3.0 |
| EET 333 | 4.0 | EET 204 | 3.0 | EET 311 | 4.0 | EET 401 | 4.0 |
| MET 209 | 4.0 | EET 205 | 4.0 | EET 319 | 4.0 | INDE 240 | 3.0 |
| STAT 201 | 4.0 | MET 205 | 3.0 | MET 213 | 4.0 | MET 204 | 3.0 |
| | | MHT 205 | 3.0 | | | MHT 226 | 3.0 |
| | **16** | | **17** | | **15** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 206 | 4.0 | EET 313 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| EET 322 | 4.0 | EET 317 | 4.0 | | | | |
| EET 324 | 4.0 | EET 323 | 3.0 | | | | |
| PHIL 315 | 3.0 | INDE 370 | 3.0 | | | | |
| | | Free elective | 3.0 | | | | |
| | **15** | | **17** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| MET 421 | 3.0 | MET 422 | 3.0 | EET 325 | 3.0 |
| HIST 285 | 4.0 | Free elective | 3.0 | MET 423 | 3.0 |
| General Education elective | 3.0 | General Education elective | 3.0 | Free elective | 3.0 |
| Technical elective | 3.0 | Technical elective | 3.0 | General Education elective | 3.0 |
| | **13** | | **12** | | **12** |

**Total Credits 186.5**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## 5 Year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | COOP 101* | 1.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | EET 208 | 3.0 | EET 209 | 3.0 | | |
| EET 102 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 110 | 3.0 | MATH 121 | 4.0 | MATH 122 | 4.0 | | |
| PHYS 152 | 4.0 | MET 100 | 3.0 | MET 101 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 153 | 4.0 | PHYS 154 | 4.0 | | |
| | **17.5** | | **18** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 201 | 4.0 | EET 202 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| EET 333 | 4.0 | EET 204 | 3.0 | | | | |
| MET 209 | 4.0 | EET 205 | 4.0 | | | | |
| STAT 201 | 4.0 | MET 205 | 3.0 | | | | |
| | | MHT 205 | 3.0 | | | | |
| | **16** | | **17** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COM 230 | 3.0 | EET 320 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| EET 311 | 4.0 | EET 401 | 4.0 | | | | |
| EET 319 | 4.0 | INDE 240 | 3.0 | | | | |
| MET 213 | 4.0 | MET 204 | 3.0 | | | | |
| | | MHT 226 | 3.0 | | | | |
| | **15** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 206 | 4.0 | EET 313 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| EET 322 | 4.0 | EET 317 | 4.0 | | | | |
| EET 324 | 4.0 | EET 323 | 3.0 | | | | |
| PHIL 315 | 3.0 | INDE 370 | 3.0 | | | | |
| | | Free elective | 3.0 | | | | |
| | **15** | | **17** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| HIST 285 | 4.0 | MET 422 | 3.0 | EET 325 | 3.0 |
| MET 421 | 3.0 | Free elective | 3.0 | MET 423 | 3.0 |
| General Education elective | 3.0 | General Education elective | 3.0 | Free elective | 3.0 |
| Technical elective | 3.0 | Technical elective | 3.0 | General Education elective | 3.0 |
| | **13** | | **12** | | **12** |

**Total Credits 186.5**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

# Engineering Technology

## Healthcare Engineering Technology Concentration

**Effective March 15, 2020, new students are no longer being accepted into this concentration, however similar options are available. Contact Gerry Willis at** gtm23@drexel.edu **or 215-895-6253 for additional information.**

The Healthcare Engineering Technology concentration focuses on the practice of medical equipment operation and support in the clinical environment. This concentration provides students with the knowledge they need to work in the medical field, operating complicated diagnostic and patient care equipment.

During the first three years, students of all concentrations in Engineering Technology take electrical, mechanical, and industrial courses to get a solid, systematic background in different engineering fields. Students are required to complete general and concentration engineering technology courses, technical electives, and free elective courses that permit students great latitude in tailoring the program of study to match their career goals.

## Additional Information

For more information on the Healthcare Engineering Technology concentration, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

## Degree Requirements

| | | |
|---|---|---|
| **Humanities and Social Sciences Requirements** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| HIST 285 | Technology in Historical Perspective | 4.0 |
| PHIL 315 | Engineering Ethics | 3.0 |
| General Educational Electives | | 9.0 |
| **Basic Science Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| PHYS 152 | Introductory Physics I | 4.0 |
| PHYS 153 | Introductory Physics II | 4.0 |
| PHYS 154 | Introductory Physics III | 4.0 |
| **Mathematics Requirements** | | |
| MATH 110 | Precalculus | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| STAT 201 | Introduction to Business Statistics | 4.0 |
| **Engineering Technology Core** | | |
| EET 102 | Introduction to Engineering Technology | 3.0 |
| EET 201 | Circuit Analysis I | 4.0 |
| EET 202 | Circuit Analysis II | 4.0 |
| EET 204 | Introduction to Nanotechnology | 3.0 |
| EET 205 | Digital Electronics | 4.0 |
| EET 208 | Introduction to Programming for Embedded Systems | 3.0 |
| EET 209 | Fundamentals of Virtual Instrumentation | 3.0 |
| EET 311 | Modeling of Engineering Systems | 4.0 |
| EET 319 | PLC Fundamentals | 4.0 |
| EET 320 | Renewable Energy Systems | 3.0 |
| EET 333 [WI] | Non-Destructive Evaluation of Materials | 4.0 |
| EET 401 | Applied Microcontrollers | 4.0 |
| MET 100 | Graphical Communication | 3.0 |
| MET 101 | Engineering Materials | 3.0 |
| MET 204 | Applied Quality Control | 3.0 |
| MET 205 | Robotics and Mechatronics | 3.0 |
| MET 209 | Fluid Power | 4.0 |
| MET 213 | Applied Mechanics | 4.0 |
| MHT 205 | Thermodynamics I | 3.0 |
| MHT 226 | Measurement Techniques and Instrumentation | 3.0 |
| INDE 240 | Technology Economics | 3.0 |
| INDE 370 | Industrial Project Management | 3.0 |
| **Healthcare Engineering Technology Concentration Requirements** | | |
| BET 301 | Healthcare Technology | 3.0 |
| BET 302 | Biomedical Electronics | 4.0 |
| BET 303 | Medical Imaging Systems | 3.0 |
| BET 307 | Applied Biomedical Instrumentation | 3.0 |
| BIO 107 | Cells, Genetics & Physiology | 3.0 |
| BIO 108 | Cells, Genetics and Physiology Laboratory | 1.0 |
| BMES 302 | Laboratory II: Biomeasurements | 2.0 |
| BMES 335 | Biomedical Informatics I | 3.0 |
| BMES 391 | Biomedical Instrumentation I | 3.0 |
| BMES 488 | Medical Device Development | 3.0 |
| **Technical Electives** | | |
| Students select 6.0 additional credits from any BET, EET, MET, MHT, or INDE courses not already required. See advisor for specific courses. | | 6.0 |
| **Capstone Course Requirements** | | |
| MET 421 [WI] | Senior Design Project I | 3.0 |
| MET 422 | Senior Design Project II | 3.0 |
| MET 423 [WI] | Senior Design Project III | 3.0 |
| **Miscellaneous** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 0.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| **Free Electives** | | **7.0** |
| **Total Credits** | | **185.5** |

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Engineering Technology

## Mechanical and Manufacturing Concentration

The manufacturing-mechanical engineering technology concentration stresses on the design, development, testing, manufacturing, and integration of industrial machinery, consumer and biomedical products, CNC (Computer Numerical Control), prototyping machinery, and similar

equipment. The concentration includes study in computer graphics, statics, dynamics, stress analysis, thermo-fluid system analysis, industrial robotics and mechatronics, and Computer Aided Engineering (CAE) tools, including instrumentation and testing procedures and integration of various industrial systems.

During the first three years, students in engineering technology take electrical, mechanical, computer, and industrial courses to get a solid, multidisciplinary, systematic background in different engineering fields. Students are required to complete general and concentration engineering technology courses, technical electives, and free elective courses that permit students great latitude in tailoring the program of study to match their career goals.

## Additional Information

For more information, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

# Degree Requirements

| | | |
|---|---|---|
| **Humanities and Social Sciences Requirements** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| HIST 285 | Technology in Historical Perspective | 4.0 |
| PHIL 315 | Engineering Ethics | 3.0 |
| General Educational Electives | | 9.0 |
| **Basic Science Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| PHYS 152 | Introductory Physics I | 4.0 |
| PHYS 153 | Introductory Physics II | 4.0 |
| PHYS 154 | Introductory Physics III | 4.0 |
| **Mathematics Requirements** | | |
| MATH 110 | Precalculus | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| STAT 201 | Introduction to Business Statistics | 4.0 |
| **Engineering Technology Core** | | |
| EET 102 | Introduction to Engineering Technology | 3.0 |
| EET 201 | Circuit Analysis I | 4.0 |
| EET 202 | Circuit Analysis II | 4.0 |
| EET 204 | Introduction to Nanotechnology | 3.0 |
| EET 205 | Digital Electronics | 4.0 |
| EET 208 | Introduction to Programming for Embedded Systems | 3.0 |
| EET 209 | Fundamentals of Virtual Instrumentation | 3.0 |
| EET 311 | Modeling of Engineering Systems | 4.0 |
| EET 319 | PLC Fundamentals | 4.0 |
| EET 320 | Renewable Energy Systems | 3.0 |
| EET 333 [WI] | Non-Destructive Evaluation of Materials | 4.0 |
| EET 401 | Applied Microcontrollers | 4.0 |
| INDE 240 | Technology Economics | 3.0 |
| INDE 370 | Industrial Project Management | 3.0 |
| MET 100 | Graphical Communication | 3.0 |
| MET 101 | Engineering Materials | 3.0 |
| MET 204 | Applied Quality Control | 3.0 |
| MET 205 | Robotics and Mechatronics | 3.0 |
| MET 209 | Fluid Power | 4.0 |
| MET 213 | Applied Mechanics | 4.0 |
| MHT 205 | Thermodynamics I | 3.0 |
| MHT 226 | Measurement Techniques and Instrumentation | 3.0 |
| **Mechanical Engineering Technology Concentration Requirements** | | |
| MET 316 | Computer Numerical Control | 3.0 |
| MET 407 | Manufacturing Processes | 3.0 |
| MET 408 | MFG Information Management | 3.0 |
| MHT 206 | Thermodynamics II | 3.0 |
| MHT 222 | Applied Dynamics I | 4.0 |
| MHT 301 | Fluid Mechanics I | 3.0 |
| MHT 314 | Thermo and Heat Transfer Analysis | 3.0 |
| MHT 401 | Mechanical Design I | 4.0 |
| **MHT Technical Electives** | | |
| Students select 6.0 additional credits from any BET, EET, MET, MHT or INDE courses not already required. See advisor for specific courses. | | 6.0 |
| **Capstone Course Requirements** | | |
| MET 421 [WI] | Senior Design Project I | 3.0 |
| MET 422 | Senior Design Project II | 3.0 |
| MET 423 [WI] | Senior Design Project III | 3.0 |
| **Miscellaneous** | | |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| **Free Electives** | | **9.0** |
| **Total Credits** | | **186.5** |

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.
Students not participating in co-op will not take COOP 101; 1 credit of Free Elective will be added in place of COOP 101.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Mechanical and Manufacturing Engineering Technology Concentration

## Sample Plan of Study

### 4 year, no co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | EET 209 | 3.0 | VACATION | |
| EET 102 | 3.0 | EET 208 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | MATH 122 | 4.0 | | |
| MATH 110 | 3.0 | MATH 121 | 4.0 | MET 101 | 3.0 | | |
| PHYS 152 | 4.0 | MET 100 | 3.0 | PHYS 154 | 4.0 | | |
| UNIV E101 | 1.0 | PHYS 153 | 4.0 | | | | |
| | **17.5** | | **18** | | **17** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 201 | 4.0 | EET 202 | 4.0 | COM 230 | 3.0 | VACATION | |
| EET 333 | 4.0 | EET 204 | 3.0 | EET 311 | 4.0 | | |
| MET 209 | 4.0 | EET 205 | 4.0 | EET 319 | 4.0 | | |
| STAT 201 | 4.0 | MET 205 | 3.0 | MET 213 | 4.0 | | |
| | | MHT 205 | 3.0 | | | | |
| | **16** | | **17** | | **15** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 320 | 3.0 | MET 316 | 3.0 | INDE 370 | 3.0 | VACATION | |
| EET 401 | 4.0 | MHT 206 | 3.0 | MET 407 | 3.0 | | |
| INDE 240 | 3.0 | MHT 222 | 4.0 | MHT 314 | 3.0 | | |
| MET 204 | 3.0 | MHT 301 | 3.0 | MHT 401 | 4.0 | | |
| MHT 226 | 3.0 | PHIL 315 | 3.0 | Free elective* | 4.0 | | |
| | **16** | | **16** | | **17** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| HIST 285 | 4.0 | MET 422 | 3.0 | MET 423 | 3.0 |
| MET 408 | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| MET 421 | 3.0 | General Education elective | 3.0 | General Education elective | 3.0 |
| General Education elective | 3.0 | Technical elective** | 3.0 | Technical elective** | 3.0 |
| | **13** | | **12** | | **12** |

**Total Credits 186.5**

* Students not participating in co-op will not take COOP 101; 1 credit of Free Elective will be added in place of COOP 101.

** See advisor

### 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | COOP 101* | 1.0 | VACATION | |
| EET 102 | 3.0 | EET 208 | 3.0 | EET 209 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 110 | 3.0 | MATH 121 | 4.0 | MATH 122 | 4.0 | | |
| PHYS 152 | 4.0 | MET 100 | 3.0 | MET 101 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 153 | 4.0 | PHYS 154 | 4.0 | | |
| | **17.5** | | **18** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 201 | 4.0 | EET 202 | 4.0 | COM 230 | 3.0 | EET 320 | 3.0 |
| EET 333 | 4.0 | EET 204 | 3.0 | EET 311 | 4.0 | EET 401 | 4.0 |
| MET 209 | 4.0 | EET 205 | 4.0 | EET 319 | 4.0 | INDE 240 | 3.0 |
| STAT 201 | 4.0 | MET 205 | 3.0 | MET 213 | 4.0 | MET 204 | 3.0 |
| | | MHT 205 | 3.0 | | | MHT 226 | 3.0 |
| | **16** | | **17** | | **15** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MET 316 | 3.0 | INDE 370 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MHT 206 | 3.0 | MET 407 | 3.0 | | | | |
| MHT 222 | 4.0 | MHT 314 | 3.0 | | | | |
| MHT 301 | 3.0 | MHT 401 | 4.0 | | | | |
| PHIL 315 | 3.0 | Free elective | 3.0 | | | | |
| | **16** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| HIST 285 | 4.0 | MET 422 | 3.0 | MET 423 | 3.0 |
| MET 408 | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| MET 421 | 3.0 | General Education elective | 3.0 | General Education elective | 3.0 |
| General Education elective | 3.0 | Technical elective** | 3.0 | Technical elective** | 3.0 |
| | **13** | | **12** | | **12** |

**Total Credits 186.5**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See advisor

### 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | COOP 101* | 1.0 | VACATION | |
| EET 102 | 3.0 | EET 208 | 3.0 | EET 209 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 110 | 3.0 | MATH 121 | 4.0 | MATH 122 | 4.0 | | |
| PHYS 152 | 4.0 | MET 100 | 3.0 | MET 101 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 153 | 4.0 | PHYS 154 | 4.0 | | |
| | **17.5** | | **18** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 201 | 4.0 | EET 202 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| EET 333 | 4.0 | EET 204 | 3.0 | | | | |
| MET 209 | 4.0 | EET 205 | 4.0 | | | | |
| STAT 201 | 4.0 | MET 205 | 3.0 | | | | |
| | | MHT 205 | 3.0 | | | | |
| | **16** | | **17** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COM 230 | 3.0 | EET 320 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| EET 311 | 4.0 | EET 401 | 4.0 | | | | |
| EET 319 | 4.0 | INDE 240 | 3.0 | | | | |
| MET 213 | 4.0 | MET 204 | 3.0 | | | | |
| | | MHT 226 | 3.0 | | | | |
| | **15** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MET 316 | 3.0 | INDE 370 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MHT 206 | 3.0 | MET 407 | 3.0 | | | | |
| MHT 222 | 4.0 | MHT 314 | 3.0 | | | | |
| MHT 301 | 3.0 | MHT 401 | 4.0 | | | | |
| PHIL 315 | 3.0 | Free elective | 3.0 | | | | |
| | **16** | | **16** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| HIST 285 | 4.0 | MET 422 | 3.0 | MET 423 | 3.0 |
| MET 408 | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| MET 421 | 3.0 | General Education elective | 3.0 | General Education elective | 3.0 |
| General Education elective | 3.0 | Technical elective** | 3.0 | Technical elective** | 3.0 |
| | **13** | | **12** | | **12** |

**Total Credits 186.5**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See advisor

# Engineering Technology

## Robotics and Automation Technology Concentration

The Engineering Technology (ET) concentration in Robotics and Automation (ET-ROBT) will provide engineering students with a pathway to develop industry-relevant skills in robotics, automation, and in their underlying technologies and analytic approaches.

New trends in industry, science, and technology are developing and require new engineers to understand how to integrate robotics, automation, and effective human-machine teaming for manufacturing and critical services such as healthcare and infrastructure inspection. Such trends include the digital engineering revolution encompassing autonomous cars and drones, the Internet of Things, 5G mobile communications, digital design, and advanced manufacturing.

The core ET-ROBT curriculum combines courses and experiences that provide a strong foundation in the disciplines that comprise robotics and automation. This includes kinematics and design, electronics and instrumentation, fluid power and energy, manufacturing, materials, programming, and control. The ET-ROBT concentration builds on this foundation and provides depth in industrial robotics and mechatronics, automated manufacturing, system dynamics, digital electronics, and signal processing. Students will get knowledge and be trained to support the integration and use of robotics in the industry and society.

Potential career paths include advanced manufacturing and assembly, medical robotics, construction and infrastructure inspection, bio-robotics, knitted robotics for treatment of medical conditions, and robotics for entertainment.

## Additional Information

For more information, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

## Degree Requirements

| | | |
|---|---|---|
| **Humanities and Social Sciences Requirements** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| HIST 285 | Technology in Historical Perspective | 4.0 |
| PHIL 315 | Engineering Ethics | 3.0 |
| General Educational Electives | | 9.0 |
| **Basic Science Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| PHYS 152 | Introductory Physics I | 4.0 |
| PHYS 153 | Introductory Physics II | 4.0 |
| PHYS 154 | Introductory Physics III | 4.0 |
| **Mathematics Requirements** | | |
| MATH 110 | Precalculus | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| STAT 201 | Introduction to Business Statistics | 4.0 |
| **Engineering Technology Core** | | |
| EET 102 | Introduction to Engineering Technology | 3.0 |
| EET 201 | Circuit Analysis I | 4.0 |
| EET 202 | Circuit Analysis II | 4.0 |
| EET 204 | Introduction to Nanotechnology | 3.0 |
| EET 205 | Digital Electronics | 4.0 |
| EET 208 | Introduction to Programming for Embedded Systems | 3.0 |
| EET 209 | Fundamentals of Virtual Instrumentation | 3.0 |
| EET 311 | Modeling of Engineering Systems | 4.0 |
| EET 319 | PLC Fundamentals | 4.0 |
| EET 320 | Renewable Energy Systems | 3.0 |
| EET 333 [WI] | Non-Destructive Evaluation of Materials | 4.0 |
| EET 401 | Applied Microcontrollers | 4.0 |
| INDE 240 | Technology Economics | 3.0 |
| INDE 370 | Industrial Project Management | 3.0 |
| MET 100 | Graphical Communication | 3.0 |
| MET 101 | Engineering Materials | 3.0 |
| MET 204 | Applied Quality Control | 3.0 |
| MET 205 | Robotics and Mechatronics | 3.0 |
| MET 209 | Fluid Power | 4.0 |
| MET 213 | Applied Mechanics | 4.0 |
| MHT 205 | Thermodynamics I | 3.0 |
| MHT 226 | Measurement Techniques and Instrumentation | 3.0 |
| **Robotics and Automation Engineering Technology Concentration Requirements** | | |
| CET 301 | Advanced Digital Electronics | 4.0 |
| EET 313 | Signals and Systems I | 4.0 |
| INDE 350 | Industrial Engineering Simulation | 3.0 |
| MET 310 | Advanced Robotics and Mechatronics | 3.0 |

| | | |
|---|---|---|
| MET 316 | Computer Numerical Control | 3.0 |
| MET 404 | Digital Instrumentation | 3.0 |
| MHT 222 | Applied Dynamics I | 4.0 |
| MHT 401 | Mechanical Design I | 4.0 |
| **ROBT Technical Electives** * | | **6.0** |
| **Capstone Course Requirements** | | |
| MET 421 [WI] | Senior Design Project I | 3.0 |
| MET 422 | Senior Design Project II | 3.0 |
| MET 423 [WI] | Senior Design Project III | 3.0 |
| **Miscellaneous** | | |
| COOP 101 | Career Management and Professional Development | 1.0 |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| **Free Electives** | | **7.0** |
| **Total Credits** | | **186.5** |

* Students select 6.0 additional credits from any 300 or higher level HET, EET, MET, MHT, INDE, MEM, or ECE courses not already required. See advisor for specific courses.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

## 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | COOP 101* | 1.0 | VACATION | |
| EET 102 | 3.0 | EET 208 | 3.0 | EET 209 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 110 | 3.0 | MATH 121 | 4.0 | MATH 122 | 4.0 | | |
| PHYS 152 | 4.0 | MET 100 | 3.0 | MET 101 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 153 | 4.0 | PHYS 154 | 4.0 | | |
| | **17.5** | | **18** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 201 | 4.0 | EET 202 | 4.0 | COM 230 | 3.0 | EET 320 | 3.0 |
| EET 333 | 4.0 | EET 204 | 3.0 | EET 311 | 4.0 | EET 401 | 4.0 |
| MET 209 | 4.0 | EET 205 | 4.0 | EET 319 | 4.0 | INDE 240 | 3.0 |
| STAT 201 | 4.0 | MET 205 | 3.0 | MET 213 | 4.0 | MET 204 | 3.0 |
| | | MHT 205 | 3.0 | | | MHT 226 | 3.0 |
| | **16** | | **17** | | **15** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MET 310 | 3.0 | CET 301 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MET 316 | 3.0 | EET 313 | 4.0 | | | | |
| MET 404 | 3.0 | INDE 370 | 3.0 | | | | |
| MHT 222 | 4.0 | MHT 401 | 4.0 | | | | |
| PHIL 315 | 3.0 | | | | | | |
| | **16** | | **15** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| HIST 285 | 4.0 | MET 422 | 3.0 | MET 423 | 3.0 |
| MET 421 | 3.0 | INDE 350 | 3.0 | Free elective | 4.0 |
| General Education elective | 3.0 | General Education elective | 3.0 | General Education elective | 3.0 |
| Free elective | 3.0 | Technical elective | 3.0 | Technical elective | 3.0 |
| | **13** | | **12** | | **13** |

**Total Credits 186.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 | 1.0 | COOP 101 | 1.0 | VACATION | |
| EET 102 | 3.0 | EET 208 | 3.0 | EET 209 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 110 | 3.0 | MATH 121 | 4.0 | MATH 122 | 4.0 | | |
| PHYS 152 | 4.0 | MET 100 | 3.0 | MET 101 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 153 | 4.0 | PHYS 154 | 4.0 | | |
| | **17.5** | | **18** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| EET 201 | 4.0 | EET 202 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| EET 333 | 4.0 | EET 204 | 3.0 | | | | |
| MET 209 | 4.0 | EET 205 | 4.0 | | | | |
| STAT 201 | 4.0 | MET 205 | 3.0 | | | | |
| | | MHT 205 | 3.0 | | | | |
| | **16** | | **17** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COM 230 | 3.0 | EET 320 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| EET 311 | 4.0 | EET 401 | 4.0 | | | | |
| EET 319 | 4.0 | INDE 240 | 3.0 | | | | |
| MET 213 | 4.0 | MET 204 | 3.0 | | | | |
| | | MHT 226 | 3.0 | | | | |
| | **15** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MET 310 | 3.0 | CET 301 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MET 316 | 3.0 | EET 313 | 4.0 | | | | |
| MET 404 | 3.0 | INDE 370 | 3.0 | | | | |
| MHT 222 | 4.0 | MHT 401 | 4.0 | | | | |
| PHIL 315 | 3.0 | | | | | | |
| | **16** | | **15** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| HIST 285 | 4.0 | MET 422 | 3.0 | MET 423 | 3.0 |
| MET 421 | 3.0 | INDE 350 | 3.0 | Free elective | 4.0 |
| General Education elective | 3.0 | General Education elective | 3.0 | General Education elective | 3.0 |
| Free elective | 3.0 | Technical elective | 3.0 | Technical elective | 3.0 |
| | **13** | | **12** | | **13** |

**Total Credits 186.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

# Environmental Engineering

*Major: Environmental Engineering*
*Degree Awarded: Bachelor of Science in Environmental Engineering (BSENE)*
*Calendar Type: Quarter*
*Total Credit Hours: 190.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.1401*
*Standard Occupational Classification (SOC) code: 17-2081*

## 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 design systems, processes and policies to minimize the effect of human activities on the physical and living environment so that we can all live more healthy and sustainable lives. Environmental engineers work to meet human needs for resources in ways to minimize impact on the ecosystem and adverse effects on health. 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:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

## Additional Information

The Environmental Engineering program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (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.drexel.edu/cae/academics/bs-environmental-engineering/) page.

## Degree Requirements

**General Education/Liberal Studies Requirements**

| | | |
|---|---|---|
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |

| | | |
|---|---|---|
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Requirements [**] | | 15.0 |
| **Engineering Core Courses** | | |
| BIO 141 | Essential Biology | 4.5 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **Environmental Engineering Requirements** | | |
| BIO 221 | Microbiology | 3.0 |
| CAEE 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CHE 211 | Material and Energy Balances I | 4.0 |
| 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 230 | General Ecology | 3.0 |
| ENVS 401 | Chemistry of the Environment | 3.0 |
| **Technical Electives** | | **12.0** |
| **Total Credits** | | **191.5** |

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (p. 5).

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

### 4 year, one co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101[*] | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | CAEE 212 | 4.0 | CHEM 231 | 2.0 |
| ENGL 103 or 113 | 3.0 | CIVE 240 | 3.0 | CHE 211 | 4.0 | CIVE 330 | 4.0 |
| ENGR 220 | 4.0 | ENGR 210 | 3.0 | CHEM 230 | 4.0 | ENVE 302 | 3.0 |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | CIVE 320 | 3.0 | PHIL 315 | 3.0 |
| PHYS 201 | 4.0 | ENVS 230 | 3.0 | ENVE 300 | 3.0 | General Education elective[**] | 3.0 |
| | **17** | | **15** | | **18** | | **15** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 361 | 3.0 | BIO 221 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHEM 241 | 4.0 | CHEM 242 | 4.0 | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CIVE 430 | 3.0 | General Education electives** | 6.0 | | | | |
| ENVS 401 | 3.0 | Technical elective | 3.0 | | | | |
| General Education elective** | 3.0 | | | | | | |
| | **16** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ENVE 465 or 460 | 3.0 | CIVE 431 | 3.0 | ENVE 422 | 3.0 |
| ENVE 485 | 1.0 | ENVE 410 | 3.0 | ENVE 435 | 3.0 |
| ENVE 491 | 3.0 | ENVE 421 | 3.0 | ENVE 487 | 2.0 |
| Technical electives | 6.0 | ENVE 486 | 2.0 | ENVE 493 | 3.0 |
| | | ENVE 492 | 3.0 | General Education elective** | 3.0 |
| | | Technical elective | 3.0 | | |
| | **13** | | **17** | | **14** |

**Total Credits 191.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 53).

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| COOP 101* | 1.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| UNIV E101 | 1.0 | | | | | | |
| | **15.5** | | **16.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGL 103 or 113 | 3.0 | CIVE 240 | 3.0 | | | | |
| ENGR 220 | 4.0 | ENGR 210 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | ENVS 230 | 3.0 | | | | |
| | **17** | | **15** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 | 4.0 | CHEM 231 | 2.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 211 | 4.0 | CIVE 330 | 4.0 | | | | |
| CHEM 230 | 4.0 | ENVE 302 | 3.0 | | | | |
| CIVE 320 | 3.0 | PHIL 315 | 3.0 | | | | |
| ENVE 300 | 3.0 | General Education elective** | 3.0 | | | | |
| | **18** | | **15** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 361 | 3.0 | BIO 221 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHEM 241 | 4.0 | CHEM 242 | 4.0 | | | | |
| CIVE 430 | 3.0 | General Education electives** | 6.0 | | | | |
| ENVS 401 | 3.0 | Technical elective | 3.0 | | | | |
| General Education elective** | 3.0 | | | | | | |
| | **16** | | **16** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ENVE 465 or 460 | 3.0 | CIVE 431 | 3.0 | ENVE 422 | 3.0 |
| ENVE 485 | 1.0 | ENVE 410 | 3.0 | ENVE 435 | 3.0 |
| ENVE 491 | 3.0 | ENVE 421 | 3.0 | ENVE 487 | 2.0 |
| Technical electives | 6.0 | ENVE 486 | 2.0 | ENVE 493 | 3.0 |
| | | ENVE 492 | 3.0 | General Education elective** | 3.0 |
| | | Technical elective | 3.0 | | |
| | **13** | | **17** | | **14** |

**Total Credits 191.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 53).

## 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 BS/MS 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 (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/academic-programs/undergraduate/accelerated-and-dual-degree-programs/) 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
- 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

## Civil, Architectural and Environmental Engineering Faculty

Abieyuwa Aghayere, PhD *(University of Alberta)*. Professor. Structural design - concrete, steel and wood; structural failure analysis; retrofitting of existing structures; new structural systems and materials; engineering education.

Ivan Bartoli, PhD *(University of California, San Diego)*. Associate Professor. Non-destructive evaluation and structural health monitoring; dynamic identification, stress wave propagation modeling.

Robert Brehm, PhD *(Drexel University)*. Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

Shannon Capps, PhD *(Georgia Institute of Technology)*. Assistant Professor. Atmospheric chemistry; data assimilation; advanced sensitivity analysis; inverse modeling.

S.C. Jonathan Cheng, PhD *(West Virginia University)*. Associate Professor. Soil mechanics; geosynthetics; geotechnical engineering; probabilistic design; landfill containments; engineering education.

Eugenia Ellis, PhD, AIA *(Virginia Polytechnic Institute and State University)*. Professor. Natural and electric light sources and effects on biological rhythms and health outcomes; ecological strategies for smart, sustainable buildings of the nexus of health, energy and technology.

Yaghoob (Amir) Farnam, PhD *(Purdue University)*. Assistant Professor. Advanced and sustainable infrastructure materials; multifunctional, self-responsive and bioinspired construction materials; advanced multiscale manufacturing; characterization, and evaluation of construction materials; durability of cement-based materials.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute and State University)*. Professor. Geotechnical and geoenvironmental engineering; soil improvement; soil improvement; recycled materials in geotechnics.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Professor. Risk analysis of environmental and infrastructure systems; novel adsorbent materials; environmental standard setting; Bayesian statistical modeling; community outreach and environmental health.

Charles N. Haas, PhD *(University of Illinois-Urbana) L. D. Betz Chair Professor of Environmental Engineering and Department Head, Civil, Architectural and Environmental Engineering*. Water treatment; risk assessment; bioterrorism; environmental modeling and statistics; microbiology; environmental health.

Ahmad Hamid, PhD *(McMaster University)*. Professor. Engineered masonry; seismic behavior, design and retrofit of masonry structures; development of new materials and building systems.

Simi Hoque, PhD *(University of California - Berkeley)*. Associate Professor. Computational methods to reduce building energy and environmental impacts, urban metabolism, thermal comfort, climate resilience.

Y. Grace Hsuan, PhD *(Imperial College)*. Professor. Durability of polymeric construction materials; advanced construction materials; and performance of geosynthetics.

Joseph B. Hughes, PhD *(University of Iowa)*. Distinguished University Professor. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Architectural fluid mechanics; building automation and autonomy; implementation of natural and hybrid ventilation in buildings; airflow distribution in buildings; large-scale air movement in an urban built environment; building and urban informatics; data-enhanced sensing and control for optimal building operation and management; novel data gathering methods for building/urban problem solving; interdisciplinary research on occupant behaviors in the built environment.

Joseph P. Martin, PhD *(Colorado State University)*. Professor. Geotechnical and geoenvironmental engineering; hydrology; transportation; waste management.

James E. Mitchell, MArch *(University of Pennsylvania)*. Professor. Architectural engineering design; building systems; engineering education.

Franco Montalto, PhD *(Cornell University)*. Professor. Effects of built infrastructure on societal water needs, ecohydrologic patterns and processes, ecological restoration, green design, and water interventions.

Nariman Mostafavi, PhD *(University of Massachusetts - Amherst)*. Assistant Teaching Professor. Simulation tools for analyzing urban metabolism; environmentally responsive design; urban resilience; engineering economics; industrial ecology.

Joseph V. Mullin, PhD *(Pennsylvania State University) Associate Department Head*. Teaching Professor. Structural engineering; failure analysis; experimental stress analysis; construction materials; marine structures.

Mira S. Olson, PhD *(University of Virginia)*. Associate Professor. Peace engineering; source water quality protection and management; contaminant and bacterial fate and transport; community engagement.

Miguel A. Pando, PhD *(Virginia Polytechnic Institute and State University)*. Assistant Professor. Laboratory testing of geomaterials; geotechnical aspects of natural hazards; soil-structure-interaction; geotechnical engineering.

Michael Ryan, PhD *(Drexel University) Associate Department Head of Graduate Studies*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); dynamic engineering systems modeling; molecular microbial biology; phylogenetics; metagenomics; bioinformatics; environmental statistics; engineering economics; microbiology; potable and waste water quality; environmental management systems.

Christopher Sales, PhD *(University of California, Berkeley)*. Associate Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste; application of molecular biology, analytical chemistry and bioinformatic techniques to study environmental biological systems.

Yared Shifferaw, PhD *(Johns Hopkins University)*. Assistant Professor. Computational and experimental mechanics; structural stability; optimization; health monitoring and hazard mitigation; sustainable structures; emerging materials; thin-walled structures and metallic structures.

Kurt Sjoblom, PhD *(Massachusetts Institute of Technology)*. Assistant Professor. Laboratory testing of geomaterials, geotechnical engineering, foundation engineering.

Sabrina Spatari, PhD *(University of Toronto)*. Associate Professor. Industrial ecology; development and application of life cycle assessment (LCA) and material flow analysis (MFA) methods for guiding engineering and policy decisions; specific interest in biomass and bioenergy, biofuels, and urban infrastructure.

Robert Swan Associate Teaching Professor. Geotechnical and Geosynthetic Engineering; soil/geosynthetic interaction and performance; laboratory and field geotechnical/geosynthetic testing.

Michael Waring, PhD *(University of Texas-Austin) Associate Department Head for Undergraduate Programs; Director of Architectural Engineering Program*. Associate Professor. Indoor air quality and building sustainability; indoor particulate matter fate and transport; indoor chemistry and particle formation; secondary impacts of control technologies and strategies.

Jin Wen, PhD *(University of Iowa)*. Associate Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

Aspasia Zerva, PhD *(University of Illinois)*. Professor. Earthquake engineering; mechanics; seismology; structural reliability; system identification; advanced computational computational methods in structural analysis.

## Emeritus Faculty

Harry G. Harris, PhD *(Cornell University)*. Professor Emeritus. Structural models; dynamics of structures, plates and shells; industrialized building construction.

Richard Weggel, PhD *(University of Illinois) Samuel S. Baxter Professor Emeritus; Civil and Environmental Engineering*. Professor Emeritus. Coastal engineering; hydraulics engineering; hydrology.

Richard Woodring, PhD *(University of Illinois) Dean of Engineering Emeritus*. Professor Emeritus. Structural engineering, reinforced concrete.

# Materials Science and Engineering

*Major: Materials Science and Engineering*
*Degree Awarded: Bachelor of Science in Materials Science and Engineering (BSMSE)*
*Calendar Type: Quarter*
*Total Credit Hours: 185.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.1801*
*Standard Occupational Classification (SOC) code: 17-2131*

## 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 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 (MSE) work on a capstone senior design project over the course of three terms, with guidance from a faculty advisor and graduate student mentor. Students, generally working in small groups, synthesize information from their courses to arrive at solutions to real-world engineering problems.

Some recent senior design project topics include:

- Low Cost Plasma Cleaner Using Microwave Radiation
- Characterization of *y*' as a Function of Thermal Handling
- Grain Boundary Engineering in Alloy 625 Plus
- Effect of Titanium Additions to HSLA-100 Steel
- Synthesis and Characterizations of Metal-Halide Perovskite Containing Micelles
- Materials Discovery Through Machine Learning
- Biomimetic Mineralization of Bone
- Novel Use of Biomimetic Aggrecan to Regenerate and Molecularly Repair Damaged Skin
- 3-D Printing of PLA and Bone Scaffold Mimetic with Microstructural Analyses

## Mission Statement

The Department of Materials Science and Engineering (http://www.drexel.edu/materials/) 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 will be critical for future developments, including 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 its 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, to become leaders in industry, academia, etc.
- 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 possess 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:

1. An ability to apply, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

## Additional Information

The Materials Science and Engineering program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org (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** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ECON 201 | Principles of Microeconomics | 4.0 |
| ECON 202 | Principles of Macroeconomics | 4.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| Technical Electives/Track Courses [*] | | 12.0 |
| Non-designated General Education Requirements [**] | | 12.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 107 | Cells, Genetics & Physiology | 3.0 |
| BIO 108 | Cells, Genetics and Physiology Laboratory | 1.0 |
| CHE 350 | Statistics and Design of Experiments | 3.0 |
| CHEC 353 | Physical Chemistry and Applications III | 4.0 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| CHEM 241 | Organic Chemistry I | 4.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **Professional Requirements** | | |
| MATE 214 | Introduction to Polymers | 4.0 |
| MATE 230 | Fundamentals of Materials II | 4.0 |
| 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 | 3.0 |
| MATE 493 [WI] | Senior Project Design III | 3.0 |
| **Total Credits** | | **186.5** |

* A “Track” is a sequence of 4-5 technical electives (12.0-18.0 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. 5).

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

## 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | COOP 101* | 1.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| | | | | General Education elective** | 3.0 | | |
| | **14.5** | | **16.5** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| BIO 107 | 3.0 | CHEM 241 | 4.0 | ECON 201 | 4.0 | ECON 202 | 4.0 |
| BIO 108 | 1.0 | ENGL 103 or 113 | 3.0 | Technical elective/ Track course | 3.0 | PHIL 315 | 3.0 |
| ENGR 220 | 4.0 | ENGR 210 | 3.0 | General Education electives** | 6.0 | Free elective | 3.0 |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | | | Technical elective/ Track course | 3.0 |
| PHYS 201 | 4.0 | MATE 230 | 4.0 | | | | |
| Free elective | 3.0 | | | | | | |
| | **18** | | **17** | | **13** | | **13** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MATE 214 | 4.0 | MATE 245 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 240 | 4.0 | MATE 315 | 4.5 | | | | |
| MATE 280 | 4.0 | MATE 341 | 3.0 | | | | |
| MATE 355 | 3.0 | MATE 351 | 4.0 | | | | |
| MATE 370 | 3.0 | | | | | | |
| | **18** | | **15.5** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CHE 350 | 3.0 | MATE 345 | 4.5 | CHEC 353 | 4.0 |
| MATE 366 | 4.5 | MATE 492 | 3.0 | MATE 410 | 3.0 |
| MATE 455 | 3.0 | Technical elective/ Track course | 3.0 | MATE 493 | 3.0 |
| MATE 460 | 4.0 | General Education elective** | 3.0 | Technical elective/ Track course | 3.0 |

| | | | |
|---|---|---|---|
| MATE 491 | 2.0 | | |
| | **16.5** | **13.5** | **13** |

**Total Credits 186.5**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 58).

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | COOP 101* | 1.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| | | | | General Education elective** | 3.0 | | |
| | **14.5** | | **16.5** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| BIO 107 | 3.0 | CHEM 241 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| BIO 108 | 1.0 | ENGL 103 or 113 | 3.0 | | | | |
| ENGR 220 | 4.0 | ENGR 210 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | MATE 230 | 4.0 | | | | |
| Free elective | 3.0 | | | | | | |
| | **18** | | **17** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECON 201 | 4.0 | ECON 202 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 214 | 4.0 | MATE 245 | 4.0 | | | | |
| MATE 240 | 4.0 | MATE 315 | 4.5 | | | | |
| MATE 355 | 3.0 | MATE 341 | 3.0 | | | | |
| MATE 370 | 3.0 | | | | | | |
| | **18** | | **15.5** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MATE 280 | 4.0 | MATE 345 | 4.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 366 | 4.5 | MATE 351 | 4.0 | | | | |
| MATE 455 | 3.0 | PHIL 315 | 3.0 | | | | |
| CHEC 353 | 4.0 | Technical elective/ Track elective | 3.0 | | | | |
| | **15.5** | | **14.5** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CHE 350 | 3.0 | MATE 492 | 3.0 | MATE 410 | 3.0 |
| MATE 460 | 4.0 | Free elective | 3.0 | MATE 493 | 3.0 |
| MATE 491 | 2.0 | Technical elective/ Track course | 3.0 | Technical elective/ Track course | 3.0 |
| General Education elective** | 3.0 | General Education elective** | 3.0 | General Education elective** | 3.0 |
| Technical elective/ Track elective | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 186.5**

* COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 58).

## 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 photovoltaics); 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 Degree Program

The Accelerated Degree Program within 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 advance placement, credit by examination, flexibility of scheduling, and independent study, this "fast-track" makes it possible to complete both the undergraduate curriculum and Master's level graduate studies in 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 six-month Co-op periods instead of three, and in the last two years, the necessary graduate courses are taken.

For more information about this program, please visit the Department's BS/MS Dual Degree Program (http://www.drexel.edu/materials/academics/undergrad/bs-ms/) 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 a 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, spectrafluorometer, 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/MXene Ceramics Laboratory**
This laboratory contains a vacuum hot-press; a hot isostatic press (HIP) for materials consolidation and synthesis; laser scattering particle size analyzer; creep testers, Ar-filled glove-box, high-speed saw, and assorted high temperature furnaces; metallographic preparation facilities; high temperature closed-loop servo-hydraulic testing machines.

M**echanical Testing Laboratory**
This laboratory contains mechanical and closed-loop servo-hydraulic testing machines, hardness testers, Charpy and Izod 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 spectroscopy, scanning electron microscopy with electron beam lithography, and a scanning probe microscope.

**Nanomaterials Laboratory**
This laboratory contains instrumentation for synthesizing, testing and manipulation of nanomaterials carbon and two dimensional carbides under microscope, high-temperature autoclaves, Sievert's apparatus; glove-boxes; high-temperature vacuum and other furnaces for the synthesis of nano-carbon coatings and nanotubes; tube furnaces for synthesis of carbides and nitrides; potentiostat/galvanostat for electrochemical testings; ultraviolet-visible (UV-VIS) spectrophotometry; Raman spectrometers; Differential scanning calorimeter (DSC) and thermogravimetric analyzer (TGA) up to 1500 $^{o}$C with mass spectrometer, Zeta potential analyzer; attrition mill, bath and probe sonicators, centrifuges; 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 (PPMS) 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 cold 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); tabletop tensile tester; strip biaxial tensile tester; vacuum evaporator; spin coater; 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; refractometer; electro-spinning systems for producing nano-fibers.

**X-ray Tomography Laboratory**
This laboratory contains a high resolution X-ray micro-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 web page (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 a number of state-of-the-art materials characterization instruments, including environmental and variable pressure field-emission scanning electron microscopes (SEMs) 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 Drexel University's Centralized Research Facilities (http://crf.coe.drexel.edu/) web page.

## Materials Science and Engineering Faculty

Michel Barsoum, PhD *(Massachusetts Institute of Technology)*. Distinguished Professor. Processing and characterization of novel ceramics and ternary compounds, especially the MAX and 2-D MXene phases.

Hao Cheng, PhD *(Northwestern University)*. Associate Professor. Drug delivery, molecular self-assembly, cell-nanomaterial interactions, regenerative medicine and cell membrane engineering.

Yury Gogotsi, PhD *(Kiev Polytechnic Institute) Director, A. J. Drexel Nanotechnology Institute*. Distinguished University & Charles T. and Ruth M. Bach Professor. Nanomaterials; carbon nanotubes; nanodiamond; graphene; MXene; materials for energy storage, supercapacitors, and batteries.

Richard Knight, PhD *(Loughborough University) Associate Department Head and Undergraduate Advisor*. Teaching Professor. Thermal plasma technology; thermal spray coatings and education; plasma chemistry and synthesis.

Christopher Y. Li, PhD *(University of Akron)*. Professor. Soft and hybrid materials for optical, energy, and bio applications; polymeric materials, nanocomposites, structure and properties.

Andrew Magenau, PhD *(University of Southern Mississippi)*. Assistant Professor. Structurally complex materials exhibiting unique physical properties designed and fabricated using an assortment of methodologies involving directed self-assembly, externally applied stimuli, structure-function correlation, and applied engineering principles suited for technologies in regenerative medicine, biological interfacing, catalytic, electronic, and optical applications

Michele Marcolongo, PhD, PE *(University of Pennsylvania) Department Head, Materials Science and Engineering*. Professor. Orthopedic biomaterials; acellular regenerative medicine, biomimetic proteoglycans; hydrogels.

Steven May, PhD *(Northwestern University) Department Head*. Professor. Synthesis of complex oxide films, superlattices, and devices; materials for energy conversion and storage; magnetic and electronic materials; x-ray and neutron scattering.

Ekaterina Pomerantseva, PhD *(Moscow State University, Russia)*. Associate Professor. Solid state chemistry; electrochemical characterization, lithium-ion batteries, energy generation and storage; development and characterization of novel nanostructured materials, systems and architectures for batteries, supercapacitors and fuel cells.

Caroline L. Schauer, PhD *(SUNY Stony Brook) Associate Dean, Faculty Affairs College of Engineering*. Professor. Polysaccharide thin films and nanofibers.

Wei-Heng Shih, PhD *(Ohio State University)*. Professor. Colloidal ceramics and sol-gel processing; piezoelectric biosensors, optoelectronics, and energy harvesting devices; nanocrystalline quantum dots for bioimaging, lighting, and solar cells.

Jonathan E. Spanier, PhD *(Columbia University) Department Head, Mechanical Engineering and Mechanics*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laser spectroscopy, including Raman scattering.

Mitra Taheri, PhD *(Carnegie Mellon University) Hoeganeas Professor of Metallurgy*. Professor. Development of the ultrafast Dynamic Transmission Electron Microscope (DTEM) for the study of laser-induced microstructural evolution/phase transformations in nanostructured materials; use of various in-situ Transmission Electron Microscopy techniques.

Jörn Venderbos, PhD *(Leiden University)*. Assistant Professor. Theory of quantum materials: topological Insulators, topological semimetals, materials prediction and design, strongly correlated electron materials, complex electronic ordering phenomena, unconventional superconductors

Christopher Weyant, PhD *(Northwestern University)*. Teaching Professor. Engineering education

Antonios Zavaliangos, PhD *(Massachusetts Institute of Technology) A.W. Grosvenor Professor*. Professor. Constitutive modeling; powder compaction and sintering; pharmaceutical tableting, X-ray tomography.

## Emeritus Faculty

Roger D. Corneliussen, PhD *(University of Chicago)*. Professor Emeritus. Fracture, blends and alloys, as well as compounding.

Roger D. Doherty, PhD *(Oxford University)*. Professor Emeritus. Metallurgical processing; thermo-mechanical treatment.

Ihab L. Kamel, PhD *(University of Maryland)*. Professor Emeritus. Nanotechnology, polymers, composites, biomedical applications, and materials-induced changes through plasma and high energy radiation.

Jack Keverian, PhD *(Massachusetts Institute of Technology)*. Professor Emeritus. Rapid parts manufacturing, computer integrated manufacturing systems, strip production systems, technical and/or economic modeling, melting and casting systems, recycling systems.

# Mechanical Engineering & Mechanics

*Major: Mechanical Engineering & Mechanics*
*Degree Awarded: Bachelor of Science in Mechanical Engineering (BSME)*
*Calendar Type: Quarter*
*Total Credit Hours: 189.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.1901*
*Standard Occupational Classification (SOC) code: 17-2141*

## 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 (https://drexel.edu/engineering/academics/departments/mechanical-engineering/) (MEM) 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

- Our 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.
- Our graduates will enter and complete academic and professional programs in engineering, business, management, law, and medicine.
- Our graduates will communicate effectively with peers and be successful working with and leading multidisciplinary and multicultural teams.
- Our graduates will recognize the global, legal, societal, and ethical contexts of their work.
- Our 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:

- An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- An ability to communicate effectively with a range of audiences
- An ability to recognize ethical and professional responsibilities in engineering situations in global, economic, environmental, and societal contexts
- An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- An ability to acquire and apply new knowledge as needed using appropriate learning strategies

## 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 the MEM Department (https://drexel.edu/engineering/academics/departments/mechanical-engineering/).

# Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| HIST 285 | Technology in Historical Perspective | 4.0 |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| 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 |
| MATH 201 | Linear Algebra | 4.0 |
| MATH 210 | Differential Equations | 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** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering Design Requirements** | | |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |

| | | |
|---|---|---|
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| **Engineering Requirements** | | |
| ENGR 210 | Introduction to Thermodynamics | 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 | Statics | 3.0 |
| MEM 220 | Fluid Mechanics I | 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 391 | Introduction to Engineering Design Methods | 1.0 |
| MEM 435 | Introduction to Computer-Aided Design and Manufacturing | 4.0 |
| MEM 491 [WI] | Senior Design Project I | 2.0 |
| MEM 492 [WI] | Senior Design Project II | 3.0 |
| MEM 493 [WI] | Senior Design Project III | 3.0 |
| MEM Fundamental | Courses. Select four of the following: | 12.0-16.0 |
| 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 | Manufacturing Process I | |
| MEM 440 | Thermal Systems Design | |
| MEM 458 | Micro-Based Control Systems I | |
| MEM 459 | Control Applications of DSP Microprocessors | |
| 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 |
| **Electives or Optional Concentration** ** | | |
| **Aerospace Concentration** | | |
| Select five courses (15.0 credits) from the list below: | | |
| MEM 320 | Fluid Dynamics I | |
| MEM 330 | Mechanics of Materials II | |
| MEM 373 | Space Systems Engineering I | |
| MEM 374 | Space Systems Engineering II | |
| MEM 403 | Gas Turbines & Jet Propulsion | |
| MEM 405 | Principles of Combustion I | |
| MEM 406 | Principles of Combustion II | |
| MEM 420 | Aerodynamics | |
| MEM 423 | Mechanics of Vibration | |
| MEM 425 | Aircraft Design & Performance | |
| MEM 426 | Aerospace Structures | |
| MEM 427 | Finite Element Methods | |
| MEM 428 | Introduction to Composites I | |
| MEM 429 | Introduction to Composites II | |
| MEM 451 | Orbital Mechanics | |
| MEM 453 | Aircraft Flight Dynamics & Control I | |
| MEM 454 | Aircarft Flight Dynamics & Control II | |
| MEM 455 | Introduction to Robotics | |
| MEM 459 | Control Applications of DSP Microprocessors | |
| **Energy Concentration** | | |
| Select five courses (15.0 credits) from the list below: | | |
| AE 430 | Control Systems for HVAC | |
| CHE 431 | Fundamentals of Solar Cells | |
| ECEP 354 | Energy Management Principles | |
| ECEP 371 | Introduction to Nuclear Engineering | |
| ECEP 380 | Introduction to Renewable Energy | |
| ECEP 402 | Theory of Nuclear Reactors | |
| ECEP 403 | Nuclear Power Plant Design & Operation | |
| ECEP 406 | Introduction to Radiation Health Principles | |
| ECEP 411 | Power Systems I | |
| ECEP 422 | Power Distribution Automation and Control | |
| ECEP 480 | Solar Energy Engineering | |
| MEM 320 | Fluid Dynamics I | |
| MEM 330 | Mechanics of Materials II | |
| MEM 371 | Introduction to Nuclear Engineering I | |
| MEM 400 | Internal Combustion Engines | |
| MEM 402 | Power Plant Design | |
| MEM 403 | Gas Turbines & Jet Propulsion | |
| MEM 405 & MEM 406 | Principles of Combustion I and Principles of Combustion II | |
| MEM 410 | Thermodynamic Analysis II | |
| MEM 413 & MEM 414 | HVAC Loads and HVAC Equipment | |
| MEM 415 | Fuel Cell Engines | |
| MEM 445 | Solar Energy Fundamentals | |
| MEM 446 & MEM 447 | Fundamentals of Plasmas I and Fundamentals of Plasmas II | |
| MEM 448 | Applications of Thermal Plasmas | |
| MEM 449 | Applications of Non-Thermal Plasmas | |
| **Total Credits** | | **189.5-201.5** |

* General Education Requirements (p. 5).

** Students may choose to do a concentration in either Aerospace or Energy. Concentrations consist of 15.0 concentration credits.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses

with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

## 4 year, 1 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | COOP 101* | 1.0 | ENGL 103 or 113 | 3.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| | | PHYS 101 | 4.0 | | | | |
| | **14.5** | | **19.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CIVC 101 | 1.0 | ENGR 210 | 3.0 | CIVE 240 | 3.0 | MEM 220 | 4.0 |
| ENGR 220 | 4.0 | MATH 210 | 4.0 | HIST 285 | 4.0 | MEM 255 | 4.0 |
| MATH 201 | 4.0 | MEM 201 | 3.0 | MEM 230 | 4.0 | MEM 331 | 2.0 |
| MEM 202 | 3.0 | MEM 238 | 4.0 | MEM 310 | 4.0 | MEM 333 | 3.0 |
| PHYS 201 | 4.0 | General Education elective* | 3.0 | Free elective | 3.0 | PHIL 315 | 3.0 |
| | **16** | | **17** | | **18** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MEM 311 | 2.0 | MEM 351 | 2.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MEM 355 | 4.0 | MEM 361 | 3.0 | | | | |
| MEM 345 | 4.0 | Two MEM Fundamentals courses* | 6.0 | | | | |
| MEM 391 | 1.0 | General Education elective* | 3.0 | | | | |
| MEM 435 | 4.0 | | | | | | |
| MEM Fundamenta course* | 3.0 | | | | | | |
| | **18** | | **14** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| MEM 491 | 2.0 | MEM 492 | 3.0 | MEM 493 | 3.0 |
| General Education elective* | 3.0 | MEM elective (300+ or higher)* | 3.0 | MEM Elective (300+ higher) | 3.0 |
| MEM or College of Engineering elective (300+ or higher) | 3.0 | MEM or College of Engineering elective (300+ or higher) | 3.0 | General Education elective* | 3.0 |
| MEM Fundamenta course* | 3.0 | Math/ Science course* | 3.0 | Free electives | 3.0 |
| Math/ Science course* | 3.0 | | | | |
| | **14** | | **12** | | **12** |

**Total Credits 189.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 63).

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | COOP 101 | 1.0 | ENGL 103 or 113 | 3.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| | | PHYS 101 | 4.0 | | | | |
| | **14.5** | | **19.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CIVC 101 | 1.0 | ENGR 210 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGR 220 | 4.0 | MATH 210 | 4.0 | | | | |
| MATH 201 | 4.0 | MEM 201 | 3.0 | | | | |
| MEM 202 | 3.0 | MEM 238 | 4.0 | | | | |
| PHYS 201 | 4.0 | General Education elective* | 3.0 | | | | |
| | **16** | | **17** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CIVE 240 | 3.0 | MEM 220 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| HIST 285 | 4.0 | MEM 255 | 4.0 | | | | |
| MEM 230 | 4.0 | MEM 331 | 2.0 | | | | |
| MEM 310 | 4.0 | MEM 333 | 3.0 | | | | |
| Free elective | 3.0 | PHIL 315 | 3.0 | | | | |
| | **18** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MEM 311 | 2.0 | MEM 351 | 2.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MEM 345 | 4.0 | MEM 361 | 3.0 | | | | |
| MEM 355 | 4.0 | Two MEM Fundamentals courses* | 6.0 | | | | |
| MEM 391 | 1.0 | General Education elective* | 3.0 | | | | |
| MEM 435 | 4.0 | | | | | | |
| MEM Fundamenta course* | 3.0 | | | | | | |
| | **18** | | **14** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| MEM 491 | 2.0 | MEM 492 | 3.0 | MEM 493 | 3.0 |

| | | | | | |
|---|---|---|---|---|---|
| General Education elective* | 3.0 | MEM elective (300+ or higher) | 3.0 | Free elective | 3.0 |
| MEM or College of Engineering elective (300+ or higher) | 3.0 | MEM or College of Engineering elective (300+ or higher) | 3.0 | MEM Elective (300+ or higher) | 3.0 |
| MEM Fundamenta course* | 3.0 | Math/ Science course* | 3.0 | General Education elective* | 3.0 |
| Math/ Science course* | 3.0 | | | | |
| | **14** | | **12** | | **12** |

**Total Credits 189.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** See degree requirements (p. 63).

# 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.

# Facilities

## Instructional Laboratories

Mechanical Engineering and Mechanics (MEM) supports instructional laboratories to provide hands-on experience with engineering measurements and to augment classroom instruction in the areas of mechanics, systems and controls, thermal fluid sciences and design and manufacturing along with a college-supported machine shop to aid senior design.

## Specialized Laboratories

**BIOMEMS Lab and Lab-on-a-Chip**

Develops miniature devices for biological and medical applications using microfabrication and microfluidics technologies. Our research projects are highly multidisciplinary in nature and thus require the integration of engineering, science, biology, and medicine. Projects are conducted in close collaboration with biologists and medical doctors. Our research methodology includes design and fabrication of miniature devices, experimental characterization, theoretical analysis and numerical simulation.

**Computer-aided Design Lab (CAD)**

Provides access to software such as AutoCAD, ANSYS, Abagus, CREO, and SOLIDWORKS either in the 42 workstation lab which is available by card access 24/7, or over any network connection using our CITRIX server. Computations are performed on a virtual pc running at the server, and students can use any smart device for input and display.

**Theoretical and Applied Mechanics Group Laboratory (TAMG)**

Through experimental, analytical, and computational investigations, TAMG develops insights into the deformation and failure of materials, components and structures in a broad range of time and length scales. To accomplish this goal, TAMG develops procedures that include mechanical behavior characterization coupled with non-destructive testing and modern computational tools. This information is used both for understanding the role of important material scales in the observed bulk behavior and for the formation of laws that can model the response to prescribed loading conditions.

**Electrochemical Energy Systems Laboratory (ECSL)**

Addresses the research and development needs of emerging alternative energy technologies. ECSL specializes in the design, diagnostics, and characterization of next-generation electrochemical energy conversion and storage systems; particularly fuel cell and battery technology. Current areas of research include polymer electrolyte fuel cells for stationary, portable, and transportation areas of next-generation flow battery technology for intermittent energy storage, load leveling and smart-grid applications. ECSL uses a comprehensive approach, including advanced diagnostics, system design, materials characterization, and computational modeling of electrochemical energy systems.

**Multiscale Thermofluidics Lab**

Develops novel scalable nanomanufacturing techniques using biological templates to manipulate micro- and nano-scale thermal and fluidic phenomena. Current work includes enhancing phase-change heat transfer with super-wetting nanostructured coatings and transport and separation through nanoporous membrances.

**Biofabrication Laboratory**

Utilizes cells or biologics as basic building blocks in which biological models, systems devices and products are manufactured. Biofabrication techniques encompass a broad range of physical, chemical, biological, and/or engineering process, with various applications in tissue science and engineering, regenerative medicine, disease pathogeneses and drug testing studies, biochips and biosensors, cell printing, patterning and assembly, and organ printing.

The Program for Biofabrication at Drexel integrates computer-aided tissue engineering, modern design and manufacturing, biomaterials and biology in modeling, design, and biofabrication of tissue scaffolds, tissue constructs, micro-organ, tissue models. The ongoing research focuses on bio-tissue modeling, bio-blueprint modeling, scaffold informatics modeling, biometric design of tissue scaffold, additive manufacturing of tissue scaffolds, cell printing and organ printing.

The facilities at the Biofabrication Laboratory include:

- state-of-the-art computer-aided design/engineering/manufacturing (CAD/CAE/CAM) software, medical image processing and 3D reconstruction software, and in-house developed heterogeneous modeling and homogenization software
- proprietary multi-nozzle cell deposition system for direct cell writing and construction of tissue precursors and micro-organs
- proprietary precision extruding deposition system for fabrication of 3D bipolymer tissue scaffolds
- commercial available 3DP free-form fabrication system for bio-physical modeling
- plasma instrument for surface treatment and surface functionalization
- MTS universal testing system
- laboratory for cell and tissue culture study

**Complex Fluids and Multiphase Transport Lab**

Conducts both experimental and modeling studies on heat/mass transfer and multi-phase flows, as well as transport phenomena in additive manufacturing and energy systems. Current projects range from basic studies in interfacial transport in directed-assembly of functional materials and nanostructure-enhanced two-phase heat transfer to design of innovative dry cooling power plants and electrochemical energy storage systems.

**Laboratory for Biological Systems Analysis**

Applies system level engineering techniques to biological systems with emphasis on:

- The development of bio-robotic models as tools for investigating hypotheses about biological systems
- The use of system identification techniques to evaluate the functional performance of physiological systems under natural behavioral conditions
- The design of systems that are derived from nature and use novel techniques, such as electro-active polymers, to achieve superior performance and function

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 methodology, 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.

Biomechanics Laboratory **(**http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=2**)**
Emphasis in this laboratory is placed on experimental modelling studies of the mechanical properties of human joints, characterization of the mechanical properties of biological materials, studies of human movements, and design and development of joint replacements with particular emphasis on total ankle replacement. Facilities include a 3-D kinematic measuring system, Tensile testing machine, joint flexibility testers, and microcomputers for data acquisition and processing.

Combustion and Fuels Chemistry Laboratory **(**http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=1**)**
Investigate 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.

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.

**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.

Nyheim Plasma Institute (Formerly A.J. Drexel Plasma Institute) **(**http://www.mem.drexel.edu/current/labs/?m=research&a=lab_desc&labID=11**)**
The Nyheim Plasma Institute was formed in 2002 to stimulate and coordinate research projects related to plasma and other modern high energy engineering techniques. Today the institute 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. Present efforts are exploring the heat and mass transfer process in super-critical fluids and binary refrigerants.

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.

## Mechanical Engineering Faculty

Jennifer Atchison, PhD *(Drexel University)*. Assistant Teaching Professor. Engineering Education, Functional Fabrics, and Nanofibers

Jonathan Awerbuch, DSc *(Technion, Israel Institute of Technology)*. Professor. Mechanics of composites; fracture and fatigue; impact and wave propagation; structural dynamics.

Nicholas P. Cernansky, PhD *(University of California-Berkeley) Hess Chair Professor of Combustion*. Professor. Combustion chemistry and kinetics; combustion generated pollution; utilization of alternative and synthetic fuels.

Bor-Chin Chang, PhD *(Rice University)*. Professor. Computer-aided design of multivariable control systems; robust and optimal control systems.

Richard Chiou, PhD *(Georgia Institute of Technology)*. Associate Professor. Green manufacturing, mechatronics, Internet-based robotics and automation, and remote sensors and monitoring.

Young I. Cho, PhD *(University of Illinois-Chicago)*. Professor. Heat transfer; fluid mechanics; non-Newtonian flows; biofluid mechanics; rheology.

Bakhtier Farouk, PhD *(University of Delaware) Billings Professor of Mechanical Engineering*. Professor. Heat transfer; combustion; numerical methods; turbulence modeling; materials processing.

Alexander Fridman, DSc, PhD *(Moscow Institute of Physics and Technology) Mechanical Engineering and Mechanics, John A. Nyheim Endowed University Chair Professor, Director of the Drexel Plasma Institute*. Professor. Plasma science and technology; pollutant mitigation; super-adiabatic combustion; nanotechnology and manufacturing.

Li-Hsin Han, PhD *(University of Texas at Austin)*. Assistant Professor. Polymeric, micro/nano-fabrication, biomaterial design, tissue engineering, rapid prototyping, free-form fabrication, polymer micro actuators, photonics

Y. Grace Hsuan, PhD *(Imperial College)*. Professor. Durability of polymeric construction materials; advanced construction materials; and performance of geosynthetics.

Andrei Jablokow, PhD *(University of Wisconsin, Madison) Associate Department Head for Undergraduate Affairs, Mechanical Engineering and Mechanics*. Associate Teaching Professor. Engineering education; kinematics; geometric modeling.

Antonios Kontsos, PhD *(Rice University)*. Associate Professor. Applied mechanics; probabilistic engineering mechanics; modeling of smart multifunctional materials.

E. Caglan Kumbur, PhD *(Pennsylvania State University)*. Associate Professor. Next generation energy technologies; fuel cell design and development.

Harry G. Kwatny, PhD *(University of Pennsylvania) S. Herbert Raynes Professor of Mechanical Engineering*. Professor. Dynamic systems analysis; stochastic optimal control; control of electric power plants and systems.

Alan Lau, PhD *(Massachusetts Institute of Technology)*. Professor. Deformation and fracture of nano-devices and macroscopic structures; damage-tolerant structures and microstructures.

Michele Marcolongo, PhD, PE *(University of Pennsylvania) Department Head, Materials Science and Engineering*. Professor. Orthopedic biomaterials; acellular regenerative medicine, biomimetic proteoglycans; hydrogels.

Roger Marino, PhD *(Drexel University)*. Associate Teaching Professor. Engineering education; land development; product Development

Matthew McCarthy, PhD *(Columbia University) Associate Department Head for Graduate Affairs, Mechanical Engineering and Mechanics*. Associate Professor. Micro- and nanoscale thermofluidic systems, bio-inspired cooling, smart materials and structures for self-regulated two-phase cooling, novel architectures for integrated energy conversion and storage.

David L. Miller, PhD *(Louisiana State University)*. Professor. Gas-phase reaction kinetics; thermodynamics; biofuels.

Moses Noh, PhD *(Georgia Institute of Technology)*. Associate Professor. MEMS; BioMEMS; lab-on-a-chip; microfabrication; microfluidics.

Mira S. Olson, PhD *(University of Virginia)*. Associate Professor. Peace engineering; source water quality protection and management; contaminant and bacterial fate and transport; community engagement.

Sorin Siegler, PhD *(Drexel University)*. Professor. Orthopedic biomechanics; robotics; dynamics and control of human motion; applied mechanics.

Jonathan E. Spanier, PhD *(Columbia University) Department Head, Mechanical Engineering and Mechanics*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laser spectroscopy, including Raman scattering.

Wei Sun, PhD *(Drexel University) Albert Soffa Chair Professor of Mechanical Engineering*. Professor. Computer-aided tissue engineering; solid freeform fabrication; CAD/CAM; design and modeling of nanodevices.

Ying Sun, PhD *(University of Iowa)*. Associate Professor. Transport processes in multi-component systems with fluid flow; heat and mass transfer; phase change; pattern formation.

Tein-Min Tan, PhD *(Purdue University)*. Associate Professor. Mechanics of composites; computational mechanics and finite-elements methods; structural dynamics.

James Tangorra, PhD *(Massachusetts Institute of Technology) Department Head, Engineering Technology*. Associate Professor. Analysis of human and (other) animal physiological systems; head-neck dynamics and control; balance, vision, and the vestibular system; animal swimming and flight; robotics; system identification; bio-inspired design.

Ajmal Yousuff, PhD *(Purdue University)*. Associate Professor. Optimal control; flexible structures; model and control simplifications.

Jack G. Zhou, PhD *(New Jersey Institute of Technology)*. Professor. CAD/CAM; computer integrated manufacturing systems; rapid prototyping; system dynamics and automatic control.

## Emeritus Faculty

Leon Y. Bahar, PhD *(Lehigh University)*. Professor Emeritus. Analytical methods in engineering, coupled thermoelasticity, interaction between analytical dynamics and control systems.

Gordon D. Moskowitz, PhD *(Princeton University)*. Professor Emeritus. Biomechanics, dynamics, design, applied mathematics.

Donald H. Thomas, PhD *(Case Institute of Technology)*. Professor Emeritus. Biocontrol theory, biomechanics, fluidics and fluid control, vehicle dynamics, engineering design.

Albert S. Wang, PhD *(University of Delaware)*. Professor Emeritus. Treatment of damage evolution processes in multi-phased high-

temperature materials, including ceramics and ceramic-matrix composites.

# Engineering Undeclared

## About the Program

The Engineering Undeclared program allows students to explore academic options and stay on track with credits and critical courses within the College of Engineering before declaring a major. With the help of an advisor, students can select courses based on their unique interests and goals. No later than the end of spring term in the first academic year, students are required to select an appropriate major which will lead to a bachelor's degree.

The Engineering Undeclared program empowers students to make well-informed decisions around choosing their engineering major, getting involved on campus, and following their ambitions. *Note that this program does not lead to a degree in engineering* - all students must change their major into one of the College's degree programs (https://drexel.edu/engineering/academics/areas-of-study-programs/).

## Admission Requirements

See the Drexel Admissions (https://drexel.edu/admissions/overview/) website for information about applying to Drexel University.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirement** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education | | 22.0 |
| **Math and Science Requirements** | | |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| PHYS 101 | Fundamentals of Physics I | 4.0 |
| Science Requirement | | 16.5 |
| Math/Science Courses | | 6.0 |
| **Engineering Requirements** | | |
| Major Requirement | | 86.5 |
| Senior Design | | 9.0 |
| Free Electives | | 6.0 |
| **Total Credits** | | **181.5** |

## Sample Plan of Study

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | VACATION | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | Science Requirement | 4.5 | | |
| CHEM 101 | 3.5 | PHYS 101 | 4.0 | Major Requiremen | 8.0 | | |
| UNIV E101 | 1.0 | Major Requirement | 4.5 | | | | |
| | **14.5** | | **18.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CIVC 101 | 1.0 | General Education Requirement | 3.0 | Major Requirements | 9.0 | VACATION | |
| Science Requirement | 8.0 | Science Requirement | 4.0 | General Education Requirement | 4.0 | | |
| Major Requirement | 7.0 | Major Requirements | 10.0 | Free elective | 3.0 | | |
| | **16** | | **17** | | **16** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| Major Requirements | 13.0 | Major Requirements | 12.0 | Major Requirements | 11.0 |
| General Education | 3.0 | General Education | 3.0 | General Education Requirement | 3.0 |
| | **16** | | **15** | | **14** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| Senior Design | 3.0 | Senior Design | 3.0 | Senior Design | 3.0 |
| Math/ Science course | 3.0 | Math/ Science course | 3.0 | General Education Requiremen | 3.0 |
| General Education Requirement | 3.0 | Major Requirements | 6.0 | Major Requirement | 3.0 |
| Major Requiremen | 3.0 | | | Free elective | 3.0 |
| | **12** | | **12** | | **12** |

**Total Credits 181.5**

# Architectural Engineering, Building Systems Concentration BS / Architectural Engineering MS

*Major: Architectural Engineering*
*Degree Awarded: Bachelor of Science in Architectural Engineering (BSAE) and Masters of Science in Architectural Engineering (MSAE)*
*Calendar Type: Quarter*
*Total Credit Hours: 226.0*
*Co-op Options: Three Co-op (Five years)*
*Classification of Instructional Programs (CIP) code: 14.0401*
*Standard Occupational Classification (SOC) code: 17-2199*

## About the Program

The Architectural Engineering BS/MS allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies, a natural

progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

## Admission Requirements

Students must have a GPA of at least 3.2 and have taken coursework sufficient to demonstrate a readiness to take graduate coursework.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Requirements ** | | 12.0 |
| Free elective | | 3.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **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 |
| 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-AE | 3.0 |
| ARCH 192 | Studio 2-AE | 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 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| 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 |
| **Building Systems Concentration** | | |
| AE 430 | Control Systems for HVAC | 3.0 |
| CIVE 302 | Structural Analysis I | 4.0 |
| CIVE 303 | Structural Design I | 3.0 |
| MEM 345 | Heat Transfer | 4.0 |
| MEM 413 | HVAC Loads | 3.0 |
| MEM 414 | HVAC Equipment | 3.0 |
| Professional Elective | | 3.0 |
| CMGT 361 | Contracts And Specifications I | |
| CMGT 362 | Contracts and Specifications II | |
| CMGT 363 | Estimating I | |
| 400+ level courses in AE, ACCT, ARCH, BLAW, BMES, BUSN, CHE, CIVE, CMGT, ECE, ECON, CS, EGMT, ENVE, ENVR, FIN, INFO, INTB, MATE, MEM, MIS, MKTG, OPM or SE | | |
| **MASTERS DEGREE COURSES** | | |
| AE 510 | Intelligent Buildings | 3.0 |
| AE 544 | Building Envelope Systems | 3.0 |
| AE 550 | Comfort Analysis and Indoor Air Quality | 3.0 |
| AE 551 | Building Energy Systems I | 3.0 |
| MEM 591 | Applied Engr Analy Methods I | 3.0 |
| MEM 592 | Applied Engr Analy Methods II | 3.0 |
| **Graduate Electives** | | |
| Must complete at least 9.0 credits in one of the two themes below: | | 9.0 |
| Building Energy Theme | | |
| AE 552 | Building Energy Systems II | |
| CHE 513 | Chemical Engineering Thermodynamics I | |
| CHE 525 | Transport Phenomena I | |
| MEM 611 | Conduction Heat Transfer | |
| MEM 612 | Convection Heat Transfer | |
| MEM 621 | Foundations of Fluid Mechanics | |
| Indoor Air Quality Theme | | |
| AE 561 | Airflow Simulation in Built Environment | |
| CHE 525 | Transport Phenomena I | |
| ENVE 560 | Fundamentals of Air Pollution Control | |
| ENVE 660 | Chemical Kinetics in Environmental Engineering | |
| ENVS 501 | Chemistry of the Environment | |
| MEM 621 | Foundations of Fluid Mechanics | |
| Additional electives from any courses beyond the 9.0 credit theme and any 500+ course in Math, Science or Engineering with Advisor approval. | | 18.0 |
| **Total Credits** | | **226.0** |

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of

writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

## 5 year, 3 co-op

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | COOP 101 or CIVC 101* | 1.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 or COOP 101* | 1.0 | ENGL 103 or 113 | 3.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| UNIV 101 | 1.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| | | PHYS 101 | 4.0 | (UG) General Education Requirement** | 3.0 | | |
| | **14.5** | | **19.5** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | ARCH 191 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGR 220 | 4.0 | CAEE 203 | 3.0 | | | | |
| ENGR 231 | 3.0 | CIVE 240 | 3.0 | | | | |
| MEM 202 | 3.0 | ENGR 210 | 3.0 | | | | |
| PHYS 201 | 4.0 | ENGR 232 | 3.0 | | | | |
| | | (UG) General Education Requirement** | 3.0 | | | | |
| | **17** | | **18** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 340 | 3.0 | AE 220 | 3.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 192 | 3.0 | CIVE 250 | 4.0 | (GR) Graduate Elective | 3.0 | | |
| CAEE 212 | 4.0 | CIVE 330 | 4.0 | | | | |
| CIVE 320 | 3.0 | (UG) General Education Requirement** | 2.0 | | | | |
| MEM 230 | 4.0 | MEM 592 | 3.0 | | | | |
| MEM 591 | 3.0 | (GR) Graduate Elective | 3.0 | | | | |
| | **20** | | **19.5** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CIVE 302 | 4.0 | CIVE 303 | 3.0 | (GR) Graduate Elective | 3.0 | | |
| MEM 345 | 4.0 | (UG) Free Elective | 3.0 | | | | |
| AE 550 | 3.0 | (UG) General Education Requirement** | 4.0 | | | | |
| (GR) Graduate Elective | 3.0 | AE 510 | 3.0 | | | | |
| | | (GR) Graduate Elective | 3.0 | | | | |
| | **18** | | **20** | | **3** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ARCH 141 | 3.0 | ARCH 142 | 3.0 | AE 430 | 3.0 |
| CAE 491 | 3.0 | CAE 492 | 3.0 | ARCH 143 | 3.0 |
| CAEE 361 | 3.0 | MEM 414 | 3.0 | BIO 141 | 4.5 |
| MEM 413 | 3.0 | (UG) Professiona Elective | 3.0 | CAE 493 | 3.0 |
| AE 544 | 3.0 | (GR) Graduate Electives | 6.0 | AE 551 | 3.0 |
| (GR) Graduate Elective | 3.0 | | | (GR) Graduate Elective | 3.0 |
| | **18** | | **18** | | **19.5** |

**Total Credits 226**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements

# Civil, Architectural and Environmental Engineering Faculty

Abieyuwa Aghayere, PhD *(University of Alberta)*. Professor. Structural design - concrete, steel and wood; structural failure analysis; retrofitting of existing structures; new structural systems and materials; engineering education.

Ivan Bartoli, PhD *(University of California, San Diego)*. Associate Professor. Non-destructive evaluation and structural health monitoring; dynamic identification, stress wave propagation modeling.

Robert Brehm, PhD *(Drexel University)*. Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

Shannon Capps, PhD *(Georgia Institute of Technology)*. Assistant Professor. Atmospheric chemistry; data assimilation; advanced sensitivity analysis; inverse modeling.

S.C. Jonathan Cheng, PhD *(West Virginia University)*. Associate Professor. Soil mechanics; geosynthetics; geotechnical engineering; probabilistic design; landfill containments; engineering education.

Eugenia Ellis, PhD, AIA *(Virginia Polytechnic Institute and State University)*. Professor. Natural and electric light sources and effects on biological rhythms and health outcomes; ecological strategies for smart, sustainable buildings of the nexus of health, energy and technology.

Yaghoob (Amir) Farnam, PhD *(Purdue University)*. Assistant Professor. Advanced and sustainable infrastructure materials; multifunctional, self-responsive and bioinspired construction materials; advanced multiscale manufacturing; characterization, and evaluation of construction materials; durability of cement-based materials.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute and State University)*. Professor. Geotechnical and geoenvironmental engineering; soil improvement; soil improvement; recycled materials in geotechnics.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Professor. Risk analysis of environmental and infrastructure systems; novel adsorbent materials; environmental standard setting; Bayesian statistical modeling; community outreach and environmental health.

Charles N. Haas, PhD *(University of Illinois-Urbana) L. D. Betz Chair Professor of Environmental Engineering and Department Head, Civil, Architectural and Environmental Engineering*. Water treatment; risk assessment; bioterrorism; environmental modeling and statistics; microbiology; environmental health.

Ahmad Hamid, PhD *(McMaster University)*. Professor. Engineered masonry; seismic behavior, design and retrofit of masonry structures; development of new materials and building systems.

Simi Hoque, PhD *(University of California - Berkeley)*. Associate Professor. Computational methods to reduce building energy and environmental impacts, urban metabolism, thermal comfort, climate resilience.

Y. Grace Hsuan, PhD *(Imperial College)*. Professor. Durability of polymeric construction materials; advanced construction materials; and performance of geosynthetics.

Joseph B. Hughes, PhD *(University of Iowa)*. Distinguished University Professor. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Architectural fluid mechanics; building automation and autonomy; implementation of natural and hybrid ventilation in buildings; airflow distribution in buildings; large-scale air movement in an urban built environment; building and urban informatics; data-enhanced sensing and control for optimal building operation and management; novel data gathering methods for building/urban problem solving; interdisciplinary research on occupant behaviors in the built environment.

Joseph P. Martin, PhD *(Colorado State University)*. Professor. Geotechnical and geoenvironmental engineering; hydrology; transportation; waste management.

James E. Mitchell, MArch *(University of Pennsylvania)*. Professor. Architectural engineering design; building systems; engineering education.

Franco Montalto, PhD *(Cornell University)*. Professor. Effects of built infrastructure on societal water needs, ecohydrologic patterns and processes, ecological restoration, green design, and water interventions.

Nariman Mostafavi, PhD *(University of Massachusetts - Amherst)*. Assistant Teaching Professor. Simulation tools for analyzing urban metabolism; environmentally responsive design; urban resilience; engineering economics; industrial ecology.

Joseph V. Mullin, PhD *(Pennsylvania State University) Associate Department Head*. Teaching Professor. Structural engineering; failure analysis; experimental stress analysis; construction materials; marine structures.

Mira S. Olson, PhD *(University of Virginia)*. Associate Professor. Peace engineering; source water quality protection and management; contaminant and bacterial fate and transport; community engagement.

Miguel A. Pando, PhD *(Virginia Polytechnic Institute and State University)*. Assistant Professor. Laboratory testing of geomaterials; geotechnical aspects of natural hazards; soil-structure-interaction; geotechnical engineering.

Michael Ryan, PhD *(Drexel University) Associate Department Head of Graduate Studies*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); dynamic engineering systems modeling; molecular microbial biology; phylogenetics; metagenomics; bioinformatics; environmental statistics; engineering economics; microbiology; potable and waste water quality; environmental management systems.

Christopher Sales, PhD *(University of California, Berkeley)*. Associate Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste; application of molecular biology, analytical chemistry and bioinformatic techniques to study environmental biological systems.

Yared Shifferaw, PhD *(Johns Hopkins University)*. Assistant Professor. Computational and experimental mechanics; structural stability; optimization; health monitoring and hazard mitigation; sustainable structures; emerging materials; thin-walled structures and metallic structures.

Kurt Sjoblom, PhD *(Massachusetts Institute of Technology)*. Assistant Professor. Laboratory testing of geomaterials, geotechnical engineering, foundation engineering.

Sabrina Spatari, PhD *(University of Toronto)*. Associate Professor. Industrial ecology; development and application of life cycle assessment (LCA) and material flow analysis (MFA) methods for guiding engineering and policy decisions; specific interest in biomass and bioenergy, biofuels, and urban infrastructure.

Robert Swan Associate Teaching Professor. Geotechnical and Geosynthetic Engineering; soil/geosynthetic interaction and performance; laboratory and field geotechnical/geosynthetic testing.

Michael Waring, PhD *(University of Texas-Austin) Associate Department Head for Undergraduate Programs; Director of Architectural Engineering Program*. Associate Professor. Indoor air quality and building sustainability; indoor particulate matter fate and transport; indoor chemistry and particle formation; secondary impacts of control technologies and strategies.

Jin Wen, PhD *(University of Iowa)*. Associate Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

Aspasia Zerva, PhD *(University of Illinois)*. Professor. Earthquake engineering; mechanics; seismology; structural reliability; system identification; advanced computational computational methods in structural analysis.

## Emeritus Faculty

Harry G. Harris, PhD *(Cornell University)*. Professor Emeritus. Structural models; dynamics of structures, plates and shells; industrialized building construction.

Richard Weggel, PhD *(University of Illinois) Samuel S. Baxter Professor Emeritus; Civil and Environmental Engineering*. Professor Emeritus. Coastal engineering; hydraulics engineering; hydrology.

Richard Woodring, PhD *(University of Illinois) Dean of Engineering Emeritus*. Professor Emeritus. Structural engineering, reinforced concrete.

# Architectural Engineering, Structural Concentration BSAE / Civil Engineering, Structural Track MS

*Major: Architectural Engineering and Civil Engineering*
*Degree Awarded: Bachelor of Science in Architectural Engineering (BSAE) and Master of Science in Civil Engineering (MSAE)*
*Calendar Type: Quarter*
*Total Credit Hours: 228.0*
*Co-op Options: Three Co-op (Five years)*
*Classification of Instructional Programs (CIP) code: 14.0401*
*Standard Occupational Classification (SOC) code: 17-2199*

## About the Program

The program Architectural Engineering/Civil Engineering BSMS program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies, a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

## Admission Requirements

Students must have a GPA of at least 3.2 and have taken coursework sufficient to demonstrate a readiness to take graduate coursework.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Requirements ** | | 12.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **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 |
| 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-AE | 3.0 |
| ARCH 192 | Studio 2-AE | 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 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| 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 |
| MEM 238 | Dynamics | 4.0 |
| **Structural Concentration** | | |
| CIVE 302 | Structural Analysis I | 4.0 |
| CIVE 303 | Structural Design I | 3.0 |
| CIVE 312 | Soil Mechanics I | 4.0 |
| CIVE 315 | Soil Mechanics II | 4.0 |
| CIVE 400 | First Principles of Structural Design | 3.0 |
| CIVE 401 | Structural Design II | 3.0 |
| CIVE 402 | Structural Design III | 3.0 |
| **MASTERS DEGREE COURSES** | | |
| AE 544 | Building Envelope Systems | 3.0 |
| CIVE 605 | Advanced Mechanics Of Material | 3.0 |
| CIVE 615 | Infrastructure Condition Evaluation | 3.0 |
| or ENVE 555 | Geographic Information Systems | |
| CIVE 701 | Structural Analysis I | 3.0 |
| CIVE 702 | Structural Analysis II | 3.0 |
| CIVE 703 | Structural Analysis III | 3.0 |

| | | |
|---|---|---|
| CIVE T880 | Special Topics in CIVE | 3.0 |
| ENVE 571 | Environmental Life Cycle Assessment | 3.0 |
| ENVE 727 | Risk Assessment | 3.0 |
| **Graduate Electives** | | **18.0** |
| CIVE 510 | Prestressed Concrete | |
| CIVE 520 | Advanced Concrete Technology | |
| CIVE 615 | Infrastructure Condition Evaluation | |
| CIVE 704 | Behavior and Stability of Structural Members I | |
| CIVE 705 | Behavior and Stability of Structural Members II | |
| CIVE 711 | Engineered Masonry I | |
| CIVE 714 | Behavior of Concrete Structures I | |
| ENVE 555 | Geographic Information Systems | |
| ENVE 727 | Risk Assessment | |
| ENVE 750 | Data-based Engineering Modeling | |
| MATH 520 | Numerical Analysis I | |
| MATH 521 | Numerical Analysis II | |
| MEM 591 | Applied Engr Analy Methods I | |
| MEM 592 | Applied Engr Analy Methods II | |
| MEM 660 | Theory of Elasticity I | |
| MEM 663 | Continuum Mechanics | |
| MEM 664 | Introduction to Plasticity | |
| MEM 681 | Finite Element Methods I | |
| MEM 682 | Finite Element Methods II | |
| Other courses as approved by department | | |
| **Total Credits** | | **228.0** |

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | COOP 101 or CIVC 101* | 1.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 or COOP 101* | 1.0 | ENGL 103 or 113 | 3.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| UNIV 101 | 1.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| | | PHYS 101 | 4.0 | | | | |
| | **14.5** | | **19.5** | | **15** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ARCH 141 | 3.0 | ARCH 191 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | ENVE 571 | 3.0 | | |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | | | | |
| MEM 202 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | MEM 238 | 4.0 | | | | |
| | **20** | | **19** | | **3** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 340 | 3.0 | AE 220 | 3.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 192 | 3.0 | CIVE 250 | 4.0 | (GR) Graduate Elective | 3.0 | | |
| CAEE 212 | 4.0 | CIVE 330 | 4.0 | | | | |
| CAEE 361 | 3.0 | (UG) General Education Requirement** | 1.0 | | | | |
| CIVE 320 | 3.0 | ENVE 727 | 3.0 | | | | |
| MEM 230 | 4.0 | (GR) Graduate Elective | 3.0 | | | | |
| | **20** | | **18.5** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CIVE 302 | 4.0 | ARCH 142 | 3.0 | (GR) Graduate Elective | 3.0 | | |
| CIVE 312 | 4.0 | CIVE 303 | 3.0 | | | | |
| CIVE 605 | 3.0 | CIVE 315 | 4.0 | | | | |
| CIVE 615 or ENVE 555 | 3.0 | (GR) Graduate Electives | 6.0 | | | | |
| | **18** | | **20** | | **3** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ARCH 143 | 3.0 | CAE 492 | 3.0 | BIO 141 | 4.5 |
| CAE 491 | 3.0 | CIVE 401 | 3.0 | CAE 493 | 3.0 |
| CIVE 400 | 3.0 | (UG) General Education Requirements | 6.0 | CIVE 402 | 3.0 |

| | | | | |
|---|---|---|---|---|
| (UG) General Education Requirement | 3.0 | CIVE 702 | 3.0 | (UG) General Education Requirement 2.0 |
| AE 544 | 3.0 | CIVE T880 | 3.0 | CIVE 703 3.0 |
| CIVE 701 | 3.0 | | | (GR) Graduate Elective 3.0 |
| | **18** | | **18** | **18.5** |

**Total Credits 228**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

## Civil, Architectural and Environmental Engineering Faculty

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Y. Grace Hsuan, PhD *(Imperial College)*. Professor. Durability of polymeric construction materials; advanced construction materials; and performance of geosynthetics.

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Miguel A. Pando, PhD *(Virginia Polytechnic Institute and State University)*. Assistant Professor. Laboratory testing of geomaterials; geotechnical aspects of natural hazards; soil-structure-interaction; geotechnical engineering.

Michael Ryan, PhD *(Drexel University) Associate Department Head of Graduate Studies*. Assistant Teaching Professor. Microbial Source

Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); dynamic engineering systems modeling; molecular microbial biology; phylogenetics; metagenomics; bioinformatics; environmental statistics; engineering economics; microbiology; potable and waste water quality; environmental management systems.

Christopher Sales, PhD *(University of California, Berkeley)*. Associate Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste; application of molecular biology, analytical chemistry and bioinformatic techniques to study environmental biological systems.

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Kurt Sjoblom, PhD *(Massachusetts Institute of Technology)*. Assistant Professor. Laboratory testing of geomaterials, geotechnical engineering, foundation engineering.

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Robert Swan Associate Teaching Professor. Geotechnical and Geosynthetic Engineering; soil/geosynthetic interaction and performance; laboratory and field geotechnical/geosynthetic testing.

Michael Waring, PhD *(University of Texas-Austin) Associate Department Head for Undergraduate Programs; Director of Architectural Engineering Program*. Associate Professor. Indoor air quality and building sustainability; indoor particulate matter fate and transport; indoor chemistry and particle formation; secondary impacts of control technologies and strategies.

Jin Wen, PhD *(University of Iowa)*. Associate Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

Aspasia Zerva, PhD *(University of Illinois)*. Professor. Earthquake engineering; mechanics; seismology; structural reliability; system identification; advanced computational computational methods in structural analysis.

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Richard Weggel, PhD *(University of Illinois) Samuel S. Baxter Professor Emeritus; Civil and Environmental Engineering*. Professor Emeritus. Coastal engineering; hydraulics engineering; hydrology.

Richard Woodring, PhD *(University of Illinois) Dean of Engineering Emeritus*. Professor Emeritus. Structural engineering, reinforced concrete.

# Chemical Engineering BSCHE / Chemical Engineering MSCHE

*Major: Chemical Engineering*
*Degree Awarded: Bachelor of Science in Chemical Engineering (BSCHE) and Master of Science in Chemical Engineering (MSCHE)*
*Calendar Type: Quarter*
*Total Credit Hours: 226.5*
*Co-op Options: Three Co-op (Five years)*
*Classification of Instructional Programs (CIP) code: 14.0701*
*Standard Occupational Classification (SOC) code: 17-2041*

## About the Program

The department of Chemical and Biological Engineering's Chemical Engineering curriculum progresses through sequences in the fundamental physical sciences, humanities, engineering sciences, and engineering design.

Chemical engineers are dedicated to designing devices and processes that convert input materials into more valuable products and often to designing those products themselves. Such end products include petrochemical derivatives, fine chemicals, pharmaceuticals, plastics, and other materials, integrated circuits, electrical energy, biologically derived fuels, and much more. Chemical engineering often begins with small laboratory scale processes that must be scaled up to production levels through carefully integrated design, optimization, economic, environmental and safety analyses.

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.

The BS/MS program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies—a natural progression.

## Program Educational Objectives

The Department of Chemical and Biological Engineering has four goals pertaining to student outcomes within a few years of graduation:

- Our graduates will succeed in careers requiring strong skills in engineering, science, creative problem-solving, communication, teamwork, and appropriate leadership.
- Our graduates will continue their professional development through lifelong learning involving group or self-study and on-the-job training.
- Our graduates will hold paramount the safety, health, and welfare of the public. They will conduct their work ethically and understand its global impact and sustainability.
- Our graduates will be thought leaders in their area of expertise who are prepared to contribute to research, development, and industrial innovation at the forefront of chemical engineering and related fields.

## Additional Information

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

## Admission Requirements

Students must have an overall cumulative GPA of at least 3.0 and have taken at least two CHE courses with a cumulative CHE GPA of at least 3.3.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Electives * | | 18.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 220 | Fundamentals of Materials | 4.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| MATH 201 | Linear Algebra | 4.0 |
| MATH 210 | Differential Equations | 4.0 |
| PHYS 101 | Fundamentals of Physics I | 4.0 |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| Biology Elective | | 3.0 |
| BIO 100 | Applied Cells, Genetics & Physiology | |
| BIO 101 | Applied Biological Diversity, Ecology & Evolution | |
| BIO 122 | Cells and Genetics | |
| BIO 141 | Essential Biology | |
| **Professional Requirements** | | |
| CHE 211 | Material and Energy Balances I | 4.0 |
| CHE 212 | Material and Energy Balances II | 4.0 |
| CHE 220 | Computational Methods in Chemical Engineering I | 3.0 |
| CHE 230 | Chemical Engineering Thermodynamics I | 4.0 |
| CHE 320 | Computational Methods in Chemical Engineering II | 3.0 |
| CHE 330 | Chemical Engineering Thermodynamics II | 4.0 |
| CHE 331 | Separation Processes | 3.0 |
| CHE 341 | Fluid Mechanics | 4.0 |
| CHE 342 | Heat Transfer | 4.0 |
| CHE 343 | Mass Transfer | 4.0 |
| CHE 350 | Statistics and Design of Experiments | 3.0 |
| CHE 351 [WI] | Chemical Engineering Laboratory I | 2.5 |
| CHE 352 [WI] | Chemical Engineering Laboratory II | 2.5 |
| CHE 362 | Chemical Kinetics and Reactor Design | 4.0 |
| CHE 371 | Engineering Economics and Professional Practice | 3.0 |
| CHE 372 | Integrated Case Studies in Chemical Engineering | 3.0 |
| CHE 453 [WI] | Chemical Engineering Laboratory III | 2.5 |
| CHE 464 | Process Dynamics and Control | 3.0 |
| CHE 466 | Chemical Process Safety | 3.0 |
| CHE 471 | Process Design I | 4.0 |
| CHE 472 [WI] | Process Design II | 3.0 |
| CHE 473 [WI] | Process Design III | 3.0 |
| 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 |
| Technical Electives ** | | 12.0 |
| **Master's Degree Courses** | | |
| Graduate Core Courses | | |
| CHE 513 | Chemical Engineering Thermodynamics I | 3.0 |
| CHE 502 | Mathematical Methods in Chemical Engineering | 3.0 |
| CHE 525 | Transport Phenomena I | 3.0 |
| CHE 543 | Kinetics & Catalysis I | 3.0 |
| CHE 554 | Process Systems Engineering | 3.0 |
| Graduate Technical Electives *** | | 15.0 |
| Graduate Thesis/Non-Thesis | | 9.0 |
| CHE 898 | Master's Thesis | |
| Graduate Major Technical Electives *** | | |
| Graduate Free Electives | | 6.0 |
| **Total Credits** | | **226.5** |

* General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

** 6.0 credits STEM >=300 level and 6.0 credits STEM OR BUSN >= 200 level

*** choose from:

- Any graduate course in College of Engineering >= 500 level
- Any graduate course in STEM disciplines >= 500 level
- Graduate courses in these disciplines, subject to advisor approval: AE, BIO, BMES, CAE, CHE (including CHE I799), CHEM, CIVE, CMGT, CS, DSCI, ECE, ECEC, ECET, ECEE, ECES, EET, EGMT, ENSS, ENTP, ENVP, ENVS, FDSC, GEO, MATE, MEM, PRMT, PROJ, REAL, SYSE, PENG, MATH, PHYS, SE

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

Co-op cycle for Chemical Engineering is only spring/summer.

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | ENGL 102 or 112 | 3.0 | VACATION | |
| CIVC 101 | 1.0 | COOP 101** | 1.0 | ENGR 113 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | (UG) General Education Elective* | 3.0 | | |
| UNIV 101 | 1.0 | | | | | | |
| (UG) General Education Elective* | 3.0 | | | | | | |
| | **18.5** | | **16.5** | | **17** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHE 211 | 4.0 | CHE 212 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 220 | 3.0 | CHE 230 | 4.0 | | | | |
| CHEM 241 | 4.0 | CHEM 242 | 4.0 | | | | |
| MATH 201 | 4.0 | MATH 210 | 4.0 | | | | |
| (UG) Biology Elective*** | 3.0 | | | | | | |
| | **18** | | **16** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHE 330 | 4.0 | CHE 320 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 341 | 4.0 | CHE 342 | 4.0 | (GR) Graduate Technical Elective† | 3.0 | | |
| CHE 350 | 3.0 | CHE 343 | 4.0 | | | | |
| CHEM 356 | 2.0 | ENGL 103 | 3.0 | | | | |
| ENGR 220 | 4.0 | (GR) Graduate Technical Elective† | 3.0 | | | | |
| (GR) Graduate Free Elective | 3.0 | | | | | | |
| | **20** | | **17** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHE 331 | 3.0 | CHE 351 | 2.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 362 | 4.0 | CHE 352 | 2.5 | (GR) Graduate Technical Elective† | 3.0 | (GR) Graduate Thesis/ Non-Thesis††† | 3.0 |
| CHEC 353 | 4.0 | CHE 371 | 3.0 | | | | |
| (UG) Education Elective* | 3.0 | CHE 372 | 3.0 | | | | |
| CHE 513 | 3.0 | (UG) Technical Elective†† | 3.0 | | | | |
| (GR) Graduate Technical Elective† | 3.0 | (GR) Graduate Technical Elective† | 3.0 | | | | |
| | | (GR) Graduate Free Elective | 3.0 | | | | |
| | **20** | | **20** | | **3** | | **3** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CHE 453 | 2.5 | CHE 472 | 3.0 | CHE 466 | 3.0 |
| CHE 464 | 3.0 | (UG) Technical Electives†† | 6.0 | CHE 473 | 3.0 |
| CHE 471 | 4.0 | (UG) General Education Elective* | 3.0 | (UG) Technical Elective†† | 3.0 |
| (UG) General Education Elective* | 3.0 | CHE 525 | 3.0 | (UG) General Education Elective* | 3.0 |
| CHE 502 | 3.0 | (GR) Graduate Thesis/ Non-Thesis††† | 3.0 | CHE 543 | 3.0 |
| (GR) Graduate Thesis/ Non-Thesis††† | 3.0 | | | CHE 554 | 3.0 |
| | **18.5** | | **18** | | **18** |

**Total Credits 226.5**

* General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

** COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

*** Select from BIO 100, BIO 101, BIO 122, or BIO 141

† Choose from:

- Any graduate course in College of Engineering >= 500 level
- Any graduate course in STEM disciplines >= 500 level
- Graduate courses in these disciplines, subject to advisor approval: AE, BIO, BMES, CAE, CHE (including CHE I799), CHEM, CIVE, CMGT, CS, DSCI, ECE, ECEC, ECET, ECEE, ECES, EET, EGMT, ENSS, ENTP, ENVP, ENVS, FDSC, GEO, MATE, MEM, PRMT, PROJ, REAL, SYSE, PENG, MATH, PHYS, SE

†† 6.0 credits STEM >=300 level and 6.0 credits STEM OR BUSN >= 200 level

††† 9.0 credits in one of:

- CHE 898 (thesis)
- CHE I799 (research)
- Graduate Major Technical Electives

## Chemical Engineering Faculty

Cameron F. Abrams, PhD *(University of California, Berkeley)*. Professor. Molecular simulations in biophysics and materials; receptors for insulin and growth factors; and HIV-1 envelope structure and function.

Nicolas Alvarez, PhD *(Carnegie Mellon University)*. Assistant Professor. Phototonic crystal defect chromatography; extensional rheology of polymer/polymer composites; surfactant/polymer transport to fluid and solid interfaces; aqueous lubrication; interfacial instabilities.

Jason Baxter, PhD *(University of California, Santa Barbara)*. Professor. Solar cells, semiconductor nanomaterials, ultrafast spectroscopy.

Richard A. Cairncross, PhD *(University of Minnesota)*. Associate Professor. Effects of microstructure on transport and properties of polymers; moisture transport and degradation on biodegradation on biodegradable polymers; production of biofuel.

Aaron Fafarman, PhD *(Stanford University)*. Associate Professor. Photovoltaic energy conversion; solution-based synthesis of semiconductor thin films; colloidal nanocrystals; electromodulation and photomodulation spectroscopy.

Vibha Kalra, PhD *(Cornell University)*. Associate Professor. Electrodes for energy storage and conversion; supercapacitors; Li-S batteries; fuel cells; flow batteries; electrospinning for nanofibers; molecular dynamics simulations; Nanotechnology, polymer nanocomposites.

Kenneth K.S. Lau, PhD *(Massachusetts Institute of Technology) Associate Department Head*. Professor. Surface science; nanotechnology; polymer thin films and coatings; chemical vapor deposition.

Raj Mutharasan, PhD *(Drexel University) Frank A, Fletcher Professor*. Biochemical engineering; cellular metabolism in bioreactors; biosensors.

Giuseppe R. Palmese, PhD *(University of Delaware)*. George B Francis Professor. Reacting polymer systems; nanostructured polymers; radiation processing of materials; composites and interfaces.

Joshua Snyder, PhD *(Johns Hopkins University)*. Assistant Professor. Electrocatalysis (energy conversion/storage); hetergeneous catalysis corrosion (dealloying nanoporous metals); interfacial electrochemical phenomena in nanostructured materials; colloidal synthesis.

Masoud Soroush, PhD *(University of Michigan)*. Professor. Process systems engineering; polymer engineering.

John H. Speidel, BSHE, MCHE *(University of Delaware; Illinois Institute of Technology)*. Teaching Professor. Chemical process safety; process design engineering.

Maureen Tang, PhD *(University of California, Berkeley)*. Assistant Professor. Batteries and fuel cells; nonaqueous electrochemistry; charge transport at interfaces.

Michael Walters, PhD *(Drexel University)*. Assistant Teaching Professor. Undergraduate laboratory.

Stephen P. Wrenn, PhD *(University of Delaware)*. Professor. Biomedical engineering; biological colloids; membrane phase behavior and cholesterol transport.

## Emeritus Faculty

Charles B. Weinberger, PhD *(University of Michigan)*. Professor Emeritus. Suspension rheology; fluid mechanics of multi-phase systems.

# Civil Engineering BSCIV / Civil Engineering MSCE

*Major: Civil Engineering*
*Degree Awarded: Bachelor of Science in Civil Engineering (BSCIV) and Master of Science in Civil Engineering (MSCE)*
*Calendar Type: Quarter*
*Total Credit Hours: 225.5*
*Co-op Options: Three Co-ops (Five years)*
*Classification of Instructional Programs (CIP) code: 14.0801*
*Standard Occupational Classification (SOC) code: 17-2051*

## About the Program

The Civil Engineering BSCIV / Civil Engineering MSCE program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies, a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

## Admission Requirements

Students must have a GPA of at least 3.2 and have taken coursework sufficient to demonstrate a readiness to take graduate coursework.

## Degree Requirements

### Geotechnical / Geosynthetic Graduate Track

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Electives [*] | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **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 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 302 | Structural Analysis I | 4.0 |
| CIVE 303 | Structural Design I | 3.0 |
| CIVE 312 | Soil Mechanics I | 4.0 |
| CIVE 315 | Soil Mechanics II | 4.0 |
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| CIVE 375 | Structural Material Behavior | 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 | Statics | 3.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| MEM 238 | Dynamics | 4.0 |
| **Professional Electives** | | **9.0** |
| AE course 400+ | | |
| CIVE course 400+ | | |
| ENVE course 400+ | | |
| CMGT 361 | Contracts And Specifications I | |
| CMGT 362 | Contracts and Specifications II | |
| CMGT 451 | Heavy Construction Principles & Practices | |
| CMGT 461 | Construction Project & Company Management | |
| CMGT 463 | Value Engineering | |
| CMGT 467 | Techniques of Project Control | |
| **Master's Degree Courses** | | |
| CIVE 605 | Advanced Mechanics Of Material | 3.0 |
| or ENVE 555 | Geographic Information Systems | |
| CIVE 615 | Infrastructure Condition Evaluation | 3.0 |
| or ENVE 555 | Geographic Information Systems | |
| CIVE 632 | Advanced Soil Mechanics | 3.0 |
| CIVE 650 | Geosynthetics I | 3.0 |
| CIVE 651 | Geosynthetics II | 3.0 |
| CIVE 730 | Experimental Soil Mechanics I | 3.0 |
| or CIVE 731 | Experimental Soil Mechanics II | |
| or CIVE 651 | Geosynthetics II | |
| ENVE 571 | Environmental Life Cycle Assessment | 3.0 |
| ENVE 727 | Risk Assessment | 3.0 |
| **Graduate technical Electives (choose from any not already counted for credit)** | | **21.0** |
| CIVE 530 | Geotechnical Engineering for Highways | |
| CIVE 615 | Infrastructure Condition Evaluation | |
| CIVE 635 | Slope Stability and Landslides | |
| CIVE 636 | Ground Modification | |
| CIVE 640 | Environmental Geotechnics | |
| CIVE 650 | Geosynthetics I | |
| CIVE 651 | Geosynthetics II | |
| CIVE 562 | Introduction to Groundwater Hydrology | |
| ENVE 555 | Geographic Information Systems | |
| ENVE 727 | Risk Assessment | |
| ENVE 750 | Data-based Engineering Modeling | |
| MATH 520 | Numerical Analysis I | |
| MATH 521 | Numerical Analysis II | |
| MEM 591 | Applied Engr Analy Methods I | |
| MEM 592 | Applied Engr Analy Methods II | |
| MEM 660 | Theory of Elasticity I | |
| MEM 663 | Continuum Mechanics | |
| MEM 664 | Introduction to Plasticity | |
| MEM 681 | Finite Element Methods I | |
| MEM 682 | Finite Element Methods II | |
| Other courses as approved by department | | |
| **Total Credits** | | **225.5** |

## Structural Graduate Track

| | | |
|---|---|---|
| **General Education / Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Electives [*] | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **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 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 302 | Structural Analysis I | 4.0 |
| CIVE 303 | Structural Design I | 3.0 |
| CIVE 312 | Soil Mechanics I | 4.0 |
| CIVE 315 | Soil Mechanics II | 4.0 |

| | | |
|---|---|---|
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| CIVE 375 | Structural Material Behavior | 3.0 |
| CIVE 400 | First Principles of Structural Design | 3.0 |
| CIVE 401 | Structural Design II | 3.0 |
| CIVE 402 | Structural Design III | 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 | Statics | 3.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| MEM 238 | Dynamics | 4.0 |
| **Master's Degree Courses** | | |
| ENVE 571 | Environmental Life Cycle Assessment | 3.0 |
| ENVE 727 | Risk Assessment | 3.0 |
| CIVE 605 | Advanced Mechanics Of Material | 3.0 |
| CIVE 615 | Infrastructure Condition Evaluation | 3.0 |
| or ENVE 555 | Geographic Information Systems | |
| CIVE 701 | Structural Analysis I | 3.0 |
| CIVE 702 | Structural Analysis II | 3.0 |
| CIVE T880 | Special Topics in CIVE | 3.0 |
| CIVE 703 | Structural Analysis III | 3.0 |
| **Graduate Technical Electives (choose from any not already counted for credit)** | | **21.0** |
| CIVE 510 | Prestressed Concrete | |
| CIVE 520 | Advanced Concrete Technology | |
| CIVE 615 | Infrastructure Condition Evaluation | |
| CIVE 704 | Behavior and Stability of Structural Members I | |
| CIVE 705 | Behavior and Stability of Structural Members II | |
| CIVE 711 | Engineered Masonry I | |
| CIVE 714 | Behavior of Concrete Structures I | |
| ENVE 555 | Geographic Information Systems | |
| ENVE 727 | Risk Assessment | |
| ENVE 750 | Data-based Engineering Modeling | |
| MATH 520 | Numerical Analysis I | |
| MATH 521 | Numerical Analysis II | |
| MEM 591 | Applied Engr Analy Methods I | |
| MEM 592 | Applied Engr Analy Methods II | |
| MEM 660 | Theory of Elasticity I | |
| MEM 663 | Continuum Mechanics | |
| MEM 664 | Introduction to Plasticity | |
| MEM 681 | Finite Element Methods I | |
| MEM 682 | Finite Element Methods II | |
| Other courses as approved by department | | |
| **Total Credits** | | **225.5** |

## Water Resources Graduate Track

| | | |
|---|---|---|
| **General Education / Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Electives * | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **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 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 302 | Structural Analysis I | 4.0 |
| CIVE 303 | Structural Design I | 3.0 |
| CIVE 312 | Soil Mechanics I | 4.0 |
| CIVE 315 | Soil Mechanics II | 4.0 |
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| CIVE 375 | Structural Material Behavior | 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 | Statics | 3.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| MEM 238 | Dynamics | 4.0 |
| **Professional Electives** | | **9.0** |
| AE course 400+ | | |
| CIVE course 400+ | | |
| ENVE cousre 400+ | | |
| CMGT 361 | Contracts And Specifications I | |
| CMGT 362 | Contracts and Specifications II | |
| CMGT 461 | Construction Project & Company Management | |
| CMGT 463 | Value Engineering | |
| CMGT 451 | Heavy Construction Principles & Practices | |
| CMGT 467 | Techniques of Project Control | |
| **Master's Degree Courses** | | |
| CIVE 565 | Urban Ecohydraulics | 3.0 |
| CIVE 567 | Watershed Analysis | 3.0 |
| or ENVE 681 | Analytical and Numerical Techniques in Hydrology | |
| CIVE 615 | Infrastructure Condition Evaluation | 3.0 |
| or ENVE 555 | Geographic Information Systems | |
| CIVE 664 | Open Channel Hydraulics | 3.0 |
| ENVE 571 | Environmental Life Cycle Assessment | 3.0 |
| ENVE 665 | Hazardous Waste & Groundwater Treatment | 3.0 |
| or CIVE 564 | Sustainable Water Resource Engineering | |
| ENVE 727 | Risk Assessment | 3.0 |

| | | |
|---|---|---|
| ENVS 501 | Chemistry of the Environment | 3.0 |
| **Graduate Technical Electives (choose from any not already taken for credit)** | | **21.0** |
| CIVE 562 | Introduction to Groundwater Hydrology | |
| CIVE 564 | Sustainable Water Resource Engineering | |
| CIVE 567 | Watershed Analysis | |
| CIVE 615 | Infrastructure Condition Evaluation | |
| ENVE 555 | Geographic Information Systems | |
| ENVE 660 | Chemical Kinetics in Environmental Engineering | |
| ENVE 661 | Env Engr Op-Chem & Phys | |
| ENVE 665 | Hazardous Waste & Groundwater Treatment | |
| ENVE 727 | Risk Assessment | |
| ENVE 750 | Data-based Engineering Modeling | |
| ENVE 865 | Benefit-Cost Analysis for Infrastructure | |
| Other courses as approved by department | | |
| **Total Credits** | | **225.5** |

* General Education Requirements

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Sample Plan of Study

## 5 year, 3 co-ops - Geotechnical / Geosynthetic Graduate Track

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 or COOP 101* | 1.0 | COOP 101 or CIVC 101* | 1.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| UNIV E101 | 1.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| | | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| | **14.5** | | **19.5** | | **19.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | COOP EXPERIENCE* | | COOP EXPERIENCE* | |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | | | | |
| MEM 202 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | (UG) General Education Elective** | 3.0 | | | | |
| | **17** | | **15** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 | 4.0 | CIVE 250 | 4.0 | COOP EXPERIENCE* | | COOP EXPERIENCE* | |
| CAEE 361 | 3.0 | CIVE 330 | 4.0 | ENVE 571 | 3.0 | | |
| CIVE 320 | 3.0 | MEM 238 | 4.0 | | | | |
| ENVE 300 | 3.0 | (GR) Graduate Technical Elective | 3.0 | | | | |
| MEM 230 | 4.0 | ENVE 727 | 3.0 | | | | |
| (GR) Graduate Technical Elective | 3.0 | | | | | | |
| | **20** | | **18** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CIVE 302 | 4.0 | CIVE 303 | 3.0 | COOP EXPERIENCE* | | COOP EXPERIENCE* | |
| CIVE 312 | 4.0 | CIVE 315 | 4.0 | (GR) Graduate Technical Elective | 3.0 | | |
| CIVE 430 | 3.0 | CIVE 375 | 3.0 | | | | |
| (UG) General Education Elective | 3.0 | (UG) General Education Elective | 3.0 | | | | |
| CIVE 605 | 3.0 | (UG) Professional Elective / (GR) Graduate Technical Elective | 3.0 | | | | |
| CIVE 615 or ENVE 555 | 3.0 | (GR) Graduate Technical Electives | 3.0 | | | | |
| | **20** | | **19** | | **3** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CAE 491 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| CIVE 477 | 2.0 | CIVE 478 | 1.0 | (UG) Professional Elective | 3.0 |
| (UG) Professional Elective | 3.0 | (UG) Professional Elective | 3.0 | (UG) General Education Electives | 6.0 |
| (UG) General Education Electives | 6.0 | (UG) Free Electives | 6.0 | (UG) Professiona Electives / (GR) Graduate Technical Electives | 6.0 |
| CIVE 632 | 3.0 | CIVE 651 | 3.0 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CIVE 650 | 3.0 | CIVE 730, 731, or 651 | 3.0 | | | | |
| | **20** | | **19** | | **18** | | |

**Total Credits 225.5**

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

## 5 year, 3 co-ops - Structural Graduate Track

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 or COOP 101* | 1.0 | COOP 101 or CIVC 101* | 1.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| UNIV E101 | 1.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| | | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| | **14.5** | | **19.5** | | **19.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | COOP EXPERIENCE** | | COOP EXPERIENCE** | |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | | | | |
| MEM 202 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | (UG) General Education Electives** | 6.0 | | | | |
| | **17** | | **18** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 | 4.0 | CIVE 250 | 4.0 | COOP EXPERIENCE* | | COOP EXPERIENCE* | |
| CAEE 361 | 3.0 | CIVE 330 | 4.0 | ENVE 571 | 3.0 | | |
| CIVE 320 | 3.0 | MEM 238 | 4.0 | | | | |
| ENVE 300 | 3.0 | ENVE 727 | 3.0 | | | | |
| MEM 230 | 4.0 | (GR) Graduate Technical Elective*** | 3.0 | | | | |
| (GR) Graduate Technical Elective*** | 3.0 | | | | | | |
| | **20** | | **18** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CIVE 302 | 4.0 | CIVE 303 | 3.0 | COOP EXPERIENCE* | | COOP EXPERIENCE* | |
| CIVE 312 | 4.0 | CIVE 315 | 4.0 | (GR) Graduate Technical Elective*** | 3.0 | | |
| CIVE 430 | 3.0 | CIVE 375 | 3.0 | | | | |
| (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 | | | | |
| CIVE 605 | 3.0 | (UG) Professional Elective / (GR) Graduate Technical Elective | 3.0 | | | | |
| CIVE 615 or ENVE 555 | 3.0 | (GR) Graduate Technical Elective*** | 3.0 | | | | |
| | **20** | | **19** | | **3** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CAE 491 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| CIVE 400 | 3.0 | CIVE 401 | 3.0 | CIVE 402 | 3.0 |
| CIVE 477 | 2.0 | CIVE 478 | 1.0 | (UG) General Education Electives** | 6.0 |
| (UG) General Education Elective** | 3.0 | (UG) Free Electives | 6.0 | (UG) Professiona Elective / (GR) Graduate Technical Elective*** | 3.0 |
| (UG) Professional Elective / (GR) Graduate Technical Elective*** | 3.0 | CIVE 702 | 3.0 | CIVE 703 | 3.0 |
| CIVE 701 | 3.0 | CIVE T880 | 3.0 | | |
| | **17** | | **19** | | **18** |

**Total Credits 225.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements

*** **Graduate Technical Electives:**

- CIVE 510, CIVE 520, CIVE 615, CIVE 704, CIVE 705, CIVE 711, CIVE 714
- ENVE 555, ENVE 727, ENVE 750
- MATH 520, MATH 521
- MEM 591, MEM 592, MEM 660, MEM 663, MEM 664, MEM 681, MEM 682
- Other courses approved by department

## 5 year, 3 co-ops - Water Resources Graduate Track

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 or COOP 101* | 1.0 | COOP 101 or CIVC 101* | 1.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| UNIV E101 | 1.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| | | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| | **14.5** | | **19.5** | | **19.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | COOP EXPERIENCE* | | COOP EXPERIENCE* | |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | | | | |
| MEM 202 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | (UG) General Education Elective** | 3.0 | | | | |
| | **17** | | **15** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 | 4.0 | CIVE 250 | 4.0 | COOP EXPERIENCE* | | COOP EXPERIENCE* | |
| CAEE 361 | 3.0 | CIVE 330 | 4.0 | ENVE 571 | 3.0 | | |
| CIVE 320 | 3.0 | MEM 238 | 4.0 | | | | |
| ENVE 300 | 3.0 | ENVE 727 | 3.0 | | | | |
| MEM 230 | 4.0 | (GR) Graduate Technical Elective*** | 3.0 | | | | |
| (GR) Graduate Technical Elective*** | 3.0 | | | | | | |
| | **20** | | **18** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CIVE 302 | 4.0 | CIVE 303 | 3.0 | COOP EXPERIENCE* | | COOP EXPERIENCE* | |
| CIVE 312 | 4.0 | CIVE 315 | 4.0 | (UG) Professiona Elective / (GR) Graduate Technical Elective*** | 3.0 | | |
| CIVE 430 | 3.0 | CIVE 375 | 3.0 | | | | |
| (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 | | | | |
| CIVE 615 or ENVE 555 | 3.0 | (UG) Professional Electives / (GR) Graduate Technical Electives*** | 6.0 | | | | |
| CIVE 664 | 3.0 | | | | | | |
| | **20** | | **19** | | **3** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CAE 491 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| CIVE 477 | 2.0 | CIVE 478 | 1.0 | (UG) General Education Electives* | 6.0 |
| (UG) General Education Electives*** | 6.0 | (UG) Free Electives | 6.0 | (UG) Professional Elective† | 3.0 |
| (UG) Professional Elective | 3.0 | (UG) Professional Elective | 3.0 | ENVE 665 or CIVE 564 | 3.0 |
| CIVE 567 or ENVE 681 | 3.0 | CIVE 565 | 3.0 | (GR) Graduate Technical Elective*** | 3.0 |
| ENVS 501 | 3.0 | (GR) Graduate Technical Elective*** | 3.0 | | |
| | **20** | | **19** | | **18** |

**Total Credits 225.5**

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements

*** **Graduate Technical Electives:**

- CIVE 562, CIVE 564, CIVE 567, CIVE 615
- ENVE 555, ENVE 660, ENVE 661, ENVE 665, ENVE 727, ENVE 750, ENVE 865
- Other courses approved by department

† **Professional Electives:**

- AE 400 and above (Special Topics on a case by case basis)
- CIVE 400 and above
- ENVE 400 and above
- CMGT 361, CMGT 362, CMGT 461, CMGT 463, CMGT 451, CMGT 467

## Civil, Architectural and Environmental Engineering Faculty

Abieyuwa Aghayere, PhD *(University of Alberta)*. Professor. Structural design - concrete, steel and wood; structural failure analysis; retrofitting of existing structures; new structural systems and materials; engineering education.

Ivan Bartoli, PhD *(University of California, San Diego)*. Associate Professor. Non-destructive evaluation and structural health monitoring; dynamic identification, stress wave propagation modeling.

Robert Brehm, PhD *(Drexel University)*. Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

Shannon Capps, PhD *(Georgia Institute of Technology)*. Assistant Professor. Atmospheric chemistry; data assimilation; advanced sensitivity analysis; inverse modeling.

S.C. Jonathan Cheng, PhD *(West Virginia University)*. Associate Professor. Soil mechanics; geosynthetics; geotechnical engineering; probabilistic design; landfill containments; engineering education.

Eugenia Ellis, PhD, AIA *(Virginia Polytechnic Institute and State University)*. Professor. Natural and electric light sources and effects on biological rhythms and health outcomes; ecological strategies for smart, sustainable buildings of the nexus of health, energy and technology.

Yaghoob (Amir) Farnam, PhD *(Purdue University)*. Assistant Professor. Advanced and sustainable infrastructure materials; multifunctional, self-responsive and bioinspired construction materials; advanced multiscale manufacturing; characterization, and evaluation of construction materials; durability of cement-based materials.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute and State University)*. Professor. Geotechnical and geoenvironmental engineering; soil improvement; soil improvement; recycled materials in geotechnics.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Professor. Risk analysis of environmental and infrastructure systems; novel adsorbent materials; environmental standard setting; Bayesian statistical modeling; community outreach and environmental health.

Charles N. Haas, PhD *(University of Illinois-Urbana) L. D. Betz Chair Professor of Environmental Engineering and Department Head, Civil, Architectural and Environmental Engineering*. Water treatment; risk assessment; bioterrorism; environmental modeling and statistics; microbiology; environmental health.

Ahmad Hamid, PhD *(McMaster University)*. Professor. Engineered masonry; seismic behavior, design and retrofit of masonry structures; development of new materials and building systems.

Simi Hoque, PhD *(University of California - Berkeley)*. Associate Professor. Computational methods to reduce building energy and environmental impacts, urban metabolism, thermal comfort, climate resilience.

Y. Grace Hsuan, PhD *(Imperial College)*. Professor. Durability of polymeric construction materials; advanced construction materials; and performance of geosynthetics.

Joseph B. Hughes, PhD *(University of Iowa)*. Distinguished University Professor. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Architectural fluid mechanics; building automation and autonomy; implementation of natural and hybrid ventilation in buildings; airflow distribution in buildings; large-scale air movement in an urban built environment; building and urban informatics; data-enhanced sensing and control for optimal building operation and management; novel data gathering methods for building/urban problem solving; interdisciplinary research on occupant behaviors in the built environment.

Joseph P. Martin, PhD *(Colorado State University)*. Professor. Geotechnical and geoenvironmental engineering; hydrology; transportation; waste management.

James E. Mitchell, MArch *(University of Pennsylvania)*. Professor. Architectural engineering design; building systems; engineering education.

Franco Montalto, PhD *(Cornell University)*. Professor. Effects of built infrastructure on societal water needs, ecohydrologic patterns and processes, ecological restoration, green design, and water interventions.

Nariman Mostafavi, PhD *(University of Massachusetts - Amherst)*. Assistant Teaching Professor. Simulation tools for analyzing urban metabolism; environmentally responsive design; urban resilience; engineering economics; industrial ecology.

Joseph V. Mullin, PhD *(Pennsylvania State University) Associate Department Head*. Teaching Professor. Structural engineering; failure analysis; experimental stress analysis; construction materials; marine structures.

Mira S. Olson, PhD *(University of Virginia)*. Associate Professor. Peace engineering; source water quality protection and management; contaminant and bacterial fate and transport; community engagement.

Miguel A. Pando, PhD *(Virginia Polytechnic Institute and State University)*. Assistant Professor. Laboratory testing of geomaterials; geotechnical aspects of natural hazards; soil-structure-interaction; geotechnical engineering.

Michael Ryan, PhD *(Drexel University) Associate Department Head of Graduate Studies*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); dynamic engineering systems modeling; molecular microbial biology; phylogenetics; metagenomics; bioinformatics; environmental statistics; engineering economics; microbiology; potable and waste water quality; environmental management systems.

Christopher Sales, PhD *(University of California, Berkeley)*. Associate Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste; application of molecular biology, analytical chemistry and bioinformatic techniques to study environmental biological systems.

Yared Shifferaw, PhD *(Johns Hopkins University)*. Assistant Professor. Computational and experimental mechanics; structural stability; optimization; health monitoring and hazard mitigation; sustainable structures; emerging materials; thin-walled structures and metallic structures.

Kurt Sjoblom, PhD *(Massachusetts Institute of Technology)*. Assistant Professor. Laboratory testing of geomaterials, geotechnical engineering, foundation engineering.

Sabrina Spatari, PhD *(University of Toronto)*. Associate Professor. Industrial ecology; development and application of life cycle assessment (LCA) and material flow analysis (MFA) methods for guiding engineering and policy decisions; specific interest in biomass and bioenergy, biofuels, and urban infrastructure.

Robert Swan Associate Teaching Professor. Geotechnical and Geosynthetic Engineering; soil/geosynthetic interaction and performance; laboratory and field geotechnical/geosynthetic testing.

Michael Waring, PhD *(University of Texas-Austin) Associate Department Head for Undergraduate Programs; Director of Architectural Engineering Program*. Associate Professor. Indoor air quality and building

sustainability; indoor particulate matter fate and transport; indoor chemistry and particle formation; secondary impacts of control technologies and strategies.

Jin Wen, PhD *(University of Iowa)*. Associate Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

Aspasia Zerva, PhD *(University of Illinois)*. Professor. Earthquake engineering; mechanics; seismology; structural reliability; system identification; advanced computational computational methods in structural analysis.

## Emeritus Faculty

Harry G. Harris, PhD *(Cornell University)*. Professor Emeritus. Structural models; dynamics of structures, plates and shells; industrialized building construction.

Richard Weggel, PhD *(University of Illinois) Samuel S. Baxter Professor Emeritus; Civil and Environmental Engineering*. Professor Emeritus. Coastal engineering; hydraulics engineering; hydrology.

Richard Woodring, PhD *(University of Illinois) Dean of Engineering Emeritus*. Professor Emeritus. Structural engineering, reinforced concrete.

# Civil Engineering BSCIV / Environmental Engineering MSENE

*Major: Civil Engineering and Environmental Engineering*
*Degree Awarded: Bachelor of Science in Civil Engineering (BSCIV) and Masters of Science in Environmental Engineering (MSENE)*
*Calendar Type: Quarter*
*Total Credit Hours: 225.5*
*Co-op Options: Three Co-ops (Five years)*
*Classification of Instructional Programs (CIP) code: 14.0801*
*Standard Occupational Classification (SOC) code: 17-2051*

## About the Program

The program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. Their undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies, a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved. The American Society of Civil Engineers publishes the Journal of Environmental Engineering, so these are recognized as kindred disciplines

## Admission Requirements

Students must have a GPA of at least 3.2 and have taken coursework sufficient to demonstrate a readiness to take graduate coursework.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Requirements ** | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 210 | Introduction to Thermodynamics | 3.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| ENGR 220 | Fundamentals of Materials | 4.0 |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| 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 |
| **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 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 302 | Structural Analysis I | 4.0 |
| CIVE 303 | Structural Design I | 3.0 |
| CIVE 312 | Soil Mechanics I | 4.0 |
| CIVE 315 | Soil Mechanics II | 4.0 |
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| CIVE 375 | Structural Material Behavior | 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 | Statics | 3.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| MEM 238 | Dynamics | 4.0 |
| Professional Electives *** | | 9.0 |
| **Master's Degree Courses** | | |
| ENVE 516 | Fundamentals of Environmental Biotechnology | 3.0 |
| ENVE 660 | Chemical Kinetics in Environmental Engineering | 3.0 |
| ENVE 727 | Risk Assessment | 3.0 |
| ENVS 501 | Chemistry of the Environment | 3.0 |
| **Graduate Policy Course** | | **3.0** |
| CIVE 564 | Sustainable Water Resource Engineering | |
| ECON 616 | Public Finance and Cost Benefit Analysis | |
| ENVE 865 | Benefit-Cost Analysis for Infrastructure | |
| PLCY 503 | Theory and Practice of Policy Analysis | |
| PLCY 504 | Methods of Policy Analysis | |

| | | |
|---|---|---|
| PBHL 560 | Overview of Issues in Global Health | |
| Graduate Electives † | | 30.0 |
| **Total Credits** | | **225.5** |

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (p. 5).

*** Professional Electives:

- AE 400-level and above (Special Topics on a case by case basis)
- CIVE 400-level and above
- ENVE 400-level and above
- CMGT 361, CMGT 362, CMGT 461, CMGT 463, CMGT 451, CMGT 467

† **Graduate Electives:**

One Specialization Track:

- Environmental Treatment Proc: ENVE 661, ENVE 546, ENVE 662, ENVE 665
- Human Risks: ENVE 727, AE 550 or PBHL 641, PBHL 640
- Water Resources: CIVE 664 or ENVE 681, CIVE 565, CIVE 567, CIVE 564
- Environmental Modeling: ENVE 555 or ENVE 571, ENVE 750, ENVE 681, one advanced MATH course (MEM 591, CHE 502 or MATE 535)
- Air Quality: AE 550, PBHL 640, ENVE 560

One Cognate Sequence:

- 4-course coherent sequence in addition to the specialization, either in environmental engineering, environmental science, or related STEM field. Advisor must approve of courses chosen.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 | 1.0 | COOP 101* | 1.0 | | |
| ENGR 113 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| UNIV 101 | 1.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| | | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| | **14.5** | | **19.5** | | **19.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ENGR 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 210 | 3.0 | | | | |
| MEM 202 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | (UG) General Education Elective** | 3.0 | | | | |
| | **17** | | **15** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 | 4.0 | CIVE 250 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CAEE 361 | 3.0 | CIVE 330 | 4.0 | (GR) Graduate Elective*** | 3.0 | | |
| CIVE 320 | 3.0 | MEM 238 | 4.0 | | | | |
| ENVE 300 | 3.0 | ENVE 727 | 3.0 | | | | |
| MEM 230 | 4.0 | (GR) Graduate Policy Course† | 3.0 | | | | |
| (GR) Graduate Elective*** | 3.0 | | | | | | |
| | **20** | | **18** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CIVE 302 | 4.0 | CIVE 303 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CIVE 312 | 4.0 | CIVE 315 | 4.0 | (GR) Graduate Elective*** | 3.0 | | |
| CIVE 430 | 3.0 | CIVE 375 | 3.0 | | | | |
| (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 | | | | |
| ENVE 516 | 3.0 | ENVE 660 | 3.0 | | | | |
| ENVS 501 | 3.0 | (GR) Graduate Elective*** | 3.0 | | | | |
| | **20** | | **19** | | **3** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CAE 491 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| CIVE 477 | 2.0 | CIVE 478 | 1.0 | (UG) Professiona Elective | 3.0 |
| (UG) Professional Elective | 3.0 | (UG) Professional Elective | 3.0 | (GR) General Education Elective** | 6.0 |
| (UG) General Education Electives*** | 6.0 | (UG) Free Electives | 6.0 | (GR) Graduate Elective / (UG) Professional Elective*** | 3.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| (GR) Graduate Elective / (UG) Professional Elective*** | 3.0 | (GR) Graduate Elective / (UG) Professional Elective*** | 3.0 | (GR) Graduate Elective*** | 3.0 | | |
| (GR) Graduate Elective*** | 3.0 | (GR) Graduate Elective*** | 3.0 | | | | |
| | **20** | | **19** | | **18** | | |

**Total Credits 225.5**

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** **Graduate Electives:**

One Specialization Track:

- Environmental Treatment Proc: ENVE 661, ENVE 546, ENVE 662, ENVE 665
- Human Risks: ENVE 727, AE 550 or PBHL 641, PBHL 640
- Water Resources: CIVE 664 or ENVE 681, CIVE 565, CIVE 567, CIVE 564
- Environmental Modeling: ENVE 555 or ENVE 571, ENVE 750, ENVE 681, one advanced MATH course (MEM 591, CHE 502 or MATE 535)
- Air Quality: AE 550, PBHL 640, ENVE 560

One Cognate Sequence:

- 4-course coherent sequence in addition to the specialization, either in environmental engineering, environmental science, or related STEM field. Advisor must approve of courses chosen.

† 1. CIVE 564, ECON 616, ENVE 865, PLCY 503, PLCY 504, PBHL 560

†† Professional Electives:

- AE 400-level and above (Special Topics on a case by case basis)
- CIVE 400-level and above
- ENVE 400-level and above
- CMGT 361, CMGT 362, CMGT 461, CMGT 463, CMGT 451, CMGT 467

# Computer Engineering BSCE / Computer Engineering MSCE

*Major: Computer Engineering*
*Degree Awarded: Bachelor of Science in Computer Engineering (BSCE) and Master of Science in Computer Engineering*
*Calendar Type: Quarter*
*Total Credit Hours: 226.5*
*Co-op Options: Three Co-ops (Five years)*
*Classification of Instructional Programs (CIP) code: 14.0901*
*Standard Occupational Classification (SOC) code: 15-1132; 15-1133; 15-1143; 17-2031*

## About the Program

The BS/MS in Computer Engineering is an accelerated degree program that gives academically qualified ECE students the opportunity to receive two diplomas (BS and MS) at the same time in five years, graduating in the same time to earn the bachelor's degree alone. Students can still enjoy the benefits and rewards of the Drexel Co-op experience while gaining research experience by working with research faculty. Typical salaries for students with MS degrees are about 25% higher than those with BS degrees. An additional benefit of pursuing the BS/MS at Drexel's College of Engineering is the possibility of receiving a BS degree in one discipline and a MS degree in the same or related discipline.

## Admission Requirements

Students must have a GPA of at least 3.30 and have taken 300/400-level coursework sufficient to demonstrate a readiness to take graduate coursework. Students are encouraged to review ECE course foundations to identify specific undergraduate courses needed to take the corresponding graduate course.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| COM Elective: ** | | 3.0 |
| COM 230 | Techniques of Speaking | |
| or COM 310 | Technical Communication | |
| General Education Electives ** | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CS 265 | Advanced Programming Tools and Techniques | 3.0 |
| CS 260 | Data Structures | 3.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| MATH 221 | Discrete Mathematics | 3.0 |
| MATH 291 | Complex and Vector Analysis for Engineers | 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 |
| Science Elective *** | | 3.0 |
| **Professional Requirements** | | |
| ECE 101 | Electrical and Computer Engineering in the Real World | 1.0 |
| ECE 105 | Programming for Engineers II | 3.0 |
| ECE 200 | Digital Logic Design | 4.0 |
| ECE 201 | Foundations of Electric Circuits I | 4.0 |
| ECE 301 | Foundations of Electric Circuits II | 4.0 |
| ECE 303 | ECE Laboratory | 3.0 |
| ECE 361 | Probability and Data Analytics for Engineers | 4.0 |
| ECE 491 [WI] | Senior Design Project I † | 3.0 |
| ECE 492 [WI] | Senior Design Project II † | 3.0 |
| ECE 493 | Senior Design Project III † | 3.0 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECEC 355 | Computer Organization & Architecture | 3.0 |

| | |
|---|---|
| ECES 301 Signals and Systems I | 4.0 |
| CE Core Elective †† | 3.0 |
| ECE Electives †† | 6.0 |
| 400+ ECE and/or ECEC Electives | 9.0 |
| Free Electives | 27.0 |
| **MASTERS DEGREE COURSES** | |
| Graduate CE Courses ††† | 21.0 |
| Graduate Electives ‡ | 15.0 |
| Grad General ECE Courses § | 9.0 |
| **Total Credits** | **226.5** |

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assined and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** Choose any BIO, PHYS or CHEM course

† Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 credit with an ECE elective course.

†† Courses to satisfy these electives will be identified by the ECE department.

††† 500+ level course in ECEC

‡ 500+ courses in the following areas: AE, BIO, BMES, CHE, CHEM, CIVE, CMGT, CS, ECE, ECEC, ECEE, ECEP, ECET, EGEO, EGMT, ENGR, ENVE, ET, MATE, MATH, MEM, OPR, PHYS, PROJ, PRMT, SYSE

§ 500+ level course in ECE, ECEC, ECEE, ECEP, ECES, and/or ECET

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 or COOP 101* | 1.0 | COOP 101 or CIVC 101* | 1.0 | VACATION | |
| ECE 101 | 1.0 | ECE 200 | 4.0 | ECE 105 | 3.0 | | |
| ENGL 101 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |
| UNIV 101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **16** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 201 | 4.0 | CS 265 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ECEC 201 | 3.0 | ECEC 204 | 3.0 | | | | |
| ENGL 103 or 113 | 3.0 | ENGR 232 | 3.0 | | | | |
| ENGR 231 | 3.0 | PHYS 201 | 4.0 | | | | |
| MATH 221 | 3.0 | (UG) Free Elective | 3.0 | | | | |
| (UG) Free Elective | 3.0 | Communications Elective** | 3.0 | | | | |
| | | COM 230 or 310 | | | | | |
| | **19** | | **19** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CS 260 | 3.0 | ECE 361 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ECE 301 | 4.0 | PHIL 315 | 3.0 | (GR) Graduate Elective*** | 3.0 | | |
| ECEC 355 | 3.0 | (UG) Science Elective† | 3.0 | | | | |
| ECES 301 | 4.0 | (UG) CE Core Elective†† | 3.0 | | | | |
| (UG) General Education Elective** | 3.0 | (UG) Free Elective | 3.0 | | | | |
| (GR) Graduate Elective*** | 3.0 | (GR) Graduate Elective*** | 3.0 | | | | |
| | **20** | | **19** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 303 | 3.0 | (UG) ECE Elective†† | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATH 291 | 4.0 | (UG) Free Electives | 6.0 | (GR) Graduate CE Course††† | 3.0 | (GR) Graduate Elective*** | 3.0 |
| (UG) ECE Elective†† | 3.0 | (UG) General Education Elective** | 3.0 | | | | |
| (UF) Free Elective | 3.0 | (GR) Graduate CE Courses††† | 6.0 | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| (GR) Graduate CE Courses††† | 6.0 | | | | | |
| | **19** | | **18** | | **3** | **3** |
| **Fifth Year** | | | | | | |
| **Fall** | **Credits** | **Winter** | **Credits** | **Spring** | **Credits** | |
| ECE 491‡ | 3.0 | ECE 492‡ | 3.0 | ECE 493‡ | 3.0 | |
| (UG) ECE Elective (400+ level)§ | 3.0 | (UG) ECE Elective (400+ level)§ | 3.0 | (UG) ECE Elective (400+ level)§ | 3.0 | |
| (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 | |
| (UG) Free Elective | 3.0 | (UG) Free Elective | 3.0 | (UG) Free Elective | 3.0 | |
| (GR) Graduate CE Course††† | 3.0 | (GR) Graduate CE Course††† | 3.0 | (GR) Graduate Elective*** | 3.0 | |
| (GR) Grad General ECE Course¶ | 3.0 | (GR) Grad General ECE Course¶ | 3.0 | (GR) Grad General ECE Course¶ | 3.0 | |
| | **18** | | **18** | | **18** | |
| **Total Credits 226.5** | | | | | | |

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** 500+ courses in the following areas: AE, BIO, BMES, CHE, CHEM, CIVE, CMGT, CS, ECE, ECEC, ECEE, ECEP, ECET, EGEO, EGMT, ENGR, ENVE, ET, MATE, MATH, MEM, OPR, PHYS, PROJ, PRMT, SYSE

† Any BIO, PHYS or CHEM course

†† Courses to satisfy these electives will be identified by the ECE department

††† 500+ level course in ECEC

‡ Students who choose the Master's Thesis instead of Senior Design must replace ECE 491-493 credits with an ECE elective course

§ 400 level courses in ECE and/or ECEC

¶ 500+ level course in ECEC, ECEE, ECEP, ECES, and/or ECET

## Computer Engineering Faculty

Tom Chmielewski, PhD *(Drexel University)*. Teaching Professor. Modeling and simulation of electro-mechanical systems; optimal, adaptive and non-linear control; DC motor control; system identification; kalman filters (smoothing algorithms, tracking); image processing; robot design; biometric technology and design of embedded systems for control applications utilizing MATLAB and SIMULINK

Fernand Cohen, PhD *(Brown University)*. Professor. Surface modeling; tissue characterization and modeling; face modeling; recognition and tracking.

Andrew Cohen, PhD *(Rensselaer Polytechnic Institute)*. Associate Professor. Image processing; multi-target tracking; statistical pattern recognition and machine learning; algorithmic information theory; 5-D visualization

Kapil Dandekar, PhD *(University of Texas-Austin) Director of the Drexel Wireless Systems Laboratory (DWSL); Associate Dean of Research, College of Engineering*. Professor. Cellular/mobile communications and wireless LAN; smart antenna/MIMO for wireless communications; applied computational electromagnetics; microwave antenna and receiver development; free space optical communication; ultrasonic communication; sensor networks for homeland security; ultrawideband communication.

Afshin Daryoush, ScD *(Drexel University)*. Professor. Digital and microwave photonics; nonlinear microwave circuits; RFIC; medical imaging.

Anup Das, PhD *(Universit of Singapore)*. Assistant Professor. Design of algorithms for neuromorphic computing, particularly using spiking neural networks, dataflow-based design of neuromorphic computing system, design of scalable computing system; hardware-software co-design and management, and thermal and power management of many-core embedded systems

Bruce A. Eisenstein, PhD *(University of Pennsylvania)*. Arthur J. Rowland Professor of Electrical and Computer Engineering. Pattern recognition; estimation; decision theory.

Adam K. Fontecchio, PhD *(Brown University) Director, Center for the Advancement of STEM Teaching and Learning Excellence (CASTLE)*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

Gary Friedman, PhD *(University of Maryland-College Park) Associate Department Head for Graduate Affairs*. Professor. Biological and biomedical applications of nanoscale magnetic systems.

Allon Guez, PhD *(University of Florida)*. Professor. Intelligent control systems; robotics, biomedical, automation and manufacturing; business systems engineering.

Peter R. Herczfeld, PhD *(University of Minnesota)*. Professor. Lightwave technology; microwaves; millimeter waves; fiberoptic and integrated optic devices.

Leonid Hrebien, PhD *(Drexel University)*. Professor. Tissue excitability; acceleration effects on physiology; bioinformatics.

Nagarajan Kandasamy, PhD *(University of Michigan) Associate Department Head for Undergraduate Affairs*. Associate Professor. Embedded systems, self-managing systems, reliable and fault-tolerant computing, distributed systems, computer architecture, and testing and verification of digital systems.

Youngmoo Kim, PhD *(MIT) Director, Expressive and Creative Interactive Technologies (ExCITe) Center*. Professor. Audio and music signal processing, voice analysis and synthesis, music information retrieval, machine learning.

Fei Lu, PhD *(University of Michigan)*. Assistant Professor. Power electronics; wireless power transfer technology for the high-power electric vehicles and the low-power electronic devices.

Karen Miu, PhD *(Cornell University)*. Professor. Power systems; distribution networks; distribution automation; optimization; system analysis.

Bahram Nabet, PhD *(University of Washington)*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Prawat Nagvajara, PhD *(Boston University)*. Associate Professor. System on a chip; embedded systems; power grid computation; testing of computer hardware; fault-tolerant computing; VLSI systems; error control coding.

Dagmar Niebur, PhD *(Swiss Federal Institute of Technology)*. Associate Professor. Intelligent systems; dynamical systems; power system monitoring and control.

Christopher Peters, PhD *(University of Michigan)*. Teaching Professor. Nuclear reactor design; ionizing radiation detection; nuclear forensics; power plant reliability and risk analysis; naval/marine power and propulsion; directed energy/high power microwaves; nonstationary signal processing; radar; electronic survivability/susceptibility to harsh environments; electronic warfare

Karkal Prabhu, PhD *(Harvard University)*. Teaching Professor. Computer engineering education; computer architecture; embedded systems

Gail L. Rosen, PhD *(Georgia Institute of Technology)*. Associate Professor. Signal processing, signal processing for biological analysis and modeling, bio-inspired designs, source localization and tracking.

Ioannis Savidis, PhD *(University of Rochester)*. Associate Professor. Analysis, modeling, and design methodologies for high performance digital and mixed-signal integrated circuits; Emerging integrated circuit technologies; Electrical and thermal modeling and characterization, signal and power integrity, and power and clock delivery for 3-D IC technologies

Kevin J. Scoles, PhD *(Dartmouth College) Associate Dean for Undergraduate Affairs*. Associate Professor. Microelectronics; electric vehicles; solar energy; biomedical electronics.

Harish Sethu, PhD *(Lehigh University)*. Associate Professor. Protocols, architectures and algorithms in computer networks; computer security; mobile ad hoc networks; large-scale complex adaptive networks and systems.

James Shackleford, PhD *(Drexel University)*. Associate Professor. Medical image processing, high performance computing, embedded systems, computer vision, machine learning

P. Mohana Shankar, PhD *(Indian Institute of Technology) Allen Rothwarf Professor of Electrical and Computer Engineering*. Professor. Wireless communications; biomedical ultrasonics; fiberoptic bio-sensors.

Matthew Stamm, PhD *(University of Maryland, College Park)*. Associate Professor. Information Security; multimedia forensics and anti-forensics; information verification; adversarial dynamics; signal processing

Baris Taskin, PhD *(University of Pittsburgh)*. Professor. Very large-scal integration (VLSI) systems, computer architecture, circuits and systems, electronic design automation (EDA), energy efficient computing.

John Walsh, PhD *(Cornell University)*. Associate Professor. Bounding the region of entropic vectors and its implications for the limits of communication networks, big data distributed storage systems, and graphical model based machine learning; efficient computation and analysis of rate regions for network coding and distributed storage; code construction, polyhedral computation, hierarchy, and symmetry

Steven Weber, PhD *(University of Texas-Austin) Department Head*. Professor. Mathematical modeling of computer and communication networks, specifically streaming multimedia and ad hoc networks.

Jaudelice de Oliveira, PhD *(Georgia Institute of Technology)*. Associate Professor. Software-defined networking; social and economic networks; network security; design and analysis of protocols, algorithms and architectures in computer networks, particularly solutions for the Internet of Things

## Emeritus Faculty

Suryadevara Basavaiah, PhD *(University of Pennsylvania)*. Professor Emeritus. Computer engineering; computer engineering education; custom circuit design; VLSI technology; process and silicon fabrication

Eli Fromm, PhD *(Jefferson Medical College)*. Professor Emeritus. Engineering education; academic research policy; bioinstrumentation; physiologic systems.

Edwin L. Gerber, PhD *(University of Pennsylvania)*. Professor Emeritus. Computerized instruments and measurements; undergraduate engineering education.

# Computer Engineering BS / Project Management MS

*Major: Computer Engineering*
*Degree Awarded: Bachelor of Science in Computer Engineering (BSCE)*
*Calendar Type: Quarter*
*Total Credit Hours: 226.5*
*Co-op Options: Three Co-op (Five years); One Co-op (Four years)*
*Classification of Instructional Programs (CIP) code: 14.0901*
*Standard Occupational Classification (SOC) code: 15-1132; 15-1133; 15-1143; 17-2031*

## About the Program

Although most of the students in the Project Management are mid-level working professionals, many College of Engineering students have completed at least 1 co-op experience. This will give them sufficient professional background to make meaningful contributions to the courses in our program. The BSCE students students will get to interact with project management professionals who are currently in industry which will serve them well in future co-ops and when they enter the workplace.

## Admission Requirements

Students must have a cumulative GPA of at least 3.2; be classified as a 3rd year (pre-junior) student and have completed at least completed at least 1 co-op experience or have at least one year of professional experience. We will also require students to submit an essay discussing the following:

- Why they are pursuing a BS in Computer Engineering (BSCE) / MS in Project Management (MJPROJ)
- How they feel having a BSCE/MSPROJ will set them apart from their peers in future co-ops/career choice

## Degree Requirements

| General Education/Liberal Studies Requirements | | |
|---|---|---|
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |

| | | |
|---|---|---|
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| COM Elective: ** | | 3.0 |
| COM 230 | Techniques of Speaking | |
| or COM 310 | Technical Communication | |
| General Education Electives ** | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CS 260 | Data Structures | 3.0 |
| CS 265 | Advanced Programming Tools and Techniques | 3.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| MATH 221 | Discrete Mathematics | 3.0 |
| MATH 291 | Complex and Vector Analysis for Engineers | 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 |
| Science Elective: Any BIO, PHYS or CHEM course | | 3.0 |
| **Professional Requirements** | | |
| ECE 101 | Electrical and Computer Engineering in the Real World | 1.0 |
| ECE 105 | Programming for Engineers II | 3.0 |
| ECE 200 | Digital Logic Design | 4.0 |
| ECE 201 | Foundations of Electric Circuits I | 4.0 |
| ECE 301 | Foundations of Electric Circuits II | 4.0 |
| ECE 303 | ECE Laboratory | 3.0 |
| ECE 361 | Probability and Data Analytics for Engineers | 4.0 |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 | Senior Design Project III | 3.0 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECEC 355 | Computer Organization & Architecture | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| CE Core Elective *** | | 3.0 |
| ECE Electives *** | | 6.0 |
| 400+ ECE and/or ECEC Electives | | 9.0 |
| Free Electives | | 27.0 |
| **MASTERS DEGREE COURSES** | | |
| PROJ 501 | Introduction to Project Management | 3.0 |
| PROJ 502 | Project Planning & Scheduling | 3.0 |
| PROJ 515 | Project Estimation & Cost Management | 3.0 |
| PROJ 510 | Project Quality Management | 3.0 |
| PROJ 520 | Project Risk Assessment & Management | 3.0 |
| PROJ 530 | Managing Multiple Projects | 3.0 |
| PROJ 540 | Project Procurement Management | 3.0 |
| PROJ 535 | International Project Management | 3.0 |
| PROJ 525 | E-Tools for Project Management | 3.0 |
| or PROJ 645 | Project Management Tools | |
| PROJ 601 | Project Leadership | 1.5 |
| PROJ 602 | Project Teamwork | 1.5 |
| PROJ 695 | Capstone Project in Project Management | 3.0 |
| Graduate Electives † | | 12.0 |
| **Total Credits** | | **226.5** |

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** Courses to satisfy these electives will be identified by the ECE department.

† Students should use electives to increase project management, creativity, communication, or leadership skills or to develop areas of specialization. Any appropriate graduate course offered in the University can serve as an elective if the student has sufficient background to take the course. In addition, the program will offer its own elective courses including special topics (PROJ T580; PROJ T680; or PROJ T780). Qualified students may also pursue independent study (PROJ I599; PROJ I699; or PROJ I799) for elective credit in special cases.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

| First Year | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Fall** | **Credits** | **Winter** | **Credits** | **Spring** | **Credits** | **Summer** | **Credits** |
| CHEM 101 | 3.5 | CIVC 101 or COOP 101* | 1.0 | COOP 101 or CIVC 101* | 1.0 | VACATION | |
| ECE 101 | 1.0 | ECE 200 | 4.0 | ECE 105 | 3.0 | | |
| ENGL 101 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| UNIV 101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **16** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 201 | 4.0 | CS 265 | 3.0 | COOP EXPERIENCE* | | COOP EXPERIENCE | |
| ECEC 201 | 3.0 | ECEC 204 | 3.0 | | | | |
| ENGL 103 or 113 | 3.0 | ENGR 232 | 3.0 | | | | |
| ENGR 231 | 3.0 | PHYS 201 | 4.0 | | | | |
| MATH 221 | 3.0 | (UG) Free Elective | 3.0 | | | | |
| (UG) Free Elective | 3.0 | Communications Elective** | 3.0 | | | | |
| | | COM 230 or 310 | | | | | |
| | **19** | | **19** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CS 260 | 3.0 | ECE 361 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ECE 301 | 4.0 | PHIL 315 | 3.0 | PROJ 515 | 3.0 | PROJ 510 | 3.0 |
| ECEC 355 | 3.0 | (UG) CE Core Elective*** | 3.0 | | | | |
| ECES 301 | 4.0 | (UG) Science Elective: Any BIO, PHYS or CHEM course | 3.0 | | | | |
| (UG) General Education Elective** | 3.0 | (UG) Free Elective | 3.0 | | | | |
| PROJ 501 | 3.0 | PROJ 502 | 3.0 | | | | |
| | **20** | | **19** | | **3** | | **3** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 303 | 3.0 | (UG) ECE Elective*** | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATH 291 | 4.0 | (UG) Free Elective | 6.0 | PROJ 535 | 3.0 | GR Graduate Elective† | 3.0 |
| ECE Elective[6] | 3.0 | (UG) General Education Elective** | 3.0 | | | | |
| (UG) Free Elective | 3.0 | PROJ 530 | 3.0 | | | | |
| PROJ 520 | 3.0 | PROJ 540 | 3.0 | | | | |
| (GR) Graduate Elective† | 3.0 | | | | | | |
| | **19** | | **18** | | **3** | | **3** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| (UG) ECE Elective (400+ level)†† | 3.0 | (UG) ECE Elective (400+ level)†† | 3.0 | (UG) ECE Elective (400+ level)†† | 3.0 |
| (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 |
| (UG) Free Elective | 3.0 | (UG) Free Elective | 3.0 | (UG) Elective | 3.0 |
| PROJ 525 or 645 | 3.0 | PROJ 602 | 1.5 | PROJ 695 | 3.0 |
| PROJ 601 | 1.5 | (GR) Graduate Elective† | 3.0 | (GR) Graduate Elective† | 3.0 |
| | **16.5** | | **16.5** | | **18** |

**Total Credits 226.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** Courses to satisfy these electives will be identified by the ECE department

† Students should use graduate electives to increase project management, creativity, communication, or leadership skills or to develop areas of specialization. Any appropriate graduate course offered in the University can serve as an elective if the student has sufficient background to take the course. In addition, the program will offer its own elective courses including special topics (PROJ T580; PROJ T680; or PROJ T780). Qualified students may also pursue independent study (PROJ I599; PROJ I699; or PROJ I799) for elective credit in special cases.

†† 400 level courses in ECE and/or ECEC

# Electrical Engineering BS / Electrical Engineering MS

*Major: Electrical Engineering*
*Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE) and Master of Science (MS)*
*Calendar Type: Quarter*
*Total Credit Hours: 226.5*
*Co-op Options: Three Co-ops (Five years)*
*Classification of Instructional Programs (CIP) code: 14.1001*
*Standard Occupational Classification (SOC) code: 17-2071*

## About the Program

The BS/MS in Electrical Engineering is an accelerated degree program that gives academically qualified ECE students the opportunity to receive two diplomas (BS and MS) at the same time in five years, graduating in the same time to earn the bachelor's degree alone. Students can still enjoy the benefits and rewards of the Drexel Co-op experience while gaining research experience by working with research faculty. Typical salaries for students with MS degrees are about 25% higher than those with BS degrees. An additional benefit of pursuing the BS/MS at Drexel's College of Engineering is the possibility of receiving a BS degree in one discipline and a MS degree in the same or related discipline.

## Admission Requirements

Students must have a GPA of at least 3.30 and have taken 300/400-level coursework sufficient to demonstrate a readiness to take graduate coursework. Students are encouraged to review ECE course

foundations to identify specific undergraduate courses needed to take the corresponding graduate course.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| Communications Elective ** | | 3.0 |
| COM 230 | Techniques of Speaking | |
| or COM 310 | Technical Communication | |
| General Education Electives ** | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| MATH 221 | Discrete Mathematics | 3.0 |
| MATH 291 | Complex and Vector Analysis for Engineers | 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 |
| Science Elective: Any BIO, PHYS or CHEM course | | 3.0 |
| **Professional Requirements** | | |
| ECE 101 | Electrical and Computer Engineering in the Real World | 1.0 |
| ECE 105 | Programming for Engineers II | 3.0 |
| ECE 200 | Digital Logic Design | 4.0 |
| ECE 201 | Foundations of Electric Circuits I | 4.0 |
| ECE 301 | Foundations of Electric Circuits II | 4.0 |
| ECE 303 | ECE Laboratory | 3.0 |
| ECE 361 | Probability and Data Analytics for Engineers | 4.0 |
| ECE 491 [WI] | Senior Design Project I *** | 3.0 |
| ECE 492 [WI] | Senior Design Project II *** | 3.0 |
| ECE 493 | Senior Design Project III *** | 3.0 |
| ECE 370 | Electronic Devices | 3.0 |
| ECE 371 | Foundations of Electromagnetics for Computing & Wireless Systems | 3.0 |
| ECE 380 | Fundamentals of Power and Energy | 3.0 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| EE Core Electives † | | 3.0 |
| ECE Electives † | | 6.0 |
| Free Electives | | 27.0 |
| ECE Electives (400 level or higher) †† | | 9.0 |
| **Master's Program Courses** | | |
| Graduate EE Courses ††† | | 21.0 |
| Graduate Elective Courses ‡ | | 12.0 |
| Graduate General ECE Courses § | | 12.0 |
| **Total Credits** | | **226.5** |

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration i determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 credits with ECE elective credits.

† Courses to satisfy these electives will be identified by the ECE Department

†† 400 level courses in ECE, ECEE, ECEP and/or ECES

††† 500+ level course in ECE ECEE, ECEP, ECES, and/or ECET

‡ 500+ courses in the following areas: AE, BIO, BMES, CHE, CHEM, CIVE, CMGT, CS, ECE, ECEC, ECEE, ECEP, ECES, ECET, EGEO, EGMT, ENGR, ENVE, ET, MATE, MATH, MEM, OPR, PHYS, PROJ, PRMT, SYSE

§ 500+ level course in ECE, ECEC, ECEE, ECEP, ECES, and/or ECET

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CIVC 101 or COOP 101 * | 1.0 | COOP 101 or CIVC 101 * | 1.0 | VACATION | |
| ECE 101 | 1.0 | ECE 200 | 4.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | MATH 122 | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | PHYS 101 | 4.0 | MATH 200 | 4.0 | | |

| | | | | | |
|---|---|---|---|---|---|
| UNIV E101 | 1.0 | | PHYS 102 | 4.0 | |
| | **15.5** | **16** | | **18** | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 201 | 4.0 | ECEC 204 | 3.0 | COOP EXPERIENCE* | | COOP EXPERIENCE | |
| ECEC 201 | 3.0 | ENGR 232 | 3.0 | | | | |
| ENGL 103 | 3.0 | PHIL 315 | 3.0 | | | | |
| ENGR 231 | 3.0 | PHYS 201 | 4.0 | | | | |
| MATH 291 | 4.0 | (UG) Free Elective | 3.0 | | | | |
| (UG) Free Elective | 3.0 | Communications Elective** COM 230 or 310 | 3.0 | | | | |
| | **20** | | **19** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 301 | 4.0 | ECE 361 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ECE 370 | 3.0 | ECE 371 | 3.0 | (GR) Graduate Elective† | 3.0 | | |
| ECES 301 | 4.0 | ECE 380 | 3.0 | | | | |
| (UG) EE Core Elective*** | 3.0 | (UG) Science Elective: Any BIO, PHYS or CHEM course | 3.0 | | | | |
| (UG) General Education Elective** | 3.0 | (UG) Free Elective | 3.0 | | | | |
| (GR) Graduate Elective† | 3.0 | (GR) Graduate Elective† | 3.0 | | | | |
| | **20** | | **19** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 303 | 3.0 | (UG) ECE Elective*** | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATH 221 | 3.0 | (UG) Free Electives | 6.0 | (GR) Graduate EE Course†† | 3.0 | (GR) Graduate Elective† | 3.0 |
| (UG) ECE Elective*** | 3.0 | (UG) General Education Elective** | 3.0 | | | | |
| (UG) Free Elective | 3.0 | (GR) Graduate EE Courses†† | 6.0 | | | | |
| (GR) Graduate EE Courses†† | 6.0 | | | | | | |
| | **18** | | **18** | | **3** | | **3** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491††† | 3.0 | ECE 492††† | 3.0 | ECE 493††† | 3.0 |
| 400-level ECE Elective‡ | 3.0 | 400-level ECE Elective‡ | 3.0 | 400-Level ECE Elective‡ | 3.0 |
| (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 |
| (UG) Free Elective | 3.0 | (UG) Free Elective | 3.0 | (UG) Free Elective | 3.0 |
| (GR) Graduate EE Course†† | 3.0 | (GR) Graduate EE Course†† | 3.0 | (GR) Grad General ECE Courses§ | 6.0 |
| (GR) Grad General ECE Course§ | 3.0 | (GR) Grad General ECE Course§ | 3.0 | | |
| | **18** | **18** | | **18** | |

**Total Credits 226.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** Courses to satisfy these electives will be identified by the ECE Department

† 500+ courses in the following areas: AE, BIO, BMES, CHE, CHEM, CIVE, CMGT, CS, ECE, ECEC, ECEE, ECEP, ECES, ECET, EGEO, EGMT, ENGR, ENVE, ET, MATE, MATH, MEM, OPR, PHYS, PROJ, PRMT, SYSE

†† 500+ level course in ECEE, ECEP, ECES, and/or ECET

††† Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 credit with ECE elective credits.

‡ 400 level courses in ECE, ECEE, ECEP and/or ECES

§ 500+ level course in ECE, ECEC, ECEE, ECEP, ECES, and/or ECET

# Electrical Engineering Faculty

Tom Chmielewski, PhD *(Drexel University)*. Teaching Professor. Modeling and simulation of electro-mechanical systems; optimal, adaptive and non-linear control; DC motor control; system identification; kalman filters (smoothing algorithms, tracking); image processing; robot design; biometric technology and design of embedded systems for control applications utilizing MATLAB and SIMULINK

Fernand Cohen, PhD *(Brown University)*. Professor. Surface modeling; tissue characterization and modeling; face modeling; recognition and tracking.

Andrew Cohen, PhD *(Rensselaer Polytechnic Institute)*. Associate Professor. Image processing; multi-target tracking; statistical pattern recognition and machine learning; algorithmic information theory; 5-D visualization

Kapil Dandekar, PhD *(University of Texas-Austin) Director of the Drexel Wireless Systems Laboratory (DWSL); Associate Dean of Research, College of Engineering*. Professor. Cellular/mobile communications and wireless LAN; smart antenna/MIMO for wireless communications; applied computational electromagnetics; microwave antenna and receiver development; free space optical communication; ultrasonic communication; sensor networks for homeland security; ultrawideband communication.

Afshin Daryoush, ScD *(Drexel University)*. Professor. Digital and microwave photonics; nonlinear microwave circuits; RFIC; medical imaging.

Anup Das, PhD *(Universit of Singapore)*. Assistant Professor. Design of algorithms for neuromorphic computing, particularly using spiking neural networks, dataflow-based design of neuromorphic computing system, design of scalable computing system; hardware-software co-design and management, and thermal and power management of many-core embedded systems

Bruce A. Eisenstein, PhD *(University of Pennsylvania)*. Arthur J. Rowland Professor of Electrical and Computer Engineering. Pattern recognition; estimation; decision theory.

Adam K. Fontecchio, PhD *(Brown University) Director, Center for the Advancement of STEM Teaching and Learning Excellence (CASTLE)*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

Gary Friedman, PhD *(University of Maryland-College Park) Associate Department Head for Graduate Affairs*. Professor. Biological and biomedical applications of nanoscale magnetic systems.

Allon Guez, PhD *(University of Florida)*. Professor. Intelligent control systems; robotics, biomedical, automation and manufacturing; business systems engineering.

Leonid Hrebien, PhD *(Drexel University)*. Professor. Tissue excitability; acceleration effects on physiology; bioinformatics.

Nagarajan Kandasamy, PhD *(University of Michigan) Associate Department Head for Undergraduate Affairs*. Associate Professor. Embedded systems, self-managing systems, reliable and fault-tolerant computing, distributed systems, computer architecture, and testing and verification of digital systems.

Youngmoo Kim, PhD *(MIT) Director, Expressive and Creative Interactive Technologies (ExCITe) Center*. Professor. Audio and music signal processing, voice analysis and synthesis, music information retrieval, machine learning.

Fei Lu, PhD *(University of Michigan)*. Assistant Professor. Power electronics; wireless power transfer technology for the high-power electric vehicles and the low-power electronic devices.

Karen Miu, PhD *(Cornell University)*. Professor. Power systems; distribution networks; distribution automation; optimization; system analysis.

Bahram Nabet, PhD *(University of Washington)*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Prawat Nagvajara, PhD *(Boston University)*. Associate Professor. System on a chip; embedded systems; power grid computation; testing of computer hardware; fault-tolerant computing; VLSI systems; error control coding.

Dagmar Niebur, PhD *(Swiss Federal Institute of Technology)*. Associate Professor. Intelligent systems; dynamical systems; power system monitoring and control.

Christopher Peters, PhD *(University of Michigan)*. Teaching Professor. Nuclear reactor design; ionizing radiation detection; nuclear forensics; power plant reliability and risk analysis; naval/marine power and propulsion; directed energy/high power microwaves; nonstationary signal processing; radar; electronic survivability/susceptibility to harsh environments; electronic warfare

Gail L. Rosen, PhD *(Georgia Institute of Technology)*. Associate Professor. Signal processing, signal processing for biological analysis and modeling, bio-inspired designs, source localization and tracking.

Ioannis Savidis, PhD *(University of Rochester)*. Associate Professor. Analysis, modeling, and design methodologies for high performance digital and mixed-signal integrated circuits; Emerging integrated circuit technologies; Electrical and thermal modeling and characterization, signal and power integrity, and power and clock delivery for 3-D IC technologies

Kevin J. Scoles, PhD *(Dartmouth College) Associate Dean for Undergraduate Affairs*. Associate Professor. Microelectronics; electric vehicles; solar energy; biomedical electronics.

Harish Sethu, PhD *(Lehigh University)*. Associate Professor. Protocols, architectures and algorithms in computer networks; computer security; mobile ad hoc networks; large-scale complex adaptive networks and systems.

James Shackleford, PhD *(Drexel University)*. Associate Professor. Medical image processing, high performance computing, embedded systems, computer vision, machine learning

P. Mohana Shankar, PhD *(Indian Institute of Technology) Allen Rothwarf Professor of Electrical and Computer Engineering*. Professor. Wireless communications; biomedical ultrasonics; fiberoptic bio-sensors.

Jonathan E. Spanier, PhD *(Columbia University) Department Head, Mechanical Engineering and Mechanics*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laser spectroscopy, including Raman scattering.

Matthew Stamm, PhD *(University of Maryland, College Park)*. Associate Professor. Information Security; multimedia forensics and anti-forensics; information verification; adversarial dynamics; signal processing

Baris Taskin, PhD *(University of Pittsburgh)*. Professor. Very large-scal integration (VLSI) systems, computer architecture, circuits and systems, electronic design automation (EDA), energy efficient computing.

John Walsh, PhD *(Cornell University)*. Associate Professor. Bounding the region of entropic vectors and its implications for the limits of communication networks, big data distributed storage systems, and graphical model based machine learning; efficient computation and analysis of rate regions for network coding and distributed storage; code construction, polyhedral computation, hierarchy, and symmetry

Steven Weber, PhD *(University of Texas-Austin) Department Head*. Professor. Mathematical modeling of computer and communication networks, specifically streaming multimedia and ad hoc networks.

Jaudelice de Oliveira, PhD *(Georgia Institute of Technology)*. Associate Professor. Software-defined networking; social and economic networks; network security; design and analysis of protocols, algorithms and architectures in computer networks, particularly solutions for the Internet of Things

## Emeritus Faculty

Eli Fromm, PhD *(Jefferson Medical College)*. Professor Emeritus. Engineering education; academic research policy; bioinstrumentation; physiologic systems.

Edwin L. Gerber, PhD *(University of Pennsylvania)*. Professor Emeritus. Computerized instruments and measurements; undergraduate engineering education.

# Environmental Engineering BS/MS

*Major: Environmental Engineering*
*Degree Awarded: Bachelor of Science in Environmental Engineering (BSENE); Master of Science (MS)*
*Calendar Type: Quarter*
*Total Credit Hours: 225.0*
*Co-op Options: Three Co-op (Five years)*
*Classification of Instructional Programs (CIP) code: 14.1401*
*Standard Occupational Classification (SOC) code: 17-2081*

## About the Program

The Environmental Engineering BS/MS program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies—a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

## Admission Requirements

Students must have a GPA of at least 3.2 and have taken coursework sufficient to demonstrate a readiness to take graduate coursework.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Requirements ** | | 15.0 |
| **Engineering Core Courses** | | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **Environmental Engineering Requirements** | | |
| BIO 220 | Essential Microbiology | 3.0 |
| CAEE 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles in Engineering | 4.0 |
| CHE 211 | Material and Energy Balances I | 4.0 |
| 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 230 | General Ecology | 3.0 |
| **Technical Electives *** ** | | **8.0** |
| **MASTERS DEGREE COURSES** | | |
| ENVE 516 | Fundamentals of Environmental Biotechnology | 3.0 |
| ENVE 727 | Risk Assessment | 3.0 |
| ENVE 660 | Chemical Kinetics in Environmental Engineering | 3.0 |
| ENVS 501 | Chemistry of the Environment | 3.0 |
| **Graduate Policy Course** | | **3.0** |
| CIVE 564 | Sustainable Water Resource Engineering | |
| ECON 616 | Public Finance and Cost Benefit Analysis | |
| ENVE 865 | Benefit-Cost Analysis for Infrastructure | |
| PLCY 503 | Theory and Practice of Policy Analysis | |
| PLCY 504 | Methods of Policy Analysis | |
| PBHL 560 | Overview of Issues in Global Health | |
| Graduate Electives [4] | | 30.0 |
| **Total Credits** | | **225.0** |

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
COOP 101 registration is determined by the co-op cycle assigned and may be scheduled in a different term. Select students may be eligible to take COOP 001 in place of COOP 101.

** General Education Requirements (p. 5).

*** **Technical Electives:**

- 300+ level MATH, PHYS, BIO, GEO, CHEM, CHEC, and ENVS (excluding MATH 310, MATH 311 and MATH 312)
- 300+ CoE courses including MEM 202 and CIVE 250 (excluding MEM 361, ECE 361)

† **Graduate Electives:**

One Specialization Track:

- Environmental Treatment Proc: ENVE 546 ENVE 661, ENVE 662, ENVE 665
- Human Risks: ENVE 727, AE 550 or PBHL 641, PBHL 640
- Water Resources: CIVE 664 or ENVE 681, CIVE 565, CIVE 567, CIVE 564
- Environmental Modeling: ENVE 555 or ENVE 571, ENVE 750, ENVE 681, one advanced MATH course (MEM 591, CHE 502 or MATE 535)
- Air Quality: AE 550, PBHL 640, ENVE 560

One Cognate Sequence:

- a 4-course coherent sequence in addition to the specialization, either in environmental engineering, environmental science, or related STEM field. Advisor must approve of courses chosen.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | COOP 101 or 101* | 1.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 or COOP 101* | 1.0 | ENGL 103 | 3.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| UNIV 101 | 1.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| | | PHYS 101 | 4.0 | | | | |
| | **14.5** | | **19.5** | | **15** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CIVE 240 | 3.0 | ENGR 210 | 3.0 | | | | |
| ENGR 220 | 4.0 | ENGR 232 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENVS 230 | 3.0 | | | | |
| PHYS 201 | 4.0 | PHIL 315 | 3.0 | | | | |
| (UG) General Education Requiremen | 3.0 | | | | | | |
| | **20** | | **15** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 | 4.0 | CHEM 241 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CAEE 361 | 3.0 | CIVE 330 | 4.0 | (GR) Graduate Elective | 3.0 | | |
| CHE 211 | 4.0 | CIVE 431 | 3.0 | | | | |
| CIVE 320 | 3.0 | ENVE 302 | 3.0 | | | | |
| ENVE 300 | 3.0 | ENVE 727 | 3.0 | | | | |
| (GR) Graduate Elective | 3.0 | (GR) Graduate Policy Course | 3.0 | | | | |
| | **20** | | **20** | | **3** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 230 | 4.0 | ENVE 410 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHEM 231 | 2.0 | (UG) General Education Requirements** | 9.0 | (GR) Graduate Elective | 3.0 | | |
| CHEM 242 | 4.0 | ENVE 660 | 3.0 | | | | |
| CIVE 430 | 3.0 | (GR) Graduate Elective | 3.0 | | | | |
| ENVE 516 | 3.0 | | | | | | |
| ENVS 501 | 3.0 | | | | | | |
| | **19** | | **18** | | **3** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| BIO 220 | 3.0 | ENVE 421 | 3.0 | ENVE 422 | 3.0 |
| ENVE 460 or 465 | 3.0 | ENVE 486 | 2.0 | ENVE 435 | 3.0 |
| ENVE 485 | 1.0 | ENVE 492 | 3.0 | ENVE 487 | 2.0 |
| ENVE 491 | 3.0 | (UG) Technical Elective | 4.0 | ENVE 493 | 3.0 |
| (UG) Technical Elective | 4.0 | (GR) Graduate Elective | 6.0 | (UG) General Education Requirement** | 3.0 |
| (GR) Graduate Elective | 6.0 | | | (GR) Graduate Electives | 6.0 |
| | **20** | | **18** | | **20** |

**Total Credits 225**

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

# Materials Science & Engineering BS / Materials Science & Engineering MS

*Major: Materials Science and Engineering*
*Degree Awarded: Bachelor of Science in Materials Science and Engineering (BSMSE) and Masters of Science in Materials Science and Engineering (MSMSE)*
*Calendar Type: Quarter*
*Total Credit Hours: 225.5*
*Co-op Options: Three Co-op (Five years)*
*Classification of Instructional Programs (CIP) code: 14.1801*
*Standard Occupational Classification (SOC) code: 17-2131*

## About the Program

The Materials Science and Engineering BS/MS program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. Their undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies, a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

## Admission Requirements

Students must have a cumulative GPA of at least 3.4 and have taken coursework sufficient to demonstrate a readiness to take graduate coursework.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| ECON 201 | Principles of Microeconomics | 4.0 |
| ECON 202 | Principles of Macroeconomics | 4.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Electives ** | | 12.0 |
| Specialization Track Courses *** | | 6.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 107 | Cells, Genetics & Physiology | 3.0 |
| BIO 108 | Cells, Genetics and Physiology Laboratory | 1.0 |
| CHE 350 | Statistics and Design of Experiments | 3.0 |
| CHEC 353 | Physical Chemistry and Applications III | 4.0 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| CHEM 241 | Organic Chemistry I | 4.0 |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| 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 |
| 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 |
| **Professional Requirements** | | |
| MATE 214 | Introduction to Polymers | 4.0 |
| MATE 230 | Fundamentals of Materials II | 4.0 |
| 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 † | 3.0 |
| MATE 493 [WI] | Senior Project Design III † | 3.0 |
| **Master's Courses** | | |
| MATE 510 | Thermodynamics of Solids | 3.0 |
| MATE 512 | Introduction to Solid State Materials | 3.0 |
| MATE 897 | Research | 6.0 |
| MATE 898 [WI] | Master's Thesis | 9.0 |
| Graduate Selected Core Courses †† | | 12.0 |
| GR Graduate Optional Core Courses | | 9.0 |
| Graduate Technical Electives ¶ | | 3.0 |
| **Total Credits** | | **225.5** |

* Co-op Cycles for Materials Science & Engineering are only Spring/Summer

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** 6.0 credits of Undergraduate Specialization Track Courses are shared with Graduate Selected Core Courses.
Specialization tracks allow upper-class students to focus on a specific area of materials science and engineering. Combining foundational knowledge of materials with a tailored topic gives students a customized educational experience that has relevance for co-op, graduate school and future career opportunities. Students select a track in their third (pre-junior) year, with the option of choosing from five pre-determined tracks or creating their own path. The pre-determined tracks are:

- Advanced Materials Design and Processing
- Biomaterials
- Electronic and Photonic Materials
- Nanoscale Materials and Nanotechnology
- Soft Materials and Polymers

† MATE courses are required as part of the non-thesis option. For students taking the thesis option, MATE 491 [WI] , MATE 492, and MATE 493 [WI] are substituted by Undergraduate MSE Electives.

†† Any MATE 5xx or 6xx course excluding MATE 536 and MATE 504

¶ MATE 501, MATE 507, MATE 515, MATE 535, MATE 563, MATE 610, MATE 661
Any graduate level course in a STEM field (Engineering, Physical Sciences, or Computing/Data), excluding MATE 536 (1 credit seminar) and MATE 504 (Art of Being a Scientist).

# Sample Plan of Study

## 5 year, 3 co-op: Non-thesis option

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | COOP 101* | 1.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| (UG) General Education Elective** | 3.0 | | | (UG) General Education Elective** | 3.0 | | |
| | **17.5** | | **16.5** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| BIO 107 | 3.0 | CHEM 241 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| BIO 108 | 1.0 | ENGL 103 or 113 | 3.0 | | | | |
| ENGR 220 | 4.0 | ENGR 210 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | MATE 230 | 4.0 | | | | |
| (UG) Free Elective | 3.0 | | | | | | |
| | **18** | | **17** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECON 201 | 4.0 | ECON 202 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 214 | 4.0 | MATE 245 | 4.0 | (GR) Graduate Optional Core Course*** | 3.0 | (GR) Technical Elective††† | 3.0 |
| MATE 240 | 4.0 | MATE 315 | 4.5 | | | | |
| MATE 355 | 3.0 | MATE 341 | 3.0 | | | | |
| MATE 370 | 3.0 | (GR) Graduate Selected Core Course† | 3.0 | | | | |
| | **18** | | **18.5** | | **3** | | **3** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEC 353 | 4.0 | MATE 345 | 4.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 280 | 4.0 | MATE 351 | 4.0 | MATE 897 | 3.0 | MATE 897 | 3.0 |
| MATE 366 | 4.5 | PHIL 315 | 3.0 | | | | |
| MATE 455 | 3.0 | (UG) Track Elective†† | 3.0 | | | | |
| (GR) Graduate Optional Core Course*** | 3.0 | MATE 510 | 3.0 | | | | |
| | **18.5** | | **17.5** | | **3** | | **3** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CHE 350 | 3.0 | MATE 492 | 3.0 | MATE 410 | 3.0 |
| MATE 460 | 4.0 | (UG) Track Elective/ (GR) Selected Core Course | 3.0 | MATE 493 | 3.0 |
| MATE 491 | 2.0 | (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 3.0 |
| (UG) Track Elective/ (GR) Selected Core Course | 3.0 | (UG) Free Electives | 3.0 | (UG) Track Elective†† | 3.0 |
| (GR) Graduate Selected Core Course† | 3.0 | MATE 512 | 3.0 | (GR) Graduate Selected Core Course† | 3.0 |
| (GR) Technical Elective | 3.0 | (GR) Graduate Selected Core Course | 3.0 | (GR) Technical Elective | 3.0 |
| | **18** | | **18** | | **18** |

**Total Credits 225.5**

* Co-Op cycles for Materials Science & Engineering are only Spring/ Summer

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** Any MATE 5xx or 6xx course excluding MATE 536 and MATE 504

† Three of: MATE 501, MATE 507, MATE 515, MATE 535, MATE 563, MATE 610, or MATE 661

†† Specialization tracks allow upper-class students to focus on a specific area of materials science and engineering. Combining foundational knowledge of materials with a tailored topic gives students a customized educational experience that has relevance for co-op, graduate school and future career opportunities. Students select a track in their third (pre-junior) year, with the option of choosing from five pre-determined tracks or creating their own path. The pre-determined tracks are:

- Advanced Materials Design and Processing
- Biomaterials
- Electronic and Photonic Materials
- Nanoscale Materials and Nanotechnology
- Soft Materials and Polymers

††† Any graduate level course in a STEM field (engineering, physical sciences, or computing/data), excluding MATE 536 (1 credit seminar) and MATE 504 (Art of Being a Scientist)

## 5 year, 3 co-op: Thesis option

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | COOP 101* | 1.0 | VACATION | |
| ENGL 101 or 111 | 3.0 | CIVC 101 | 1.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| MATH 121 | 4.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| (UG) General Education Elective** | 3.0 | | | (UG) General Education Elective** | 3.0 | | |
| | **17.5** | | **16.5** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| BIO 107 | 3.0 | CHEM 241 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| BIO 108 | 1.0 | ENGL 103 | 3.0 | | | | |
| ENGR 220 | 4.0 | ENGR 210 | 3.0 | | | | |
| ENGR 231 | 3.0 | ENGR 232 | 3.0 | | | | |
| PHYS 201 | 4.0 | MATE 230 | 4.0 | | | | |
| (UG) Free Elective | 3.0 | | | | | | |
| | **18** | | **17** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECON 201 | 4.0 | ECON 202 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 214 | 4.0 | MATE 245 | 4.0 | (GR) Graduate Optional Core Course*** | 3.0 | (GR) Technical Elective††† | 3.0 |
| MATE 240 | 4.0 | MATE 315 | 4.5 | | | | |
| MATE 355 | 3.0 | MATE 341 | 3.0 | | | | |
| MATE 370 | 3.0 | (GR) Graduate Selected Core Course† | 3.0 | | | | |
| | **18** | | **18.5** | | **3** | | **3** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MATE 280 | 4.0 | MATE 345 | 4.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 366 | 4.5 | MATE 351 | 4.0 | MATE 897 | 3.0 | MATE 897 | 3.0 |
| MATE 455 | 3.0 | PHIL 315 | 3.0 | | | | |
| CHEC 353 | 4.0 | (UG) Track Elective†† | 3.0 | | | | |
| (GR) Graduate Optional Core Course*** | 3.0 | MATE 510 | 3.0 | | | | |
| | **18.5** | | **17.5** | | **3** | | **3** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CHE 350 | 3.0 | (UG) General Education Elective** | 3.0 | MATE 410 | 3.0 |
| MATE 460 | 4.0 | (UG) Free Elective | 3.0 | (UG) MSE Elective | 3.0 |
| (UG) MSE Elective | 2.0 | (UG) MSE Elective | 3.0 | (UG) General Education Elective** | 3.0 |
| (UG) Track Elective/ (GR) Selected Core Course | 3.0 | (UG) Track Elective/ (GR) Selected Core Course | 3.0 | (UG) Track Elective†† | 3.0 |
| MATE 898 | 3.0 | MATE 512 | 3.0 | MATE 898 | 3.0 |
| (GR) Graduate Selected Core Course† | 3.0 | MATE 898 | 3.0 | (GR) Graduate Selected Core Course† | 3.0 |
| | **18** | | **18** | | **18** |

**Total Credits 225.5**

* Co-Op cycles for Materials Science & Engineering are only Spring/Summer

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** Any MATE 5xx or 6xx course excluding MATE 536 and MATE 504

† Three of: MATE 501, MATE 507, MATE 515, MATE 535, MATE 563, MATE 610, or MATE 661

†† Specialization tracks allow upper-class students to focus on a specific area of materials science and engineering. Combining foundational knowledge of materials with a tailored topic gives students a customized educational experience that has relevance for co-op, graduate school and future career opportunities. Students select a track in their third (pre-junior) year, with the option of choosing from five pre-determined tracks or creating their own path. The pre-determined tracks are:

- Advanced Materials Design and Processing
- Biomaterials
- Electronic and Photonic Materials
- Nanoscale Materials and Nanotechnology
- Soft Materials and Polymers

††† Any graduate level course in a STEM field (engineering, physical sciences, or computing/data), excluding MATE 536 (1 credit seminar) and MATE 504 (Art of Being a Scientist)

## Materials Science and Engineering Faculty

Michel Barsoum, PhD *(Massachusetts Institute of Technology)*. Distinguished Professor. Processing and characterization of novel ceramics and ternary compounds, especially the MAX and 2-D MXene phases.

Hao Cheng, PhD *(Northwestern University)*. Associate Professor. Drug delivery, molecular self-assembly, cell-nanomaterial interactions, regenerative medicine and cell membrane engineering.

Yury Gogotsi, PhD *(Kiev Polytechnic Institute) Director, A. J. Drexel Nanotechnology Institute*. Distinguished University & Charles T. and Ruth M. Bach Professor. Nanomaterials; carbon nanotubes; nanodiamond; graphene; MXene; materials for energy storage, supercapacitors, and batteries.

Richard Knight, PhD *(Loughborough University) Associate Department Head and Undergraduate Advisor*. Teaching Professor. Thermal plasma technology; thermal spray coatings and education; plasma chemistry and synthesis.

Christopher Y. Li, PhD *(University of Akron)*. Professor. Soft and hybrid materials for optical, energy, and bio applications; polymeric materials, nanocomposites, structure and properties.

Andrew Magenau, PhD *(University of Southern Mississippi)*. Assistant Professor. Structurally complex materials exhibiting unique physical properties designed and fabricated using an assortment of methodologies involving directed self-assembly, externally applied stimuli, structure-function correlation, and applied engineering principles suited for technologies in regenerative medicine, biological interfacing, catalytic, electronic, and optical applications

Michele Marcolongo, PhD, PE *(University of Pennsylvania) Department Head, Materials Science and Engineering*. Professor. Orthopedic biomaterials; acellular regenerative medicine, biomimetic proteoglycans; hydrogels.

Steven May, PhD *(Northwestern University) Department Head*. Professor. Synthesis of complex oxide films, superlattices, and devices; materials for energy conversion and storage; magnetic and electronic materials; x-ray and neutron scattering.

Ekaterina Pomerantseva, PhD *(Moscow State University, Russia)*. Associate Professor. Solid state chemistry; electrochemical characterization, lithium-ion batteries, energy generation and storage; development and characterization of novel nanostructured materials, systems and architectures for batteries, supercapacitors and fuel cells.

Caroline L. Schauer, PhD *(SUNY Stony Brook) Associate Dean, Faculty Affairs College of Engineering*. Professor. Polysaccharide thin films and nanofibers.

Wei-Heng Shih, PhD *(Ohio State University)*. Professor. Colloidal ceramics and sol-gel processing; piezoelectric biosensors, optoelectronics, and energy harvesting devices; nanocrystalline quantum dots for bioimaging, lighting, and solar cells.

Jonathan E. Spanier, PhD *(Columbia University) Department Head, Mechanical Engineering and Mechanics*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laser spectroscopy, including Raman scattering.

Mitra Taheri, PhD *(Carnegie Mellon University) Hoeganeas Professor of Metallurgy*. Professor. Development of the ultrafast Dynamic Transmission Electron Microscope (DTEM) for the study of laser-induced microstructural evolution/phase transformations in nanostructured materials; use of various in-situ Transmission Electron Microscopy techniques.

Jörn Venderbos, PhD *(Leiden University)*. Assistant Professor. Theory of quantum materials: topological Insulators, topological semimetals, materials prediction and design, strongly correlated electron materials, complex electronic ordering phenomena, unconventional superconductors

Christopher Weyant, PhD *(Northwestern University)*. Teaching Professor. Engineering education

Antonios Zavaliangos, PhD *(Massachusetts Institute of Technology) A.W. Grosvenor Professor*. Professor. Constitutive modeling; powder compaction and sintering; pharmaceutical tableting, X-ray tomography.

## Emeritus Faculty

Roger D. Corneliussen, PhD *(University of Chicago)*. Professor Emeritus. Fracture, blends and alloys, as well as compounding.

Roger D. Doherty, PhD *(Oxford University)*. Professor Emeritus. Metallurgical processing; thermo-mechanical treatment.

Ihab L. Kamel, PhD *(University of Maryland)*. Professor Emeritus. Nanotechnology, polymers, composites, biomedical applications, and materials-induced changes through plasma and high energy radiation.

Jack Keverian, PhD *(Massachusetts Institute of Technology)*. Professor Emeritus. Rapid parts manufacturing, computer integrated manufacturing systems, strip production systems, technical and/or economic modeling, melting and casting systems, recycling systems.

# Mechanical Engineering & Mechanics BSME / MS

*Major: Mechanical Engineering & Mechanics*
*Degree Awarded: Bachelor of Science in Mechanical Engineering (BSME) & Master of Science in Mechanical Engineering (MSME)*
*Calendar Type: Quarter*
*Total Credit Hours: 225.5*
*Co-op Options: Three Co-ops (Five years)*
*Classification of Instructional Programs (CIP) code: 14.1901*
*Standard Occupational Classification (SOC) code: 17-2141*

## About the Program

The BSME/MSME program allows students to develop technical depth and breadth in their professional and related area which enhances their professional productivity, whether in industry or as they proceed to the PhD. Their undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies—a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

## Admission Requirements

Students must have a cumulative GPA of at least 3.3 and have taken coursework sufficient to demonstrate a readiness to take graduate coursework. Specifically, students must have earned a minimum 3.5 cumulative GPA in the following seven courses (or their equivalent): *Introduction to Thermodynamics* (ENGR 210), *Fundamentals of Materials* (ENGR 220), *Linear Algebra* (MATH 201), *Differential Equations* (MATH 210), *Foundations of Computer Aided Design* (MEM 201), *Statics* (MEM 202), and *Dynamics* (MEM 238).

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development * | 1.0 |
| ENGL 101 | Composition and Rhetoric I: Inquiry and Exploratory Research | 3.0 |
| or ENGL 111 | English Composition I | |
| ENGL 102 | Composition and Rhetoric II: Advanced Research and Evidence-Based Writing | 3.0 |
| or ENGL 112 | English Composition II | |
| ENGL 103 | Composition and Rhetoric III: Themes and Genres | 3.0 |
| or ENGL 113 | English Composition III | |
| HIST 285 | Technology in Historical Perspective | 4.0 |
| PHIL 315 | Engineering Ethics | 3.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| General Education Electives ** | | 12.0 |
| **Mathematics Requirements** | | |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| MATH 201 | Linear Algebra | 4.0 |
| MATH 210 | Differential Equations | 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** | | |
| BIO 141 | Essential Biology | 4.5 |
| CHEM 101 | General Chemistry I | 3.5 |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering Design Requirements** | | |
| ENGR 111 | Introduction to Engineering Design & Data Analysis | 3.0 |
| ENGR 113 | First-Year Engineering Design | 3.0 |
| ENGR 131 | Introductory Programming for Engineers | 3.0 |
| or ENGR 132 | Programming for Engineers | |
| **Engineering Requirements** | | |
| ENGR 210 | Introduction to Thermodynamics | 3.0 |
| **Engineering Economics Requirements** | | |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| **Materials Requirements** | | |
| ENGR 220 | Fundamentals of Materials | 4.0 |
| **Mechanical Requirements** | | |
| ECE 391 | Introduction to Engineering Design Methods | 1.0 |
| or MEM 391 | Introduction to Engineering Design Methods | |
| MEM 201 | Foundations of Computer Aided Design | 3.0 |
| MEM 202 | Statics | 3.0 |
| MEM 220 | Fluid Mechanics I | 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 *** | 2.0 |
| MEM 492 [WI] | Senior Design Project II *** | 3.0 |
| MEM 493 [WI] | Senior Design Project III *** | 3.0 |
| MEM Fundamental Courses. Select four of the following: | | 12.0 |
| 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 | Manufacturing Process I | |
| MEM 440 | Thermal Systems Design | |
| MEM 458 | Micro-Based Control Systems I | |
| MEM 459 | Control Applications of DSP Microprocessors | |
| MEM Open Electives (Any two MEM courses 300 level or higher.) | | 6.0 |
| Math/Science Electives (300+ level MATH, PHYS, BIO, CHEM, CHEC, and ENVS.) | | 6.0 |
| Free Electives | | 3.0 |
| **Electives or Optional Concentration †** | | |
| **Aerospace Concentration** | | |
| Select five courses from the list below: | | |
| MEM 320 | Fluid Dynamics I | |
| MEM 330 | Mechanics of Materials II | |
| MEM 373 | Space Systems Engineering I | |
| MEM 374 | Space Systems Engineering II | |
| MEM 403 | Gas Turbines & Jet Propulsion | |
| MEM 405 | Principles of Combustion I | |
| MEM 406 | Principles of Combustion II | |
| MEM 420 | Aerodynamics | |
| MEM 423 | Mechanics of Vibration | |
| MEM 425 | Aircraft Design & Performance | |
| MEM 426 | Aerospace Structures | |
| MEM 427 | Finite Element Methods | |
| MEM 428 | Introduction to Composites I | |
| MEM 429 | Introduction to Composites II | |
| MEM 451 | Orbital Mechanics | |
| MEM 453 | Aircraft Flight Dynamics & Control I | |
| MEM 454 | Aircarft Flight Dynamics & Control II | |
| MEM 455 | Introduction to Robotics | |
| MEM 459 | Control Applications of DSP Microprocessors | |
| **Energy Concentration** | | |
| Select five courses from the list below: | | |
| AE 430 | Control Systems for HVAC | |
| CHE 431 | Fundamentals of Solar Cells | |
| ECEP 354 | Energy Management Principles | |
| ECEP 371 | Introduction to Nuclear Engineering | |
| ECEP 380 | Introduction to Renewable Energy | |
| ECEP 402 | Theory of Nuclear Reactors | |
| ECEP 403 | Nuclear Power Plant Design & Operation | |
| ECEP 406 | Introduction to Radiation Health Principles | |
| ECEP 411 | Power Systems I | |
| ECEP 422 | Power Distribution Automation and Control | |
| ECEP 480 | Solar Energy Engineering | |
| MEM 320 | Fluid Dynamics I | |

| | | |
|---|---|---|
| MEM 330 | Mechanics of Materials II | |
| MEM 371 | Introduction to Nuclear Engineering I | |
| MEM 400 | Internal Combustion Engines | |
| MEM 402 | Power Plant Design | |
| MEM 403 | Gas Turbines & Jet Propulsion | |
| MEM 405 & MEM 406 | Principles of Combustion I and Principles of Combustion II | |
| MEM 410 | Thermodynamic Analysis II | |
| MEM 413 & MEM 414 | HVAC Loads and HVAC Equipment | |
| MEM 415 | Fuel Cell Engines | |
| MEM 445 | Solar Energy Fundamentals | |
| MEM 446 & MEM 447 | Fundamentals of Plasmas I and Fundamentals of Plasmas II | |
| MEM 448 | Applications of Thermal Plasmas | |
| MEM 449 | Applications of Non-Thermal Plasmas | |
| **Master's Degree Requirements** | | |
| Graduate Core Courses | | 12.0 |
| Select 2 courses in each of 2 Core Areas: | | |
| Core Area: Mechanics | | |
| Subject Area: Solid Mechanics | | |
| MEM 660 | Theory of Elasticity I | |
| MEM 663 | Continuum Mechanics | |
| Subject Area: Advanced Dynamics | | |
| MEM 666 | Advanced Dynamics I | |
| MEM 667 | Advanced Dynamics II | |
| Core Area: Thermal & Fluid Sciences | | |
| Subject Area: Advanced Thermodynamics | | |
| MEM 601 | Statistical Thermodynamics I | |
| MEM 602 | Statistical Thermodynamics II | |
| Subject Area: Heat Transfer | | |
| MEM 611 | Conduction Heat Transfer | |
| MEM 612 | Convection Heat Transfer | |
| MEM 613 | Radiation Heat Transfer | |
| Subject Area: Fluid Mechanics | | |
| MEM 621 | Foundations of Fluid Mechanics | |
| MEM 622 | Boundry Layers-Laminar & Turbulent | |
| Core Area: Systems & Control | | |
| Subject Area: Robust Control Systems | | |
| MEM 633 | Robust Control Systems I | |
| MEM 634 | Robust Control Systems II | |
| Subject Area: Non-linear Control Theory | | |
| MEM 636 | Theory of Nonlinear Control I | |
| MEM 637 | Theory of Nonlinear Control II | |
| Subject Area: R/T Microcomputer Control | | |
| MEM 639 | Real Time Microcomputer Control I | |
| MEM 640 | Real Time Microcomputer Control II | |
| Core Area: Design & Manufacturing | | |
| Subject Area: Manufacturing | | |
| MEM 617 | Introduction to Microfabrication | |
| MEM 687 | Manufacturing Processes I | |
| MEM 688 | Manufacturing Processes II | |
| Graduate Electives † | | 24.0 |
| Graduate Math Courses | | |
| MEM 591 | Applied Engr Analy Methods I | 3.0 |
| MEM 592 | Applied Engr Analy Methods II | 3.0 |
| MEM 593 | Applied Engr Analy Methods III | 3.0 |
| **Total Credits** | | **225.5** |

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Electives (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** If a student chooses to pursue a graduate thesis in place of senior design, they will need to replace the 8.0 undergraduate credits from MEM 491 [WI] , MEM 492 [WI] , MEM 493 [WI] with 8.0 credits from 400+ level MEM courses.

† **Graduate Electives**

- Students can take all 8 electives from MEM graduate courses.
- Any MEM graduate course is eligible to serve as electives. This includes those core courses that you do not use as core course but use as elective courses.
- This also includes MEM I699 *Independent Study and Research*, and MEM 898 *Master's Thesis*.
- If students do not want to take all 8 elective technical courses from MEM, they may take a maximum of 4 non-MEM courses.
- Each non- MEM course to be used as technical elective needs be approved by listing it on the Plan of Study (GR-1 form) and the Graduate Advisor signing the form to approve it.
- To ensure you will receive the MSME degree, please consult with the Graduate Advisor before taking non-MEM graduate courses.
- Graduate courses of 600 level from these 4 College of Engineering Departments (CAE, CBE, ECE and MSE) are automatically approved to serve as non-MEM technical elective courses.
- Students may register for MEM I699 *Independent Study and Research* (3.0 credits per term) to serve as electives, up to 9.0 credits.
- Students on the thesis-option typically register for MEM 898 *Master's Thesis* for 3 terms, and they count as 3 elective courses.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Sample Plan of Study

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101 | 3.5 | CHEM 102 | 4.5 | BIO 141 | 4.5 | VACATION | |
| ENGL 101 or 111 | 3.0 | COOP 101 or CIVC 101* | 1.0 | COOP 101 or CIVC 101* | 1.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| MATH 121 | 4.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| UNIV 101 | 1.0 | MATH 122 | 4.0 | MATH 200 | 4.0 | | |
| | | PHYS 101 | 4.0 | PHYS 102 | 4.0 | | |
| | **14.5** | | **19.5** | | **19.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ENGR 220 | 4.0 | ENGR 210 | 3.0 |
| | | | | MATH 201 | 4.0 | MATH 210 | 4.0 |
| | | | | MEM 202 | 3.0 | MEM 201 | 3.0 |
| | | | | PHYS 201 | 4.0 | MEM 238 | 4.0 |
| | | | | (UG) General Education Elective** | 3.0 | (UG) General Education Elective** | 4.0 |
| | **0** | | **0** | | **18** | | **18** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | MEM 230 | 4.0 | MEM 220 | 4.0 |
| | | | | MEM 310 | 4.0 | MEM 255 | 4.0 |
| | | | | PHIL 315 | 3.0 | MEM 331 | 2.0 |
| | | | | (UG) General Education Elective** | 3.0 | MEM 333 | 3.0 |
| | | | | (UG) CoE Elective/ (GR) Graduate Elective† | 3.0 | (UG) CoE Elective (GR) Graduate Elective† | 3.0 |
| | | | | (GR) Graduate Core Course | 3.0 | (GR) Graduate Core Course | 3.0 |
| | **0** | | **0** | | **20** | | **19** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | MEM 311 | 2.0 | ECE 391*** | 1.0 |
| | | | | MEM 345 | 4.0 | MEM 351 | 2.0 |
| | | | | MEM 355 | 4.0 | MEM 361 | 3.0 |
| | | | | MEM 435 | 4.0 | (UG) MEM Fundamental Electives | 6.0 |
| | | | | (GR) Graduate Core Course | 3.0 | (GR) Graduate Core Course | 3.0 |
| | | | | (GR) Graduate Elective† | 3.0 | (GR) Graduate Elective† | 3.0 |
| | **0** | | **0** | | **20** | | **18** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CIVE 240 | 3.0 | MEM 492*** | 3.0 | HIST 285 | 4.0 |
| MEM 491*** | 2.0 | (UG) General Education Elective** | 2.0 | MEM 493*** | 3.0 |
| (UG) Free Elective | 3.0 | (UG) Free Elective | 3.0 | (UG) MEM Open Elective†† | 3.0 |
| (UG) Math/ Science Elective†† | 3.0 | (UG) MEM Fundamental Elective†† | 3.0 | (UG) Math Science Elective/ (GR) Graduate Elective | 3.0 |
| (UG) MEM Fundamental Elective†† | 3.0 | (UG) MEM Open Elective†† | 3.0 | MEM 593 | 3.0 |
| MEM 591 | 3.0 | MEM 592 | 3.0 | (GR) Graduate Elective† | 3.0 |
| (GR) Graduate Elective† | 3.0 | (GR) Graduate Elective† | 3.0 | | |
| | **20** | | **20** | | **19** |

**Total Credits 225.5**

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/ winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** If a student chooses to pursue a graduate thesis in place of senior design, they will need to replace the eight (8.0) undergraduate credits from MEM 491 [WI] , MEM 492 [WI] , MEM 493 [WI] with eight (8.0) credits from 400+ level MEM courses.

† **Graduate Electives:**

- Students can take all 8 electives from MEM graduate courses.
- Any MEM graduate course is eligible to serve as electives. This includes those core courses that you do not use as core course but use as elective courses.
- This also includes MEM I699 *Independent Study and Research*, and MEM 898 *Master's Thesis*.
- If students do not want to take all 8 elective technical courses from MEM, they may take a maximum of 4 non-MEM courses.
- Each non-MEM course to be used as technical elective needs be approved by listing it on the Plan of Study (GR-1 form) and the Graduate Advisor signing the form to approve it.
- To ensure you will receive the MSME degree, please consult with the Graduate Advisor before taking non-MEM graduate courses.
- Graduate courses of 600 level from these 4 College of Engineering Departments (CAE, CBE, ECE and MSE) are automatically approved to serve as non-MEM technical elective courses.
- Students may register for MEM I699 *Independent Study and Research* (3.0 credits per term) to serve as electives, up to 9.0 credits.
- Students on the thesis-option typically register for MEM 898 *Master's Thesis* for 3 terms, and they count as 3 elective courses.

†† Consult your advisor for a list of courses that satisfy this requirement.

# Minor in Architectural Engineering

## About the Minor

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 25.5 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.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| AE 220 | Introduction to HVAC | 3.5 |
| AE 340 | Architectural Illumination and Electrical Systems * | 3.0 |
| AE 390 | Architectural Engineering Design I | 4.0 |
| CAEE 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CIVE 302 | Structural Analysis I | 4.0 |
| Select two of the following: | | 8.0 |
| AE 391 | Architectural Engineering Design II | |
| ARCH 191 | Studio 1-AE | |
| or ARCH 181 | Architecture Studio 1A | |
| CIVE 240 [WI] | Engineering Economic Analysis | |
| CIVE 250 | Construction Materials | |
| CIVE 303 | Structural Design I | |
| MEM 310 | Thermodynamic Analysis I | |
| MEM 413 | HVAC Loads | |
| **Total Credits** | | **25.5** |

* Students can elect to take ARCH 293 *Building Systems III* (1.5 credits) AND ARCH 396 *Building Systems IV* (1.5 credits) in place of ARCH 340.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Minor in Chemical Engineering

## About the Minor

Engineering students can obtain a minor in Chemical Engineering by taking 27.0 credits from the courses listed below.

## Admission Requirements

Pre-requisites for the 200-level minor core.

## Program Requirements

| | | |
|---|---|---|
| **Required Core Courses** | | |
| CHE 211 | Material and Energy Balances I | 4.0 |
| CHE 212 | Material and Energy Balances II | 4.0 |
| CHE 220 | Computational Methods in Chemical Engineering I | 3.0 |
| CHE 362 | Chemical Kinetics and Reactor Design | 4.0 |
| **Thermodynamics** | | |
| Complete one of the following * | | 4.0 |
| CHE 230 | Chemical Engineering Thermodynamics I | |
| or CHE 330 | Chemical Engineering Thermodynamics II | |
| **Transport** | | |
| Complete one of the following courses ** | | 4.0 |
| CHE 341 | Fluid Mechanics | |
| CHE 342 | Heat Transfer | |
| CHE 343 | Mass Transfer | |
| **Electives** | | |
| Choose from other CHE core courses, elective courses or research | | 4.0 |
| **Total Credits** | | **27.0** |

* CHE will not accept ENGR 210 towards the thermodynamics requirement

** Students who take an equivalent transport course as part of their core curriculum must take a different transport course (e.g., MEM cannot count CHE 341 towards the transport requirement)

# Minor in Computer Engineering

## About the Minor

The Computer Engineering minor provides students from other majors with the foundation needed to understand both the hardware and software aspects of computers. Our engineers contribute to industry and research areas such as electronic circuits and systems, computer architecture, computer networking, embedded systems, high-performance computing, software engineering, robotics and machine intelligence, computer security, medical devices, and many more.

## Prerequisites

The minor assumes that students will have a background in programming which would include ECE 105, ECE 203, or CS 171. Courses taken to meet these requirements will not count toward the minor.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| ECE 200 | Digital Logic Design | 4.0 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECEC 355 | Computer Organization & Architecture | 3.0 |
| ECEC 357 | Introduction to Computer Networks | 3.0 |

| | |
|---|---|
| **Electives** * | **9.0** |
| **Total Credits** | **25.0** |

* Students should choose an additional 9 credits from 300- and/or 400-level Computer Engineering (ECEC) courses. All prerequisites must be satisfied.

## Additional Information

More information about this minor is available on the ECE Department website (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/).

For advising questions, please contact the ECE advisor (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/resources/current-undergrad/).

# Minor in Construction Management

## About the Minor

Students in civil engineering, architectural engineering, architecture, and business may select to pursue Construction Management as a minor area of study. Because construction is inherently related to design in these disciplines, the Construction Management minor can be a natural extension of each field of study.

The requirements for the minor include:

- Completion of a minimum of 24.0 credits
- Courses used to fulfill general education requirements may not be counted toward an academic minor.
- Up to 9.0 credits earned within the student's major may be counted toward the minor with minor department approval.
- Prerequisite courses may be counted toward the minor if recommended by the minor department.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| CMGT 161 | Building Materials and Construction Methods I | 3.0 |
| CMGT 162 | Building Materials and Construction Methods II | 3.0 |
| CMGT 361 | Contracts And Specifications I | 3.0 |
| CMGT 362 | Contracts and Specifications II | 3.0 |
| CMGT 363 | Estimating I | 3.0 |
| CMGT 467 | Techniques of Project Control | 4.0 |
| Select two of the following: * | | 6.0 |
| CMGT 261 | Construction Safety | |
| CMGT 262 | Building Codes | |
| CMGT 263 | Understanding Construction Drawings | |
| CMGT 355 | Introduction to Sustainability in Construction | |
| CMGT 364 | Estimating II | |
| CMGT 385 [WI] | Selling and Negotiation Techniques in Construction | |
| CMGT 450 | Management of Field Operations | |
| CMGT 451 | Heavy Construction Principles & Practices | |
| CMGT 461 | Construction Project & Company Management | |
| CMGT 463 | Value Engineering | |
| CMGT 468 | Real Estate | |
| **Total Credits** | | **25.0** |

* Choice of electives must be approved by the department based on the student's major field and prior experience.

Certain courses within the student's major may also be used to meet the minor requirements. These include:

| | | |
|---|---|---|
| ARCH 221 | Materials & Methods I | 1.5 |
| ARCH 222 | Materials & Methods II | 1.5 |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| **Total Credits** | | **6.0** |

* ARCH 221 and ARCH 222 can be substituted for CMGT 161 for Architects. An elective may be substituted for CMGT 162.

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Minor in Electrical Engineering

## About the Minor

The minor provides students with the foundation needed to understand the diverse areas covered by the electrical engineering major. Our engineers contribute to industry and research in areas that include electronic circuits and systems, lasers and photonics, semiconductor devices, computer and communication networks, biomedical engineering, bioinformatics, robotics, automation and control, and power and energy systems.

## 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 include calculus (MATH 121 - MATH 122 and MATH 200), linear algebra, and differential equations. The physics requirements are PHYS 101 and PHYS 102. Courses taken to meet these requirements will not count toward the minor.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| ECE 200 | Digital Logic Design | 4.0 |

| | | |
|---|---|---|
| ECE 201 | Foundations of Electric Circuits I | 4.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| Electives * | | 12.0 |
| **Total Credits** | | **24.0** |

* Students should choose 12.0 credits from the 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

More information about this minor is available on the ECE Department website (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/).

For advising questions, please contact the ECE advisor. (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/resources/current-undergrad/)

# Minor in Engineering Leadership

## About the Minor

By completing a minor in Engineering Leadership, students will gain practice in self-reflection, mentorship, management, and communication. Students will customize their minor by choosing from one of four available tracks: entrepreneurship, leadership, management, and technology. A culminating project focused on solving engineering problems in the local community will connect students' technical knowledge with service to others.

## Admission Requirements

This program is currently open to students in engineering disciplines, which include programs from the College of Engineering, College of Computing and Informatics, School of Biomedical Engineering, and students in the Business & Engineering program in the LeBow College of Business.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| EGMT 404 [WI] | Introduction to Engineering Management Communications | 3.0 |
| EGMT 462 | Introduction to Engineering Management | 3.0 |
| EGMT 470 | Engineering Leadership Capstone | 2.0 |
| ORGB 320 | Leadership: Theory and Practice | 4.0 |
| **Elective Tracks: Students must choose one of the following elective tracks. Substitutions may be made in any of these tracks with prior approval from the Department.** | | **12.0** |
| Management Track | | |
| BLAW 201 | Business Law I | |
| CIVE 240 [WI] | Engineering Economic Analysis | |
| EGMT 465 | Introduction to Systems Engineering | |
| PROJ 401 | Introduction to Project Management | |
| Entrepreneurship Track | | |
| ENTP 210 [WI] | Leading Start-Ups * | |
| ENTP 215 | Building Entrepreneurial Teams * | |
| ENTP 329 | Entrepreneurship & New Technologies * | |
| ENTP 370 | Global Entrepreneurship * | |
| ENTP 385 | Innovation in Established Companies * | |
| Leadership Track | | |
| ORGB 300 [WI] | Organizational Behavior | |
| ORGB 400 | Team Development and Leadership | |
| ORGB 420 | Negotiations and Conflict Resolution | |
| PROJ 403 | Essentials of Project Leadership and Teamwork | |
| Technology Track | | |
| MGMT 201 | Introduction to Technology Innovation Management | |
| MGMT 301 | Designing Innovative Organizations | |
| MGMT 302 | Competing in Technology Industries | |
| MGMT 364 | Technology Management | |
| SYSE 488 | Systems Engineering Analysis | |
| Optional (these courses may be substituted for any of the above elective options) | | |
| EGMT 295 | Survey of Mentorship | |
| EGMT 296 | Survey of Leadership | |
| **Total Credits** | | **24.0** |

* ENTP 101 is a prerequisite for all ENTP courses, but it will not count towards the Minor in Engineering Leadership.

# Minor in Engineering Management

## About the Minor

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, students from other majors (biomedical engineering science, for example) with the equivalent science background 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.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| BLAW 201 | Business Law I | 4.0 |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| PROJ 401 | Introduction to Project Management | 3.0 |
| EGMT 404 [WI] | Introduction to Engineering Management Communications | 3.0 |
| EGMT 462 | Introduction to Engineering Management | 3.0 |
| or MEM 462 | Introduction to Engineering Management | |
| EGMT 465 | Introduction to Systems Engineering | 3.0 |
| **Complete 2 classes from the list below** | | **7.0** |
| ECON 201 | Principles of Microeconomics | |
| ECON 202 | Principles of Macroeconomics | |
| ENTP 329 | Entrepreneurship & New Technologies | |
| Other courses accepted with Director approval | | |
| **Total Credits** | | **26.0** |

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid "clustering" these courses near the end

of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Additional Information

More information is available on the Engineering Management Minor (https://drexel.edu/engineering/academics/departments/construction-engineering-project-management-systems-engineering/academic-programs/graduate/engineering-management/) web page.

# Minor in Engineering Policy Analysis

## About the 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 credentials relevant not only to engineering careers, but also to other fields, including urban planning, management consulting, and public administration.

The minor 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.

## Program Requirements

| | | |
|---|---|---|
| **Applied Quantitative Methods (6.0 credits minimum)** | | |
| 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 350 | 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 |
| | 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 |
| | ENSS 347 | Introduction to Environmental Policy Analysis |
| | PSCI 110 | American Government |
| | PSCI 220 | Constitutional Law I |
| | PSCI 372 | City in United States Political Development |
| | SOC 215 | Sociology of Work |
| | SOC 240 | Urban Sociology |
| **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** | | **24.0-26.0** |

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/

academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Minor in Engineering Product Development

## About the Minor

One of the final steps in creating a marketable product is the manufacturing of components. Throughout the design process, engineers must fully understand a variety of processes in which parts can be produced and assembled. Selecting a manufacturing method and ensuring the parts are capable of production is a difficult but critical part of the product design process.

The Minor in Engineering Product Development (EPD) will allow students to apply the theory of design for manufacturing (DFM) and design for assembly (DFA) to the overall design process. Topics include practical techniques for selection of materials and processes, design considerations for production, manual assembly and automated assembly, and Boothroyd and Dewhurst methods. Students review case studies and analyze production assemblies.

## Program Requirements

| | | |
|---|---|---|
| EET 208 | Introduction to Programming for Embedded Systems | 3.0 |
| MET 100 | Graphical Communication | 3.0 |
| MET 101 | Engineering Materials | 3.0 |
| MET 201 | Introduction to Manufacturing Processes | 3.0 |
| MET 316 | Computer Numerical Control | 3.0 |
| MET 321 | Changing World of 3D Printing and Rapid Prototyping | 3.0 |
| MET 322 | Design for Manufacturing and Assembly | 3.0 |
| PROD 101 | History and Analysis of Product Design | 3.0 |
| PROD 210 | Introduction to Product Design | 3.0 |
| **Total Credits** | | **27.0** |

## Additional Information

For more information on the Engineering Product Development minor, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

# Minor in Entertainment Engineering

## About the Minor

**Note: The Entertainment Engineering minor is not accepting new students until further notice. Please contact one of our advisors for additional information.**

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 prerequisite requirements will not count toward the minor.

## Program Requirements

| | | |
|---|---|---|
| **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 | |
| INFO 310 | Human-Centered Design Process & Methods | |
| Select one of the following: | | 3.0 |
| FMVD 110 | Basic Shooting and Lighting | |
| FMVD 115 | Basic Editing | |
| FMVD 120 | Basic Sound | |
| MIP 133 | Digital Audio Workstations I | |
| **Total Credits** | | **24.0** |

## Additional Information

Computer Engineering and Electrical Engineering majors must substitute ECES 301: *Systems and Signals I* for ECES 201.

More information about this minor is available on the ECE Department website (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/).

For advising questions, please contact the ECE advisor (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/resources/current-undergrad/).

# Minor in Environmental Engineering

## About the Minor

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 three additional courses 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.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| ENVE 300 | Introduction to Environmental Engineering | 3.0 |
| ENVE 302 | Environmental Transport and Kinetics | 3.0 |
| ENVS 401 | Chemistry of the Environment | 3.0 |
| Select three of the following: | | 8.0 |
| CIVE 430 | Hydrology | |
| 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 | |
| **Total Credits** | | **24.0** |

# Minor in Global Engineering

## About the Minor

Engineering is a critical component of our increasingly connected and complex global economy. Whether developing sanitation systems in Nigeria for Engineers Without Borders, or managing engineering projects for a multinational company, understanding how to get things done in an international context is critical for today's engineers.

The Minor in Global Engineering is designed for engineers who plan to use their technical expertise in an international context. The coursework prepares students to become global citizens who are skilled and adaptive in meeting the challenges of a global work environment. The minor develops students' historical, political, and cultural awareness at a global level. It also provides students with the necessary 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 (http://www.drexel.edu/studyabroad/) 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 (8.0) credits of 200-level or higher foreign language toward the credit requirements for the minor.

## Restrictions

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

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| ENGR 280 | Introduction to Global Engineering | 2.0 |
| EGMT 350 | Conflict Management for Engineers | 3.0 |
| EGMT 465 | Introduction to Systems Engineering | 3.0 |
| PROJ 401 | Introduction to Project Management | 3.0 |
| PROJ 435 | Essentials of International Project Management | 3.0 |
| Select three of the following (a minimum of one course from each of the three categories): | | 10.0 |
| **International Business** | | |
| BLAW 340 | International Business Law | |
| ECON 342 | Economic Development * | |
| EGMT T380 | Special Topics in EGMT | |
| INTB 200 | International Business | |
| INTB 332 | Multinational Corporations * | |
| INTB 334 | International Trade * | |
| INTB 336 | International Money and Finance * | |
| **Political Science/History** | | |
| HIST 259 | History of Europe in the 20th Century | |
| PSCI 140 | Comparative Politics I | |
| PSCI 150 | International Politics | |
| PSCI 351 | The United Nations in World Politics | |
| PSCI 352 | Ethics and International Relations | |
| PSCI 353 | International Human Rights | |
| PSCI 357 | The European Union in World Politics | |
| **Culture and Communications** | | |
| COM 360 | International Communication | |
| SOC 330 | Development and Underdevelopment in the Global South | |
| PHIL 335 | Global Ethical Issues ** | |
| WGST 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 Engineering Management Department Head 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.

# Minor in Green Energy and Sustainability

## About the Minor

This minor program aims to familiarize students with recent technological developments in renewable energy technologies and sustainability, as well as to conduct experimental work in these areas.

Students will explore the principles, characteristics, and operation of various renewable energy sources, storage devices, and energy conversion systems. In addition, this minor is designed to encourage students to enhance their knowledge of the fields of sustainability and green energy technologies so they may be able to expand their skills and career opportunities.

The Minor in Green Energy and Sustainability has a broad audience, created to give students both breadth and depth in this field with focus on technologies and their societal, economic, and environmental impact with emphasis on the manufacturing industry.

## Program Requirements

| | | |
|---|---|---|
| ECEP 480 | Solar Energy Engineering | 3.0 |
| EET 201 | Circuit Analysis I | 4.0 |
| EET 202 | Circuit Analysis II | 4.0 |

| | | |
|---|---|---|
| EET 320 | Renewable Energy Systems | 3.0 |
| EET 322 | Energy Conversion | 4.0 |
| INDE 240 | Technology Economics | 3.0 |
| INDE 420 | Industrial Energy Systems | 3.0 |
| **Total Credits** | | **24.0** |

## Additional Information

For more information on the Green Energy and Sustainability minor, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

# Minor in Materials Science and Engineering

## About the Minor

In addition to the core engineering curriculum and the courses required for majors in chemical, civil, architectural and environmental, electrical, or mechanical engineering, engineering students from other majors can obtain a minor in Materials Science and Engineering by completing 25.0 credits from the courses listed below.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| MATE 230 | Fundamentals of Materials II | 4.0 |
| 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** | | **25.0** |

* 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 MATH 201 or CHEM 241) can count toward the required 25.0 credits. In other words, both MATE 214 and MATE 370 can be used to fulfill the requirements for the minor, but only the prerequisite for one of those courses will be counted toward the 25.0 credits required for the minor. Similarly, neither MATH 201 nor CHEM 241 can 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, respectively. Substitution for these courses by 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 of the MSE department as prerequisites do not count towards the 25.0 credits required for the minor. They may, however, be used as technical or free electives in students' home departments.

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.

# Minor in Mechanical Engineering and Mechanics

## About the Minor

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

## Program Requirements

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 | Fluid Mechanics I | |
| 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 | Manufacturing 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 | Control Applications of DSP Microprocessors | |
| MEM 462 [WI] | Introduction to Engineering Management | |
| **Total Credits** | | **24.0** |

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic

advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Minor in Nuclear Engineering

## About the Minor

The field of nuclear engineering covers topics from fundamental particle physics to nuclear power. Example commercial applications where nuclear engineers are utilized are power, medicine, oil exploration, and testing of materials. The nuclear engineering minor familiarizes students with terminology, mathematical applications, theory, and ethics corresponding to common nuclear engineering topics. This minor is open to all engineering, physics, and chemistry majors.

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 include calculus (MATH 121 - MATH 122) and dynamic engineering systems (ENGR 232). The physics requirements are PHYS 101, PHYS 102 and PHYS 201. In addition, CHEM 101, ENGR 220, and ENGR 231 are needed. Courses taken to meet these requirements will not count toward the minor.

## Program Requirements

| | | |
|---|---|---|
| **Required Courses** | | |
| ECEP 371 | Introduction to Nuclear Engineering | 2.0 |
| or MEM 371 | Introduction to Nuclear Engineering I | |
| ECEP 372 | Radiation Detection and Measurement | 3.0 |
| ECEP 402 | Theory of Nuclear Reactors | 4.0 |
| ECEP 406 | Introduction to Radiation Health Principles | 3.0 |
| PHYS 330 | Introduction to Nuclear Physics | 2.0 |
| Select 12.0 credits from at least two of the following principal areas | | 12.0 |
| **Electrical Engineering Courses** | | |
| ECEP 352 | Electric Motor Control Principles | |
| ECEP 354 | Energy Management Principles | |
| ECEP 403 | Nuclear Power Plant Design & Operation | |
| ECEP 411 | Power Systems I | |
| ECEP 412 | Power Systems II | |
| **Mechanical Engineering Courses** | | |
| MEM 220 | Fluid Mechanics I | |
| MEM 345 | Heat Transfer | |
| MEM 402 | Power Plant Design | |
| MEM 446 | Fundamentals of Plasmas I | |
| MEM 447 | Fundamentals of Plasmas II | |
| MEM 448 | Applications of Thermal Plasmas | |
| MEM 449 | Applications of Non-Thermal Plasmas | |
| **Materials Science Courses** | | |
| MATE 230 | Fundamentals of Materials II | |
| MATE 341 | Defects in Solids | |
| MATE 355 | Structure and Characterization of Crystalline Materials | |
| MATE 370 | Mechanical Behavior of Solids | |
| MATE 450 | The Nuclear Fuel Cycle & Materials | |
| **Chemical Engineering Courses** | | |
| CHE 341 | Fluid Mechanics | |
| CHE 342 | Heat Transfer | |
| CHE 343 | Mass Transfer | |
| **Civil Engineering Courses** | | |
| CIVE 320 | Introduction to Fluid Flow | |
| **Physics Courses** | | |
| PHYS 105 | Computational Physics I | |
| PHYS 305 | Computational Physics II | |
| **Total Credits** | | **26.0** |

## Additional Information

More information about this minor is available on the ECE Department website (https://drexel.edu/engineering/academics/departments/). (http://drexel.edu/ece/academics/undergrad/minors/)

For advising questions, please contact the ECE advisor (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/resources/current-undergrad/).

# Minor in Robotics and Automation

## About the Minor

Robotics and Automation Engineering has evolved around several engineering and technology fields such as electrical, mechanical, and electro-mechanical, as well as electronics engineering. It merges the fundamental principles of electrical hardware and sensor usage with pneumatics, hydraulics, computer programming and instrumentation science, and related applications.

The Minor in Robotics and Automation (ROBT) introduces students to mechatronics engineering and prepares them for automation-related careers in process control, manufacturing, computerized hardware/software integration, and sustainable automated systems. It allows students to engage in real-life, industrial processes related to automation in an industrial robotics laboratory setting.

## Program Requirements

| | | |
|---|---|---|
| EET 201 | Circuit Analysis I | 4.0 |
| EET 205 | Digital Electronics | 4.0 |
| EET 319 | PLC Fundamentals | 4.0 |
| INDE 350 | Industrial Engineering Simulation | 3.0 |
| MET 205 | Robotics and Mechatronics | 3.0 |
| MET 209 | Fluid Power | 4.0 |
| MET 310 | Advanced Robotics and Mechatronics | 3.0 |
| **Total Credits** | | **25.0** |

## Additional Information

For more information on the Robotics and Automation minor, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

# Minor in Systems Engineering

## About the Minor

Systems engineering is a set of processes and tools used to guide the engineering of large scale systems. Unlike traditional engineering which may focus on very specific technical components, systems engineers focus on the entirety of a system to ensure it is run efficiently and effectively. The minor will prepare undergraduate students for the current demands of industry and provide them with the opportunity to achieve a formal education in systems engineering.

The Minor in Systems Engineering is designed for students in the College of Engineering and School of Biomedical Engineering who are interested in the management of large, complex systems. It leads to careers in a wide range of industries, such as aerospace, communications, healthcare, manufacturing, and transportation.

The opportunity to pursue a minor in systems engineering will be offered to students who meet the following conditions:

- Minimum 3.0 cumulative GPA
- Upper level students (sophomores, juniors, pre-juniors, and seniors)
- Student in the College of Engineering or the School of Biomedical Engineering

| | | |
|---|---|---|
| **Core Requirements** | | |
| CIVE 240 [WI] | Engineering Economic Analysis | 3.0 |
| EGMT 462 | Introduction to Engineering Management | 3.0 |
| or MEM 462 | Introduction to Engineering Management | |
| EGMT 465 | Introduction to Systems Engineering | 3.0 |
| INDE 362 | Operations Research for Engineering I | 3.0 |
| SYSE 488 | Systems Engineering Analysis | 3.0 |
| **Complete 9 credits of courses from the following list** | | **9.0** |
| ECES 356 | Theory of Control | |
| ECES 444 | Systems and Control I | |
| INDE 350 | Industrial Engineering Simulation | |
| INDE 365 | Systems Analysis Methods I | |
| INDE 366 | Systems Analysis Methods II | |
| MEM 355 | Performance Enhancement of Dynamic Systems | |
| SYSE 530 | Systems Engineering Design | |
| SYSE 531 | Systems Architecture Development | |
| SYSE 532 | Software Systems Engineering | |
| SYSE 533 | Systems Integration and Test | |
| **Total Credits** | | **24.0** |

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Minor in Technology

## About the Minor

This minor provides both the breadth and the depth of knowledge in emerging technologies. It consists of a sampling of Engineering Technology courses that would provide students with a greater knowledge and appreciation of emerging technologies. The courses span the range of levels from first year to advanced undergraduate courses. The minor also covers emerging technology fields such as nanotechnology and renewable energy, and emerging technological applications such as 3D printing and Computer Numerical Control (CNC).

The minor will serve students interested in an advance knowledge in emerging technologies or will be working in the technology field but whose majors are not necessarily engineering or engineering technology. These students will gain solid understanding of technology to stay competitive with their peers.

## Program Requirements

| | | |
|---|---|---|
| EET 204 | Introduction to Nanotechnology | 3.0 |
| EET 320 | Renewable Energy Systems | 3.0 |
| EET 333 [WI] | Non-Destructive Evaluation of Materials | 4.0 |
| INDE 240 | Technology Economics | 3.0 |
| MET 100 | Graphical Communication | 3.0 |
| MET 205 | Robotics and Mechatronics | 3.0 |
| MET 316 | Computer Numerical Control | 3.0 |
| MET 321 | Changing World of 3D Printing and Rapid Prototyping | 3.0 |
| **Total Credits** | | **25.0** |

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

## Additional Information

For more information on the Technology minor, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

# Certificate in Construction Management Concepts

*Certificate Level: Undergraduate*
*Admission Requirements: Fundamentals of Construction Management & Construction Science certificates*
*Certificate Type: Certificate*
*Number of Credits to Completion: 19.0*
*Instructional Delivery: Face-to-Face; Online*
*Calendar Type: Quarter*
*Expected Time to Completion: 1 year*
*Financial Aid Eligibility: Aid eligible as of Fall 2020 term*
*Classification of Instructional Program (CIP) Code: 52.2001*
*Standard Occupational Classification (SOC) Code: 11-9021*

## About the Program

If you are looking for a way to move your construction, architecture, or engineering career forward or are considering an undergraduate or graduate degree but are unable to make the full commitment at this time, consider a certificate program from Drexel's Construction Management program.

Developed at the request of two contractors' associations—the General Building Contractors Association and the Contractors Association of Eastern Pennsylvania—this certificate is suitable for those who have undergraduate degrees in other fields but wish to work in the construction industry, along with those who are already employed in the industry but seek career advancement or updated training.

The Construction Management Concepts certificate focuses on construction contracts, specifications, and practices with regard to business law and liability. The certificate also covers value engineering and construction planning, scheduling, and network systems, as well as the communications required for project control and claims prevention.

## Admission Requirements

Successful completion of the Fundamentals of Construction Management certificate (p. 116) and the Construction Science certificate (p. 115).

## Program Requirements

| Requirements | | |
|---|---|---|
| CMGT 361 | Contracts And Specifications I | 3.0 |
| CMGT 362 | Contracts and Specifications II | 3.0 |
| CMGT 385 [WI] | Selling and Negotiation Techniques in Construction | 3.0 |
| CMGT 461 | Construction Project & Company Management | 3.0 |
| CMGT 463 | Value Engineering | 3.0 |
| CMGT 467 | Techniques of Project Control | 4.0 |
| **Total Credits** | | **19.0** |

## Sample Plan of Study

| Term 1 | Credits | Term 2 | Credits | Term 3 | Credits |
|---|---|---|---|---|---|
| CMGT 361 | 3.0 | CMGT 362 | 3.0 | CMGT 461 | 3.0 |
| CMGT 467 | 4.0 | CMGT 385 | 3.0 | CMGT 463 | 3.0 |
| | **7** | | **6** | | **6** |

**Total Credits 19**

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid "clustering" these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/writing-intensive-courses/) at the University Writing Program (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/). (http://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/drexel-writing-center/) Students scheduling their courses can also conduct a search for courses with the attribute "WI" to bring up a list of all writing-intensive courses available that term.

# Certificate in Construction Science

*Certificate Level: Undergraduate*
*Admission Requirements: Fundamentals of Construction Management certificate*
*Certificate Type: Certificate*
*Number of Credits to Completion: 18.0*
*Instructional Delivery: Face-to-Face; Online*
*Calendar Type: Quarter*
*Expected Time to Completion: 1 year*
*Financial Aid Eligibility: Aid eligible as of Fall 2020 term*
*Classification of Instructional Program (CIP) Code: 52.2001*
*Standard Occupational Classification (SOC) Code: 11-9021*

## About the Program

If you are looking for a way to move your construction, architecture, or engineering career forward or are considering an undergraduate or graduate degree but are unable to make the full commitment at this time, consider a certificate program from Drexel's Construction Management program.

Developed at the request of two contractors' associations—the General Building Contractors Association and the Contractors Association of Eastern Pennsylvania—this certificate is suitable for those who have undergraduate degrees in other fields but wish to work in the construction industry, along with those who are already employed in the industry but seek career advancement or updated training.

## Admission Requirements

Successful completion of the Fundamentals of Construction Management certificate (p. 116).

## Program Requirements

| Requirements | | |
|---|---|---|
| CMGT 266 | Building Systems I | 3.0 |
| CMGT 267 | Building Systems II | 3.0 |
| CMGT 363 | Estimating I | 3.0 |
| CMGT 364 | Estimating II | 3.0 |
| Select two of the following: | | 6.0 |
| CMGT 262 | Building Codes | |
| CMGT 265 | Information Technologies in Construction | |
| CMGT 450 | Management of Field Operations | |
| **Total Credits** | | **18.0** |

## Sample Plan of Study

| Term 1 | Credits | Term 2 | Credits | Term 3 | Credits |
|---|---|---|---|---|---|
| CMGT 266 | 3.0 | CMGT 267 | 3.0 | Select two of the following: | 6.0 |
| CMGT 363 | 3.0 | CMGT 364 | 3.0 | CMGT 262 | |
| | | | | CMGT 265 | |
| | | | | CMGT 450 | |
| | **6** | | **6** | | **6** |

**Total Credits 18**

# Fundamentals of Construction Management

*Certificate Level: Undergraduate*
*Admission Requirements: High school diploma or GED*
*Certificate Type: Certificate*
*Number of Credits to Completion: 18.0*
*Instructional Delivery: Face-to-Face; Online*
*Calendar Type: Quarter*
*Expected Time to Completion: 1 year*
*Financial Aid Eligibility: Aid eligible as of Fall 2020 term*
*Classification of Instructional Program (CIP) Code: 52.2001*
*Standard Occupational Classification (SOC) Code: 11-9021*

## About the Program

If you are looking for a way to move your construction, architecture, or engineering career forward or are considering an undergraduate or graduate degree but are unable to make the full commitment at this time, consider a certificate program from Drexel's Construction Management program.

The undergraduate certificate in the Fundamentals of Construction Management is designed to fill the training needs of industry leaders.

Developed at the request of two contractors' associations—the General Building Contractors Association and the Contractors Association of Eastern Pennsylvania—this certificate is suitable for those who have undergraduate degrees in other fields but wish to work in the construction industry along with those who are already employed in the industry but seek career advancement or updated training.

## Admission Requirements

High school diploma or GED

## Program Requirements

| Requirements | | |
|---|---|---|
| CMGT 101 | Introduction to Construction Management | 3.0 |
| CMGT 161 | Building Materials and Construction Methods I | 3.0 |
| CMGT 162 | Building Materials and Construction Methods II | 3.0 |
| CMGT 163 | Building Materials and Construction Methods III | 3.0 |
| CMGT 261 | Construction Safety | 3.0 |
| CMGT 263 | Understanding Construction Drawings | 3.0 |
| **Total Credits** | | **18.0** |

## Sample Plan of Study

| Term 1 | Credits | Term 2 | Credits | Term 3 | Credits |
|---|---|---|---|---|---|
| CMGT 101 | 3.0 | CMGT 162 | 3.0 | CMGT 163 | 3.0 |
| CMGT 161 | 3.0 | CMGT 261 | 3.0 | CMGT 263 | 3.0 |
| | **6** | | **6** | | **6** |

**Total Credits 18**

# NAE Grand Challenge Scholars Program

## About the Program

The National Academy of Engineering (NAE) Grand Challenge Scholars Program is a combined curricular and extracurricular program with five components that are designed to prepare students to be the generation that solves the grand challenges facing society in this century. Students will work with a mentor on research related to a NAE Grand Challenge, engage in an interdisciplinary curriculum, entrepreneurship, global perspective, and service learning. Upon completing the program the student will receive a certificate of completion signed by both the NAE and the responsible Drexel University official.

## Admission Requirements

Students have the opportunity to join the program anytime in the third quarter of their freshman year but not later than the end of their third year. Candidates must have a GPA of at least 3.25. The application includes a statement on why the student wishes to be a part of the program and vision statement for completion of the program requirements, including the research and civic engagement requirements. Students will complete a proposed plan of study that satisfies the requirements of the GCSP and must identify a mentor who they will work with in meeting the GCSP objectives.

## Program Requirements

**Project or research activity**
Each Scholar will engage in some research that can be identified with one of the very broadly identified NAE Grand Challenges with a research mentor.

**Civic Engagement activity**
Each student will complete service with one community organization. The Scholar will be required to submit a written report on their activity and accomplishments.

**Please note:** *In each of the coursework areas below, a student has the option of choosing an alternate course, provided it is approved by the program director and satisfies NAE requirements.*

| Program Requirements | |
|---|---|
| Entrepreneurship and Innovation experience. Select two courses from the following: | 6.0-8.0 |
| ENTP 210 [WI] Leading Start-Ups | |
| or ENTP 440 Launch it!: Early Stage | |
| or MGMT 260 Introduction to Entrepreneurship | |
| or MGMT 365 Business Plan for Entrepreneurs | |
| Global and cross-cultural perspectives. Select one course from the following: | 2.0-3.0 |
| ENTP 370 Global Entrepreneurship | |
| or ENGR 280 International to Global Engineering | |
| International Business. Select one course from the following: | 4.0 |
| INTB 200 International Business | |
| or BLAW 342 Criminal Law | |
| Political Science/History. Select one course from the following: | 4.0 |
| PSCI 140 Comparative Politics I | |
| or PSCI 352 Ethics and International Relations | |
| PSCI 357 The European Union in World Politics | |
| Culture and Communications. Select one course from the following: | 3.0 |
| COM 360 International Communication | |
| or GST 359 Culture and Values | |
| or WGST 240 Women and Society in a Global Context | |
| **Total Credits** | **19.0-22.0** |

## Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

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## Additional Information

For more information and program contacts, please visit the NAE Grand Challenges Scholars Program (https://drexel.edu/engineering/resources/for-students/leadership-research-programs/nae-grand-challenges-scholars-program/) webpage.