DREXEL UNIVERSITY
College of
Engineering

# CATALOG
## 2025-2026

**UNDERGRADUATE**

catalog.drexel.edu

# Table of Contents


The College of Engineering ..... 3

Undergraduate Programs ..... 6

Architectural Engineering ..... 6

Chemical Engineering ..... 13

Civil Engineering ..... 18

Computer Engineering ..... 26

Construction Management ..... 36

Electrical Engineering ..... 41

Engineering ..... 51

Engineering Technology BSET ..... 54

Environmental Engineering ..... 56

Materials Science and Engineering ..... 63

Mechanical Engineering ..... 71

Engineering Undeclared ..... 79

Accelerated Degrees .....

Architectural Engineering, Mechanical Concentration BSAE / Architectural Engineering MSAE ..... 81

Architectural Engineering, Structural Concentration BSAE / Civil Engineering, Structural Track MS ..... 83

Architectural Engineering BS / Construction Management MS ..... 85

Chemical Engineering BSCHE / Chemical Engineering MSCHE ..... 87

Chemical Engineering BSCHE / Materials Science & Engineering MSMSE ..... 89

Civil Engineering BSCIV / Civil Engineering MSCE ..... 91

Civil Engineering BSCIV / Construction Management MS ..... 95

Civil Engineering BSCIV / Environmental Engineering MSENE ..... 97

Computer Engineering BSCE / Computer Engineering MSCE ..... 101

Computer Engineering BSCE / Cybersecurity MS ..... 104

Computer Engineering BSCE / Electrical Engineering MSEE ..... 106

Computer Engineering BSCE / Machine Learning Engineering MSMLE ..... 108

Computer Engineering BSCE / Robotics & Autonomy MSRA ..... 110

Electrical Engineering BSEE / Computer Engineering MSCPE ..... 112

Electrical Engineering BSEE / Cybersecurity MS ..... 114

Electrical Engineering BS / Electrical Engineering MS ..... 117

Electrical Engineering BSEE / Machine Learning Engineering MSMLE ..... 118

Electrical Engineering BSEE / Robotics & Autonomy MSRA ..... 120

Environmental Engineering BS/MS ..... 122

Environmental Engineering BSENE / Materials Science and Engineering MSMSE ..... 126

Materials Science & Engineering BS / Materials Science & Engineering MS ..... 128

Mechanical Engineering & Mechanics BS / Environmental Engineering MS ..... 134

Mechanical Engineering BSME / Materials Science & Engineering MSMSE ..... 136

Mechanical Engineering & Mechanics BSME / MS ..... 138

Minors .....
Minor in Architectural Engineering ..... 140
Minor in Chemical Engineering ..... 141
Minor in Computer Engineering ..... 141
Minor in Construction Management ..... 142
Minor in Electrical Engineering ..... 142
Minor in Engineering Leadership ..... 143
Minor in Engineering Management ..... 143
Engineering Policy Analysis Minor ..... 144
Minor in Environmental Engineering ..... 145
Minor in Global Engineering ..... 145
Minor in Green Energy and Sustainability ..... 146
Minor in Materials Science and Engineering ..... 146
Minor in Mechanical Engineering and Mechanics ..... 148
Minor in Robotics and Automation ..... 148
Minor in Systems Engineering ..... 149
Certificates .....
Certificate in Construction Management Concepts ..... 149
Certificate in Construction Science ..... 150
Fundamentals of Construction Management ..... 150
NAE Grand Challenge Scholars Program ..... 151
Index ..... 153

# The College of Engineering

Engineering as a discipline strives to find answers to humanity's most pressing issues. The emphasis at Drexel University's College of Engineering is in going beyond the academics to the application of learning, facilitating a career as an innovator and solution-driven engineer that can make a difference right from the start.

The engineering curriculum provides a strong foundation and a thorough understanding of scientific, mathematical, and engineering fundamentals, while the hands-on components of the programs give added perspective for applying these areas of knowledge creatively to a take on any engineering challenge.

## Majors

- Architectural Engineering (BSAE) (p. 6)
  - Mechanical Concentration
  - Structural Concentration
  - Digital Building Concentration
- Chemical Engineering (BSCHE) (p. 13)
- Civil Engineering (BSCIV) (p. 18)
- Computer Engineering (BSCE) (p. 26)
- Construction Management (BSCMGT) (p. 36)
  - Real Estate Concentration (p. 38)
- Electrical Engineering (BSEE) (p. 41)
- Engineering (BSE) (p. 51)
- Engineering Technology (BSET) (p. 54)
  - Electrical Engineering Technology Concentration (https://catalog.drexel.edu/undergraduate/collegeofengineering/electricalengineeringtechnology/)
  - Mechanical and Manufacturing Concentration (https://catalog.drexel.edu/undergraduate/collegeofengineering/engineeringtechnology/mechanicalandmanufacturingconcentration/)
  - Robotics and Automation Concentration (https://catalog.drexel.edu/undergraduate/collegeofengineering/engineeringtechnology/roboticsandautomationconcentration/)
  - Systems and Industrial Engineering Concentration (https://catalog.drexel.edu/undergraduate/collegeofengineering/systemsindustrialengineeringtechnology/)
- Environmental Engineering (BSENE) (p. 56)
- Materials Science and Engineering (BSMSE) (p. 63)
- Mechanical Engineering & Mechanics (BSME) (p. 71)

## Undeclared Majors

- Engineering Undeclared (p. 79)

## Accelerated Degree Programs

- Architectural Engineering - Mechanical Concentration (BSAE) / Architectural Engineering (MS) (p. 81)
- Architectural Engineering - Structural Concentration (BSAE) / Civil Engineering - Structural Track (MS (p. 83))
- ***NEW***: Architectural Engineering BS / Construction Management MS
- Chemical Engineering (BSCHE) / Chemical Engineering (MSCHE) (p. 87)
- Chemical Engineering (BSCHE) / Materials Science Engineering (MSME) (p. 89)
- Civil Engineering (BSCIV) / Civil Engineering (MSCIV) (p. 91)
- ***NEW***: Civil Engineering (BSCIV) / Construction Management (MSCMGT)
- Civil Engineering (BSCIV) / Environmental Engineering (MSENE) (p. 97)
- Computer Engineering (BSCE) / Computer Engineering (MSCE) (p. 101)
- Computer Engineering (BSCE) / Cybersecurity (MS) (p. 104)
- Computer Engineering (BSCE) / Electrical Engineering (MS) (p. 106)
- Computer Engineering (BSCE) / Machine Learning Engineering (MSMLE) (p. 108)
- Computer Engineering (BSCE) / Robotics & Autonomy (MSRA) (p. 110)
- Electrical Engineering (BSEE) / Computer Engineering (MSCPE) (p. 112)
- Electrical Engineering (BSEE) / Cybersecurity (MS) (p. 114)
- Electrical Engineering (BSEE) / Electrical Engineering (MS) (p. 117)
- Electrical Engineering (BSEE) / Machine Learning Engineering (MSMLE) (p. 118)
- Electrical Engineering (BSEE) / Robotics & Autonomy (MSRA) (p. 120)
- Environmental Engineering (BSENE) / Environmental Engineering (MSENE) (p. 122)
- ***NEW***: Environmental Engineering (BSENE) / Materials Science & Engineering (MS)
- Materials Science & Engineering (BS) / Materials Science & Engineering (MSMSE) (p. 128)
- Mechanical Engineering & Mechanics (BSME) / Environmental Engineering (MSENE) (p. 134)
- Mechanical Engineering (BSME) / Materials Science & Engineering (MSMSE) (p. 136)
- Mechanical Engineering & Mechanics (BSME) / Mechanical Engineering & Mechanics (MSME) (p. 138)

## Minors

- Architectural Engineering (p. 140)
- Chemical Engineering (p. 141)
- Computer Engineering (p. 141)
- Construction Management (p. 142)
- Electrical Engineering (p. 142)
- Engineering Leadership (p. 143)
- Engineering Management (p. 143)
- Engineering Policy Analysis (p. 144)
- Environmental Engineering (p. 145)
- Global Engineering (p. 145)
- Green Energy and Sustainability (p. 146)
- Materials Science and Engineering (p. 146)
- Mechanical Engineering and Mechanics (p. 148)

- Robotics and Automation (p. 148)
- Systems Engineering (p. 149)

## Certificates

- Construction Management Concepts (p. 149)
- Construction Science (p. 150)
- Fundamentals of Construction Management (p. 150)
- NAE Grand Challenge Scholars Program (p. 151)

# About the College

For more than 130 years, engineering has been the cornerstone of the University. From the start at Drexel through today, the engineering programs at the College of Engineering have valued applied learning, exploration of emerging subjects and the preparation of students for the launch of their careers as innovators and solution-driven engineers. Through teaching the foundation sciences and providing opportunities to discover the boundaries of the disciplines, faculty and industry experts guide students through the curriculum with emphasis on hands-on learning in classrooms, participation in research, gaining experience through our renowned co-op program (https://drexel.edu/engineering/academics/experiential-learning-co-op/), enhancing perspectives and showing students how they can make an impact. The College of Engineering offers students a diverse academic learning and research environment embodying the highest standards of knowledge to explore interests and find innovative solutions that promote economic development, improve the human-condition and preserve our planet. Through these principles students become technically trained, adaptable engineers who advance from their studies dedicated to the practice and discovery of sustainable solutions to our society's greatest challenges.

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.

In addition to the engineering curriculum, the college offers majors in Engineering Technology (p. 54) and Construction Management (p. 36).

# Cooperative Education

In both four-year and the five-year cooperative education programs, engineering majors spend a total of 12 terms in school, with either two or six terms on co-op assignment, respectively. In the five-year program, first-year students attend classes for three terms, followed by sophomore, pre-junior, and junior years where students generally attend class for two terms and participate in 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 specialties 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 students must maintain an overall grade point average of 2.0 in all required courses in their major.

## Curricular Organization

Students in the traditional engineering programs study many of the same subjects during the three terms in the first year. After the first year, curricula begin to differentiate more and more, as major-specific coursework is introduced.

The first two years are devoted to the foundation of the engineering curriculum. Their purpose is to provide an integrated view of the basic sciences and an introduction to the art of engineering, which they do through group projects that deal with open-ended problems characteristic of the practice of engineering. Students also learn to use both computer- and laboratory-based engineering tools to support data gathering, analysis, engineering design, problem-solving, and evaluation.

Incoming engineering students take placement exams in June before their first year to 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 those courses starting in the fall term. Students that may need additional preparation are given the option to participate in online, self-paced preparatory reviews which can lead to a fall placement in the core courses. Fall schedules may also be affected by transfer and/or advanced credit.

Professional subjects are introduced in the second year and completed by the fourth year. The fifth 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 senior design experience in the fifth year.

## Electives

Recognizing the importance of general education, all curricula require that courses be taken in this area, including some identified as Writing Intensive. These requirements are described in more detail in the General Education Requirements section.

In addition to a minimum of 30.0 General Education Credits (p. 5), most programs have other types of required electives as well, including math/science, communications, technical, and free. Technical electives are courses in engineering, science, or management that build on the required professional courses and lead to a specific technical specialization. Elective sequence options should be discussed with and approved by academic advisors. Free electives are generally any course but should also be discussed before registering.

## The Common Curriculum

While programs vary in curricular detail, the following courses are fairly common to most. See each program's plan of study for specifics.

| | | |
|---|---|---|
| **University Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COOP 101 | Career Management and Professional Development | 1.0 |
| UNIV E101 | The Drexel Experience | 1.0 |
| **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 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MATH 121 | Calculus I | 4.0 |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| PHYS 101 | Fundamentals of Physics I | 4.0 |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| PHYS 201 | Fundamentals of Physics III | 4.0 |

## 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

General Education electives must be non-technical. Computer, math, engineering, and science courses do not count as General Education electives.

Courses in the following subject codes fulfill General Education requirements, other than those listed as exclusions. Additional courses may be accepted upon academic advisor approval.

Accounting (ACCT), Africana Studies (AFAS), ANIM (Animation), Anthropology (ANTH), Arabic (ARBC), Architecture (ARCH), Art History (ARTH), Legal Studies (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), Honors (HNRS), Hotel & Restaurant Management (HRM), Interior Design (INTR), International Business (INTB), Italian (ITAL), Japanese (JAPN), Jewish Studies (JWST), Korean (KOR), Language (LANG), Law (LAW ), Management (MGMT), Marketing (MKTG), Military Science (MLSC, except lab courses), Music (MUSC), Music Industry Program (MIP), Operations Management (OPM), Operations Research (OPR), Organizational Behavior (ORGB), Philosophy (PHIL), Photography (PHTO), Philosophy, Politics & Economics (PPE ), 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), TV Studies (TVST), Visual Studies (VSST), WEST Studies (WEST), Women's and Gender Studies (WGST), and Writing (WRIT).

Non-lab ROTC courses taken at the University of Pennsylvania in Naval Science (NSCI) and at St. Joseph's University in Aerospace (AER) may be transferred to fulfill General Education requirements.

There are many elective courses with no pre-requisites, but note that they must also meet the criteria outlined on this page to count specifically as a General Education elective.

# Special Programs

## BS/MS Accelerated Degree Program

The Accelerated Degree Program of the College of Engineering provides highly talented and strongly motivated students to progress toward their educational goals. This is achieved by completing a Bachelor's degree and Master's degree in the same five years it generally takes to complete the BS only.

Students prepare for this plan of study in their first and second years. Interested students are encouraged to begin discussing their interest with their academic advisor after their first term at Drexel.

Students admitted provisionally at the time they were accepted to the College of Engineering may still apply in their second or third year, but are not obligated to do so. Likewise, those not accepted provisionally may apply and will be accepted if they meet the entrance criteria.

The division of courses toward the BS and MS degrees during the fourth and fifth years may impact some students' financial aid package. They will be directed to speak with specialists in Drexel Central as part of the application process.

Visit the BS/MS program on the College of Engineering website (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) to learn more.

# Facilities

## Core Engineering Facilities

The College of Engineering's Innovation Studio hosts activities for all class levels, from First-Year Design at one end through Senior Design at the other. It includes 3D printers, multiple sensor suites, and the college machine shop that students can use for projects and clubs. It supports the flow of ideas from design through complex fabrication.

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 Studio is an example of Drexel's commitment to undergraduate education by providing up-to-date, high-quality technology to facilitate the kind of experiential learning that keeps Drexel at the cutting edge.

## Department Facilities

Departments within the College of Engineering have many new and upgraded laboratories and cutting-edge equipment appropriate for required lab coursework within their respective curricula and for the emerging research conducted in the departments. Visit the Drexel Engineering departments (https://drexel.edu/engineering/academics/departments/) for more information.

# Architectural Engineering BSAE

*Major: Architectural Engineering*
*Degree Awarded: Bachelor of Science in Architectural Engineering (BSAE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 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 develop a depth of knowledge in at least one area while gaining an understanding of the principles of structural support and external cladding, building environmental systems and project management.

The program integrates building disciplines, including coordination with architects, construction managers, civil, mechanical, and electrical engineers and others. Students present their work and complete coursework using computer-aided design tools to understand system interactions, perform analysis, design, scheduling and cost analysis.

The first two years of the curriculum cover fundamentals necessary for all engineers. The third and fourth 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. The academic program is complemented by exposure to professional practice in the co-op experience.

The fifth year focus on either structural or building environmental systems design, or develop skills in digital building and construction management as well as a full-year realistic design project. Senior design is a highlight of the program. Groups of students work 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 to enjoy rewarding careers and make substantial contributions to society.

## Program Educational Objectives

Architectural engineering graduates will be responsible professionals who analyze, design, construct, manage, operate buildings and their systems, work collaboratively and communicate with stakeholders, 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

**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

**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

## Additional Information

The Architectural Engineering program is accredited by the Engineering Accreditation Commission of ABET (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Architectural and Similarly Named Engineering Programs.

For more information about this program and to apply, visit the BS in Architectural Engineering web page (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/architectural-engineering/) or contact the program head:

Simi Hoque, PhD
Professor
Civil, Architectural & Environmental Engineering
sth55@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 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Mathematics Requirements** | | |
| Select one of the following options: † | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II †† | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 444 | Building Envelope Systems | 3.0 |
| ARCH 118 | Architectural Design Foundations I | 3.0 |
| ARCH 119 | Architectural Design Foundations II | 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 |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| MEM 202 | Statics | 3.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| **Concentration Courses** | | |
| Select one of the following concentrations: | | 29.0-34.0 |
| **Mechanical 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 | |
| Select three professional electives in the following subjects (400-499) from the list below: | | |
| **Structural Concentration** | | |
| CIVE 302 | Structural Analysis I | |
| CIVE 303 | Structural Design I | |
| CIVE 312 | Soil Mechanics I | |

| | | |
|---|---|---|
| | CIVE 315 | Soil Mechanics II |
| | CIVE 400 | Structural Analysis II |
| | CIVE 401 | Structural Design II |
| | CIVE 402 | Structural Design III |
| | MEM 238 | Dynamics |
| | Select two professional electives in the following subjects (400-499) from the list below: | |
| **Digital Building Concentration** | | |
| | AE 410 | Intelligent Buildings |
| | AE 430 | Control Systems for HVAC |
| | AE 455 | Data Acquisition and Analytics in Built Environment |
| | CIVE 302 | Structural Analysis I |
| | CIVE 303 | Structural Design I |
| | CMGT 361 | Contracts And Specifications I |
| | CMGT 467 | Techniques of Project Control |
| | Select three professional electives in the following subjects (400-499) from the list below: | |
| **Professional Electives** | | |
| | Any ACCT (Accounting) course | |
| | Any AE (Architectural Engineering) course | |
| | Any ARCH (Architecture) course | |
| | Any BLAW (Legal Studies) course | |
| | Any BMES (Biomedical Engineering & Sci) course | |
| | Any BUSN (General Business) course | |
| | Any CHE (Chemical Engineering) course | |
| | Any CIVE (Civil Engineering) course | |
| | Any CMGT (Construction Management) course | |
| | Any CS (Computer Science) course | |
| | Any ECE (Electrical Engineering) course | |
| | Any ECON (Economics) course | |
| | Any ENVE (Environmental Engineering) course | |
| | Any FIN (Finance) course | |
| | Any INTB (International Business) course | |
| | Any MATE (Materials Engineering) course | |
| | Any MEM (Mechanical Engr & Mechanics) course | |
| | Any MIS (Management Information Systems) course | |
| | Any MKTG (Marketing) course | |
| | Any OPM (Operations Management) course | |
| | Any SE (Software Engineering) course | |
| | CMGT 361 | Contracts And Specifications I |
| | CMGT 362 | Contracts and Specifications II |
| | CMGT 363 | Estimating I |
| **Total Credits** | | **190.0-209.0** |

*****

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)

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

††

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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, Spring/Summer

**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 |
|---|---|---|---|---|---|---|---|
| ARCH 118 | 3.0 | ARCH 119 | 3.0 | AE 340 | 3.0 | AE 220 | 3.5 |
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | CAEE 212 or GEO 101 | 4.0 | CIVE 250 | 4.0 |
| CAEE 231 | 3.0 | CAEE 232 | 3.0 | CIVE 320 | 3.0 | CIVE 330 | 4.0 |
| MATE 220 | 4.0 | CIVE 240 | 3.0 | MEM 230 | 4.0 | General Education Elective[†] | 3.0 |
| MEM 202 | 3.0 | ENGL 103 or 113 | 3.0 | | | | |
| PHYS 201 | 4.0 | MEM 210 | 3.0 | | | | |
| | **20** | | **18** | | **14** | | **14.5** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 390 | 4.0 | AE 391 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 141 | 3.0 | ARCH 142 | 3.0 | | | | |
| Concentration courses | 8.0 | General Education elective† | 3.0 | | | | |
| Free elective | 3.0 | Concentratic course | 3.0 | | | | |
| | | Professional elective†† | 3.0 | | | | |
| | **18** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 444 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| ARCH 143 | 3.0 | Concentratic course | 3.0 | Concentratic course | 3.0 |
| CAE 491 | 3.0 | Concentration course or Professional elective†† | 3.0 | Professional elective†† | 3.0 |
| CAEE 361 | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| Concentration Course | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 190**

*****

CHEM Sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

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.

*******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

See degree requirements (p. 7).

††

Required professional elective courses must be selected from the following list of courses:
AE 400-499, ACCT 400-499, ARCH 400-499, BLAW 400-499, BMES 400-499, BUSN 400-499, CHE 400-499, CIVE 400-499, CMGT 361, CMGT 362, CMGT 363, CMGT 400-499, ECE 400-499, ECON 400-499, CS 400-499, ENVE 400-499, FIN 400-499, INTB 400-499, MATE 400-499, MEM 400-499, MIS 400-499, MKTG 400-499, OPM 400-499, SE 400-499

## 4 year, 1 co-op, Fall/Winter

**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 |
|---|---|---|---|---|---|---|---|
| ARCH 118 | 3.0 | ARCH 119 | 3.0 | AE 340 | 3.0 | AE 220 | 3.5 |
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | CAEE 212 or GEO 101 | 4.0 | CIVE 250 | 4.0 |
| CAEE 231 | 3.0 | CAEE 232 | 3.0 | CIVE 320 | 3.0 | CIVE 330 | 4.0 |
| MATE 220 | 4.0 | CIVE 240 | 3.0 | MEM 230 | 4.0 | General Education Elective† | 3.0 |
| MEM 202 | 3.0 | ENGL 103 or 113 | 3.0 | | | | |
| PHYS 201 | 4.0 | MEM 210 | 3.0 | | | | |
| | **20** | | **18** | | **14** | | **14.5** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP Experience | | COOP Experience | | AE 390 | 4.0 | AE 391 | 4.0 |
| | | | | ARCH 141 | 3.0 | ARCH 142 | 3.0 |
| | | | | Concentration courses | 8.0 | General Education Elective† | 3.0 |
| | | | | Free Elective | 3.0 | Concentratic course | 3.0 |
| | | | | | | Concentration course or Professional Elective†† | 3.0 |
| | **0** | | **0** | | **18** | | **16** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 444 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| ARCH 143 | 3.0 | Professiona elective†† | 3.0 | Concentratic course | 3.0 |
| CAE 491 | 3.0 | Concenttration course | 3.0 | Professional elective†† | 3.0 |
| CAEE 361 | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| Concentration course | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 190**

*****

CHEM Sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**

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.

***

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

See degree requirements (p. 7).

††

Required professional elective courses must be selected from the following list of courses:
AE 400-499, ACCT 400-499, ARCH 400-499, BLAW 400-499, BMES 400-499, BUSN 400-499, CHE 400-499, CIVE 400-499, CMGT 361, CMGT 362, CMGT 363, CMGT 400-499, ECE 400-499, ECON 400-499, CS 400-499, ENVE 400-499, FIN 400-499, INTB 400-499, MATE 400-499, MEM 400-499, MIS 400-499, MKTG 400-499, OPM 400-499, SE 400-499

## 5 year, 3 co-op, Spring/Summer

**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 | |
| CAEE 231 | 3.0 | CAEE 232 | 3.0 | | | | |
| MATE 220 | 4.0 | CIVE 240 | 3.0 | | | | |
| MEM 202 | 3.0 | ENGL 103 or 113 | 3.0 | | | | |
| PHYS 201 | 4.0 | MEM 210 | 3.0 | | | | |
| | **17** | | **15** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| AE 340 | 3.0 | ARCH 119 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ARCH 118 | 3.0 | AE 220 | 3.5 | | | | |
| CAEE 212 or GEO 101 | 4.0 | CIVE 250 | 4.0 | | | | |
| CIVE 320 | 3.0 | CIVE 330 | 4.0 | | | | |
| MEM 230 | 4.0 | General Education elective† | 3.0 | | | | |
| | **17** | | **17.5** | | **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 141 | 3.0 | ARCH 142 | 3.0 | | | | |
| Concentration courses | 8.0 | Concentration course | 3.0 | | | | |
| Free elective | 3.0 | General Education elective† | 3.0 | | | | |
| | | Professional elective†† | 3.0 | | | | |
| | **18** | | **16** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 444 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| ARCH 143 | 3.0 | MEM 414 | 3.0 | Concentratic course | 3.0 |
| CAE 491 | 3.0 | Concentration course | 3.0 | Professional elective†† | 3.0 |
| CAEE 361 | 3.0 | Concentratic course or Professiona elective†† | 3.0 | General Education elective† | 3.0 |
| Concentration course | 3.0 | General Education elective† | 3.0 | | |
| | **15** | | **15** | | **12** |

**Total Credits 193**

*

CHEM Sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**

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 101 in place of COOP 101.

***

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

See degree requirements (p. 7).

††

Required professional elective courses must be selected from the following list of courses:
AE 400-499, ACCT 400-499, ARCH 400-499, BLAW 400-499, BMES 400-499, BUSN 400-499, CHE 400-499, CIVE 400-499, CMGT 361, CMGT 362, CMGT 363, CMGT 400-499, ECE 400-499, ECON 400-499, CS 400-499, ENVE 400-499, FIN 400-499, INTB 400-499, MATE 400-499, MEM 400-499, MIS 400-499, MKTG 400-499, OPM 400-499, SE 400-499

## 5 year, 3 co-op, Fall/Winter

**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 |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | CAEE 202 | 3.0 | CAEE 203 | 3.0 |
| | | | | CAEE 231 | 3.0 | CAEE 232 | 3.0 |
| | | | | MATE 220 | 4.0 | CIVE 240 | 3.0 |
| | | | | MEM 202 | 3.0 | ENGL 103 or 113 | 3.0 |
| | | | | PHYS 201 | 4.0 | MEM 210 | 3.0 |
| | **0** | | **0** | | **17** | | **15** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | AE 340 | 3.0 | AE 220 | 3.5 |
| | | | | ARCH 118 | 3.0 | ARCH 119 | 3.0 |
| | | | | CAEE 212 or GEO 101 | 4.0 | CIVE 250 | 4.0 |
| | | | | CIVE 320 | 3.0 | CIVE 330 | 4.0 |
| | | | | MEM 230 | 4.0 | Professional Elective† | 3.0 |
| | **0** | | **0** | | **17** | | **17.5** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | AE 390 | 4.0 | AE 391 | 4.0 |
| | | | | ARCH 141 | 3.0 | ARCH 142 | 3.0 |
| | | | | Concentration courses | 8.0 | General Education Elective† | 3.0 |
| | | | | Free elective | 3.0 | Concentratic course or Professiona Elective | 3.0 |
| | | | | | | Professional Elective†† | 3.0 |
| | **0** | | **0** | | **18** | | **16** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| AE 444 | 3.0 | CAE 492 | 3.0 | CAE 493 | 3.0 |
| ARCH 143 | 3.0 | Concentratic course | 3.0 | Concentratic course | 3.0 |
| CAE 491 | 3.0 | Professional elective†† | 3.0 | Professional elective†† | 3.0 |
| CAEE 361 | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| Concentration course | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 190**

*****

CHEM Sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

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 101 in place of COOP 101.

*******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

See degree requirements (p. 7).

††

Required professional elective courses must be selected from the following list of courses:
AE 400-499, ACCT 400-499, ARCH 400-499, BLAW 400-499, BMES 400-499, BUSN 400-499, CHE 400-499, CIVE 400-499, CMGT 361, CMGT 362, CMGT 363, CMGT 400-499, ECE 400-499, ECON 400-499, CS 400-499, ENVE 400-499, FIN 400-499, INTB 400-499, MATE 400-499, MEM 400-499, MIS 400-499, MKTG 400-499, OPM 400-499, SE 400-499

## 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 - Mechanical Concentration BS / Architectural Engineering MS (p. 81) and Architectural Engineering BS - Structural Concentration / Civil Engineering MS -Structural Track (p. 83).

## 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 Accelerated Degree Program

Exceptional students can also pursue a Master of Science degree in the same period as the Bachelor of Science. For more information about this program, visit the Department's BS/MS Dual Degree Program (http://www.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.

# Program Level Outcomes

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

# 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.

A. Emin Aktan, PhD *(University of Illinois at Urbana-Champaign) John Roebling Professor of Infrastructure Studies*. Professor. Structural engineering; health monitoring of large infrastructure systems; infrastructure evaluation; intelligent systems.

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)*. Associate Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

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

Peter DeCarlo, PhD *(University of Colorado)*. Assistant Professor. Outdoor air quality, particulate matter size and composition instrumentation and measurements, source apportionment of ambient particulate matter, climate impacts of particulate matter.

Eugenia Ellis, RA, PhD *(Virginia Polytechnic State University)*. Associate Professor. Extended-care facilities design, research on spatial visualization, perception and imagination.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute)*. Associate Professor. Soil mechanics; geoenvironmental; ground improvement; sustainability.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Associate 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 Professor and Department Head, Civil, Architectural and Environmental Engineering*. Professor. Control of human exposures to and risk assessment of pathogenic organisms; water and waste treatment; homeland security.

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

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) Dean of the College of Engineering and Distinguished Professor*. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Computational Fluid Dynamics (CFD) and airflow simulation; Indoor Environmental Quality; Building control integration with building information management systems.

Roger Marino, PhD *(Drexel University)*. Associate Teaching Professor. Fluid mechanics; water resources; engineering education; land development.

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

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

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

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) Graduate Studies Advisor*. Associate Professor. Environmental remediation; contaminant and bacterial transport in porous media and bacterial response to dynamic environments.

Michael Ryan, PhD *(Drexel University)*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); Dynamic Engineering Systems Modeling; Molecular Microbial Biology; Environmental Statistics; Engineering Economics; Microbiology

Christopher Sales, PhD *(University of California, Berkeley)*. Assistant Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste.

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. Research in 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 BSCHE

*Major: Chemical Engineering*
*Degree Awarded: Bachelor of Science in Chemical Engineering (BSCHE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 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 offers a rigorous curriculum grounded in the fundamental physical sciences, integrates practical engineering design and modern computational techniques throughout, and includes expansive opportunities to explore the humanities. An extensive, hands-on laboratory experience rounds out a dynamic program that prepares our graduates for rewarding careers in chemical engineering as well as other quantitative disciplines.

Chemical engineers are dedicated to designing devices and processes that convert input materials into valuable products, and also to the design of those products. These include end products such as pharmaceuticals, plastics and other materials, fine chemicals, integrated circuits, electrical energy, petrochemicals, 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 to make substantial contributions to society.

### Sample Senior Design Projects

A special feature of the major is senior design. Teams of chemical engineering seniors work with a faculty or industrial advisor over an entire academic year to develop a realistic, practical industrial design project of their choosing. Some recent examples include the start-to-finish design of production processes for:

- Low-cost solar cells, manufactured by printing
- Scaled-up synthesis of MXene, a novel nanomaterial for energy storage discovered at Drexel
- Biotechnologically derived antibiotic medicine
- Jet fuel derived from bioethanol

### Mission Statement

The Chemical and Biological Engineering Department (CBE) will equip graduates with the broad technical knowledge, real-world experience and

teamwork skills required for a productive professional and civic life, in a department conducting a nationally recognized research whose focus is providing technical solutions for society's challenges.

## 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 quantitative and scientific rigor, creative problem solving, engineering design expertise and excellent communication and teamwork skills
- 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, taking into consideration sustainability as well as local and global impact
- Our graduates will be 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 BS in Chemical Engineering is accredited by The Engineering Accreditation Commission of ABET **(**https://www.abet.org/**)**, under the commission's General Criteria and Program Criteria for Chemical, Biochemical, Biomolecular, and Similarly Named Engineering Programs.

For more information about this program and to apply, visit the BS in Chemical Engineering program (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/chemical-engineering/) and Drexel University's Department of Chemical and Biological Engineering (https://drexel.edu/engineering/academics/departments/chemical-biological-engineering/) webpage.

# 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** | | |
| BIO Elective: Select from BIO 100, BIO 101, BIO 122, or BIO 141 | | 3.0-4.5 |
| **Chemistry Requirements *** ** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Math Requirements †** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II ‡ | |
| OR | | |
| MATH 121 | Calculus I | |
| 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 †** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| **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** | | **181.5-197.0** |

*****

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).

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

‡

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^**

6 credits in the following subjects (200-499): ACCT, AE, BIO, BLAW, BMES, BUSN, CAEE, CHEM, CIVE, CMGT, CS, CT, ECE, ECEC, ECEE, ECEP, ECES, ECON, EET, EGMT, ENSS, ENVE, ENVS, FDSC, FIN GEO, INDE, INFO, INTB, MATE, MATH, MEM (except MEM 310), MET MGMT, MIS, MKTG, NFS, ORGB, OPM, PBHL, PENG, PHYS, SE, or CHE 399-380, CHE I399, CHE T480, ENGR 370, or courses approved by CHE advisor.
**AND**
6 credits in the following subjects (300-499): AE, BIO, BMES, CAEE, CHEM, CIVE, CMGT, CS, CT, ECE, ECEC, ECEE, ECEP, ECES, EET, EGMT, ENSS, ENVE, ENVS, FDSC, GEO INDE, INFO, MATE, MATH, MEM (except MEM 310), MET, NFS, PBHL, PENG, PHYS, SE, or CHE 360, CHE 373, CHE 452, CHE 460, CHE 399-480, CHE I399, CHE T480, CHEM 230, CHEM 231 [WI] , CHEM 243, ENGR 370, or courses approved by CHE advisor.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 | 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 | MATE 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†† | 3.0-4.5 | General Education elective† | 3.0 | | | | |
| | **16-17.5** | | **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 | CHE Technical elective† | 3.0 | CHE 473 | 3.0 |
| CHE 471 | 4.0 | General Education electives† | 6.0 | 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 181.5-183**

*****

CHEM Sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

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.

*******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

See degree requirements (p. 14)

††

Select 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 | | | | |
| MATE 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†† | 3.0-4.5 | General Education elective† | 3.0 | | | | |
| | **16-17.5** | | **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 | CHE Technical elective† | 3.0 | CHE 473 | 3.0 |
| CHE 471 | 4.0 | General Education elective† | 6.0 | 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 181.5-183**

*****

CHEM Sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

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.

*******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

See degree requirements (p. 14).

††

Select 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.

## 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 Accelerated 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.

## 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.

## Program Level Outcomes

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

## 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)*. Associate 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.

Nily R. Dan, PhD *(University of Minnesota)*. Associate Professor. Design of synthetic gene and drug carriers; design of polymeric drug carriers; metal cluster formation in polymeric matrices; colloidal absorption in patterned surfaces.

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

Vibha Kalra, PhD *(Cornell University) Chemical and Biological Engineering*. Assistant 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) Chemical and Biological Engineering*. Associate 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) Department Head, Chemical and Biological Engineering*. 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) Assistant Dean of Graduate Affairs, College of Engineering*. Associate 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

*Major: Civil Engineering*
*Degree Awarded: Bachelor of Science in Civil Engineering (BSCIV)*
*Calendar Type: Quarter*
*Minimum Required Credits: 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.

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. With the approval of the department head, seniors can elect to take certain graduate courses.

All students participate in senior design, a special feature of the program. A group of students works with a faculty advisor to develop a significant design project selected by the group. Learn more (https://drexel.edu/engineering/academics/undergraduate-programs/engineering-design/)

## 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 be responsible professionals who analyze, design, construct, manage, or operate built and natural infrastructure and systems, work collaboratively and communicate with stakeholders, 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

## Additional Information

The Civil Engineering program is accredited by the Engineering Accreditation Commission of ABET (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Civil and Similarly Named Engineering Programs.

For more information about this major or to apply, visit the webpage for the BS in Civil Engineering (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/civil-engineering/) or the Department of Civil, Architectural and Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/), or contact the program head:
Ivan Bartoli, PhD
Professor
Civil, Architectural and Environmental Engineering
ib77@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 ** | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | |
| Select one of the following options: † | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II † | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | 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 I | 2.0 |
| CIVE 478 [WI] | Seminar II | 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 |
| **Senior Professional Electives** | | |
| Major Area of Focus | | |
| Select a major area of focus from a sequence listed below: | | 9.0 |
| Structural Engineering Focus: | | |
| CIVE 400 | Structural Analysis II | |
| CIVE 401 | Structural Design II | |
| CIVE 402 | Structural Design III | |
| Geotechnical Engineering Focus: | | |
| CIVE 421 | Foundation Engineering | |
| CIVE 422 | Lateral Earth Pressures and Retaining Structures | |
| CIVE 423 | Engineering Ground Improvement | |
| Transportation Engineering Focus: | | |

| | | |
|---|---|---|
| CIVE 450 | Transportation Engineering | |
| CIVE 451 | Transportation System Planning | |
| CIVE 452 | Traffic Signal Systems | |
| Water Resources Focus: | | |
| CIVE 664 | Open Channel Hydraulics | |
| CIVE 431 | Hydrology-Ground Water | |
| or CIVE 565 | Urban Ecohydraulics | |
| CIVE 564 | Sustainable Water Resource Engineering | |
| Environmental Engineering Focus: | | |
| ENVE 465 | Indoor Air Quality | |
| or AE 550 | Indoor Air Quality | |
| ENVE 410 | Solid and Hazardous Waste | |
| or ENVE 42 | Water and Waste Treatment II | |
| ENVE 435 | Groundwater Remediation | |
| or ENVE 422 | Water and Waste Treatment Design | |
| Other Areas of Focus | | |
| Select from the list of courses below: ^ | | 9.0 |
| Any 400 and 500+ level AE (Architectural Engineering) course | | |
| Any 400 and 500+ level CIVE (Civil Engineering) course | | |
| Any 400 and 500+ level ENVE (Environmental Engineering) course | | |
| Special Topics courses offered by the Civil, Architecture & Environmental Engineering (CAEE) Department on a case-by-case basis. | | |
| CMGT 361 | Contracts And Specifications I | |
| CMGT 362 | Contracts and Specifications II | |
| CMGT 451 | Heavy Construction Principles & Practices | |
| CMGT 463 | Value Engineering | |
| CMGT 467 | Techniques of Project Control | |
| **Total Credits** | | **189.5-203.5** |

*****

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).

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

††

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^**

500+ level courses will require an override
Only 3 CMGT courses are allowed to count as 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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, Spring/Summer

**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 | 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 |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | CAEE 212 or GEO 101 | 4.0 | CIVE 250 | 4.0 |
| CAEE 231 | 3.0 | CAEE 232 | 3.0 | CIVE 320 | 3.0 | CIVE 330 | 4.0 |
| MATE 220 | 4.0 | CIVE 240 | 3.0 | ENVE 300 | 3.0 | COOP 101† | 1.0 |
| MEM 202 | 3.0 | ENGL 103 or 113 | 3.0 | MEM 230 | 4.0 | MEM 238 | 4.0 |
| PHYS 201 | 4.0 | ENGR 210 | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| | | | | | | Free elective | 3.0 |
| | **17** | | **15** | | **17** | | **19** |

**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 | Professiona 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 | Free elective | 3.0 | | |
| | **14** | | **13** | | **15** | | |

**Total Credits 189.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

General Education Requirements (p. 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.

‡

A sequence of three (3-credit) professional elective courses in a major area of focus is required. Pick a sequence from the list below:

- Structural Engineering Focus: CIVE 400, CIVE 401, and CIVE 402
- Geotechnical Engineering Focus: CIVE 421, CIVE 422, and CIVE 423
- Transportation Engineering Focus: CIVE 450, CIVE 451 , and CIVE 452
- Water Resources Focus: CIVE 664, CIVE 431 or CIVE 565, and CIVE 564
- Environmental Engineering Focus: ENVE 465 or AE 550 , ENVE 410 or ENVE 421, and ENVE 435or ENVE 422

An additional three (3-credit) professional elective courses are required. :Acceptable courses are as follows:
1. All 400 level CAEE courses; this includes CIVE, AE, and ENVE.
2. All AE, CIVE, and ENVE graduate level (500+) courses (you will need an override for these courses).
3. CMGT 361, CMGT 362, CMGT 451, CMGT 461, CMGT 463, and CMGT 467. Only 3 CMGT courses are allowed to count as Professional Electives.
4. Special Topics courses offered by the CAEE department on a case-by-case basis.

## 4 year, 1 co-op, Fall/Winter

**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 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | COOP 101[***] | 1.0 | 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** | | **17.5** | | **18.5** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | CAEE 212 or GEO 101 | 4.0 | CIVE 250 | 4.0 |
| CAEE 231 | 3.0 | CAEE 232 | 3.0 | CIVE 320 | 3.0 | CIVE 330 | 4.0 |
| MATE 220 | 4.0 | CIVE 240 | 3.0 | ENVE 300 | 3.0 | MEM 238 | 4.0 |
| MEM 202 | 3.0 | ENGL 103 or 113 | 3.0 | MEM 230 | 4.0 | General Education elective[†] | 3.0 |
| PHYS 201 | 4.0 | ENGR 210 | 3.0 | General Education elective[†] | 3.0 | Free elective | 3.0 |
| | **17** | | **15** | | **17** | | **18** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | CAEE 361 | 3.0 | CIVE 303 | 3.0 |
| | | | | 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 | | |
| | **0** | | **0** | | **17** | | **13** |

**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 | Professiona 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 | Free elective | 3.0 |
| | **14** | | **13** | | **15** |

**Total Credits 189.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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).

‡
A sequence of three (3-credit) professional elective courses in a major area of focus is required. Pick a sequence from the list below:

- Structural Engineering Focus: CIVE 400, CIVE 401, and CIVE 402
- Geotechnical Engineering Focus: CIVE 421, CIVE 422, and CIVE 423
- Transportation Engineering Focus: CIVE 450, CIVE 451 , and CIVE 452
- Water Resources Focus: CIVE 664, CIVE 431 or CIVE 565, and CIVE 564
- Environmental Engineering Focus: ENVE 465 or AE 550 , ENVE 410 or ENVE 421, and ENVE 435or ENVE 422

An additional three (3-credit) professional elective courses are required. :Acceptable courses are as follows:
1. All 400 level CAEE courses; this includes CIVE, AE, and ENVE.
2. All AE, CIVE, and ENVE graduate level (500+) courses (you will need an override for these courses).
3. CMGT 361, CMGT 362, CMGT 451, CMGT 461, CMGT 463, and CMGT 467. Only 3 CMGT courses are allowed to count as Professional Electives.
4. Special Topics courses offered by the CAEE department on a case-by-case basis.

## 5 year, 3 co-op, Spring/Summer

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

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 or GEO 101 | 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 | General Education elective† | 3.0 | | | | |
| General Education elective† | 3.0 | Free 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 | Professiona 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 | Free elective | 3.0 |
| | **14** | | **13** | | **15** |

**Total Credits 189.5**

*****
CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******
MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******
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).

‡
A sequence of three (3-credit) professional elective courses in a major area of focus is required. Pick a sequence from the list below:

- Structural Engineering Focus: CIVE 400, CIVE 401, and CIVE 402
- Geotechnical Engineering Focus: CIVE 421, CIVE 422, and CIVE 423
- Transportation Engineering Focus: CIVE 450, CIVE 451 , and CIVE 452
- Water Resources Focus: CIVE 664, CIVE 431 or CIVE 565, and CIVE 564
- Environmental Engineering Focus: ENVE 465 or AE 550 , ENVE 410 or ENVE 421, and ENVE 435or ENVE 422

An additional three (3-credit) professional elective courses are required. :Acceptable courses are as follows:
1. All 400 level CAEE courses; this includes CIVE, AE, and ENVE.
2. All AE, CIVE, and ENVE graduate level (500+) courses (you will need an override for these courses).
3. CMGT 361, CMGT 362, CMGT 451, CMGT 461, CMGT 463, and CMGT 467. Only 3 CMGT courses are allowed to count as Professional Electives.
4. Special Topics courses offered by the CAEE department on a case-by-case basis.

## 5 year, 3 co-op, Fall/Winter

**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 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | COOP 101*** | 1.0 | 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** | | **17.5** | | **18.5** | | **0** |

**Second Year**

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

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | CAEE 212 or GEO 101 | 4.0 | CIVE 250 | 4.0 |
| | | | | CIVE 320 | 3.0 | CIVE 330 | 4.0 |
| | | | | ENVE 300 | 3.0 | MEM 238 | 4.0 |
| | | | | MEM 230 | 4.0 | General Education Elective† | 3.0 |
| | | | | General Education† | 3.0 | Free Elective | 3.0 |
| | **0** | | **0** | | **17** | | **18** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | CAEE 361 | 3.0 | CIVE 303 | 3.0 |
| | | | | 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 | | |
| | **0** | | **0** | | **17** | | **13** |

**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 | Professiona 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 | Free elective | 3.0 |
| | **14** | | **13** | | **15** |

**Total Credits 189.5**

*****
CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******
MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******
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).

‡
A sequence of three (3-credit) professional elective courses in a major area of focus is required. Pick a sequence from the list below:

- Structural Engineering Focus: CIVE 400, CIVE 401, and CIVE 402
- Geotechnical Engineering Focus: CIVE 421, CIVE 422, and CIVE 423
- Transportation Engineering Focus: CIVE 450, CIVE 451 , and CIVE 452
- Water Resources Focus: CIVE 664, CIVE 431 or CIVE 565, and CIVE 564
- Environmental Engineering Focus: ENVE 465 or AE 550 , ENVE 410 or ENVE 421, and ENVE 435or ENVE 422

An additional three (3-credit) professional elective courses are required. :Acceptable courses are as follows:
1. All 400 level CAEE courses; this includes CIVE, AE, and ENVE.
2. All AE, CIVE, and ENVE graduate level (500+) courses (you will need an override for these courses).
3. CMGT 361, CMGT 362, CMGT 451, CMGT 461, CMGT 463, and CMGT 467. Only 3 CMGT courses are allowed to count as Professional Electives.
4. Special Topics courses offered by the CAEE department on a case-by-case basis.

## 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.

## Program Level Outcomes

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

## 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.

A. Emin Aktan, PhD *(University of Illinois at Urbana-Champaign) John Roebling Professor of Infrastructure Studies*. Professor. Structural engineering; health monitoring of large infrastructure systems; infrastructure evaluation; intelligent systems.

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)*. Associate Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

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

Peter DeCarlo, PhD *(University of Colorado)*. Assistant Professor. Outdoor air quality, particulate matter size and composition instrumentation and measurements, source apportionment of ambient particulate matter, climate impacts of particulate matter.

Eugenia Ellis, RA, PhD *(Virginia Polytechnic State University)*. Associate Professor. Extended-care facilities design, research on spatial visualization, perception and imagination.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute)*. Associate Professor. Soil mechanics; geoenvironmental; ground improvement; sustainability.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Associate 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 Professor and Department Head, Civil, Architectural and Environmental Engineering*. Professor. Control of human exposures to and risk assessment of pathogenic organisms; water and waste treatment; homeland security.

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

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) Dean of the College of Engineering and Distinguished Professor*. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Computational Fluid Dynamics (CFD) and airflow simulation; Indoor Environmental Quality; Building control integration with building information management systems.

Roger Marino, PhD *(Drexel University)*. Associate Teaching Professor. Fluid mechanics; water resources; engineering education; land development.

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

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

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

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) Graduate Studies Advisor*. Associate Professor. Environmental remediation; contaminant and bacterial transport in porous media and bacterial response to dynamic environments.

Michael Ryan, PhD *(Drexel University)*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); Dynamic Engineering Systems Modeling; Molecular Microbial Biology; Environmental Statistics; Engineering Economics; Microbiology

Christopher Sales, PhD *(University of California, Berkeley)*. Assistant Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste.

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. Research in 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 BSCE

*Major: Computer Engineering*
*Degree Awarded: Bachelor of Science in Computer Engineering (BSCE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 182.5*
*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

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. The added combination of the co-op experience opens up 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 electrical and computer engineering 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 Electrical and Computer Engineering (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 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

- 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 and make informed judgments, which must consider the impact of the engineering solutions 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 Computer Engineering program is accredited by the Engineering Accreditation Commission of ABET (https://nam10.safelinks.protection.outlook.com/?url=http%3A%2F%2Fwww.abet.org%2F&data=05%7C02%7Cdag56%40drexel.edu%7C95b40f2040474d12129008dd8354efda%7C3664e6fa47bd45a696708c4f080f8ca6%7C0%7C0%7C638811123025119579%7CTWFpbGZsb3d8eyJFbXB0eU1hcGkiOnRydWUsIlYiOiIwLjAuMDAwMCIsIlAiOiJ%3D%3D%7C0%7C%7C%7C&sdata=29cHcitymNR5NL%2BtVcUTPZdR5Xxp9Qbb1%2FklwRklqQw%3D&reserved=0), under the commission's General Criteria and Program Criteria for Electrical, Computer, Communications, Telecommunication(s), and Similarly Named Programs. The computer engineering program is accredited by the Engineering Accreditation Commission of ABET (https://www.abet.org/).

Additional information about the major or to apply is available on the ECE Department website (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/) and on the BS in Computer engineering program (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/computer-engineering/) page. For advising questions, please contact the ECE advisor (https://drexel.edu/engineering/resources/for-students/student-advising-support/current-students/).

## 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** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| or COM 310 | Technical Communication | |
| General Education Requirements ** | | 15.0 |
| **Foundation Requirements** | | |
| **Chemistry Requirements *** ** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| **Computer Science (CS) Requirements** | | |
| CS 260 | Data Structures | 4.0 |
| CS 265 | Advanced Programming Tools and Techniques | 3.0 |

| | | |
|---|---|---|
| **General Engineering 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| **Mathematics Requirements** † | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II ‡ | |
| OR | | |
| MATH 121 | Calculus I | |
| 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 |
| **Physics Requirements** † | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 |
| Senior Design | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | 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 |
| CE Core Elective (Choose one of the following): | | 3.0 |
| ECE 370 | Electronic Devices | |
| ECE 371 | Foundations of Electromagnetics for Computing & Wireless Systems | |
| ECE 380 | Fundamentals of Power and Energy | |
| **ECE Electives** ^ | | **6.0** |
| **ECE 400+ Electives** ^^ | | **9.0** |
| **Free Electives** | | **27.0** |
| **Total Credits** | | **182.5-198.5** |

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.

*****

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)

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

‡

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^**

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

**^^**

3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 (Spring/Summer Cycle)

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101* | 3.5 | ECE 200 | 4.0 | CIVC 101 | 1.0 | VACATION | |
| ECE 101 | 1.0 | ENGR 131 or 132 | 3.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | MATH 122 | 4.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | PHYS 101** | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121** | 4.0 | | | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **15** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 201 | 4.0 | COM 230 or 310 | 3.0 | CS 260 | 4.0 | COOP 101*** | 1.0 |
| ECEC 201 | 3.0 | CS 265 | 3.0 | ECE 301 | 4.0 | ECE 361 | 4.0 |
| ENGL 103 | 3.0 | ECEC 204 | 3.0 | ECE 350 | 3.0 | PHIL 315 | 3.0 |
| ENGR 231, ECE 231, CAEE 231, or MATH 201 | 3.0-4.0 | ENGR 232, ECE 232, CAEE 232, or MATH 210 | 3.0-4.0 | ECES 301 | 4.0 | CE Core elective | 3.0 |
| MATH 221 | 3.0 | PHYS 201 | 4.0 | | | Free elective | 3.0 |
| | | | | | | Science elective | 3.0 |
| | **16-17** | | **16-17** | | **15** | | **17** |

**Third Year**

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

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| ECE 400+ Elective‡ | 3.0 | ECE 400+ Elective‡ | 3.0 | ECE 400+ Elective‡ | 3.0 |
| ECE Elective†† | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| General Education elective† | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 182.5-184.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of a summer online preparatory courses available based on that score.

*******

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)

††

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

‡

3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

## 4 year, 1 co-op (Fall/Winter Cycle)

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101* | 3.5 | ECE 200 | 4.0 | CIVC 101 | 1.0 | VACATION | |
| ECE 101 | 1.0 | ENGR 131 or 132 | 3.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | MATH 122 | 4.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | PHYS 101** | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121** | 4.0 | | | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **15** | | **18** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| ECE 201 | 4.0 | COM 230 or 310 | 3.0 | CS 260 | 4.0 | ECE 361 | 4.0 |
| ECEC 201 | 3.0 | COOP 101*, | 1.0 | ECE 301 | 4.0 | PHIL 315 | 3.0 |
| ENGL 103 | 3.0 | CS 265 | 3.0 | ECE 350 | 3.0 | CE Core elective | 3.0 |
| ENGR 231, ECE 231, CAEE 231, or MATH 201 | 3.0-4.0 | ECEC 204 | 3.0 | ECES 301 | 4.0 | Free elective | 3.0 |
| MATH 221 | 3.0 | ENGR 232, ECE 232, CAEE 232, or MATH 210 | 3.0-4.0 | | | Science elective | 3.0 |
| | | PHYS 201 | 4.0 | | | | |
| | **16-17** | | **17-18** | | **15** | | **16** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | ECE 303 | 3.0 | ECE Elective†† | 3.0 |
| | | | | MATH 291 | 4.0 | Free electives | 9.0 |
| | | | | Free electives | 6.0 | General Education elective† | 3.0 |

| | | | | |
|---|---|---|---|---|
| | | General Education elective† | 3.0 | |
| | **0** | **0** | **16** | **15** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| ECE 400+ Elective‡ | 3.0 | ECE 400+ Elective‡ | 3.0 | ECE 400+ Elective‡ | 3.0 |
| ECE Elective†† | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| General Education elective† | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 182.5-184.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of a summer online preparatory courses available based on that score.

*******

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)

††

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

‡

3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

## 5 year, 3 co-op (Spring/Summer Cycle)

**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 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ECEC 201 | 3.0 | CS 265 | 3.0 | | | | |
| ENGL 103 or 113 | 3.0 | ECEC 204 | 3.0 | | | | |
| ENGR 231, ECE 231, CAEE 231, or MATH 201 | 3.0-4.0 | ENGR 232, ECE 232, CAEE 232, or MATH 210 | 3.0-4.0 | | | | |
| MATH 221 | 3.0 | PHYS 201 | 4.0 | | | | |
| | **16-17** | | **16-17** | | | **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 | | | | |
| ECE 350 | 3.0 | CE Core elective | 3.0 | | | | |
| ECES 301 | 4.0 | Science elective | 3.0 | | | | |
| | | Free elective | 3.0 | | | | |
| | **14** | | **16** | | | **0** | **0** |

**Fourth Year**

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

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| ECE 400+ Elective‡ | 3.0 | ECE 400+ Elective‡ | 3.0 | ECE 400+ Elective‡ | 3.0 |
| ECE Elective†† | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| General Education elective† | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 181.5-183.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of a summer online preparatory courses available based on that score.

***
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)

††
2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

‡
3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

## 5 year, 3 co-op (Fall/Winter Cycle)

**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 | COM 230 or 310 | 3.0 |
| | | | | ECEC 201 | 3.0 | CS 265 | 3.0 |
| | | | | ENGL 103 or 113 | 3.0 | ECEC 204 | 3.0 |
| | | | | ENGR 231, ECE 231, CAEE 231, or MATH 201 | 3.0-4.0 | ENGR 232, ECE 232, CAEE 232, or MATH 210 | 3.0-4.0 |
| | | | | MATH 221 | 3.0 | PHYS 201 | 4.0 |
| | **0** | | **0** | | **16-17** | | **16-17** |

**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 | Free elective | 3.0 |
| | | | | | | Science 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 | ECE Elective†† | 3.0 |
| | | | | MATH 291 | 4.0 | Free electives | 9.0 |
| | | | | | | Free electives | 6.0 |
| | | | | | | General Education elective† | 3.0 |
| | | | | | | General Education elective† | 3.0 |
| | **0** | | **0** | | **16** | | **15** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| ECE 491 | 3.0 | ECE 492 | 3.0 | ECE 493 | 3.0 |
| ECE 400+ Elective‡ | 3.0 | ECE 400+ Elective‡ | 3.0 | ECE 400+ Elective‡ | 3.0 |
| ECE Elective†† | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| General Education elective† | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 181.5-183.5**

*
CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**
MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of a summer online preparatory courses available based on that score.

***
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)

††
2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

‡
3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

## 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

## Additional Information

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 (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/resources/current-undergrad/).

## Bachelor's/Master's Accelerated Degree Program

Exceptional students can also pursue a Master of Science degree in the same period as a Bachelor of Science.

For more information on these and other options, visit the Department of Electrical and Computer Engineering BS/MS page (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## 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 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 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+ 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.

## Program Level Outcomes

Upon completion of the program, graduates will be prepared to:

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

## Computer Engineering Faculty

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

Tom Chmielewski, PhD *(Drexel University)*. Assistant 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.

Bruce A. Eisenstein, PhD *(University of Pennsylvania) Vice Dean, College of Engineering; Arthur J. Rowland Professor*. Professor. Pattern recognition; estimation; decision theory.

Adam K. Fontecchio, PhD *(Brown University) Vice Dean, Graduate College*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

Gary Friedman, PhD *(University of Maryland-College Park)*. Professor. Biological and biomedical applications of nanoscale magnetic systems.

Eli Fromm, PhD *(Jefferson Medical College) LeRoy A. Brothers University Professor / Director for Center of Educational Research*. Professor. Engineering education; academic research policy; bioinstrumentation; physiologic systems.

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

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) Lester A. Kraus Professor/Director, Center for Microwave/Lightwave Engineering*. 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 Graduate Affairs*. Associate Professor. Embedded systems, self-managing systems, reliable and fault-tolerant computing, distributed systems, computer architecture, and testing and verification of digital systems.

Bruce Katz, PhD *(University of Illinois)*. Adjunct Professor. Speech communication and computer science; artificial intelligence.

Youngmoo Kim, PhD *(MIT)*. Associate Professor. Audio and music signal processing, voice analysis and synthesis, music information retrieval, machine learning.

Timothy P. Kurzweg, PhD *(University of Pittsburgh)*. Associate Professor. Micro-optical systems; optical spectroscopy; programmable imaging with MEMS; bio-sensors; diffuse optical communication; MEMS fabrication; diffractive optics; optical automation; optical modeling and simulation; magnetic particle locomotion; meta-materials; reconfigurable antennas

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

Bahram Nabet, PhD *(University of Washington) Associate Dean for Special Projects, College of Engineering; Electrical and Computer Engineering*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Prawat Nagvajara, Ph.D. *(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.

Chika Nwankpa, PhD *(Illinois Institute of Technology) ECE Department Head*. Professor. Power system dynamics; power electronic switching systems; optically controlled high power switches.

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 S. Prahbu, PhD *(Harvard University)*. Auxiliary Professor. Computer and software engineering; advanced microprocessors and distributed operating 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.

Ionnis Savidis, PhD *(University of Rochester)*. Assistant 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 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)*. Assistant 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)*. Assistant Professor. Information Security; multimedia forensics and anti-forensics; information verification; adversarial dynamics; signal processing

Jaudelice Cavalcante 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

# Construction Management BSCMGT

*Major: Construction Management*
*Degree Awarded: Bachelor of Science in Construction Management (BSCMGT)*
*Calendar Type: Quarter*
*Minimum Required Credits: 187.0*
*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. Construction has traditionally been a very conservative industry, but 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.

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 to include extensive leadership development.

## 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
- Part-time, degree completion on average takes six years.

## Additional Information

The Baccalaureate program in Construction Management is accredited by the American Council for Construction Education (https://www.acce-hq.org/accreditation-process/).

For additional information, visit the BS in Construction Management (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/construction-management/) program or contact your advisor here (https://drexel.edu/engineering/resources/for-students/student-advising-support/).

## 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** * | | **7.0-10.0** |
| MATH 110 & MATH 121 | Precalculus and Calculus I | |
| OR | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 121 | Calculus I (and an approved elective) | |
| **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 |
| STAT 201 | Introduction to Business Statistics | 4.0 |
| ORGB 300 [WI] | Organizational Behavior | 4.0 |
| BLAW 201 | Business Law I | 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 Construction Management | |
| Other Approved CMGT Elective * | | |
| **Construction Capstone** | | |
| CMGT 491 [WI] | Senior Capstone I | 3.0 |
| CMGT 492 [WI] | 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** | | **187.0-190.0** |

*****

MATH sequence is determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

******

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

*******

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.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 | | | | |
| ORGB 300 | 4.0 | BLAW 201 | 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**

*****

MATH sequence is determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

**

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 | | | | |
| Free elective | 3.0 | Physical Science elective | 3.0 | | | | |
| | **17** | | **16** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CMGT 265 | 3.0 | CMGT 267 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CMGT 266 | 3.0 | CMGT 364 | 3.0 | | | | |
| CMGT 363 | 3.0 | CMGT 372 | 3.0 | | | | |
| CMGT 371 | 3.0 | CMGT 385 | 3.0 | | | | |
| PHIL 315 | 3.0 | STAT 201 | 4.0 | | | | |
| | **15** | | **16** | | **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 | | | | |
| ORGB 300 | 4.0 | CMGT 375 | 3.0 | | | | |
| Construction Management elective | 3.0 | CMGT 485 | 3.0 | | | | |
| Humanities/ Social Science elective | 3.0 | Construction Management elective | 3.0 | | | | |
| | **16** | | **16** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| BLAW 201 | 4.0 | CMGT 450 | 3.0 | CMGT 493 | 3.0 |
| CMGT 463 | 3.0 | CMGT 461 | 3.0 | Construction Management elective | 3.0 |
| CMGT 467 | 4.0 | CMGT 486 | 3.0 | Free electives | 6.0 |
| CMGT 491 | 3.0 | CMGT 492 | 3.0 | | |
| Humanities/ Social Science elective | 3.0 | Humanities/ Social Science elective | 3.0 | | |
| | **17** | | **15** | | **12** |

**Total Credits 187**

*

MATH sequence is determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

**

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 - This concentration will be eliminated Fall 2025

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 [WI] | Senior Capstone I | 3.0 |
| CMGT 492 [WI] | 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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.
- IMC Construction

## 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.

## Program Level Outcomes

Upon completion of the program, graduates will be prepared to:

- Demonstrate knowledge of relevant subject matter described in the American Council for Construction Education (ACCE) guidelines.
- Demonstrate leadership qualities through experiential learning
- Apply various techniques and methods to efficiently and effectively plan and control construction projects

- Understand the value of and apply sustainable building practices to optimize use of available resources

## Construction Management Faculty

Robert 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.

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

Kenneth S. Sands, PhD *(Virginia Tech)*. Associate Clinical Professor. Workforce development and lifelong learning; ethics and construction education; transformative safety leadership for construction education; sustainable facilities and infrastructure.

Richard Sievert, PhD *(Northwestern University)*. Associate Clinical Professor. Project management and construction management; value engineering; cost reduction and waste minimization; facilities planning and management; marketing and selling professional services; quality management, engineering and construction business administration.

# Electrical Engineering BSEE

*Major: Electrical Engineering*
*Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 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.

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 engineering program educational objectives are that 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

**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 state-of-the-art laboratories including the Interconnected Power System Laboratory, where students can operate and control a small power system through the fusing of computer software and hardware technology with high-voltage, high-power technology. In the Ortlip Systems Laboratory various experiments can be performed 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.

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

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, communications networks, digital radio, medical diagnostic image processing, high-definition television, cellular and wireless communications, satellite communications, networked multimedia communications and personal communication systems.

## Additional Information

The Electrical Engineering program is accredited by the Engineering Accreditation Commission of ABET (https://nam10.safelinks.protection.outlook.com/?url=http%3A%2F%2Fwww.abet.org%2F&data=05%7C02%7Cdag56%40drexel.edu%7C95b40f2040474d12129008dd8354efda%7C3664e6fa47bd45a696708c4f080f8ca6%7C0%7C0%7C638811123025150%7CTWFpbGZsb3d8eyJFbXB0eU1hcGkiOnRydWUsIlYiOiIwLjAuMDAwMCIsIkFOIjoiTWFpbCIsIldUIjoyfQ%3D%3D%7C0%7C%7C%7C&sdata=pHRGc3En5XSio4fWklaK9Hi21qKnBMhtpWXz3xgrPY4%3D&reserved=0) under the commission's General Criteria and Program Criteria for Electrical, Computer, Communications, Telecommunication(s), and Similarly Named Programs.The Electrical Engineering program is accredited by the Engineering Accreditation Commission of ABET, www.abet.org.

For additional information or to apply, visit the BS in Electrical Engineering page (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/electrical-engineering/) or 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 |
| **Communications Elective** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| or COM 310 | Technical Communication | |
| General Education Courses ** | | 15.0 |
| **Foundation Requirements** | | |
| **Chemistry Requirements *** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| **General Engineering 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| **Mathematics Requirements †** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II ‡ | |
| OR | | |

| | | |
|---|---|---|
| MATH 121 | Calculus I | |
| 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 |
| **Physics Requirements** † | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| Senior Design ^ | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| EE Core Elective (Choose one of the following): | | 3.0-4.0 |
| CS 260 | Data Structures | |
| CS 265 | Advanced Programming Tools and Techniques | |
| ECE 350 | Introduction to Computer Organization | |
| ECE Electives ^^ | | 6.0 |
| ECE 400-level Electives § | | 9.0 |
| Free Electives | | 27.0 |
| **Total Credits** | | **181.5-198.5** |

*****

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 Courses (p. 5)

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

‡

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^**

Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

**^^**

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

**§**

3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 (Spring/Summer cycle)

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

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101* | 3.5 | ECE 200 | 4.0 | CIVC 101 | 1.0 | VACATION | |
| ECE 101 | 1.0 | ENGR 131 or 132 | 3.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | MATH 122 | 4.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | PHYS 101** | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121** | 4.0 | | | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **15** | | **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 | COOP 101*** | 1.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ECEC 201 | 3.0 | ECEC 204 | 3.0 | ECE 370 | 3.0 | ECE 361 | 4.0 |
| ENGL 103 or 113 | 3.0 | ENGR 232, ECE 232, CAEE 232, or MATH 210 | 3.0-4.0 | ECES 301 | 4.0 | ECE 371 | 3.0 |
| ENGR 231, ECE 231, CAEE 231, or MATH 201 | 3.0-4.0 | PHIL 315 | 3.0 | EE Core elective | 3.0 | ECE 380 | 3.0 |
| MATH 291 | 4.0 | PHYS 201 | 4.0 | | | Science elective | 3.0 |
| | | | | | | Free elective | 3.0 |
| | **17-18** | | **16-17** | | **14** | | **17** |

**Third Year**

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

**Fourth Year**

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

**Total Credits 181.5-183.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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)

††

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

‡

3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

## 4 year, 1 co-op (Fall/Winter cycle)

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

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101[*] | 3.5 | ECE 200 | 4.0 | CIVC 101 | 1.0 | VACATION | |
| ECE 101 | 1.0 | ENGR 131 or 132 | 3.0 | ECE 105 | 3.0 | | |
| ENGL 101 or 111 | 3.0 | MATH 122 | 4.0 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | PHYS 101[**] | 4.0 | ENGR 113 | 3.0 | | |
| MATH 121[**] | 4.0 | | | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | | | PHYS 102 | 4.0 | | |
| | **15.5** | | **15** | | **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 | COOP 101[*] | 1.0 | ECE 370 | 3.0 | ECE 371 | 3.0 |
| ENGL 103 or 113 | 3.0 | ECEC 204 | 3.0 | ECES 301 | 4.0 | ECE 380 | 3.0 |
| ENGR 231, ECE 231, CAEE 231, or MATH 201 | 3.0-4.0 | ENGR 232, ECE 232, CAEE 232, or MATH 210 | 3.0-4.0 | EE Core elective | 3.0 | Science elective | 3.0 |
| MATH 291 | 4.0 | PHIL 315 | 3.0 | | | Free elective | 3.0 |
| | | PHYS 201 | 4.0 | | | | |
| | **17-18** | | **17-18** | | **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 | Free electives | 9.0 |
| | | | | Free electives | 6.0 | General Education elective[†] | 3.0 |
| | | | | General Education elective[†] | 3.0 | | |
| | **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, ECEE, ECEP, ECES 400+ level elective[‡] | 3.0 | ECE, ECEE, ECEP, ECES 400+ level elective[‡] | 3.0 | ECE, ECEE, ECEP, ECES 400+ level elective[‡] | 3.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ECE elective[††] | 3.0 | Free elective | 3.0 | Free elective | 3.0 | | |
| Free elective | 3.0 | General Education elective[†] | 3.0 | General Education elective[†] | 3.0 | | |
| General Education elective[†] | 3.0 | | | | | | |
| | **15** | | **12** | | **12** | | |

**Total Credits 181.5-183.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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)

††

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

‡

3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

## 5 year, 3 co-op (Spring/Summer cycle)

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

**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 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| ECEC 201 | 3.0 | ECEC 204 | 3.0 | | | | |
| ENGL 103 or 113 | 3.0 | ENGR 232, ECE 232, CAEE 232, or MATH 210 | 3.0-4.0 | | | | |
| ENGR 231, ECE 231, CAEE 231, or MATH 201 | 3.0-4.0 | PHIL 315 | 3.0 | | | | |
| MATH 291 | 4.0 | PHYS 201 | 4.0 | | | | |
| | **17-18** | | **16-17** | | **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 | | | | |
| ECES 301 | 4.0 | ECE 380 | 3.0 | | | | |
| EE Core elective | 3.0 | Free elective | 3.0 | | | | |
| | | Science elective | 3.0 | | | | |
| | **14** | | **16** | | **0** | | **0** |

**Fourth Year**

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

**Fifth Year**

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

**Total Credits 181.5-183.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

***

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)

††
2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

‡
3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

## 5 year, 3 co-op (Fall/Winter cycle)

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

**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 | COM 230 or 310 | 3.0 |
| | | | | ECEC 201 | 3.0 | ECEC 204 | 3.0 |
| | | | | ENGL 103 or 113 | 3.0 | ENGR 232, ECE 232, CAEE 232, or MATH 210 | 3.0-4.0 |
| | | | | ENGR 231, ECE 231, CAEE 231, or MATH 201 | 3.0-4.0 | PHIL 315 | 3.0 |
| | | | | MATH 291 | 4.0 | PHYS 201 | 4.0 |
| | **0** | | **0** | | **17-18** | | **16-17** |

**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 | Free elective | 3.0 |
| | | | | | | Science 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 | ECE elective†† | 3.0 |
| | | | | MATH 221 | 3.0 | Free electives | 9.0 |
| | | | | Free electives | 6.0 | General Education elective† | 3.0 |
| | | | | 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, ECEE, ECEP, ECES 400+ level elective‡ | 3.0 | ECE, ECEE, ECEP, ECES 400+ level elective‡ | 3.0 | ECE, ECEE, ECEP, ECES 400+ level elective‡ | 3.0 |
| ECE elective†† | 3.0 | Free elective | 3.0 | Free elective | 3.0 |
| Free elective | 3.0 | General Education elective† | 3.0 | General Education elective† | 3.0 |
| General Education elective† | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 181.5-183.5**

*

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

***

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)

††
2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

‡
3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

## 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.

# Accelerated/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 (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/resources/current-undergrad/).

## Bachelor's/Master's Accelerated 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 (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) 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 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.

# Program Level Outcomes

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

## Electrical Engineering Faculty

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

Tom Chmielewski, PhD *(Drexel University)*. Assistant 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.

Bruce A. Eisenstein, PhD *(University of Pennsylvania) Vice Dean, College of Engineering; Arthur J. Rowland Professor*. Professor. Pattern recognition; estimation; decision theory.

Adam K. Fontecchio, PhD *(Brown University) Vice Dean, Graduate College*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

Gary Friedman, PhD *(University of Maryland-College Park)*. Professor. Biological and biomedical applications of nanoscale magnetic systems.

Eli Fromm, PhD *(Jefferson Medical College) LeRoy A. Brothers University Professor / Director for Center of Educational Research*. Professor. Engineering education; academic research policy; bioinstrumentation; physiologic systems.

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

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) Lester A. Kraus Professor/Director, Center for Microwave/Lightwave Engineering*. 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 Graduate Affairs*. Associate Professor. Embedded systems, self-managing systems, reliable and fault-tolerant computing, distributed systems, computer architecture, and testing and verification of digital systems.

Bruce Katz, PhD *(University of Illinois)*. Adjunct Professor. Speech communication and computer science; artificial intelligence.

Youngmoo Kim, PhD *(MIT)*. Associate Professor. Audio and music signal processing, voice analysis and synthesis, music information retrieval, machine learning.

Timothy P. Kurzweg, PhD *(University of Pittsburgh)*. Associate Professor. Micro-optical systems; optical spectroscopy; programmable imaging with MEMS; bio-sensors; diffuse optical communication; MEMS fabrication; diffractive optics; optical automation; optical modeling and simulation; magnetic particle locomotion; meta-materials; reconfigurable antennas

John Lacontora, PhD *(New Jersey Institute of Technology)*. Associate Research Professor. Service engineering; industrial engineering.

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

Bahram Nabet, PhD *(University of Washington) Associate Dean for Special Projects, College of Engineering; Electrical and Computer Engineering*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Prawat Nagvajara, Ph.D. *(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.

Chika Nwankpa, PhD *(Illinois Institute of Technology) ECE Department Head*. Professor. Power system dynamics; power electronic switching systems; optically controlled high power switches.

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 S. Prahbu, PhD *(Harvard University)*. Auxiliary Professor. Computer and software engineering; advanced microprocessors and distributed operating systems.

William C. Regli, PhD *(University of Maryland-College Park)*. Professor. Artificial intelligence; computer graphics; engineering design and Internet computing.

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.

Ionnis Savidis, PhD *(University of Rochester)*. Assistant 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 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)*. Assistant 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) Associate Dean, Strategic Planning, College of Engineering*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laster spectroscopy, including Raman scattering.

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

Jaudelice Cavalcante 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

# Engineering BSE

*Major: Engineering*
*Degree Awarded: Bachelor of Science in Engineering (BSE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 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

***This program is only available for students in year two and beyond as a change of major.***

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

Students should contact their academic advisor (https://drexel.edu/engineering/resources/for-students/student-advising-support/). More information about available engineering programs can be found 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. 51).

# 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. 51).

## 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. 51).

# 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.

## Program Level Outcomes

Upon completion of the program, graduates will be prepared to:

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

# Engineering Technology BSET

*Major: Engineering Technology*
*Degree Awarded: Bachelor of Science in Engineering Technology (BSET)*
*Calendar Type: Quarter*
*Minimum Required Credits: 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: 14.4101*
*Standard Occupational Classification (SOC) code: 17-3029; 17-3027*

## About the Program

The BS in Engineering Technology (ET) program at Drexel University is designed for those who are driven to make a difference—solution seekers who want to tackle today's most pressing engineering challenges. This is a program for thinkers, doers, and innovators who are eager to transform ideas into meaningful, tangible outcomes.

Engineering Technology is a fully accredited engineering degree that integrates applied learning with a broad, multidisciplinary foundation in mechanical, electrical, manufacturing, robotics and systems and industrial engineering. The curriculum emphasizes the application of theory, systems thinking, and practical design, preparing graduates to operate confidently at the intersection of engineering innovation and implementation.

**An Engineering Degree with a Purpose**

Drexel's BS in Engineering Technology is grounded in core engineering principles but also built around a practice- and systems-based learning philosophy. The program responds to the real-world needs of industry and society, equipping students to become agile, industry-ready professionals who are problem solvers by design.

Students learn to bring engineering solutions to life by integrating technical knowledge with professional skills—communicating across disciplines, working collaboratively, and navigating complex systems. This experiential approach allows graduates to immediately contribute in diverse engineering environments and lead with impact.

**Why Choose Drexel's ET Program?**

- **Learn by Applying Knowledge**: From day one, students engage in project-based courses and lab-intensive experiences that connect foundational knowledge in math, science, and engineering to modern-day challenges. Learning is structured, intentional, and industry aligned.
- **Engineering Across Disciplines**: The program's multidisciplinary scope gives students the versatility to analyze, design, and improve integrated systems—bridging mechanical components, electronic controls, manufacturing processes, and automation technologies.
- **Practice-Infused Education**: With extensive use of labs, real-world design challenges, and simulation tools, students gain fluency in the technologies that define modern engineering fields—from smart manufacturing and renewable energy to robotics and intelligent infrastructure.
- **Career-Ready Skillset**: Students graduate with not just a degree, but with a professional portfolio built through a three-term capstone design project, industry-sponsored initiatives, and Drexel's renowned co-op program. They are prepared to solve problems, lead teams, and contribute immediately at the workplace.
- **Strong Industry Demand**: Engineering technology professionals are in high demand across sectors including robotics, energy, advanced manufacturing, defense, healthcare, and transportation. The ET degree provides the tools, mindset, and experience to thrive in this evolving landscape.

**Flexible and Specialized Pathways**

During pre-junior year, students can customize their academic journey by choosing from one of four concentrations:

- Electrical Engineering Technology (https://catalog.drexel.edu/undergraduate/collegeofengineering/electricalengineeringtechnology/)
- Systems and  (https://catalog.drexel.edu/undergraduate/collegeofengineering/systemsindustrialengineeringtechnology/)Industrial Engineering Technology (https://catalog.drexel.edu/undergraduate/collegeofengineering/industrialengineeringtechnology/)
- Mechanical and Manufacturing Engineering Technology (https://catalog.drexel.edu/undergraduate/collegeofengineering/engineeringtechnology/mechanicalandmanufacturingconcentration/)
- Robotics and Automation Engineering Technology (https://catalog.drexel.edu/undergraduate/collegeofengineering/engineeringtechnology/roboticsandautomationconcentration/)

Each concentration allows for deeper technical preparation while maintaining the program's commitment to broad, systems-level problem solving.

**Real-World Experience That Sets You Apart**

Through Drexel's cooperative education (co-op) program, students can pursue a 4-year plan with one co-op or a 5-year plan with three. These are paid, full-time professional experiences with companies that often lead directly to post-graduation employment.

In addition to co-op, students gain valuable industry exposure through:

- Internships and research
- Industry-sponsored senior design projects
- Guest lectures and technical site visits
- Regional and global networking opportunities

**Shaping the Engineers of Tomorrow**

Graduates of the ET program are engineering professionals with a practical edge—ready to lead projects, manage systems, and implement technologies across a wide range of industries. Whether in robotics, clean energy, intelligent infrastructure, healthcare technologies, or beyond, our alumni are known for their ability to identify challenges and deliver actionable solutions.

The program also provides a strong foundation for graduate studies in areas such as engineering management, business, systems engineering, or healthcare innovation. It is ABET-accredited, supporting students' eligibility for Fundamentals of Engineering (FE) and Professional Engineer (PE) licensure.

**Mission-Driven. Outcome-Focused.**

At its core, the Drexel ET program is committed to developing engineers who are purposeful, adaptive, and technically fluent. We educate the next generation of solution seekers who are prepared to navigate complexity, lead innovation, and contribute meaningfully to society's most urgent challenges.

**Engineering Technology Program Educational Objectives**

Produces graduates who:

- Apply critical thinking, discipline-specific theory, experiments, real world experience, and advanced engineering 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 and on teams, in contributor and supervisory roles, to design, develop, manage and improve quality systems, components, products and processes in a timely, responsible and creative manner.
- Demonstrate behavior consistent with professional ethics, remaining 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 and to analyze and interpret the results to improve processes
- An ability to function effectively as a member as well as a 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), under the commission's General Criteria and Program Criteria for Engineering Technology and Similarly Named Engineering Programs.

For additional information, please visit the Engineering Technology webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/engineering-technology/) or contact your assigned College of Engineering advisor (https://drexel.edu/engineering/resources/for-students/student-advising-support/).

# 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.

# Environmental Engineering BSENE

*Major: Environmental Engineering*
*Degree Awarded: Bachelor of Science in Environmental Engineering (BSENE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 185.5*
*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 be responsible professionals who analyze, design, construct, manage or operate facilities or systems to protect or enhance the environment of people and other living things, work collaboratively and communicate with stakeholders, 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 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 while using appropriate learning strategies

## Additional Information

The Environmental Engineering program is accredited by the Engineering Accreditation Commission of ABET (https://www.abet.org/), under the commission's General Criteria and Program Criteria for Environmental and Similarly Named Engineering Programs.

For more information, visit the Civil, Architectural and Environmental Engineering Department (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/) and the BS in Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/academic-programs/undergraduate/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 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | |
| Select one of the following options: † | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II ‡ | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 |
| or ENVE 316 | Fundamentals of Environmental Biotechnology | |
| CAEE 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CHE 211 | Material and Energy Balances I | 4.0 |
| CHEM 241 | Organic Chemistry I | 4.0 |
| CHEM 242 | Organic Chemistry II | 4.0 |
| CIVE 240 | 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** | | |
| Select 6.0 credits in the following subjects (200-499): ^ | | 6.0 |
| Any AE (Architectural Engineering) course | | |
| Any BIO (Bioscience & Biotechnology) course | | |
| Any BMES (Biomedical Engineering & Sci) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CHEM (Chemistry) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any CS (Computer Science) course | | |

| | | |
|---|---|---|
| Any ECE (Electrical & Computer Engr) course | | |
| Any ECEC (Elec & Comp Engr-Computers) course | | |
| Any ECEE (Elec & Computer Engr-Electroph) course | | |
| Any ECEP (Elec & Computer Engr-Power Eng) course | | |
| Any ECES (Elec & Computer Engr-Systems) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any ENVS (Environmental Science) course | | |
| Any GEO (Geoscience) course | | |
| Any INFO (Information Science & Systems) course | | |
| Any MATE (Materials Engineering) course | | |
| Any MATH (Mathematics) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| Any PHYS (Physics) course | | |
| Any SE (Software Engineering) course | | |
| Select 6.0 credits in the following subjects (300-499): ^ | | 6.0 |
| Any AE (Architectural Engineering) course | | |
| Any BIO (Bioscience & Biotechnology) course | | |
| Any BMES (Biomedical Engineering & Sci) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CHEM (Chemistry) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any CS (Computer Science) course | | |
| Any ECE (Electrical & Computer Engr) course | | |
| Any ECEC (Elec & Comp Engr-Computers) course | | |
| Any ECEE (Elec & Computer Engr-Electroph) course | | |
| Any ECEP (Elec & Computer Engr-Power Eng) course | | |
| Any ECES (Elec & Computer Engr-Systems) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any ENVS (Environmental Science) course | | |
| Any GEO (Geoscience) course | | |
| Any INFO (Information Science & Systems) course | | |
| Any MATE (Materials Engineering) course | | |
| Any MATH (Mathematics) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| Any PHYS (Physics) course | | |
| Any SE (Software Engineering) course | | |
| PBHL 305 | Women and Children: Health & Society | |
| PBHL 314 | Environmental and Occupational Health | |
| PBHL 317 | The World's Water | |
| PBHL 321 | Disease Outbreak Investigations | |
| PBHL 350 | Introduction to Urban Health | |
| PBHL 457 | Adapting to a Hotter Climate: Protecting Health of Vulnerable Populations | |
| **Total Credits** | | **185.5-199.5** |

*****

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).

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**†**

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

**‡**

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^**

Or courses approved by ENVE advisor.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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, Spring/Summer

**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 | 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 |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | CAEE 212 or GEO 101 | 4.0 | CIVE 330 | 4.0 |
| CAEE 231 | 3.0 | CAEE 232 | 3.0 | CHE 211 | 4.0 | COOP 101* | 1.0 |
| ENGL 103 or 113 | 3.0 | CIVE 240 | 3.0 | CIVE 320 | 3.0 | ENVE 302 | 3.0 |
| MATE 220 | 4.0 | ENVS 230 | 3.0 | ENVE 300 | 3.0 | PHIL 315 | 3.0 |
| PHYS 201 | 4.0 | MEM 210 | 3.0 | | | General Education elective† | 3.0 |
| | **17** | | **15** | | **14** | | **14** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 361 | 3.0 | BIO 220 or ENVE 316 | 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 185.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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. 57).

††

6.0 credits in the following subjects (200-499): AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ECEP, ECEE, ECES, ECEC, GEO, ENVE, ENVS, INFO, MATE, MATH, MEM, PHYS, SE or courses approved by ENVE advisor.

**AND**

6.0 credits in the following subjects (300-499): AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ECEP, ECEE, ECES, ECEC, GEO, ENVE, ENVS, INFO, MATE, MATH, MEM, PHYS, SE, or PBHL 305, PBHL 314, PBHL 317, PBHL 321, PBHL 350, PBHL 457 or courses approved by ENVE advisor.

## 4 year, 1 co-op, Fall/Winter

**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 | 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 |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | CAEE 212 or GEO 101 | 4.0 | CIVE 330 | 4.0 |
| CAEE 231 | 3.0 | CAEE 232 | 3.0 | CHE 211 | 4.0 | ENVE 302 | 3.0 |
| ENGL 103 or 113 | 3.0 | CIVE 240 | 3.0 | CIVE 320 | 3.0 | PHIL 315 | 3.0 |
| MATE 220 | 4.0 | COOP 101*** | 1.0 | ENVE 300 | 3.0 | General Education elective† | 3.0 |
| PHYS 201 | 4.0 | ENVS 230 | 3.0 | | | | |
| | | MEM 210 | 3.0 | | | | |
| | **17** | | **16** | | **14** | | **13** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | CAEE 361 | 3.0 | BIO 220 or ENVE 316 | 3.0 |
| | | | | CHEM 241 | 4.0 | CHEM 242 | 4.0 |
| | | | | CIVE 430 | 3.0 | General Education Electives† | 6.0 |
| | | | | ENVS 401 | 3.0 | Technical Electives†† | 3.0 |
| | | | | General Education Electives† | 3.0 | | |
| | **0** | | **0** | | **16** | | **16** |

**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 185.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

***

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. 57).

††
6.0 credits in the following subjects (200-499): AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ECEP, ECEE, ECES, ECEC, GEO, ENVE, ENVS, INFO, MATE, MATH, MEM, PHYS, SE or courses approved by ENVE advisor.

**AND**

6.0 credits in the following subjects (300-499): AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ECEP, ECEE, ECES, ECEC, GEO, ENVE, ENVS, INFO, MATE, MATH, MEM, PHYS, SE, or PBHL 305, PBHL 314, PBHL 317, PBHL 321, PBHL 350, PBHL 457 or courses approved by ENVE advisor.

## 5 year, 3 co-op, Spring/Summer

**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 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 |
|---|---|---|---|---|---|---|---|
| CAEE 202 | 3.0 | CAEE 203 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CAEE 231 | 3.0 | CAEE 232 | 3.0 | | | | |
| ENGL 103 or 113 | 3.0 | CIVE 240 | 3.0 | | | | |
| MATE 220 | 4.0 | ENVS 230 | 3.0 | | | | |
| PHYS 201 | 4.0 | MEM 210 | 3.0 | | | | |
| | **17** | | **15** | | **0** | | **0** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 212 or GEO 101 | 4.0 | CIVE 330 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| CHE 211 | 4.0 | ENVE 302 | 3.0 | | | | |
| CIVE 320 | 3.0 | PHIL 315 | 3.0 | | | | |
| ENVE 300 | 3.0 | General Education elective† | 3.0 | | | | |
| | **14** | | **13** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CAEE 361 | 3.0 | BIO 220 or ENVE 316 | 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 185.5**

*
CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**
MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

***
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. 57).

††
6.0 credits in the following subjects (200-499): AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ECEP, ECEE, ECES, ECEC, GEO, ENVE, ENVS, INFO, MATE, MATH, MEM, PHYS, SE or courses approved by ENVE advisor.

**AND**

6.0 credits in the following subjects (300-499): AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ECEP, ECEE, ECES, ECEC, GEO, ENVE, ENVS, INFO, MATE, MATH, MEM, PHYS, SE, or PBHL 305, PBHL 314, PBHL 317, PBHL 321, PBHL 350, PBHL 457 or courses approved by ENVE advisor.

## 5 year, 3 co-op, Fall/Winter

**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 | ENGL 102 or 112 | 3.0 | | |
| ENGR 111 | 3.0 | COOP 101*** | 1.0 | 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** | | **17.5** | | **18.5** | | **0** |

**Second Year**

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

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | CAEE 212 or GEO 101 | 4.0 | CIVE 330 | 4.0 |
| | | | | CHE 211 | 4.0 | ENVE 302 | 3.0 |
| | | | | CIVE 320 | 3.0 | PHIL 315 | 3.0 |
| | | | | ENVE 300 | 3.0 | General Education Electives† | 3.0 |
| | **0** | | **0** | | **14** | | **13** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | CAEE 361 | 3.0 | BIO 220 or ENVE 316 | 3.0 |
| | | | | CHEM 241 | 4.0 | CHEM 242 | 4.0 |
| | | | | CIVE 430 | 3.0 | General Education Electives† | 6.0 |
| | | | | ENVS 401 | 3.0 | Technicsal Electives†† | 3.0 |
| | | | | General Education Electives† | 3.0 | | |
| | **0** | | **0** | | **16** | | **16** |

**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 185.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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. 57).

††

6.0 credits in the following subjects (200-499): AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ECEP, ECEE, ECES, ECEC, GEO, ENVE, ENVS, INFO, MATE, MATH, MEM, PHYS, SE or courses approved by ENVE advisor.

**AND**

6.0 credits in the following subjects (300-499): AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ECEP, ECEE, ECES, ECEC, GEO, ENVE, ENVS, INFO, MATE, MATH, MEM, PHYS, SE, or PBHL 305, PBHL 314, PBHL 317, PBHL 321, PBHL 350, PBHL 457 or courses approved by ENVE advisor.

## 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

## 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 Accelerated 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.

For more information on this program, visit the Department's BS/MS Accelerated Degree Program (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-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

## Program Level Outcomes

Upon completion of the program, graduates will be prepared to:

- Identify, formulate, and solve complex engineering problems by applying principles of engineering, science and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

## 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.

A. Emin Aktan, PhD *(University of Illinois at Urbana-Champaign) John Roebling Professor of Infrastructure Studies*. Professor. Structural engineering; health monitoring of large infrastructure systems; infrastructure evaluation; intelligent systems.

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)*. Associate Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

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

Peter DeCarlo, PhD *(University of Colorado)*. Assistant Professor. Outdoor air quality, particulate matter size and composition instrumentation and measurements, source apportionment of ambient particulate matter, climate impacts of particulate matter.

Eugenia Ellis, RA, PhD *(Virginia Polytechnic State University)*. Associate Professor. Extended-care facilities design, research on spatial visualization, perception and imagination.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute)*. Associate Professor. Soil mechanics; geoenvironmental; ground improvement; sustainability.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Associate 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 Professor and Department Head, Civil, Architectural and Environmental Engineering*. Professor. Control of human exposures to and risk assessment of pathogenic organisms; water and waste treatment; homeland security.

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

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) Dean of the College of Engineering and Distinguished Professor*. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Computational Fluid Dynamics (CFD) and airflow simulation; Indoor

Environmental Quality; Building control integration with building information management systems.

Roger Marino, PhD *(Drexel University)*. Associate Teaching Professor. Fluid mechanics; water resources; engineering education; land development.

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

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

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

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) Graduate Studies Advisor*. Associate Professor. Environmental remediation; contaminant and bacterial transport in porous media and bacterial response to dynamic environments.

Michael Ryan, PhD *(Drexel University)*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); Dynamic Engineering Systems Modeling; Molecular Microbial Biology; Environmental Statistics; Engineering Economics; Microbiology

Christopher Sales, PhD *(University of California, Berkeley)*. Assistant Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste.

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. Research in 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 BSMSE

*Major: Materials Science and Engineering*
*Degree Awarded: Bachelor of Science in Materials Science and Engineering (BSMSE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 186.5*
*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 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 process and characterize materials and evaluate their structure, properties and performance.

Several required senior level courses emphasize the role and importance of materials selection and specification in design. A number of tracks allow upper-level students to focus their technical electives in areas of specialization, including:

- Materials for Energy
- Materials for Medical Technology
- Materials for Sustainability

- Manufacturing and Materials Processing
- Custom Track

During their 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 or postdoc mentor. Students, working in small teams, synthesize information and knowledge from their courses to arrive at solutions to real-world engineering problems.

Examples of recent senior design project topics include:

- Chemical Decoration of Asymmetric Particles.
- Design of an Electrochromic Device using MXene and Oxide Nanoflake Composites.
- MXene Heat Shields for Residential Buildings, Cities on Mars, and More.
- Designing Functional Polymer Nanoparticles.
- Computational and Experimental Co-design of Synthetic Pathways to Oxynitrides.
- Design of an Electrochromic Device Using Bi-layered Vanadium Oxide.
- Modeling of Thermodynamic Properties and Phase Stability of High Entropy Alloys *via* Physics-Informed Machine Learning.
- Synthesis of Biopolymer Biocomposites Using Food Waste Derived Cellulose Nanofibers.
- Investigation of Alkali-Activated Concretes by Examining the Pozzolanic Activity in Diatomaceous Earth.
- Microneedle Patch for Therapeutic Delivery.
- Synthesis of High Glass-Transition Temperature Poly(imide) Based Covalent Adaptable Networks.
- Design of a Solvent-Based Separation Process for Recycling Polyethylene and Polypropylene.
- Fabrication of MXenes with Large Flakes.
- Polymer/Metal Additive Manufacturing Materials Development.
- Photoluminescent Nanocrystals as Photocatalysts.
- Touchspinning of Chitosan Nanofibers.
- Scaling-up a Topochemical Fluorination Reactor.
- Hybrid Nanovesicles Made of Cell Membranes and Phosphoipids.
- Stereocomplexed Nanofiber Shish-Kebabs for Sustainable Polymer Nanocomposites.
- Solid Polymer Electrolytes (SPE) for Lithium Metal Batteries.
- Photoluminescent Fibers as Smart Textiles.

## 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 will remain 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 will be recognized as a world 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:

- ***Program Educational Objective #1:*** Materials Science and Engineering program graduates possess the core technical competencies necessary to become successful practicing, professional engineers, and interface with engineers from other disciplines.
- ***Program Educational Objective #2:*** Materials Science and Engineering program graduates have progressed to become leaders in industry and academia, are engaged in lifelong learning and exhibit a strong sense of professional responsibility.
- ***Program Educational Objective #3:*** Materials Science and Engineering program graduates possess strong written and verbal communication skills required for success in the profession.

## 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 Materials Science and Engineering program (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/materials-science-engineering/) is accredited by the Engineering Accreditation Commission of ABET **(**https://nam10.safelinks.protection.outlook.com/?url=https%3A%2F%2Fwww.abet.org%2F&data=05%7C02%7Cknightr%40drexel.edu%7Cd66dd8b94ec641cc87fa08dd5ff1981b%7C3664e6fa47bd45a696708c4f080f8ca6%7C0%7C0%7C638772213428299689%7CTWFpbGZsb3d8eyJFbXB0eU1hcGkiOnRydWUsIlYiOiIwLjAuMDAwMCIsIlAiOiJ%3D%3D%7C0%7C%7C%7C&sdata=R5SzzZTTBsL0R0583W0hXCWZHWGZ0UBX2RryjgxoP1U%3D&reserved=0**)**, under the commission's General Criteria and Program

Criteria for Materials, Metallurgical, Ceramics, and Similarly Named Engineering Programs.

# 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 |
| **Technical Electives/Track Courses (Choose one track) ** ** | | **9.0** |
| **Materials for Energy** | | |
| CHE 431 | Fundamentals of Solar Cells | |
| CHE 432 | Electrochemical Engineering | |
| ECE 380 | Fundamentals of Power and Energy | |
| 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 480 | Solar Energy Engineering | |
| EET 320 | Renewable Energy Systems | |
| MATE 482 | Materials for Energy Storage | |
| MEM 415 | Fuel Cell Engines | |
| MEM 445 | Solar Energy Fundamentals | |
| **Materials for Sustainability** | | |
| CHE 430 | Introduction to Sustainable Engineering | |
| CHE 431 | Fundamentals of Solar Cells | |
| ECEP 380 | Introduction to Renewable Energy | |
| ECEP 480 | Solar Energy Engineering | |
| ENVE 316 | Fundamentals of Environmental Biotechnology | |
| ENVE 410 | Solid and Hazardous Waste | |
| ENVE 471 | Environmental Life Cycle Assessment | |
| MATE 476 | Recycling of Materials | |
| MATE 483 | Environmental Effects on Materials | |
| **Materials for Medical Technology** | | |
| BIO 201 | Human Physiology I | |
| BIO 311 | Biochemistry | |
| BMES 441 | Biomechanics I: Introduction to Biomechanics | |
| BMES 460 | Biomaterials I | |
| BMES 461 | Biomaterials II | |
| BMES 471 | Cellular and Molecular Foundations of Tissue Engineering | |
| BMES 472 | Developmental and Evolutionary Foundations of Tissue Engineering | |
| BMES 488 | Medical Device Development | |
| CHE 360 | BioProcess Principles | |
| CHE 461 | Principles of Colloid Science | |
| CHEM 371 | Chemistry of Biomolecules | |
| CHEM 375 | The Chemistry Behind Drugs: Fundamentals of Medicinal Chemistry | |
| MEM 424 | Biomechanics | |
| MEM 478 | Computer-Aided Tissue Engr | |
| **Manufacturing** | | |
| CHE 452 | Polymer Process Technology | |
| CHEM 242 | Organic Chemistry II | |
| CHEM 465 | Synthetic Polymer Chemistry | |
| CHEM 466 | Physical Chemistry of Polymers | |
| CHEM 467 | Polymer Chemistry III | |
| MEM 361 | Engineering Reliability | |
| MEM 417 | Introduction to Microfabrication | |
| MEM 427 | Finite Element Methods | |
| MEM 428 | Introduction to Composites I | |
| MEM 429 | Introduction to Composites II | |
| MEM 435 | Introduction to Computer-Aided Engineering | |
| MEM 436 | Introduction to Computer-Aided Manufacturing | |
| MEM 437 | Manufacturing Process I | |
| MEM 438 | Manufacturing Process II | |
| General Education Electives *** | | 12.0 |
| Business Elective (GE) † | | 4.0 |
| Societal Impact Elective (GE) ‡ | | 4.0 |
| 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 |
| **Chemistry Requirements ^** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| CHEM 241 | Organic Chemistry I | 4.0 |
| **Engineering (ENGR) 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 210 | Introduction to Thermodynamics | 3.0 |
| or MEM 210 | Introduction to Thermodynamics | |
| ENGR 220 | Fundamentals of Materials | 4.0 |
| or MATE 220 | Fundamentals of Materials | |
| ENGR 231 | Linear Engineering Systems | 3.0-4.0 |
| or CAEE 231 | Linear Engineering Systems | |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or CAEE 232 | Dynamic Engineering Systems | |
| or ECE 232 | Solving Dynamic Systems | |
| or MATH 210 | Differential Equations | |
| **Mathematics Requirements ^^** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II § | |
| OR | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| **Physics Requirements ^^** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 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 375 | Materials Selection for Industrial Applications | 3.0 |
| MATE 410 | Case Studies in Materials | 3.0 |
| MATE 455 | Biomedical Materials | 3.0 |
| MATE 460 | Engineering Computational Laboratory | 4.0 |
| MATE 475 | Materials Data Analysis | 3.0 |
| 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** | | **186.5-202.5** |

*****

Co-op cycles for Materials Science & Engineering are only Spring/Summer.
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.

******

Specialization tracks allow upper-class students to focus on a specific area of materials science and engineering through selection of three technical elective courses (minimum 9.0 credits). This tailored specialization, combined with foundational materials knowledge and co-op experiences, gives students a customized education to prepare them for their future career and/or graduate school. Students choose from four pre-determined specialization tracks or create their own track. In addition to the specific courses listed for each pre-determined track, other courses may be accepted subject to approval by the MSE advisor. Additional pre-requisites required for Track courses should be used to satisfy students' "Free Elective" credits. The pre-determined tracks are:

- Materials for Energy
- Materials for Medical Technologies
- Materials for Sustainability
- Manufacturing

*******

General Education Electives (p. 5)

†

Choose one of the approved Business Electives (GE): ECON 201, ACCT 110, OPM 200, ORGB 300 [WI] or approved by MSE advisor.

‡

Choose one of the approved Societal Impact Electives (GE): SOC 244, SOC 346, SCTS 202, SCTS 205 or approved by MSE advisor.

^

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

^^

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

§

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 | ENGL 103 or 113 | 3.0 | Business Elective (GE)**** | 4.0 | CHEM 241 | 4.0 |
| BIO 108 | 1.0 | ENGR 210 or MEM 210 | 3.0 | General Education Electives† | 6.0 | PHIL 315 | 3.0 |
| ENGR 220 or MATE 220 | 4.0 | ENGR 232, CAEE 232, ECE 232, or MATH 210 | 3.0-4.0 | Technical Elective/ Track Course†† | 3.0 | Free Elective | 3.0 |
| ENGR 231, CAEE 231, ECE 231, or MATH 201 | 3.0-4.0 | MATE 230 | 4.0 | | | Technical Elective/ Track Course†† | 3.0 |
| PHYS 201 | 4.0 | Free Elective | 3.0 | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Societal Impact Elective (GE)‡ | 4.0 | | | | | | | |
| | **19-20** | | **16-17** | | **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 280 | 4.0 | | | | | |
| MATE 355 | 3.0 | MATE 315 | 4.5 | | | | | |
| MATE 370 | 3.0 | MATE 351 | 4.0 | | | | | |
| | **14** | | **16.5** | | **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 375 | 3.0 | MATE 410 | 3.0 | | | |
| MATE 455 | 3.0 | MATE 475 | 3.0 | MATE 493 | 3.0 | | | |
| MATE 460 | 4.0 | MATE 492 | 3.0 | Technical Elective/ Track Course†† | 3.0 | | | |
| MATE 491 | 2.0 | General Education Elective† | 3.0 | | | | | |
| | **16.5** | | **16.5** | | **13** | | | |
| **Total Credits 186.5-188.5** | | | | | | | | |

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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.

********

Choose one of the approved Business Electives (GE): ECON 201, ACCT 110, OPM 200, ORGB 300 [WI] or approved by MSE advisor.

‡

Choose one of the approved Societal Impact Electives (GE): SOC 244, SOC 346, SCTS 202, SCTS 205 or approved by MSE advisor.

†

See degree requirements (p. 65).

††

Specialization tracks allow upper-class students to focus on a specific area of materials science and engineering through selection of three technical elective courses (minimum 9.0 credits). This tailored specialization, combined with foundational materials knowledge and co-op experiences, gives students a customized education to prepare them for their future career and/or graduate school. Students choose from four pre-determined specialization tracks or create their own track. In addition to the specific courses listed for each pre-determined track, other courses may be accepted subject to approval by the MSE advisor. Additional pre-requisites required for Track courses should be used to satisfy students' "Free Elective" credits. The pre-determined tracks are:

- Materials for Energy
- Materials for Medical Technologies
- Materials for Sustainability
- Manufacturing

## 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 or MATE 220 | 4.0 | ENGR 210 or MEM 210 | 3.0 | | | | | |
| ENGR 231, CAEE 231, ECE 231, or MATH 201 | 3.0-4.0 | ENGR 232, CAEE 232, ECE 232, or MATH 210 | 3.0-4.0 | | | | | |
| PHYS 201 | 4.0 | MATE 230 | 4.0 | | | | | |
| Free Elective | 3.0 | | | | | | | |
| | **18-19** | | **17-18** | | **0** | | | **0** |
| **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 280 | 4.0 | | | | | |
| MATE 355 | 3.0 | MATE 315 | 4.5 | | | | | |
| MATE 370 | 3.0 | Societal Impact Elective (GE) | 4.0 | | | | | |
| Business Elective (GE) | 4.0 | | | | | | | |
| | **18** | | **16.5** | | **0** | | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEC 353 | 4.0 | MATE 345 | 4.5 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 366 | 4.5 | MATE 351 | 4.0 | | | | |
| MATE 455 | 3.0 | MATE 375 | 3.0 | | | | |
| Free Elective | 3.0 | PHIL 315 | 3.0 | | | | |
| | **14.5** | | **14.5** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| CHE 350 | 3.0 | MATE 475 | 3.0 | MATE 410 | 3.0 |
| MATE 460 | 4.0 | MATE 492 | 3.0 | MATE 493 | 3.0 |
| MATE 491 | 2.0 | General Education Elective† | 3.0 | General Education Elective† | 3.0 |
| General Education Elective† | 3.0 | Technical Elective/ Track Course†† | 3.0 | Technical Elective/ Track Course†† | 3.0 |
| Technical Elective/ Track Elective†† | 3.0 | | | | |
| | **15** | | **12** | | **12** |

**Total Credits 186.5-188.5**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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.

********

Choose one of the approved Business Electives
(GE): ECON 201, ACCT 110, OPM 200, ORGB 300 [WI] or approved by MSE advisor.

‡
Choose one of the approved Societal Impact
Electives: SOC 244, SOC 346, SCTS 202, SCTS 205 or approved by MSE advisor.

†
See degree requirements (p. 5).

††
Specialization tracks allow upper-class students to focus on a specific area of materials science and engineering through selection of three technical elective courses (minimum 9.0 credits). This tailored specialization combined with foundational materials knowledge and co-op experiences gives students a customized education to prepare them for their future career and/or graduate school. Students choose from four pre-determined specialization tracks or create their own track. In addition to the specific courses listed for each pre-determined track, other courses may be accepted subject to approval by the MSE advisor. The pre-determined tracks are:

- Materials for Energy
- Materials for Medical Technologies
- Materials for Sustainability
- Manufacturing and Materials Processing

## 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, 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

### 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 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. Exceptional students can 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 (MSE) differs from the standard BS degree in that there may be two six-month Co-op periods instead of three.

For more information about this program, please visit the Department's BS/MS Degree Program (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) page.

## Facilities

**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.

**Layered Solids Laboratory**
This laboratory contains a vacuum hot-press; creep testers, Ar-atmosphere glove-box, high-speed saw, and assorted high temperature furnaces; metallographic preparation facilities; high temperature closed-loop servo-hydraulic testing machines.

**Mechanical 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.

**Macromolecular Materials Laboratory**
This laboratory contains a hybrid rheometer, inert environment glove box, size exclusion chromatography with multi-angle laser light scattering, HPLC and RI detector & MALS, centrifuge, rotovapor, and vacuum oven used for developing innovative synthetic platforms to generate functional soft materials with complex macromolecular architectures.

**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 (ALD), chemical vapor deposition (CVD), 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 °C with mass spectrometer, Zeta potential analyzer; attrition mill, bath and probe sonicators, centrifuges; electro-spinning system for producing nano-fibers.

**Functional Inorganic Materials Synthesis Laboratory**
The laboratory contains equipment for the synthesis of inorganic and hybrid materials, including gas cabinets for $NH_3$ and $H_2$, a CVD furnace, and spin-coater; UV-Vis spectrophotometer; and a photodegradation test station with Xe 1000 W lamp.

**Films and Heterostructures 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 to 400 K, up to 9 T fields; 2 tube furnaces; spectroscopic ellipsometer.

**Powder Processing Laboratory**
This laboratory contains vee blenders, ball-mills, sieve shaker + sieves for powder classification, several furnaces.

**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 high purity liquid chromatography (HPLC) system; refractometer; electro-spinning and touch-spinning systems for producing nanofibers.

**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.

**MSE Undergraduate Teaching Laboratory**
Contains an FTIR spectrometer, metallographic sample preparation, equipment, polymer 3D printers, polymer extruder and injection molder, Vickers hardness tester, inverted metallograph, multiple furnaces.

**Materials Characterization Core (MCC)**
The Department of Materials Science & Engineering relies on the Materials Characterization 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 high resolution and variable pressure field-emission scanning electron microscopes (SEMs) with Energy Dispersive Spectroscopy (EDS) for elemental analysis, Orientation Image Microscopy (OIM) for texture analysis, various *in-situ* and *in-operando* stages (cryo mat, heating, tensile, 3- and 4-point bending, and electrochemistry); two Transmission Electron Microscopes (TEMs) with STEM capability and TEM sample preparation equipment; a dual-beam focused ion beam (FIB) system for nano-characterization and nano fabrication; a Nanoindenter; an X-ray Photoelectron Spectrometer (XPS)/Electron Spectroscopy for Chemical Analysis (ESCA) system; X-Ray Diffractometers (XRD); and an X-ray microscope (NanoCT) with an *in-situ* tensile/compression temperature controlled stage.

More details of these instruments, information on how to access them, and instrument usage rates can be found at Drexel University's Materials Characterization Core webpage.

## 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. 1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. 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. 3. An ability to communicate effectively with a range of audiences.
4. 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. 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. 6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. 7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

# 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.

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

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

Adam K. Fontecchio, PhD *(Brown University) Vice Dean, Graduate College*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

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.

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

Haviva M. Goldman, PhD *(City University of New York) Neurobiology and Anatomy*. Associate Professor. Understanding how the size and shape of whole bones, as well as the distribution quantity and quality of the mineralized tissue that forms the bone, reflect both evolutionary constraints of skeletal growth and development, and responsiveness to mechanical loading during life.

Lin Han, PhD *(Massachusetts Institute of Technology)*. Assistant Professor. Nanoscale structure-property relationships of biological materials, genetic and molecular origins soft joint tissue diseases, biomaterials under extreme conditions, coupling between stimulus-responsiveness and geometry.

Maher Harb, PhD *(University of Toronto)*. Assistant Professor. Solid state physics, ultrafast electron diffraction, time-resolved X-ray diffraction, ultrafast lasers, nanofabrication, nano/microfluidics, instrument development, vacuum technologies.

Haifeng Frank Ji, PhD *(Chinese Academy of Sciences)*. Professor. Chemistry Micromechancial sensors for biological and environmental applications; Nanomechanical drug screening technology.

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

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.

E. Caglan Kumbur, PhD *(Pennsylvania State University)*. Associate Professor. Mechanical Engineering and Mechanics 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.

Leslie Lamberson, PhD *(California Institute of Technology) P.C. Chou Assistant Professor of Mechanical Angineering*. Assistant Professor. Dynamic behavior of materials, dynamic fracture, damage micromechanics, active materials.

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

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*. Professor. Orthopedic biomaterials; acellular regenerative medicine, biomimetic proteoglycans; hydrogels.

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

Bahram Nabet, PhD *(University of Washington) Associate Dean for Special Projects, College of Engineering; Electrical and Computer Engineering*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Giuseppe R. Palmese, PhD *(University of Delaware) Department Head, Chemical and Biological Engineering*. Professor. Reacting polymer systems; nanostructured polymers; radiation processing of materials; composites and interfaces.

Ekaterina Pomerantseva, PhD *(Moscow State University, Russia)*. Assistant 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) Graduate Advisor*. Associate Professor. Polysaccharide thin films and nanofibers.

Wan Y. Shih, PhD *(Ohio State University)*. Associate Professor. Piezoelectric microcantilever biosensors development, piezoelectric finger development, quantum dots development, tissue elasticity imaging, piezoelectric microcantilever force probes.

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.

Karl Sohlberg, PhD *(University of Delaware)*. Associate Professor. Chemistry Computational and theoretical materials-related chemistry: (1) complex catalytic materials; (2) mechanical and electrical molecular devices.

Jonathan E. Spanier, PhD *(Columbia University) Associate Dean, Strategic Planning, College of Engineering*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laster spectroscopy, including Raman scattering.

Kara Spiller, PhD *(Drexel University)*. Assistant Professor. Macrophage-biometerial interactions, drug delivery systems, and chronic would healing. Cell-biomaterial interactions, biomaterial design, and international engineering education.

Mitra Taheri, PhD *(Carnegie Mellon University) Hoeganeas Associate Professor of Metallurgy*. Associate 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.

Garritt Tucker, PhD *(Georgial Institute of Technology)*. Assistant Professor. Computational materials science and engineering; microstructural evolutiona nd material behavior in extreme environments; interfacial-driven processes for improving material functionality; multi-scale physics modeling.

Christopher Weinberger, PhD *(Stanford University)*. Assistant Professor. Mechanical Engineering and Mechanics Multiscale materials modeling of mechanical properties including DFT, atomistics, mesoscale and microscale FEM modeling.

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

Margaret Wheatley, PhD *(University of Toronto) John M. Reid Professor*. Ultrasound contrast agent development (tumor targeting and triggered drug delivery), controlled release technology (bioactive compounds), microencapsulated allografts (ex vivo  gene therapy) for spinal cord repair.

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.

Alan Lawley, PhD *(University of Birmingham, England)*. Professor Emeritus. Mechanical and physical metallurgy, powder metallurgy, materials engineering design, engineering education.

# Mechanical Engineering & Mechanics BSME

*Major: Mechanical Engineering & Mechanics*
*Degree Awarded: Bachelor of Science in Mechanical Engineering (BSME)*
*Calendar Type: Quarter*
*Minimum Required Credits: 190.0*
*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 Department of Mechanical Engineering and Mechanics will be a vibrant and inclusive academic community of choice for diverse students and scholars – one that welcomes and supports those underrepresented in our field into programs distinctive for integrated and collaborative education, inquiry fueled by curiosity-inspired modeling, design, and manufacturing; and the successful application of MEM discoveries and innovations to address humanity's most pressing challenges.

## Vision

The Department of Mechanical Engineering and Mechanics engages students and faculty from around the world in integrated teaching & learning, research, and service that empowers them to solve complex societal problems with technical skills, creativity, and empathy.

## 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, 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), under the commission's General Criteria and Program Criteria for Mechanical and Similarly Named Engineering Programs.

For additional information about this major, visit the Mechanical Engineering program page (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/mechanical-engineering/) or 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 |
| COM 310 [WI] | Technical Communication | 3.0 |
| 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 ** | | 12.0 |

| | | |
|---|---|---|
| **Mathematics Requirements** [***] | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II [†] | |
| OR | | |
| MATH 121 | Calculus I | |
| 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** [***] | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| PHYS 201 | Fundamentals of Physics III | 4.0 |
| **Chemistry Requirements** [‡] | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| 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 Economics Requirements** | | |
| CIVE 240 | Engineering Economic Analysis | 3.0 |
| **Materials Requirements** | | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Mechanical Requirements** | | |
| MEM 201 | Foundations of Computer Aided Design | 3.0 |
| MEM 202 | Statics | 3.0 |
| MEM 210 | Introduction to Thermodynamics | 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 260 | Thinking Like a Mechanical Engineer | 3.0 |
| MEM 261 | Introduction to Mechatronics for Mechanical Engineers | 3.0 |
| MEM 310 | Thermodynamic Analysis I | 4.0 |
| MEM 311 | Thermal Fluid Science Laboratory | 2.0 |
| MEM 321 | Fluid Mechanics II | 4.0 |
| MEM 330 | Mechanics of Materials II | 4.0 |
| MEM 331 | Experimental Mechanics I | 2.0 |
| MEM 333 | Mechanical Behavior of Materials | 3.0 |
| MEM 345 | Heat Transfer | 4.0 |
| MEM 351 | Dynamic Systems Laboratory I | 2.0 |
| MEM 355 | Performance Enhancement of Dynamic Systems | 4.0 |
| MEM 360 | Numerical Methods in Mechanical Engineering Design | 3.0 |
| MEM 361 | Engineering Reliability | 3.0 |
| MEM 423 | Mechanics of Vibration | 4.0 |
| MEM 431 | Machine Design I | 3.0 |
| MEM 435 | Introduction to Computer-Aided Engineering | 4.0 |
| MEM 491 [WI] | Senior Design Project I | 3.0 |
| MEM 492 [WI] | Senior Design Project II | 3.0 |
| MEM 493 [WI] | Senior Design Project III | 3.0 |
| MEM Open Electives (Any two MEM courses 300 level or higher.) | | 6.0-8.0 |
| COE Electives (Any College of Engineering courses, including MEM courses, 300 level or higher.) | | 3.0-4.0 |
| Math Elective (Any one of MATH 291, MATH 300, MATH 321, MATH 322, or MATH 323) | | 3.0-4.0 |
| Free Electives | | 6.0-8.0 |
| **Total Credits** | | **190.0-210.0** |

*****

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).

*******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

‡

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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, Spring-Summer

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101[*] | 3.5 | CHEM 102 | 4.5 | CIVC 101 | 1.0 | VACATION | |
| MATH 121[**] | 4.0 | MATH 122 | 4.0 | ENGL 103 or 113 | 3.0 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGR 113 | 3.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | MATH 200 | 4.0 | | |
| UNIV E101 | 1.0 | PHYS 101** | 4.0 | PHYS 102 | 4.0 | | |
| | **14.5** | | **18.5** | | **15** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MATH 201 | 4.0 | MATH 210 | 4.0 | CIVE 240 | 3.0 | COOP 101*** | 1.0 |
| MATE 220 | 4.0 | MEM 201 | 3.0 | MEM 230 | 4.0 | MEM 220 | 4.0 |
| MEM 202 | 3.0 | MEM 210 | 3.0 | MEM 255 | 4.0 | MEM 330 | 4.0 |
| MEM 260 | 3.0 | MEM 238 | 4.0 | MEM 310 | 4.0 | MEM 331 | 2.0 |
| PHYS 201 | 4.0 | MEM 261 | 3.0 | MEM 360 | 3.0 | MEM 355 | 4.0 |
| | **18** | | **17** | | **18** | | **15** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COM 310 | 3.0 | MEM 333 | 3.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MEM 311 | 2.0 | MEM 345 | 4.0 | | | | |
| MEM 321 | 4.0 | MEM 351 | 2.0 | | | | |
| MEM 435 | 4.0 | MEM 423 | 4.0 | | | | |
| PHIL 315 | 3.0 | College of Engineering elective (300+ or higher) | 3.0 | | | | |
| | **16** | | **16** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| MEM 361 | 3.0 | MEM 492 | 3.0 | MEM 493 | 3.0 |
| MEM 431 | 3.0 | Math Elective (Any one of MATH 291, MATH 300, MATH 321, MATH 322, or MATH 323)† | 3.0 | MEM Elective (300+ higher) | 3.0 |
| MEM 491 | 3.0 | General Education Electives† | 6.0 | General Education elective† | 3.0 |
| MEM elective (300+ or higher) | 3.0 | Free Elective | 3.0 | Free electives | 3.0 |
| General Education elective† | 3.0 | | | | |
| | **15** | | **15** | | **12** |

**Total Credits 190**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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. 72).

## 4 year, 1 co-op, Fall-Winter

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101* | 3.5 | CHEM 102 | 4.5 | MATH 200 | 4.0 | VACATION | |
| MATH 121** | 4.0 | MATH 122 | 4.0 | PHYS 102 | 4.0 | | |
| ENGL 101 | 3.0 | ENGL 102 or 112 | 3.0 | CIVC 101 | 1.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 101** | 4.0 | ENGR 113 | 3.0 | | |
| | **14.5** | | **18.5** | | **15** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MATH 201 | 4.0 | COOP 101*** | 1.0 | MEM 230 | 4.0 | MEM 220 | 4.0 |
| PHYS 201 | 4.0 | MATH 210 | 4.0 | MEM 255 | 4.0 | MEM 330 | 4.0 |
| MATE 220 | 4.0 | MEM 201 | 3.0 | MEM 310 | 4.0 | MEM 331 | 2.0 |
| MEM 202 | 3.0 | MEM 210 | 3.0 | MEM 360 | 3.0 | MEM 355 | 4.0 |
| MEM 260 | 3.0 | MEM 238 | 4.0 | CIVE 240 | 3.0 | | |
| | | MEM 261 | 3.0 | | | | |
| | **18** | | **18** | | **18** | | **14** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | MEM 311 | 2.0 | MEM 345 | 4.0 |
| | | | | MEM 321 | 4.0 | MEM 351 | 2.0 |
| | | | | MEM 435 | 4.0 | MEM 423 | 4.0 |
| | | | | PHIL 315 | 3.0 | MEM 333 | 3.0 |
| | | | | COM 310 | 3.0 | MEM or College of Engineering Elective (300+ or higher) | 3.0 |
| | **0** | | **0** | | **16** | | **16** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| MEM 491 | 3.0 | MEM 491 | 3.0 | MEM 493 | 3.0 |
| MEM 361 | 3.0 | MATH Elective (Any one of MATH 291, MATH 300, MATH 321, MATH 322, or MATH 323) | 3.0 | MEM Elective (300+ or higher) | 3.0 |
| MEM 431 | 3.0 | General Education Elective† | 6.0 | General Education Elective† | 3.0 |
| MEM Elective (300+ or higher) | 3.0 | Free Elective | 3.0 | Free Elective | 3.0 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| General Education Elective[†] | 3.0 | | | | | | |
| | **15** | | **15** | | **12** | | |

**Total Credits 190**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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. 72).

## 5 year, 3 co-op, Spring-Summer

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101[*] | 3.5 | CHEM 102 | 4.5 | CIVC 101 | 1.0 | VACATION | |
| MATH 121[**] | 4.0 | MATH 122 | 4.0 | COOP 101[***] | 1.0 | | |
| ENGL 101 or 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGL 103 or 113 | 3.0 | | |
| ENGR 111 | 3.0 | ENGR 131 or 132 | 3.0 | ENGR 113 | 3.0 | | |
| UNIV E101 | 1.0 | PHYS 101[**] | 4.0 | MATH 200 | 4.0 | | |
| | | | | PHYS 102 | 4.0 | | |
| | **14.5** | | **18.5** | | **16** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| MATH 201 | 4.0 | MATH 210 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MATE 220 | 4.0 | MEM 201 | 3.0 | | | | |
| MEM 202 | 3.0 | MEM 210 | 3.0 | | | | |
| MEM 260 | 3.0 | MEM 238 | 4.0 | | | | |
| PHYS 201 | 4.0 | MEM 261 | 3.0 | | | | |
| | **18** | | **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 | |
| MEM 230 | 4.0 | MEM 330 | 4.0 | | | | |
| MEM 255 | 4.0 | MEM 331 | 2.0 | | | | |
| MEM 310 | 4.0 | MEM 355 | 4.0 | | | | |
| MEM 360 | 3.0 | | | | | | |
| | **18** | | **14** | | **0** | | **0** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COM 310 | 3.0 | MEM 345 | 4.0 | COOP EXPERIENCE | | COOP EXPERIENCE | |
| MEM 311 | 2.0 | MEM 351 | 2.0 | | | | |
| MEM 321 | 4.0 | MEM 333 | 3.0 | | | | |
| MEM 435 | 4.0 | MEM 423 | 4.0 | | | | |
| PHIL 315 | 3.0 | College of Engineering elective (300+ or higher) | 3.0 | | | | |
| | **16** | | **16** | | **0** | | **0** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| MEM 361 | 3.0 | MEM 492 | 3.0 | MEM 493 | 3.0 |
| MEM 431 | 3.0 | Math Elective (Any one of MATH 291, MATH 300, MATH 321, MATH 322, or MATH 323) | 3.0 | MEM Elective (300+ or higher) | 3.0 |
| MEM 491 | 3.0 | General Education Elective[†] | 6.0 | Free elective | 3.0 |
| MEM Elective (300+ or higher) | 3.0 | Free Elective | 3.0 | General Education Elective[†] | 3.0 |
| General Education Elective[†] | 3.0 | | | | |
| | **15** | | **15** | | **12** |

**Total Credits 190**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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. 72).

## 5 year, 3 co-op, Fall-Winter

**First Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| CHEM 101[*] | 3.5 | CHEM 102 | 4.5 | MATH 200 | 4.0 | Vacation | |
| MATH 121[**] | 4.0 | COOP 101[***] | 1.0 | PHYS 102 | 4.0 | | |
| ENGL 101 or 111 | 3.0 | MATH 122 | 4.0 | ENGL 103 or 113 | 3.0 | | |
| ENGR 111 | 3.0 | ENGL 102 or 112 | 3.0 | ENGR 113 | 3.0 | | |
| UNIV E101 | 1.0 | ENGR 131 or 132 | 3.0 | CIVC 101 | 1.0 | | |
| | | PHYS 101[**] | 4.0 | | | | |
| | **14.5** | | **19.5** | | **15** | | **0** |

**Second Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | MATH 201 | 4.0 | MATH 210 | 4.0 |
| | | | | PHYS 201 | 4.0 | MEM 201 | 3.0 |
| | | | | MATE 220 | 4.0 | MEM 210 | 3.0 |
| | | | | MEM 202 | 3.0 | MEM 238 | 4.0 |
| | | | | MEM 260 | 3.0 | MEM 261 | 3.0 |
| | **0** | | **0** | | **18** | | **17** |

**Third Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | MEM 230 | 4.0 | MEM 220 | 4.0 |
| | | | | MEM 255 | 4.0 | MEM 330 | 4.0 |
| | | | | MEM 310 | 4.0 | MEM 331 | 2.0 |
| | | | | MEM 360 | 3.0 | MEM 355 | 4.0 |
| | | | | CIVE 240 | 3.0 | | |
| | **0** | | **0** | | **18** | | **14** |

**Fourth Year**

| Fall | Credits | Winter | Credits | Spring | Credits | Summer | Credits |
|---|---|---|---|---|---|---|---|
| COOP EXPERIENCE | | COOP EXPERIENCE | | MEM 311 | 2.0 | MEM 423 | 4.0 |
| | | | | MEM 435 | 4.0 | MEM 345 | 4.0 |
| | | | | MEM 321 | 4.0 | MEM 351 | 2.0 |
| | | | | COM 310 | 3.0 | MEM 333 | 3.0 |
| | | | | PHIL 315 | 3.0 | MEM or College of Engineering Elective (300+ or higher) | 3.0 |
| | **0** | | **0** | | **16** | | **16** |

**Fifth Year**

| Fall | Credits | Winter | Credits | Spring | Credits |
|---|---|---|---|---|---|
| MEM 491 | 3.0 | MEM 492 | 3.0 | MEM 493 | 3.0 |
| MEM 361 | 3.0 | MATH Elective (Any one of MATH 291, MATH 300, MATH 321, MATH 322, or MATH 323) | 3.0 | MEM Elective (300+ or higher) | 3.0 |
| MEM 431 | 3.0 | General Education Elective† | 6.0 | General Education Elective† | 3.0 |
| MEM Elective (300+ or higher) | 3.0 | Free Elective | 3.0 | Free Elective | 3.0 |
| General Education Elective† | 3.0 | | | | |
| | **15** | | **15** | | **12** |

**Total Credits 190**

*****

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

*******

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. 72).

# 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 **(**https://drexel.edu/engineering/academics/departments/mechanical-engineering/department-research/laboratories/?_gl=1*1jtlnh8*_ga*NjUyMzQyMzYyLjE2OTUzMjQ5NzA.*_ga_6KJ1PNLE19*MTcxOT
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**
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)**
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.

## Program Level Outcomes

- Identify, formulate and solve complex engineering problems by applying principles of engineering, science, and mathematics
- 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
- Communicate effectively with a range of audiences
- 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
- Function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks and meet objectives
- Develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- Acquire and apply new knowledge as needed, using appropriate learning strategies

## Mechanical Engineering Faculty

Hisham Abdel-Aal, PhD *(University of North Carolina)*. Associate Teaching Professor. Bio-tribology; biomimetics and bio-inspired design; high-speed machining; metrology of biological surfaces; mechano-biology thermodynamics

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.

Alisa Clyne, PhD *(Harvard-Massachusetts Institute of Technology)*. Associate Professor. Cardiovascular biomechanics.

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.

Michael Glaser, MFA *(Ohio State University) Program Director for Product Design*. Associate Professor. Westphal College of Media Arts & Design Quantifying the designer's intuition; the interplay between digital and physical forms; human desire to shape our surroundings.

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

Ani Hsieh, PhD *(University of Pennsylvania)*. Associate Professor. Multi-robot systems, decentralized and distributed control, bio-inspired control, swarm robotics.

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. 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. Mechanical Engineering and Mechanics Next generation energy technologies; fuel cell design and development.

John Lacontora, PhD *(New Jersey Institute of Technology)*. Associate Research Professor. Service engineering; industrial engineering.

Leslie Lamberson, PhD *(California Institute of Technology) P.C. Chou Assistant Professor of Mechanical Angineering*. Assistant

Professor. Dynamic behavior of materials, dynamic fracture, damage micromechanics, active materials.

Alan Lau, PhD *(Massachusetts Institute of Technology) Associate Department Head for Graduate Affairs, Mechanical Engineering and Mechanics*. Professor. Deformation and fracture of nano-devices and macroscopic structures; damage-tolerant structures and microstructures.

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

Matthew McCarthy, PhD *(Columbia University)*. Assistant 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) Department Head, Mechanical Engineering and Mechanics*. Professor. Gas-phase reaction kinetics; thermodynamics; biofuels.

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

Mira S. Olson, PhD *(University of Virginia) Graduate Studies Advisor*. Associate Professor. Environmental remediation; contaminant and bacterial transport in porous media and bacterial response to dynamic environments.

William C. Regli, PhD *(University of Maryland-College Park)*. Professor. Artificial intelligence; computer graphics; engineering design and Internet computing.

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

Jonathan E. Spanier, PhD *(Columbia University) Associate Dean, Strategic Planning, College of Engineering*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laster 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)*. 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.

Christopher Weinberger, PhD *(Stanford University)*. Assistant Professor. Mechanical Engineering and Mechanics Multiscale materials modeling of mechanical properties including DFT, atomistics, mesoscale and microscale FEM modeling.

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) Albert and Harriet Soffa Professor*. 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 winter 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 (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/undeclared/) 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/).

For additional information, please visit the Engineering Undeclared program (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/undeclared/?_gl=1*2a9hst*_ga*OTEwNTAxODM1LjE2NjQ0NjE3MzI.*_ga_6KJ1PNLE19*MTY4N
web page.

## 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 Requiremer | 8.0 | Science Requiremen | 4.0 | General Education Requiremen | 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 Requiremen | 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, Mechanical Concentration BSAE / Architectural Engineering MSAE

*Major: Architectural Engineering*
*Degree Awarded: Bachelor of Science in Architectural Engineering (BSAE) and Master of Science in Architectural Engineering (MSAE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.0*
*Co-op Options: Three Co-op (Five years)*

## About the Program

The BSAE/MS program allows students to develop technical depth and breadth in their major and an additional complementary related area, which enhances their professional capabilities in industry, or as they proceed to earn a PhD. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. The underlying technical concepts of engineering are common, and so students readily achieve their master's degree in a related discipline in their area of interest.

## Additional Information

For more information, visit the BS/MS (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) and the Department of Civil, Architectural and Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/) webpages.

## 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 |
| **Chemistry Requirements** | | **3.5-7.5** |
| Select one of the following options: *** | | |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | **4.0-10.0** |
| Select one of the following options: † | | |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II ‡ | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** † | | **4.0-8.0** |
| Select one of the following options: | | |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 118 | Architectural Design Foundations I | 3.0 |
| ARCH 119 | Architectural Design Foundations II | 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 |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| MEM 202 | Statics | 3.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| **Mechanical 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 |

| | | |
|---|---|---|
| Select 9.0 credits of Professional Electives (400-499) from the list of subject codes below: (Note: two Graduate Technical Electives count as 6.0 credits of Professional Electives) | | 3.0 |
| **Master's Degree Courses** | | |
| **Professional Electives** | | |
| Any ACCT (Acounting) course | | |
| Any AE (Architectural Engineering) course | | |
| Any ARCH (Architecture) course | | |
| Any BLAW (Legal Studies) se | | |
| Any BMES (Biomedical Engineering & Sci) course | | |
| Any BUSN (General Business) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any CMGT (Construction Management) course | | |
| Any ECE (Electrical Engineering) course | | |
| Any CS (Computer Science) course | | |
| Any ECON (Economics) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any FIN (Finance) course | | |
| Any INTB (International Business) course | | |
| Any MATE (Materials Engineering) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| Any MIS (Management Information Systems) course | | |
| Any MKTG (Marketing) course | | |
| Any OPM (Operations Management) course | | |
| Any SE (Software Engineering) course | | |
| **Required Courses** | | |
| AE 510 | Intelligent Buildings | 3.0 |
| AE 544 | Building Envelope Systems | 3.0 |
| Counts as AE 444 as shared coursework | | |
| AE 550 | Indoor Air Quality | 3.0 |
| AE 551 | Building Energy Systems I ^^ | 3.0 |
| or AE 552 | Building Energy Systems II | |
| MEM 591 | Applied Engr Analy Methods I | 3.0 |
| MEM 592 | Applied Engr Analy Methods II | 3.0 |
| **Graduate Technical Electives** | | |
| Must complete at least 9.0 credits from the list below: | | 9.0 |
| AE 552 | Building Energy Systems II ^^ | |
| AE 555 | Data Acquisition and Analytics in Built Environment | |
| AE 561 | Airflow Simulation in Built Environment | |
| CHE 513 | Chemical Engineering Thermodynamics I | |
| CHE 525 | Transport Phenomena I | |
| ENVE 560 | Fundamentals of Air Pollution Control | |
| ENVE 571 | Environmental Life Cycle Assessment | |
| ENVE 660 | Chemical Kinetics in Environmental Engineering | |
| ENVE 727 | Risk Assessment | |
| ENVE 750 | Data-based Engineering Modeling | |
| ENVS 501 | Chemistry of the Environment | |
| MEM 611 | Conduction Heat Transfer | |
| MEM 612 | Convection Heat Transfer | |
| MEM 621 | Foundations of Fluid Mechanics | |
| **Additional Electives** § | | |
| Select 18.0 from the subject codes below (500-699): | | 18.0 |
| Any AE (Architectural Engineering) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CHEC (Chemical Engineering Chemistry) course | | |
| Any CHEM (Chemistry) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any ENSS (Environmental Studies & Sustainability) course | | |
| Any ENVP (Environmental Policy) course | | |
| Any ENVS (Environmental Science) course | | |
| Any MATH (Mathematics) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| **Total Credits** | | **226.0-240.0** |

*****

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

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

‡

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^^**

AE 552 can only be taken as either a core required course or a technical elective and can only be counted once.

**§**

Additional electives from any courses beyond the 9.0 credit theme will be electives approved by the student's advisor and the departmental graduate advisor.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# 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*
*Minimum Required Credits: 231.0*
*Co-op Options: Three Co-op (Five years)*

## About the Program

The Architectural Engineering/Civil Engineering BSMS program allows students to develop technical depth and breadth in their major and an additional complementary related area, which enhances their professional capabilities in industry, or as they proceed to earn a PhD. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. The underlying technical concepts of engineering are common, and so students readily achieve their master's degree in a related discipline in their area of interest.

## Additional Information

For more information, visit the BS/MS (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) and the Department of Civil, Architectural and Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/) webpage.

## 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 credits (Please note that a (GR) Core Technical Elective course counts as 3 credits of UG Free Electives) | | |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Math Requirements** | | |
| Select one of the following options: † | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 444 | Building Envelope Systems | 3.0 |
| ARCH 118 | Architectural Design Foundations I | 3.0 |

| | | |
|---|---|---|
| ARCH 119 | Architectural Design Foundations II | 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 |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| MEM 202 | Statics | 3.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| **Structural Concentration** | | **28.0** |
| CIVE 302 | Structural Analysis I | |
| CIVE 303 | Structural Design I | |
| CIVE 312 | Soil Mechanics I | |
| CIVE 315 | Soil Mechanics II | |
| CIVE 400 | Structural Analysis II | |
| CIVE 401 | Structural Design II | |
| CIVE 402 | Structural Design III | |
| MEM 238 | Dynamics | |
| Professional Electives 6 Credits (Please note that two Graduate Required Theme Courses count as 6.0 credits of Professional Electives) | | |
| **Master's Degree Courses** | | |
| Select 15.0 credits from the courses below: | | 15.0 |
| **Required Theme Courses** | | |
| CIVE 605 | Advanced Mechanics of Materials | |
| CIVE 701 | Advanced Structural Analysis I | |
| CIVE 702 | Advanced Structural Analysis II | |
| CIVE 703 | Advanced Structural Analysis III | |
| CIVE 708 | Fundamentals of Structural Dynamics | |
| **Core Technical Elective Courses** | | |
| Select 15-30 credits from the list of courses below: | | 15.0-30.0 |
| CIVE 510 | Prestressed Concrete | |
| CIVE 511 | Advanced Steel Design | |
| CIVE 512 | Wood and Timber Design | |
| CIVE 513 | Introduction to Artificial Intelligence for Smart Structures and Systems | |
| CIVE 520 | Advanced Concrete Technology | |
| CIVE 540 | Forensic Structural Engineering | |
| CIVE 615 | Infrastructure Condition Evaluation | |
| CIVE 704 | Behavior and Stability of Structural Members I | |
| CIVE 711 | Engineered Masonry I | |
| CIVE 714 | Behavior of Concrete Structures I | |
| MATH 520 | Numerical Analysis I | |
| or MATH 521 | Numerical Analysis II | |
| MEM 591 | Applied Engr Analy Methods I | |
| or 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 | |
| or MEM 682 | Finite Element Methods II | |
| MEM 777 | Fracture Mechanics I | |
| **Additional Technical Elective Courses** | | |
| These courses must be approved by the student's advisor and the gradute advisor. | | |
| Select from any of the following that were not already counted for credit. | | 0.0-15.0 |
| AE 510 | Intelligent Buildings | |
| AE 561 | Airflow Simulation in Built Environment | |
| CIVE 531 | Advanced Foundation Engineering | |
| CIVE 615 | Infrastructure Condition Evaluation | |
| CIVE 633 | Lateral Earth Pressures and Retaining Structures | |
| CIVE 639 | Applied Finite Element Analysis in Geotechnical Engineering | |
| CIVE 839 | Constitutive Models in Geomechanics | |
| ENVE 555 | Geographic Information Systems | |
| ENVE 571 | Environmental Life Cycle Assessment | |
| ENVE 727 | Risk Assessment | |
| ENVE 750 | Data-based Engineering Modeling | |
| Electives or Thesis ^ | | 0.0-9.0 |
| **Total Credits** | | **231.0-260.0** |

*****

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)

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

‡

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^**

For students writing an M.S. thesis, nine of the 21.0 credits should consist of six research credits (CIVE 997) and three thesis credits (CIVE 898). Full time Masters students are encouraged to do a thesis. Students not doing a thesis will be required to complete 21.0 elective credits from the list above.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/

#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Architectural Engineering BS / Construction Management MS

*Major: Architectural Engineering and Construction Management*
*Degree Awarded: Bachelor of Science in Architectural Engineering (BSAE) and Master of Science in Construction Management (MS)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.0*
*Co-op Options: Three Co-op (Five years)*

## 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. In a natural progression, undergraduate courses provide the necessary technical prerequisite understanding and skills for graduate studies. The common technical concepts of engineering allow for the MS in the related discipline to be readily achieved. Recognized by The American Society of Civil Engineers, the publisher of the Journal of Construction Engineering and Management, as kindred disciplines, students will add a depth of complementary knowledge to their skillsets.

## Additional Information

For more information visit the BS/MS overview (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) page.

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.0 and completion of 90 credits.

## 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 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | **4.0-10.0** |
| Select one of the following options: † | | |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II †† | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 444 | Building Envelope Systems | 3.0 |
| ARCH 118 | Architectural Design Foundations I | 3.0 |
| ARCH 119 | Architectural Design Foundations II | 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 |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | Engineering Economic Analysis | 3.0 |
| CIVE 250 | Construction Materials | 4.0 |
| CIVE 320 | Introduction to Fluid Flow | 3.0 |
| CIVE 330 | Hydraulics | 4.0 |
| MEM 202 | Statics | 3.0 |
| MEM 230 | Mechanics of Materials I | 4.0 |
| **Concentration Courses** | | |
| Students select one of the following concentrations: | | 20.0-28.0 |
| **Mechanical 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 | |
| Select 9.0 credits of Professional Electives (400-499) from the list of subject codes below (Note: three Graduate Elective courses count as 9.0 credits of 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 | Structural Analysis II | |
| CIVE 401 | Structural Design II | |
| CIVE 402 | Structural Design III | |
| MEM 238 | Dynamics | |
| Select 6.0 credits of Professional Electives (400-499) from the list of subject codes below (Note: two Graduate Elective courses count as 6.0 credits of Professional Electives): | | |
| **Digital Building Concentration** | | |
| AE 410 | Intelligent Buildings | |
| AE 430 | Control Systems for HVAC | |
| AE 455 | Data Acquisition and Analytics in Built Environment | |
| CIVE 302 | Structural Analysis I | |
| CIVE 303 | Structural Design I | |
| CMGT 361 | Contracts And Specifications I | |
| CMGT 467 | Techniques of Project Control | |
| Select 9.0 credits of Professional Electives (400-499) from the list of subject codes below (Note: three Graduate Elective courses count as 9.0 credits of Professional Electives): | | |
| **Professional Electives** | | |
| Any ACCT (Accounting) course | | |
| Any AE (Architectural Engineering) course | | |
| Any ARCH (Architecture) course | | |
| Any BLAW (Legal Studies) course | | |
| Any BMES (Biomedical Engineering & Sci) course | | |
| Any BUSN (General Business) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any CMGT (Construction Management) course | | |
| Any CS (Computer Science) course | | |
| Any ECE (Electrical Engineering) course | | |
| Any ECON (Economics) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any FIN (Finance) course | | |
| Any INTB (International Business) course | | |
| Any MATE (Materials Engineering) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| Any MIS (Management Information Systems) course | | |
| Any MKTG (Marketing) course | | |
| Any OPM (Operations Management) course | | |
| Any SE (Software Engineering) course | | |
| CMGT 361 | Contracts And Specifications I | |
| CMGT 362 | Contracts and Specifications II | |
| CMGT 363 | Estimating I | |
| **Master's Degree Courses** | | |
| **Core Foundation Courses** | | |
| CMGT 501 | Leadership in Construction | 3.0 |
| CMGT 505 | Construction Accounting and Financial Management | 3.0 |
| CMGT 510 | Construction Control Techniques | 3.0 |
| CMGT 512 | Cost Estimating and Bidding Strategies | 3.0 |
| CMGT 515 | Risk Management in Construction | 3.0 |
| CMGT 528 | Construction Contract Administration | 3.0 |
| **Electives** | | |
| Students may select 7 elective courses from the following areas. | | 21.0 |
| CMGT 525 | Applied Construction Project Management | |
| CMGT 530 | Equipment Applications and Economy | |
| CMGT 532 | International Construction Practices | |
| CMGT 535 | Community Impact Analysis | |
| CMGT 538 | Strategic Management in Construction | |
| CMGT 540 | Schedule Impact Analysis | |
| CMGT 545 | Sustainable Principles & Practices | |
| CMGT 546 | Sustainable Technologies | |
| CMGT 547 | LEED Concepts | |
| CMGT 548 | Quality Management and Construction Performance | |
| CMGT 550 | Productivity Analysis and Improvement | |
| CMGT 558 | Community Sustainability | |
| REAL 568 | Real Estate Development | |
| REAL 571 | Advanced Real Estate Investment & Analysis | |
| REAL 572 | Advanced Market Research & Analysis | |
| REAL 573 | Sales & Marketing of Real Estate | |
| REAL 574 | Real Estate Economics in Urban Markets | |
| REAL 575 | Real Estate Finance | |
| REAL 576 | Real Estate Valuation & Analysis | |
| REAL 577 | Legal Issues in Real Estate Development | |
| **Culminating Experience** | | **6.0** |
| CMGT 696 | Capstone Project in Construction Management I | |
| CMGT 697 | Capstone Project in Construction Management II | |
| **Total Credits** | | **226.0-248.0** |

*
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)

***
CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†
MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

††
Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

## Sample Plan of Study

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# 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*
*Minimum Required Credits: 226.5*
*Co-op Options: Three Co-op (Five years)*

## About the Program

The Department of Chemical and Biological Engineering is responsible for equipping graduates with the broad technical knowledge and teamwork skills required to make substantial contributions to society. The rigorous curriculum is grounded in the fundamental physical sciences, integrating practical engineering design and modern computational techniques throughout, and includes expansive opportunities to explore the humanities. An extensive, hands-on laboratory experience rounds out a dynamic program that prepares our graduates for rewarding careers in chemical engineering as well as other quantitative disciplines.

Chemical engineers are dedicated to designing devices and processes that convert input materials into more valuable products and to the design of those products. Such end products include pharmaceuticals, plastics and other materials, fine chemicals, integrated circuits, electrical energy, petrochemicals, 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 BS/MS is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. Students develop technical depth and breadth, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary, prerequisite understanding and skills for the graduate studies in the later years of the program. BS/MS students take graduate courses that delve deeper into the fundamentals of chemical engineering in the graduate core courses and gain knowledge and exposure to advanced applications through diverse graduate technical electives, all alongside the PhD and MS students participating in our robust research enterprise.

## 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

For more information on the BS portion of the BS/MS, please visit the Chemical Engineering BSCHE (p. 13) catalog page or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## 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 Requirements ** | | 18.0 |
| **Foundation Requirements** | | |
| **Chemistry Requirements *** ** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Math Requirements †** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II ‡ | |
| OR | | |
| MATH 121 | Calculus I | |
| 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 †** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| **Biology Elective (select one):** | | **3.0-4.5** |
| 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 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 |
| **Graduate Technical Electives ‡** | | **15.0** |
| **Graduate Thesis/Non-Thesis** | | **9.0** |
| For Thesis Option: | | |
| CHE 898 | Master's Thesis | |
| For Non-Thesis Option: | | |
| Graduate Major Technical Electives ^^ | | |
| **Graduate Free Electives** | | **6.0** |
| **Total Credits** | | **226.5-242.0** |

*****

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)

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

‡

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

^
6.0 credits in the following subjects (200-499): ACCT, AE, BIO, BLAW, BMES, BUSN, CAE, CHEM, CIVE, CMGT, CS, CT, ECE, ECEC, ECEE, ECEP, ECES, ECON, EET, EGMT, ENSS, ENVE, ENVS, FDSC, FIN GEO, INDE, INFO, INTB, MATE, MATH, MEM (except MEM 310), MET, MGMT, MIS, MKTG, NFS, ORGB, OPM, PBHL, PENG, PHYS, SE, or CHE 399-480, CHE I399, CHE T480, ENGR 370, or courses approved by CHE advisor.
**AND**
6.0 credits in the following subjects (300-499): AE, BIO, BMES, CAE, CHEM, CIVE, CMGT, CS, CT, ECE, ECEC, ECEE, ECEP, ECES, EET, EGMT, ENSS, ENVE, ENVS, FDSC, GEO INDE, INFO, MATE, MATH, MEM (except MEM 310), MET, NFS, PBHL, PENG, PHYS, SE, or CHE 360, CHE 373, CHE 452, CHE 460, CHE 399-480, CHE I399, CHE T480, CHEM 230, CHEM 231 [WI] , CHEM 243, ENGR 370, or courses approved by CHE advisor.

^^
Choose from:

- Any graduate course (500+ level) in the College of Engineering
- Graduate courses (500+ level) in these disciplines, which are subject to advisor approval: AE, BIO, BMES, CAEE, CHE (including CHE I799), CHEM, CIVE, CMGT, CS, DSCI, ECE, ECEC, ECET, ECEE, ECES, EET, EGMT, ENSS, ENTP, ENVP, ENVS, FDSC, GEO, MATE, MEM, PROJ, REAL, SYSE, PENG, MATH, PHYS, SE, or approved by CHE advisor.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Chemical Engineering BSCHE / Materials Science & Engineering MSMSE

*Major: Chemical Engineering and Materials Science & Engineering*
*Degree Awarded: Bachelor of Science in Chemical Engineering (BSCHE) and Master of Science in Materials Science & Engineering (MSMSE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Chemical Engineering and Materials Science and Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can range up to 25% higher than those with BS degrees alone, and prepares students to excel if pursuing a PhD.

For more information, visit the BS/MS (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) and the COE programs (https://drexel.edu/engineering/academics/overview/) webpages (https://drexel.edu/engineering/academics/overview/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.4 and completion of 80.0 credits.

## 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** | | |
| **Chemistry Requirements *** ** | | **3.5-7.5** |
| BIO Elective: Select from BIO 100, BIO 101, BIO 122 or BIO 141 | | 3.0-4.5 |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Math Requirements **** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II † | |
| OR | | |
| MATH 121 | Calculus I | |
| 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 **** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| **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 |
| **Master's Degree Courses:** | | |
| **Materials Science and Engineering (MSMSE) Core Courses** | | |
| Required Core Courses: | | |
| MATE 510 | Thermodynamics of Solids ((GR)) | 3.0 |
| MATE 512 | Introduction to Solid State Materials ((GR)) | 3.0 |
| Four additional Selected Core (SC) courses from the following: | | 12.0 |
| MATE 501 | Structure and Properties of Polymers | |
| MATE 507 | Kinetics | |
| MATE 515 | Experimental Technique in Materials | |
| MATE 535 | Numerical Engineering Methods | |
| MATE 563 | Ceramics | |
| MATE 610 | Mechanical Behavior of Solids | |
| MATE 661 | Biomedical Materials I | |
| Any additional related courses if approved by the graduate advisor. | | |
| **Graduate Technical Electives ^** | | **18.0** |
| **Thesis and Alternatives** | | **9.0** |
| 9.0 credits MATE 898 (MS thesis) or 9.0 credits of Technical Electives (TE). | | |
| **Total Credits** | | **226.5-242.0** |

*****

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).

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

********

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

‡

6.0 credits in the following subjects (200-499): ACCT, AE, BIO, BLAW, BMES, BUSN, CAEE, CHEM, CIVE, CMGT, CS, CT, ECE, ECEC, ECEE, ECEP, ECES, ECON, EET, EGMT, ENSS, ENVE, ENVS, FDSC, FIN GEO, INDE, INFO, INTB, MATE, MATH, MEM (except MEM 310), MET, MGMT, MIS, MKTG, NFS, ORGB, OPM, PBHL, PENG, PHYS, SE, or CHE 399-480, CHE I399, CHE T480, ENGR 370, or courses approved by CHE advisor.

**AND**

6.0 credits in the following subjects (300-499): AE, BIO, BMES, CAEE, CHEM, CIVE, CMGT, CS, CT, ECE, ECEC, ECEE, ECEP, ECES, EET, EGMT, ENSS, ENVE, ENVS, FDSC, GEO INDE, INFO, MATE, MATH, MEM (except MEM 310), MET, NFS, PBHL, PENG, PHYS, SE, or CHE 360, CHE 373,CHE 452, CHE 460, CHE 399-480, CHE I399, CHE T480, CHEM 230, CHEM 231 [WI] , CHEM 243, ENGR 370, or courses approved by CHE advisor.

^

Of the 18.0 technical elective credits, which may include up to 6.0 credits of MATE 897 at least 9.0 credits must be taken as Materials Science and Engineering (MATE) courses, while the rest may be taken within the College of Engineering, College of Arts and Sciences, or at other colleges if consistent with the student's plan of study (and given advance written approval by their advisor). At least 9.0 of these 18.0 technical electives must be exclusive of independent study courses or research credits. Any graduate-level course in a STEM field (Engineering, Physical Sciences, or Computing/Data), as approved by the MSE Graduate Advisor, excluding MATE 536, MATE 503, and MATE 504.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# 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*
*Minimum Required Credits: 225.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The Civil Engineering BSCIV / Civil Engineering MSCE program allows students to develop technical depth and breadth in their major and an additional complementary related area, which enhances their professional capabilities in industry, or as they proceed on to earn a PhD. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. The underlying technical concepts of engineering are common, and so students readily achieve their master’s degree in a related discipline in their area of interest.

## Additional Information

For more information, visit the BS/MS program (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) and Department of Civil, Architectural and Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/) webpages.

## 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 Engineering 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 Requirements ** | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | |
| Selection one of the following options: † | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | 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 I | 2.0 |
| CIVE 478 [WI] | Seminar II | 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 |
| **Senior Professional Electives (18 credits total) ‡** | | **9.0** |
| CIVE 421 | Foundation Engineering | |
| CIVE 422 | Lateral Earth Pressures and Retaining Structures | |
| CIVE 432 | Water Resources Design | |
| 9 credits of GR Theme Courses as 9 credits of UG Professional Electives | | |
| **Master's Degree Courses** | | |
| **Required Theme Course ^** | | **15.0** |
| CIVE 531 | Advanced Foundation Engineering | |
| CIVE 632 | Advanced Soil Mechanics | |
| CIVE 633 | Lateral Earth Pressures and Retaining Structures | |
| CIVE 635 | Slope Stability and Landslides | |
| CIVE 637 | Seepage and Consolidation | |
| **Core Technical Electives** | | **15.0-30.0** |
| These courses must be approved by the student's advisor and the graduate advisor. | | |
| Select from any of the following: | | |
| CIVE 516 | Geotechnical Site Investigation | |
| CIVE 518 | Natural Hazards and Infrastructure | |
| CIVE 605 | Advanced Mechanics of Materials | |
| CIVE 636 | Engineering Ground Improvement | |
| CIVE 639 | Applied Finite Element Analysis in Geotechnical Engineering | |
| CIVE 650 | Geosynthetics in Civil Infrastructure | |
| or CIVE 651 | Geosynthetics in Waste Containment | |
| CIVE 730 | Experimental Soil Mechanics I | |
| or CIVE 731 | Experimental Soil Mechanics II | |
| CIVE 737 | Seismic Geotechnics | |
| CIVE 839 | Constitutive Models in Geomechanics | |
| MATH 520 | Numerical Analysis I | |
| or MATH 521 | Numerical Analysis II | |
| MEM 591 | Applied Engr Analy Methods I | |
| or MEM 591 | Applied Engr Analy Methods I | |
| MEM 681 | Finite Element Methods I | |
| or MEM 682 | Finite Element Methods II | |
| MEM 777 | Fracture Mechanics I | |
| **Additional Technical Elective Courses ^^** | | **0.0-15.0** |
| These courses must be approved by the student's advisor and the graduate advisor. | | |
| Select from any of the following or courses from the Core Technical Electives which have not aready been taken for credit. | | |
| CIVE 562 | Introduction to Groundwater Hydrology | |
| CIVE 640 | Environmental Geotechnics | |
| ENVE 555 | Geographic Information Systems | |
| ENVE 727 | Risk Assessment | |
| ENVE 750 | Data-based Engineering Modeling | |
| MEM 660 | Theory of Elasticity I | |
| MEM 663 | Continuum Mechanics | |
| MEM 664 | Introduction to Plasticity | |
| Thesis, Research Project, or additional Graduate Technical Electives ^^^ | | 0.0-9.0 |
| **Total Credits** | | **225.5-254.5** |

## Structural Engineering 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 Requirements ** | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |

| | | |
|---|---|---|
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Math Requirements** | | |
| Select one of the following options: † | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | 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 I | 2.0 |
| CIVE 478 [WI] | Seminar II | 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 |
| **Senior Professional Electives** ‡ | | |
| CIVE 400 | Structural Analysis II | 3.0 |
| CIVE 401 | Structural Design II | 3.0 |
| CIVE 402 | Structural Design III | 3.0 |
| 9 credits of GR Theme Courses count as 9 credits of UG Professional Electives | | |
| **Master's Degree Courses** | | |
| **Required Theme Courses** ^ | | **15.0** |
| CIVE 605 | Advanced Mechanics of Materials ^ | |
| CIVE 701 | Advanced Structural Analysis I | |
| CIVE 702 | Advanced Structural Analysis II | |
| CIVE 703 | Advanced Structural Analysis III | |
| CIVE 708 | Fundamentals of Structural Dynamics | |
| **Core Technical Elective Courses** | | **15.0-30.0** |
| Select from any of the following: | | |
| CIVE 510 | Prestressed Concrete | |
| CIVE 511 | Advanced Steel Design | |
| CIVE 512 | Wood and Timber Design | |
| CIVE 513 | Introduction to Artificial Intelligence for Smart Structures and Systems | |
| CIVE 520 | Advanced Concrete Technology | |
| CIVE 540 | Forensic Structural Engineering | |
| CIVE 615 | Infrastructure Condition Evaluation | |
| CIVE 704 | Behavior and Stability of Structural Members I | |
| CIVE 711 | Engineered Masonry I | |
| CIVE 714 | Behavior of Concrete Structures I | |
| MATH 520 | Numerical Analysis I | |
| or MATH 521 | Numerical Analysis II | |
| MEM 591 | Applied Engr Analy Methods I | |
| or 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 | |
| or MEM 682 | Finite Element Methods II | |
| MEM 777 | Fracture Mechanics I | |
| **Additional Technical Elective Courses** ^^ | | **0.0-15.0** |
| These courses must be approved by the student's advisor and the graduate advisor. | | |
| Select from any of the following or courses from the Core Technical Electives which have not aready been taken for credit.: | | |
| AE 510 | Intelligent Buildings | |
| AE 561 | Airflow Simulation in Built Environment | |
| CIVE 531 | Advanced Foundation Engineering | |
| CIVE 633 | Lateral Earth Pressures and Retaining Structures | |
| CIVE 639 | Applied Finite Element Analysis in Geotechnical Engineering | |
| CIVE 839 | Constitutive Models in Geomechanics | |
| ENVE 555 | Geographic Information Systems | |
| ENVE 571 | Environmental Life Cycle Assessment | |
| ENVE 727 | Risk Assessment | |
| ENVE 750 | Data-based Engineering Modeling | |
| Thesis, Research Project, or additional Graduate Technical Electives ^^^ | | 0.0-9.0 |
| **Total Credits** | | **225.5-254.5** |

## Water Resources Engineering 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 Requirements [**] | | 21.0 |
| Free Electives | | 6.0 |
| **Foundation Requirements** | | |
| BIO 141 | Essential Biology | 4.5 |
| **Chemistry Requirements** | | |
| Select one of the following options: [***] | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | |
| Select one of the following options: [†] | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II [‡] | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: [†] | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | 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 I | 2.0 |
| CIVE 478 [WI] | Seminar II | 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 |
| **Senior Professional Electives [^]** | | **9.0** |
| 9 credits of GR Theme Courses count as 9 credits of UG Professional Electives | | |
| **Master's Degree Courses** | | |
| **Required Theme Courses [^^]** | | **15.0** |
| CIVE 564 | Sustainable Water Resource Engineering | |
| CIVE 565 | Urban Ecohydraulics | |
| CIVE 664 | Open Channel Hydraulics | |
| ENVE 681 | Analytical and Numerical Techniques in Hydrology | |
| or CIVE 567 | Watershed Analysis | |
| ENVS 501 | Chemistry of the Environment | |
| **Core Technical Elective Course** | | **15.0-30.0** |
| CIVE 562 | Introduction to Groundwater Hydrology | |
| CIVE 567 | Watershed Analysis | |
| 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 | |
| **Additional Technical Elective Courses [§]** | | **0.0-15.0** |
| These courses must be approved by the student's advisor and the graduate advisor. | | |
| Select from any of the following or courses from the Core Technical Electives which have not aready been taken for credit.: | | |
| CIVE 615 | Infrastructure Condition Evaluation | |
| ENVE 555 | Geographic Information Systems | |
| ENVE 571 | Environmental Life Cycle Assessment | |
| Thesis, Research Project, or additional Graduate Technical Electives [±] | | 0.0-9.0 |
| **Total Credits** | | **225.5-254.5** |

*****

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

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

‡

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

^
Three (3-credit) professional elective courses are required. Acceptable courses are as follows:
1. All 400 level CAEE courses; this includes CIVE, AE, and ENVE.
2. All AE, CIVE, and ENVE graduate level (500+) courses (you will need an override for these courses).
3. CMGT 361, CMGT 362, CMGT 451, CMGT 461, CMGT 463, and CMGT 467. Only 3 CMGT courses are allowed to count as Professional Electives.
4. Special Topics courses offered by the CAEE department on a case-by-case basis.

^
Must achieve grade of B or better.

§
For students writing an master's thesis, nine credits should consist of a minimum of 8 research credits (CIVE 997) and a minimum of 1 thesis credit (CIVE 898). Full time master's students are encouraged to do a thesis. Students opting not to do a thesis could do a research project which would consist of a minimum of 5 research credits (CIVE 997) and a minimum of 1 thesis credit (CIVE 898) or would require the completion of an additional 9.0 graduate technical elective credits from the list above, therefore, the total graduate technical elective credits required will be 15.0.
It should be noted that up to 15 credits from an approved certificate program can be applied to meet the requirements for the "Additional Technical Electives".

±
For students writing an master's thesis, nine credits should consist of a minimum of 8 research credits (CIVE 997) and a minimum of 1 thesis credit (CIVE 898). Full time master's students are encouraged to do a thesis. Students opting not to do a thesis could do a research project which would consist of a minimum of 5 research credits (CIVE 997) and a minimum of 1 thesis credit (CIVE 898) or would require the completion of an additional 9.0 graduate technical elective credits from the list above, therefore, the total graduate technical elective credits required will be 21.0.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Civil Engineering BSCIV / Construction Management MS

*Major: Civil Engineering and Construction Management*
*Degree Awarded: Bachelor of Science in Civil Engineering (BSCIV) and Master of Science in Construction Management*
*Calendar Type: Quarter*
*Minimum Required Credits: 225.5*
*Co-op Options: Three Co-ops (Five years)*

## 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 Construction Engineering and Management, so these are recognized as kindred disciplines

## Additional Information

For more information visit the BS/MS overview (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) page.

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.0 and completion of 90 credits.

## 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 |
| **Chemistry Requirements** | | |
| Select one of the following options: [***] | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Mathematics Requirements** | | |
| Select one of the following options: [***] | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II [†] | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: [***] | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | 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 I | 2.0 |
| CIVE 478 [WI] | Seminar II | 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 |
| **Senior Professional Electives** | | |
| Major Area of Focus | | |
| Select a major area of focus from a sequence listed below: | | 9.0 |
| Structural Engineering Focus | | |
| CIVE 400 | Structural Analysis II | |
| CIVE 401 | Structural Design II | |
| CIVE 402 | Structural Design III | |
| Geotechnical Engineering Focus: | | |
| CIVE 421 | Foundation Engineering | |
| CIVE 422 | Lateral Earth Pressures and Retaining Structures | |
| CIVE 423 | Engineering Ground Improvement | |
| Transportation Engineering Focus: | | |
| CIVE 450 | Transportation Engineering | |
| CIVE 451 | Transportation System Planning | |
| CIVE 452 | Traffic Signal Systems | |
| Water Resources Focus: | | |
| CIVE 431 | Hydrology-Ground Water | |
| CIVE 565 | Urban Ecohydraulics | |
| or CIVE 564 | Sustainable Water Resource Engineering | |
| CIVE 664 | Open Channel Hydraulics | |
| Environmental Engineering Focus: | | |
| ENVE 410 | Solid and Hazardous Waste | |
| or ENVE 421 | Water and Waste Treatment II | |
| ENVE 435 | Groundwater Remediation | |
| or ENVE 42 | Water and Waste Treatment Design | |
| ENVE 465 | Indoor Air Quality | |
| or AE 550 | Indoor Air Quality | |
| 9 credits of GR Elective Courses count as 9 credits of UG Professional Electives | | |
| **Master's Degree Courses** | | |
| **Core Foundation Courses** | | |
| CMGT 501 | Leadership in Construction | 3.0 |
| CMGT 505 | Construction Accounting and Financial Management | 3.0 |
| CMGT 510 | Construction Control Techniques | 3.0 |
| CMGT 512 | Cost Estimating and Bidding Strategies | 3.0 |
| CMGT 515 | Risk Management in Construction | 3.0 |
| CMGT 528 | Construction Contract Administration | 3.0 |
| **Electives** | | **21.0** |
| Students may select 7 elective courses from the following areas. | | |
| CMGT 525 | Applied Construction Project Management | |
| CMGT 530 | Equipment Applications and Economy | |
| CMGT 532 | International Construction Practices | |
| CMGT 535 | Community Impact Analysis | |
| CMGT 538 | Strategic Management in Construction | |
| CMGT 540 | Schedule Impact Analysis | |
| CMGT 545 | Sustainable Principles & Practices | |
| CMGT 546 | Sustainable Technologies | |
| CMGT 547 | LEED Concepts | |
| CMGT 548 | Quality Management and Construction Performance | |

| | | |
|---|---|---|
| CMGT 550 | Productivity Analysis and Improvement | |
| CMGT 558 | Community Sustainability | |
| REAL 568 | Real Estate Development | |
| REAL 571 | Advanced Real Estate Investment & Analysis | |
| REAL 572 | Advanced Market Research & Analysis | |
| REAL 573 | Sales & Marketing of Real Estate | |
| REAL 574 | Real Estate Economics in Urban Markets | |
| REAL 575 | Real Estate Finance | |
| REAL 576 | Real Estate Valuation & Analysis | |
| REAL 577 | Legal Issues in Real Estate Development | |
| **Culminating Experience** | | **6.0** |
| CMGT 696 | Capstone Project in Construction Management I | |
| CMGT 697 | Capstone Project in Construction Management II | |
| **Total Credits** | | **225.5-239.5** |

*****

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).

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

††

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Civil Engineering BSCIV / Environmental Engineering MSENE

*Major: Civil Engineering and Environmental Engineering*
*Degree Awarded: Bachelor of Science in Civil Engineering (BSCIV) and Master of Science in Environmental Engineering (MSENE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 225.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

This program allows students to develop technical depth and breadth in their major and an additional complementary related area, which enhances their professional capabilities in industry, or as they proceed on to earn a PhD. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. The underlying technical concepts of engineering are common, so students readily achieve their master’s degree in a related discipline in their area of interest. The American Society of Civil Engineers publishes the Journal of Environmental Engineering, so these are recognized as connected disciplines.

## Additional Information

For more information, visit the BS/MS program (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) or Department of Civil, Architectural and Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/) webpage.

## 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 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | |
| Select one of the following options: † | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II † | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| CIVE 240 | 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 I | 2.0 |
| CIVE 478 [WI] | Seminar II | 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** | | |
| Select a sequence of three (3-credit) professional elective courses from the list below: | | 9.0 |
| Structural Engineering Focus | | |
| CIVE 400 | Structural Analysis II | |
| CIVE 401 | Structural Design II | |
| CIVE 402 | Structural Design III | |
| Geotechnical Engineering Focus | | |
| CIVE 421 | Foundation Engineering | |
| CIVE 422 | Lateral Earth Pressures and Retaining Structures | |
| CIVE 423 | Engineering Ground Improvement | |
| Transportation Engineering Focus | | |
| CIVE 450 | Transportation Engineering | |
| CIVE 451 | Transportation System Planning | |
| CIVE 452 | Traffic Signal Systems | |
| Water Resources Focus | | |
| CIVE 431 | Hydrology-Ground Water | |
| or CIVE 565 | Urban Ecohydraulics | |
| CIVE 564 | Sustainable Water Resource Engineering | |
| CIVE 664 | Open Channel Hydraulics | |
| Environmental Engineering Focus: | | |
| ENVE 465 | Indoor Air Quality | |
| or AE 550 | Indoor Air Quality | |
| ENVE 410 | Solid and Hazardous Waste | |
| or ENVE 421 | Water and Waste Treatment II | |
| ENVE 435 | Groundwater Remediation | |
| or ENVE 42 | Water and Waste Treatment Design | |
| 9 credits of GR Theme Courses as 9 credits of UG Professional Electives | | |
| **Master's Degree Courses** | | |
| **Core Courses (15 credits)** | | |
| ENVE 660 | Chemical Kinetics in Environmental Engineering | 3.0 |
| ENVS 501 | Chemistry of the Environment | 3.0 |
| **Approved Statistics course** | | **3.0-4.0** |
| BMES 510 | Biomedical Statistics | |
| or ENVE 750 | Data-based Engineering Modeling | |
| or ENVS 506 | Biostatistics | |
| **Approved Policy course** | | **3.0** |
| CIVE 564 | Sustainable Water Resource Engineering | |
| or ECON 615 | Public Finance and Cost Benefit Analysis | |

| | | |
|---|---|---|
| or PLCY 503 | Theory and Practice of Policy Analysis | |
| or PLCY 504 | Methods of Policy Analysis | |
| **Approved Life Sciences course** | | **3.0** |
| ENVE 516 | Fundamentals of Environmental Biotechnology | |
| or ENVS 511 | Evolutionary Ecology | |
| or ENVS 530 | Aquatic Ecology | |
| **Specialization Courses** | | |
| Select one area from the list below to complete: | | 9.0-12.0 |
| **Environmental Treatment Processes:** | | |
| ENVE 546 | Solid Waste Systems | |
| & ENVE 661 | and Env Engr Op-Chem & Phys | |
| & ENVE 662 | and Enviro Engr Unit Oper-Bio | |
| & ENVE 665 | and Hazardous Waste & Groundwater Treatment | |
| **Human Risks:** | | |
| AE 550 | Indoor Air Quality | |
| or EOH 612 | Environmental Exposure Science | |
| EOH 510 | Principles and Practice of Environmental and Occupational Health | |
| ENVE 727 | Risk Assessment | |
| **Water Resources:** | | |
| CIVE 564 | Sustainable Water Resource Engineering | |
| & CIVE 565 | and Urban Ecohydraulics | |
| & ENVE 571 | and Environmental Life Cycle Assessment | |
| CIVE 664 | Open Channel Hydraulics †††† | |
| or ENVE 68 | Analytical and Numerical Techniques in Hydrology | |
| **Environmental Modeling:** | | |
| ENVE 555 | Geographic Information Systems †††† | |
| or ENVE 57 | Environmental Life Cycle Assessment | |
| ENVE 681 | Analytical and Numerical Techniques in Hydrology | |
| & ENVE 750 | and Data-based Engineering Modeling | |
| Approved Advanced Math course: | | |
| MEM 591 | Applied Engr Analy Methods I | |
| or CHE 502 | Mathematical Methods in Chemical Engineering | |
| or MATE 535 | Numerical Engineering Methods | |
| **Air Qualty:** | | |
| AE 550 | Indoor Air Quality | |
| & EOH 510 | and Principles and Practice of Environmental and Occupational Health | |
| & ENVE 560 | and Fundamentals of Air Pollution Control | |
| **Cognate Discipline Track ^^** | | |
| Complete a sequence of 12.0 credits at the 500-699 level from another specialization in the following subjects: | | 12.0 |
| Any AE (Architectural Engineering) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CHEC (Chemical Engineering Chemistry) course | | |
| Any CHEM (Chemistry) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any ENSS (Environmental Studies & Sustainability) course | | |
| Any ENVP (Environmental Policy) course | | |
| Any ENVS (Environmental Science) course | | |
| Any MATH (Mathematics) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| **MS Thesis or Graduate Electives §** | | **9.0** |
| **Total Credits** | | **225.5-243.5** |

*****

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).

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

††

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^^**

Could include a second specialization course sequence or a sequence of elective courses as approved by the student's advisor and the departmental graduate advisor.

**§**

For students writing an M.S. thesis, these nine credits should consist of six research credits (CIVE 997) and three thesis credits (CIVE 898). Full time Masters students are encouraged to do a thesis. Students opting not to do a thesis will be required to complete an additional 9.0 elective 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

## 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.

A. Emin Aktan, PhD *(University of Illinois at Urbana-Champaign) John Roebling Professor of Infrastructure Studies*. Professor. Structural engineering; health monitoring of large infrastructure systems; infrastructure evaluation; intelligent systems.

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)*. Associate Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

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

Peter DeCarlo, PhD *(University of Colorado)*. Assistant Professor. Outdoor air quality, particulate matter size and composition instrumentation and measurements, source apportionment of ambient particulate matter, climate impacts of particulate matter.

Eugenia Ellis, RA, PhD *(Virginia Polytechnic State University)*. Associate Professor. Extended-care facilities design, research on spatial visualization, perception and imagination.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute)*. Associate Professor. Soil mechanics; geoenvironmental; ground improvement; sustainability.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Associate 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 Professor and Department Head, Civil, Architectural and Environmental Engineering*. Professor. Control of human exposures to and risk assessment of pathogenic organisms; water and waste treatment; homeland security.

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

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) Dean of the College of Engineering and Distinguished Professor*. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Computational Fluid Dynamics (CFD) and airflow simulation; Indoor Environmental Quality; Building control integration with building information management systems.

Roger Marino, PhD *(Drexel University)*. Associate Teaching Professor. Fluid mechanics; water resources; engineering education; land development.

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

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

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

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) Graduate Studies Advisor*. Associate Professor. Environmental remediation; contaminant and bacterial transport in porous media and bacterial response to dynamic environments.

Michael Ryan, PhD *(Drexel University)*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); Dynamic Engineering Systems Modeling; Molecular Microbial Biology; Environmental Statistics; Engineering Economics; Microbiology

Christopher Sales, PhD *(University of California, Berkeley)*. Assistant Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste.

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. Research in 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 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*
*Minimum Required Credits: 227.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Computer Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can be about 25% higher than those with BS degrees.

For more information, visit the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) or for more information about these programs visit the ECE Department webpage (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/).

## 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 Requirements ** | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CS 260 | Data Structures | 4.0 |
| 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| 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 |
| Any BIO, CHEM or PHYS course | | |
| **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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| **Senior Design** *** | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| **CE Core Elective (choose one of the following):** | | **3.0** |
| ECE 370 | Electronic Devices | |
| ECE 371 | Foundations of Electromagnetics for Computing & Wireless Systems | |
| ECE 380 | Fundamentals of Power and Energy | |
| ECE Electives † | | 6.0 |
| ECE 400-level Electives †† | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| ECEC 500+ Courses | | 21.0 |
| General ECE Courses ‡ | | 9.0 |
| Graduate Electives ‡‡ | | 15.0 |
| **Total Credits** | | **227.5-229.5** |

*****

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 (p. 5)

*******

Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

†

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

††

3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

‡

9.0 credits at the 500+ level from subject codes ECEC, ECEE, ECEP, ECES, ECET, ECE.

‡‡

500+ courses in the following areas: AE, BIO, BMES, CHE, CHEM, CIVE, CMGT, CS, ECE, ECEC, ECEE, ECEP, ECES, ECET, EGMT, ENGR, ENVE, ET, MATE, MATH, MEM, OPR, PHYS, PROJ, SYSE.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

## Computer Engineering Faculty

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

Tom Chmielewski, PhD *(Drexel University)*. Assistant 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.

Bruce A. Eisenstein, PhD *(University of Pennsylvania) Vice Dean, College of Engineering; Arthur J. Rowland Professor*. Professor. Pattern recognition; estimation; decision theory.

Adam K. Fontecchio, PhD *(Brown University) Vice Dean, Graduate College*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

Gary Friedman, PhD *(University of Maryland-College Park)*. Professor. Biological and biomedical applications of nanoscale magnetic systems.

Eli Fromm, PhD *(Jefferson Medical College) LeRoy A. Brothers University Professor / Director for Center of Educational Research*. Professor. Engineering education; academic research policy; bioinstrumentation; physiologic systems.

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

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) Lester A. Kraus Professor/Director, Center for Microwave/Lightwave Engineering*. 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 Graduate Affairs*. Associate Professor. Embedded systems, self-managing systems, reliable and fault-tolerant computing, distributed systems, computer architecture, and testing and verification of digital systems.

Bruce Katz, PhD *(University of Illinois)*. Adjunct Professor. Speech communication and computer science; artificial intelligence.

Youngmoo Kim, PhD *(MIT)*. Associate Professor. Audio and music signal processing, voice analysis and synthesis, music information retrieval, machine learning.

Timothy P. Kurzweg, PhD *(University of Pittsburgh)*. Associate Professor. Micro-optical systems; optical spectroscopy; programmable imaging with MEMS; bio-sensors; diffuse optical communication; MEMS fabrication; diffractive optics; optical automation; optical modeling and simulation; magnetic particle locomotion; meta-materials; reconfigurable antennas

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

Bahram Nabet, PhD *(University of Washington) Associate Dean for Special Projects, College of Engineering; Electrical and Computer Engineering*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Prawat Nagvajara, Ph.D. *(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.

Chika Nwankpa, PhD *(Illinois Institute of Technology) ECE Department Head*. Professor. Power system dynamics; power electronic switching systems; optically controlled high power switches.

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 S. Prahbu, PhD *(Harvard University)*. Auxiliary Professor. Computer and software engineering; advanced microprocessors and distributed operating 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.

Ionnis Savidis, PhD *(University of Rochester)*. Assistant 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 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)*. Assistant 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)*. Assistant Professor. Information Security; multimedia forensics and anti-forensics; information verification; adversarial dynamics; signal processing

Jaudelice Cavalcante 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

# Computer Engineering BSCE / Cybersecurity MS

*Major: Computer Engineering and Cybersecurity*
*Degree Awarded: Bachelor of Science in Computer Engineering (BSCE) and Master of Science in Cybersecurity (MS)*
*Calendar Type: Quarter*
*Minimum Required Credits: 227.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Computer Engineering and Cybersecurity is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. The program is a natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, and prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience while gaining research experience by working with research faculty. Salaries for students with MS degrees can be approximately 25% higher than those with BS degrees.

As a greater percentage of people worldwide use computers, there is a marked increase in cybersecurity concerns. Motivated through discussions with the National Security Agency (NSA), Drexel University's MS in Cybersecurity program prepares students with both academic and practical training to be competitive in today's rapidly changing technical landscape. The program provides deeply technical and specialized training and enables graduates to understand, adapt, and develop new techniques to confront emerging threats in cybersecurity.

For more information, visit COE E (p. 5)CE Department page (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate and readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.3 and completion of 80 credits.

## Degree Requirements

*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.

| | | |
|---|---|---|
| **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** | | |
| COM 230 | Techniques of Speaking | 3.0 |
| or COM 310 | Technical Communication | |
| General Education Requirements ** | | 15.0 |
| **Foundation Requirements** | | |
| **Chemistry Requirements *** ** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| **Computer Science (CS) Requirements** | | |
| CS 260 | Data Structures | 4.0 |
| CS 265 | Advanced Programming Tools and Techniques | 3.0 |
| **General Engineering 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| **Mathematics Requirements †** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II ‡ | |
| OR | | |
| MATH 121 | Calculus I | |
| 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 |
| **Physics Requirements †** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |

| | | |
|---|---|---|
| ECES 301 | Signals and Systems I | 4.0 |
| Senior Design ^ | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| **CE Core Elective (select one)** | | **3.0** |
| ECE 370 | Electronic Devices | |
| or ECE 371 | Foundations of Electromagnetics for Computing & Wireless Systems | |
| or ECE 380 | Fundamentals of Power and Energy | |
| ECE Electives ^^ | | 6.0 |
| ECE 400+ level Electives § | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| INFO 517 | Principles of Cybersecurity | 3.0 |
| INFO 725 | Information Policy and Ethics | 3.0 |
| SE 578 | Security Engineering | 3.0 |
| **Cybersecurity Track-Specific Technical Electives** | | **27.0** |
| Choose from lists below depending on track | | |
| Computer Science Track Electives | | |
| CS 500 | Fundamentals of Databases | |
| CS 501 | Introduction to Programming | |
| CS 502 | Data Structures and Algorithms | |
| CS 503 | Systems Basics | |
| CS 510 | Introduction to Artificial Intelligence | |
| CS 521 | Data Structures and Algorithms I | |
| CS 522 | Data Structures and Algorithms II | |
| CS 540 | High Performance Computing | |
| CS 543 | Operating Systems | |
| CS 544 | Computer Networks | |
| CS 550 | Programming Languages | |
| CS 551 | Compiler Construction | |
| CS 590 | Privacy | |
| CS 610 | Advanced Artificial Intelligence | |
| CS 613 | Machine Learning | |
| CS 621 | Approximation Algorithms | |
| CS 630 | Cognitive Systems | |
| CS 645 | Network Security | |
| CS 647 | Distributed Systems Software | |
| CS 650 | Program Generation and Optimization | |
| CS 695 | Research Rotations in Cybersecurity | |
| CS 759 | Complexity Theory | |
| CS 770 | Topics in Artificial Intelligence | |
| SE 575 | Software Design | |
| SE 576 | Software Reliability and Testing | |
| SE T680 | Special Topics in Software Engineering | |
| Electrical & Computer Engineering Track Electives | | |
| ECE 610 | Machine Learning & Artificial Intelligence | |
| ECE 687 | Pattern Recognition | |
| ECEC 500 | Fundamentals Of Computer Hardware | |
| ECEC 501 | Computational Principles of Representation and Reasoning | |
| ECEC 502 | Principles of Data Analysis | |
| ECEC 503 | Principles of Decision Making | |
| ECEC 511 | Combinational Circuit Design | |
| ECEC 512 | Sequential Circuit Design | |
| ECEC 513 | Design for Testability | |
| ECEC 520 | Dependable Computing | |
| ECEC 531 | Principles of Computer Networking | |
| ECEC 600 | Fundamentals of Computer Networks | |
| ECEC 621 | High Performance Computer Architecture | |
| ECEC 622 | Parallel Programming | |
| ECEC 623 | Advanced Topics in Computer Architecture | |
| ECEC 632 | Performance Analysis of Computer Networks | |
| ECEC 633 | Advanced Topics in Computer Networking | |
| ECEC 641 | Web Security I | |
| ECEC 642 | Web Security II | |
| ECEC 643 | Web Security III | |
| ECEC 661 | Digital Systems Design | |
| ECES 511 | Fundamentals of Systems I | |
| ECES 512 | Fundamentals of Systems II | |
| ECES 513 | Fundamentals of Systems III | |
| ECES 521 | Probability & Random Variables | |
| ECES 522 | Random Process & Spectral Analysis | |
| ECES 523 | Detection & Estimation Theory | |
| ECES 558 | Digital Signal Processing for Sound & Hearing | |
| ECES 559 | Processing of the Human Voice | |
| ECES 604 | Optimal Estimation & Stochastic Control | |
| ECES 607 | Estimation Theory | |
| ECES 620 | Multimedia Forensics and Security | |
| ECES 621 | Communications I | |
| ECES 622 | Communications II | |
| ECES 623 | Communications III | |
| ECES 631 | Fundamentals of Deterministic Digital Signal Processing | |
| ECES 632 | Fundamentals of Statistical Digital Signal Processing | |
| ECES 641 | Bioinformatics | |
| ECES 642 | Optimal Control | |
| ECES 643 | Digital Control Systems Analysis & Design | |
| ECES 644 | Computer Control Systems | |
| ECES 651 | Intelligent Control | |
| ECES 682 | Fundamentals of Image Processing | |
| ECES 685 | Image Reconstruction Algorithms | |
| ECES 811 | Optimization Methods for Engineering Design | |
| ECES 812 | Mathematical Program Engineering Design | |
| ECES 813 | Computer-Aided Network Design | |
| ECES 818 | Machine Learning & Adaptive Control | |
| ECES 821 | Reliable Communications & Coding I | |
| ECES 822 | Reliable Communications & Coding II | |
| ECES 823 | Reliable Communications & Coding III | |
| ECET 501 | Fundamentals of Communications Engineering | |
| ECET 511 | Physical Foundations of Telecommunications Networks | |
| ECET 512 | Wireless Systems | |
| ECET 513 | Wireless Networks | |
| ECET 602 | Information Theory and Coding | |
| ECET 603 | Optical Communications and Networks | |
| ECET 604 | Internet Laboratory | |
| Information Track Electives | | |
| INFO 532 | Software Development | |
| INFO 540 | Perspectives on Information Systems | |
| INFO 590 | Foundations of Data and Information | |
| INFO 605 | Database Management Systems | |
| INFO 606 | Advanced Database Management | |
| INFO 607 | Applied Database Technologies | |
| INFO 624 | Intelligent Search and Language Models | |
| INFO 629 | Applied Artificial Intelligence | |
| INFO 633 | Information Visualization | |
| INFO 634 | Data Mining | |
| INFO 646 | Information Systems Management | |
| INFO 655 | Intro to Web Programming | |
| INFO 659 | Introduction to Data Analytics | |
| INFO 662 | Metadata and Resource Description | |
| INFO 670 | Cross-platform Mobile Development | |
| INFO 680 | US Government Information | |
| INFO 710 | Information Forensics | |
| INFO 712 | Information Assurance | |

| | |
|---|---|
| Cybersecurity Non-Track Electives ± | 9.0 |
| **Total Credits** | **227.5-243.5** |

*****

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

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**†**

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

**^**

Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

**^^**

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

**§**

3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

**±**

If enrolled in the Computer Science Track, choose 3 courses (9.0 credits) from either Electrical & Computer Engineering Track or Information Systems Track Technical Electives list.
If enrolled in the Information Systems Track, choose 3 courses (9.0 credits) from either the Computer Science or Electrical & Computer Engineering Tracks.
If enrolled in the Electrical & Computer Engineering Track, choose 3 courses (9.0 credits) from either the Computer Science or Information Systems Tracks.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Computer Engineering BSCE / Electrical Engineering MSEE

*Major: Computer Engineering and Electrical Engineering*
*Degree Awarded: Bachelor of Science in Computer Engineering (BSCE) and Master of Science in Electrical Engineering (MSEE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Computer Engineering and Electrical Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can be about 25% higher than those with BS degrees.

The MS program in Electrical Engineering prepares students for careers in research and development, and aims to endow graduates with the ability to identify, analyze, and address new technical and scientific challenges. At present, the department offers graduate coursework the following general areas: computer engineering; control, robotics, and intelligent systems; electrophysics; image and signal processing and

interpretation; power engineering and energy; and telecommunications and networking.

For more information, visit COE, E (https://catalog.drexel.edu/undergraduate/collegeofengineering/#specialprogramstext)CE Department (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.3 and completion of 90.0 credits.

## 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 Requirements ** | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CS 260 | Data Structures | 4.0 |
| 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| 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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| Senior Design *** | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| CE Core Elective (choose one of the following): | | 3.0 |
| ECE 370 | Electronic Devices | |
| ECE 371 | Foundations of Electromagnetics for Computing & Wireless Systems | |
| ECE 380 | Fundamentals of Power and Energy | |
| ECE Electives † | | 6.0 |
| ECE 400-level Electives †† | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| Electrical Engineering Courses ‡ | | 21.0 |
| General ECE Courses ‡‡ | | 9.0 |
| Graduate Electives § | | 15.0 |
| **Total Credits** | | **227.5-229.5** |

*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.

*****

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 who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits

†

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

††

3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

‡

500-level or higher courses in ECEE, ECEP, ECES, and ECET

‡‡

500-level or higher courses in ECE, ECEC, ECEE, ECEP, ECES, ECET. Research-intensive courses (ECE 697, ECE 898, ECE 997, and ECE 998) cannot be used to fulfill this requirement.

**§**
500-level or higher courses in the following areas: AE, BIO, BMES, CHE, CHEM, CIVE, CMGT, CS, ECE, ECEC, ECEE, ECEP, ECES, ECET, EGMT, ENGR, ENVE, ET, MATE, MATH, MEM, OPR, PROJ, PHYS, PRMT, SYSE.

## Sample Plan of Study

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Computer Engineering BSCE / Machine Learning Engineering MSMLE

*Major: Computer Engineering and Machine Learning Engineering*
*Degree Awarded: Bachelor of Science in Computer Engineering (BSCE) and Master of Science in Machine Learning Engineering (MSMLE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 227.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Computer Engineering and Machine Learning Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can be about 25% higher than those with BS degrees.

The MS in Machine Learning is designed to provide students with a strong academic background in machine learning and prepare them for a career as a machine learning engineer or similar position. Using a curriculum based on core machine learning topics, aligned mathematical theory, and signal processing, this graduate program provides a solid mathematical and theoretical understanding of how machine learning algorithms are designed, implemented, and applied to practical problems. Students will gain the ability to implement machine learning systems using standard programming languages, software frameworks, and systems both as an individual and as a member of a development team.

For more information, visit COE ECE Department page (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/)or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.3 and completion of 90.0 credits.

## 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 Requirements ** | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CS 260 | Data Structures | 4.0 |
| 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| 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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| **Senior Design** *** | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| **CE Core Elective (choose one of the following):** | | **3.0** |
| ECE 370 | Electronic Devices | |
| ECE 371 | Foundations of Electromagnetics for Computing & Wireless Systems | |
| ECE 380 | Fundamentals of Power and Energy | |
| ECE Electives † | | 6.0 |
| ECE 400-level Electives †† | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| **Core Courses** | | |
| ECE 610 | Machine Learning & Artificial Intelligence | 3.0 |
| ECE 612 | Applied Machine Learning Engineering | 3.0 |
| ECE 687 | Pattern Recognition | 3.0 |
| ECES 521 | Probability & Random Variables | 3.0 |
| **Aligned Mathematical Theory Courses** | | **6.0** |
| Choose two of the following: | | |
| ECES 522 | Random Process & Spectral Analysis | |
| ECES 523 | Detection & Estimation Theory | |
| ECES 811 | Optimization Methods for Engineering Design | |
| ECET 602 | Information Theory and Coding | |
| MATH 504 | Linear Algebra & Matrix Analysis | |
| MATH 510 | Applied Probability and Statistics I | |
| **Signal Processing** | | **3.0** |
| Choose one of the following: | | |
| ECES 631 | Fundamentals of Deterministic Digital Signal Processing | |
| ECES 681 | Fundamentals of Computer Vision | |
| ECES 682 | Fundamentals of Image Processing | |
| **Applications** | | **3.0** |
| Choose one of the following: | | |
| ECE 686 | Cell & Tissue Image Analysis | |
| ECES 620 | Multimedia Forensics and Security | |
| ECES 641 | Bioinformatics | |
| ECES 650 | Statistical Analysis of Genomics | |
| ECES 660 | Machine Listening and Music IR | |
| **Transformational Electives** | | **6.0** |
| Choose two elective courses that promote the development of leadership, communication, and ethics: | | |
| COM 610 | Theories of Communication and Persuasion | |
| EDGI 510 | Culture, Society & Education in Comparative Perspective | |
| EDGI 522 | Education for Global Citizenship, Sustainability, and Social Justice | |
| Engineering Electives ‡ | | 9.0 |
| **Mastery (Thesis and Non-Thesis Option)** ‡‡ | | **6.0** |
| ECE 898 | Master's Thesis | |
| **Total Credits** | | **227.5-229.5** |

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.

*****

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 who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

†

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

††

3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

‡

Choose 3 classes at the 500 level or higher from: ECEC, ECEE, ECEP, ECES, ECET, ECE, AE, CHE, CIVE, CMGT, EGMT, ENGR, ENVE, ET, MATE, MEM, PROJ, and SYSE.

‡‡

Thesis Option: A minimum of two terms of laboratory-based research that leads to a publicly defended MS thesis. Students will be advised by a faculty member, and when applicable, a representative of industry or government sponsor.
Non-Thesis Option: In lieu of research and thesis, students will complete 6.0 additional credits of coursework from the Mathematical Theory, Applications, or Signal Processing areas.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Computer Engineering BSCE / Robotics & Autonomy MSRA

*Major: Computer Engineering and Robotics & Autonomy*
*Degree Awarded: Bachelor of Science in Computer Engineering (BSCE) and Master of Science in Robotics & Autonomy (MSRA)*
*Calendar Type: Quarter*
*Minimum Required Credits: 227.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Computer Engineering with Robotics and Autonomy is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area while earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. The program is a natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, and prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gain research experience by working with research faculty. Salaries for students with MS degrees can be approximately 25% higher than those with BS degrees.

The graduate program in Robotics and Autonomy will educate professionals who are prepared to lead and conduct research, development, and design in robotic systems and technologies. This MS degree is built upon four foundational concepts in robotics: perception, cognition, control, and action. Roughly, these four capabilities comprise: 1) obtaining data from the robot's surroundings (perception); 2) reasoning about how that data yields information about the robot's environment (cognition); 3) mapping environmental information to a decision about how to react to the environment (control); and 4) translating that reaction decision into movement and an interaction with the physical environment (action).

For more information, visit C (p. 5)OE ECE Department (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.3 and completion of 80.0 credits.

## 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 Requirements ** | | 15.0 |
| **Foundation Requirements** | | |
| CHEM 101 | General Chemistry I | 3.5 |
| CS 260 | Data Structures | 4.0 |
| 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| 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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| **Senior Design** *** | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| **CE Core Elective (choose one of the following):** | | **3.0** |
| ECE 370 | Electronic Devices | |
| ECE 371 | Foundations of Electromagnetics for Computing & Wireless Systems | |
| ECE 380 | Fundamentals of Power and Energy | |
| ECE Electives † | | 6.0 |
| ECE 400-level Electives †† | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| **Foundation Courses** | | **6.0** |
| Choose 2 courses in mathematics and/or signal processing | | |
| Mathematics | | |
| ECES 510 | Analytical Methods in Systems | |
| ECES 521 | Probability & Random Variables | |
| MATH 510 | Applied Probability and Statistics I | |
| MATH 521 | Numerical Analysis II | |
| MATH 623 | Ordinary Differential Equations I | |
| MATH 630 | Complex Variables I | |
| MEM 591 | Applied Engr Analy Methods I | |
| MEM 592 | Applied Engr Analy Methods II | |
| MEM 593 | Applied Engr Analy Methods III | |
| Signal Processing | | |
| ECES 522 | Random Process & Spectral Analysis | |
| ECES 523 | Detection & Estimation Theory | |
| ECES 604 | Optimal Estimation & Stochastic Control | |
| ECES 631 | Fundamentals of Deterministic Digital Signal Processing | |
| ECES 640 | Genomic Signal Processing | |
| ECES 641 | Bioinformatics | |
| **Systems Courses** | | **6.0** |
| Choose 2 courses in robotics and autonomy from the perspective of full systems or use | | |
| ECE 603 | Computing and Control | |
| ECE 608 | Decision-Making for Robotics | |
| ECE 610 | Machine Learning & Artificial Intelligence | |
| ECE 612 | Applied Machine Learning Engineering | |
| ECES 511 | Fundamentals of Systems I | |
| ECES 512 | Fundamentals of Systems II | |
| ECES 513 | Fundamentals of Systems III | |
| ECES 561 | Medical Robotics I | |
| ECES 562 | Medical Robotics II | |
| MEM 572 | Mechanics of Robot Manipulators | |
| MEM 573 | Industrial Application of Robots | |
| **Technical Focus Areas** | | **9.0** |
| Choose three courses from a maximum of two Core Component areas: Perception, Cognition and Behavior, Action, Control | | |
| **Core Components** | | |
| Take 1 course in each of the four disciplines critical to robotics | | |
| Perception Course | | 3.0 |
| ECE 609 | Mobile Sensing and Motion Planning | |
| ECE 687 | Pattern Recognition | |
| ECES 681 | Fundamentals of Computer Vision | |
| ECES 682 | Fundamentals of Image Processing | |
| ECET 512 | Wireless Systems | |
| ECET T580 | Special Topics in Telecommunications | |
| MEM 678 | Nondestructive Evaluation Methods | |
| Cognition and Behavior Course | | 3.0 |
| ECE 610 | Machine Learning & Artificial Intelligence | |
| ECE 612 | Applied Machine Learning Engineering | |
| ECE 686 | Cell & Tissue Image Analysis | |
| ECES 604 | Optimal Estimation & Stochastic Control | |
| ECES 631 | Fundamentals of Deterministic Digital Signal Processing | |
| Action Course | | 3.0 |
| ECES 511 | Fundamentals of Systems I | |
| ECES 512 | Fundamentals of Systems II | |
| ECES 513 | Fundamentals of Systems III | |
| MEM 530 | Aircraft Flight Dynamics & Control I | |
| MEM 666 | Advanced Dynamics I | |
| MEM 667 | Advanced Dynamics II | |
| MEM 668 | Advanced Dynamics III | |
| Control Course | | 3.0 |
| ECE 603 | Computing and Control | |
| ECE 612 | Applied Machine Learning Engineering | |
| ECES 604 | Optimal Estimation & Stochastic Control | |
| ECES 642 | Optimal Control | |
| MEM 633 | Robust Control Systems I | |
| MEM 634 | Robust Control Systems II | |
| MEM 635 | Robust Control Systems III | |
| MEM 636 | Theory of Nonlinear Control I | |
| MEM 637 | Theory of Nonlinear Control II | |
| MEM 638 | Theory of Nonlinear Control III | |
| MEM 733 | Applied Optimal Control I | |
| MEM 734 | Applied Optimal Control II | |
| MEM 735 | Advanced Topics in Optimal Control | |
| **Transformational Electives** | | **6.0** |
| Choose 2 elective courses that promote the development of leadership, communication, and ethics | | |
| COM 610 | Theories of Communication and Persuasion | |
| EDGI 510 | Culture, Society & Education in Comparative Perspective | |
| EDGI 522 | Education for Global Citizenship, Sustainability, and Social Justice | |
| **Mastery: Thesis or Alternative** | | **6.0** |
| Thesis Option: A minimum of two terms of laboratory-based research (ECE 898) that leads to a publicly defended MS thesis. Students will be advised by a faculty member, and when applicable, a representative of industry or government sponsor. | | |
| Non-thesis Option: In lieu of the research and thesis, students will complete 6.0 credits of additional coursework in a Technical Focus Area. Graduate Co-op is encouraged for non-thesis students, but is not required. | | |
| **Total Credits** | | **227.5-229.5** |

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.

*****

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 who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

†
2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

††
3 classes or at least 9.0 credits at the 400 level from subject codes ECE or ECEC. Includes Special Topics in each code (T480).

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Electrical Engineering BSEE / Computer Engineering MSCPE

*Major: Electrical Engineering and Computer Engineering*
*Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE) and Master of Science in Computer Engineering (MSCPE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Electrical Engineering and Computer Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can be about 25% higher than those with BS degrees.

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

For more information, visit COE,E (p. 5)CE Department (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.3 and completion of 90.0 credits.

## Degree Requirements

| BSEE 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 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| 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 |
| Any BIO, CHEM, or PHYS course | | |
| **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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| Senior Design *** | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| EE Core Elective (Choose one of the following): | | 3.0-4.0 |
| CS 260 | Data Structures | |
| CS 265 | Advanced Programming Tools and Techniques | |
| ECE 350 | Introduction to Computer Organization | |
| ECE Electives † | | 6.0 |
| ECE 400-level Electives †† | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| Computer Engineering Courses (ECEC 500-900 level) | | 21.0 |
| General Electrical and Computer Engineering Courses ‡ | | 9.0 |
| **Mathematical Foundations Requirement** | | |
| 6.0 credits from one of the following courses must be included within (not in addition to) the 45.0 total required MS credits: | | |
| CS 525 | Theory of Computation | |
| CS 567 | Applied Symbolic Computation | |
| CS 583 | Introduction to Computer Vision | |
| CS 613 | Machine Learning | |
| CS 621 | Approximation Algorithms | |
| CS 623 | Computational Geometry | |
| ECES 511 | Fundamentals of Systems I | |
| ECES 512 | Fundamentals of Systems II | |
| ECES 513 | Fundamentals of Systems III | |
| ECES 521 | Probability & Random Variables | |
| ECES 522 | Random Process & Spectral Analysis | |
| ECES 523 | Detection & Estimation Theory | |
| ECES 811 | Optimization Methods for Engineering Design | |
| ECET 602 | Information Theory and Coding | |
| OPR 624 | Advanced Mathematical Program | |
| OPR 992 | Applied Math Programming | |
| MATH 500-900 level | | |
| Graduate Electives ‡‡ | | 15.0 |
| **Total Credits** | | **226.5-229.5** |

*****

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 Courses (p. 5)

*******

Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

†

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

††

3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

‡

Courses at the 500-900 level from ECEC, ECEE, ECEP, ECES, ECET, or ECE.

‡‡

15.0 credits at the 500-900 level from subject codes ECEC, ECEE, ECEP, ECES, ECET, ECE, AE, CHE, CIVE, CMGT, EGMT, ENGR, ENVE, ET, MATE, MEM, PROJ, SYSE, BMES, MATH, PHYS, CHEM, BIO, OPR, or CS.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/

#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Electrical Engineering BSEE / Cybersecurity MS

*Major: Electrical Engineering and Cybersecurity*
*Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE) and Master of Science in Cybersecurity (MS)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Electrical Engineering and Cybersecurity is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can be about 25% higher than those with BS degrees.

Administered by the Electrical & Computer Engineering Department in the College of Engineering, the graduate program in Cybersecurity is interdisciplinary in nature and includes courses from Drexel University's College of Computing & Informatics. Topics covered include computer networking, probability concepts, techniques for analyzing algorithms, dependable software design, reverse software engineering, intrusion detection, ethics, privacy, confidentiality, authenticity, and social networking.

For more information, visit the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.3 and completion of 90.0 credits.

## Degree Requirements

| | | |
|---|---|---|
| **BSEE 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 Courses [**] | | 15.0 |
| **Foundation Requirements** | | |
| **Chemistry Requirements [***]** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| **General Engineering 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| **Mathematics Requirements [†]** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II [‡] | |
| OR | | |
| MATH 121 | Calculus I | |
| 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 |

| | | |
|---|---|---|
| **Physics Requirements** [†] | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| PHYS 201 | Fundamentals of Physics III | 4.0 |
| **Science Elective** | | **3.0** |
| Choose from BIO, PHYS or CHEM | | |
| **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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| Senior Design [^] | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| EE Core Elective (Choose one of the following): | | 3.0-4.0 |
| CS 260 | Data Structures | |
| CS 265 | Advanced Programming Tools and Techniques | |
| ECE 350 | Introduction to Computer Organization | |
| ECE Electives [^^] | | 6.0 |
| ECE 400-level Electives [§] | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| INFO 517 | Principles of Cybersecurity | 3.0 |
| INFO 725 | Information Policy and Ethics | 3.0 |
| SE 578 | Security Engineering | 3.0 |
| **Cybersecurity Track-Specific Technical Electives** | | **27.0** |
| Choose from lists below depending on track | | |
| Computer Science Track Electives | | |
| CS 500 | Fundamentals of Databases | |
| CS 501 | Introduction to Programming | |
| CS 502 | Data Structures and Algorithms | |
| CS 503 | Systems Basics | |
| CS 510 | Introduction to Artificial Intelligence | |
| CS 521 | Data Structures and Algorithms I | |
| CS 522 | Data Structures and Algorithms II | |
| CS 540 | High Performance Computing | |
| CS 543 | Operating Systems | |
| CS 544 | Computer Networks | |
| CS 550 | Programming Languages | |
| CS 551 | Compiler Construction | |
| CS 590 | Privacy | |
| CS 610 | Advanced Artificial Intelligence | |
| CS 613 | Machine Learning | |
| CS 621 | Approximation Algorithms | |
| CS 630 | Cognitive Systems | |
| CS 645 | Network Security | |
| CS 647 | Distributed Systems Software | |
| CS 650 | Program Generation and Optimization | |
| CS 695 | Research Rotations in Cybersecurity | |
| CS 759 | Complexity Theory | |
| CS 770 | Topics in Artificial Intelligence | |
| SE 575 | Software Design | |
| SE 576 | Software Reliability and Testing | |
| SE T680 | Special Topics in Software Engineering | |
| Electrical & Computer Engineering Track Electives | | |
| ECE 610 | Machine Learning & Artificial Intelligence | |
| ECE 687 | Pattern Recognition | |
| ECEC 500 | Fundamentals Of Computer Hardware | |
| ECEC 501 | Computational Principles of Representation and Reasoning | |
| ECEC 502 | Principles of Data Analysis | |
| ECEC 503 | Principles of Decision Making | |
| ECEC 511 | Combinational Circuit Design | |
| ECEC 512 | Sequential Circuit Design | |
| ECES 513 | Fundamentals of Systems III | |
| ECEC 520 | Dependable Computing | |
| ECEC 531 | Principles of Computer Networking | |
| ECEC 600 | Fundamentals of Computer Networks | |
| ECEC 621 | High Performance Computer Architecture | |
| ECEC 622 | Parallel Programming | |
| ECEC 623 | Advanced Topics in Computer Architecture | |
| ECEC 632 | Performance Analysis of Computer Networks | |
| ECEC 633 | Advanced Topics in Computer Networking | |
| ECEC 641 | Web Security I | |
| ECEC 642 | Web Security II | |
| ECEC 643 | Web Security III | |
| ECEC 661 | Digital Systems Design | |
| ECES 511 | Fundamentals of Systems I | |
| ECES 512 | Fundamentals of Systems II | |
| ECES 513 | Fundamentals of Systems III | |
| ECES 521 | Probability & Random Variables | |
| ECES 522 | Random Process & Spectral Analysis | |
| ECES 523 | Detection & Estimation Theory | |
| ECES 558 | Digital Signal Processing for Sound & Hearing | |
| ECES 559 | Processing of the Human Voice | |
| ECES 604 | Optimal Estimation & Stochastic Control | |
| ECES 607 | Estimation Theory | |
| ECES 620 | Multimedia Forensics and Security | |
| ECES 621 | Communications I | |
| ECES 622 | Communications II | |
| ECES 623 | Communications III | |
| ECES 631 | Fundamentals of Deterministic Digital Signal Processing | |
| ECES 632 | Fundamentals of Statistical Digital Signal Processing | |
| ECES 641 | Bioinformatics | |
| ECES 642 | Optimal Control | |
| ECES 643 | Digital Control Systems Analysis & Design | |
| ECES 644 | Computer Control Systems | |
| ECES 651 | Intelligent Control | |
| ECES 682 | Fundamentals of Image Processing | |
| ECES 685 | Image Reconstruction Algorithms | |
| ECES 811 | Optimization Methods for Engineering Design | |
| ECES 812 | Mathematical Program Engineering Design | |
| ECES 813 | Computer-Aided Network Design | |
| ECES 818 | Machine Learning & Adaptive Control | |
| ECES 821 | Reliable Communications & Coding I | |
| ECES 822 | Reliable Communications & Coding II | |
| ECES 823 | Reliable Communications & Coding III | |
| ECET 501 | Fundamentals of Communications Engineering | |
| ECET 511 | Physical Foundations of Telecommunications Networks | |
| ECET 512 | Wireless Systems | |
| ECET 513 | Wireless Networks | |

| | | |
|---|---|---|
| ECET 602 | Information Theory and Coding | |
| ECET 603 | Optical Communications and Networks | |
| ECET 604 | Internet Laboratory | |
| Information Track Electives | | |
| INFO 532 | Software Development | |
| INFO 540 | Perspectives on Information Systems | |
| INFO 590 | Foundations of Data and Information | |
| INFO 605 | Database Management Systems | |
| INFO 606 | Advanced Database Management | |
| INFO 607 | Applied Database Technologies | |
| INFO 624 | Intelligent Search and Language Models | |
| INFO 629 | Applied Artificial Intelligence | |
| INFO 633 | Information Visualization | |
| INFO 634 | Data Mining | |
| INFO 646 | Information Systems Management | |
| INFO 655 | Intro to Web Programming | |
| INFO 659 | Introduction to Data Analytics | |
| INFO 662 | Metadata and Resource Description | |
| INFO 670 | Cross-platform Mobile Development | |
| INFO 680 | US Government Information | |
| INFO 710 | Information Forensics | |
| INFO 712 | Information Assurance | |
| **Cybersecurity Non-Track Electives** [±] | | **9.0** |
| **Total Credits** | | **226.5-243.5** |

*****

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 able to take COOP 001 in place of COOP 101.

******

General Education Requirements (p. 5)

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**†**

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

**‡**

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**^**

Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

**^^**

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

**§**

3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

**±**

If enrolled in the Computer Science Track, choose 3 courses (9.0 credits) from either Electrical & Computer Engineering or Information Tracks.

If enrolled in the Information Track, choose 3 courses (9.0 credits) from either the Computer Science or Electrical & Computer Engineering Tracks.

If enrolled in the Electrical & Computer Engineering Track, choose 3 courses (9.0 credits) from either the Computer Science or Information Tracks.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Electrical Engineering BS / Electrical Engineering MS

*Major: Electrical Engineering*
*Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE) and Master of Science in Electrical Engineering (MSEE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Electrical Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can be about 25% higher than those with BS degrees.

For more information, visit COE ECE Department (https://drexel.edu/engineering/academics/departments/electrical-computer-engineering/) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## 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

| | | |
|---|---|---|
| **BSEE 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 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| 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 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 |
| Senior Design *** | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| EE Core Elective | | 3.0-4.0 |
| CS 260 | Data Structures | |
| or CS 265 | Advanced Programming Tools and Techniques | |
| or ECE 350 | Introduction to Computer Organization | |
| ECE Electives † | | 6.0 |
| ECE 400-level Electives †† | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Program Courses** | | |
| Graduate EE Courses ‡ | | 21.0 |
| Graduate Elective Courses ‡‡ | | 15.0 |
| Graduate General ECE Courses § | | 9.0 |
| **Total Credits** | | **226.5-229.5** |

*****

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 who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

†
2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

††
3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

‡
500+ level courses in ECEE, ECEP, ECES, and/or ECET

‡‡
500+ level courses in the following areas: AE, BIO, BMES, CHE, CHEM, CIVE, CMGT, CS, ECE, ECEC, ECEE, ECEP, ECES, ECET, EGMT, ENGR, ENVE, ET, MATE, MATH, MEM, OPR, PHYS, PROJ, SYSE

§
500+ level courses 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Electrical Engineering BSEE / Machine Learning Engineering MSMLE

*Major: Electrical Engineering and Machine Learning Engineering*
*Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE) and Master of Science in Machine Learning Engineering (MSMLE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Electrical Engineering and Machine Learning Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can be about 25% higher than those with BS degrees.

The MS in Machine Learning is designed to provide students with a strong academic background in machine learning and prepare them for a career as a machine learning engineer or similar position. Using a curriculum based on core machine learning topics, aligned mathematical theory, and signal processing, this graduate program provides a solid mathematical and theoretical understanding of how machine learning algorithms are designed, implemented, and applied to practical problems. Students will gain the ability to implement machine learning systems using standard programming languages, software frameworks, and systems both as an individual and as a member of a development team.

For more information, visit the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.3 and completion of 90.0 credits.

## Degree Requirements

| BSEE 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 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| 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 |
| Any BIO, CHEM or PHYS course | | |
| **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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| Senior Design [***] | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| EE Core Elective (Choose one of the following): | | 3.0-4.0 |
| CS 260 | Data Structures | |
| CS 265 | Advanced Programming Tools and Techniques | |
| ECE 350 | Introduction to Computer Organization | |
| ECE Electives [†] | | 6.0 |
| ECE 400-level Electives [††] | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| **Core Courses** | | |
| ECE 610 | Machine Learning & Artificial Intelligence | 3.0 |
| ECE 612 | Applied Machine Learning Engineering | 3.0 |
| ECE 687 | Pattern Recognition | 3.0 |
| ECES 521 | Probability & Random Variables | 3.0 |
| **Aligned Mathematical Theory** | | **6.0** |
| Choose 2 courses | | |
| ECES 522 | Random Process & Spectral Analysis | |
| ECES 523 | Detection & Estimation Theory | |
| ECES 811 | Optimization Methods for Engineering Design | |
| ECET 602 | Information Theory and Coding | |
| MATH 504 | Linear Algebra & Matrix Analysis | |
| MATH 510 | Applied Probability and Statistics I | |
| **Signal Processing** | | **3.0** |
| Choose 1 course | | |
| ECES 631 | Fundamentals of Deterministic Digital Signal Processing | |
| ECES 681 | Fundamentals of Computer Vision | |
| ECES 682 | Fundamentals of Image Processing | |
| **Applications** | | **3.0** |
| Choose 1 course | | |
| ECE 686 | Cell & Tissue Image Analysis | |
| ECES 620 | Multimedia Forensics and Security | |
| ECES 641 | Bioinformatics | |
| ECES 650 | Statistical Analysis of Genomics | |
| ECES 660 | Machine Listening and Music IR | |
| **Engineering Electives [‡]** | | **9.0** |
| Choose any 3 graduate-level courses from the College of Engineering | | |
| **Transformational Electives** | | **6.0** |
| Choose 2 elective courses that promote the development of leadership, communications, and ethics | | |
| COM 610 | Theories of Communication and Persuasion | |
| EDGI 510 | Culture, Society & Education in Comparative Perspective | |
| EDGI 522 | Education for Global Citizenship, Sustainability, and Social Justice | |
| **Mastery (Thesis and Non-Thesis Option) [‡‡]** | | **6.0** |
| ECE 898 | Master's Thesis | |
| **Total Credits** | | **226.5-229.5** |

*****

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 Courses (p. 5)

*******

Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

†

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

††
3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

‡
Choose three courses of 500-level or higher from: ECEC, ECEE, ECEP, ECES, ECET, ECE, AE, CHE, CIVE, CMGT, EGMT, ENGR, ENVE, ET, MATE, MEM, PROJ, and SYSE

‡‡
Thesis Option: A minimum of two terms of laboratory-based research that leads to a publicly defended MS thesis. Students will be advised by a faculty member, and when applicable, a representative of industry or government sponsor.
Non-thesis Option: In lieu of research and thesis, students will complete 6.0 additional credits of coursework from the Mathematical Theory, Applications, or Signal Processing area.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Electrical Engineering BSEE / Robotics & Autonomy MSRA

*Major: Electrical Engineering and Robotics & Autonomy*
*Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE) and Master of Science in Robotics & Autonomy (MSRA)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.5*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Electrical Engineering and Robotics and Autonomy is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can be about 25% higher than those with BS degrees.

The graduate program in Robotics and Autonomy will educate professionals who are prepared to lead and conduct research, development, and design in robotic systems and technologies. This MS degree is built upon four foundational concepts in robotics: perception, cognition, control, and action. Roughly, these four capabilities comprise: 1) obtaining data from the robot’s surroundings (perception); 2) reasoning about how that data yields information about the robot’s environment (cognition); 3) mapping environmental information to a decision about how to react to the environment (control); and 4) translating that reaction decision into movement and an interaction with the physical environment (action).

For more information, visit COE Special Programs (p. 5) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.3 and completion of 90.0 credits.

## Degree Requirements

**BSEE 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 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 | 3.0-4.0 |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or CAEE 231 | Linear Engineering Systems | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0-4.0 |
| or ECE 232 | Solving Dynamic Systems | |
| or CAEE 232 | Dynamic Engineering Systems | |
| or MATH 210 | Differential Equations | |
| 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 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 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 3.0 |
| ECES 301 | Signals and Systems I | 4.0 |
| Senior Design [***] | | |
| ECE 491 [WI] | Senior Design Project I | 3.0 |
| ECE 492 [WI] | Senior Design Project II | 3.0 |
| ECE 493 [WI] | Senior Design Project III | 3.0 |
| EE Core Elective (Choose one of the following): | | 3.0-4.0 |
| CS 260 | Data Structures | |
| CS 265 | Advanced Programming Tools and Techniques | |
| ECE 350 | Introduction to Computer Organization | |
| ECE Electives [†] | | 6.0 |
| ECE 400-level Electives [††] | | 9.0 |
| Free Electives | | 27.0 |
| **Master's Degree Courses** | | |
| **Foundation Courses** | | **6.0** |
| Choose 2 courses in mathematics and/or signal processing | | |
| Mathematics | | |
| ECES 510 | Analytical Methods in Systems | |
| ECES 521 | Probability & Random Variables | |
| MATH 510 | Applied Probability and Statistics I | |
| MATH 521 | Numerical Analysis II | |
| MATH 623 | Ordinary Differential Equations I | |
| MATH 630 | Complex Variables I | |
| MEM 591 | Applied Engr Analy Methods I | |
| MEM 592 | Applied Engr Analy Methods II | |
| MEM 593 | Applied Engr Analy Methods III | |
| Signal Processing | | |
| ECES 522 | Random Process & Spectral Analysis | |
| ECES 523 | Detection & Estimation Theory | |
| ECES 604 | Optimal Estimation & Stochastic Control | |
| ECES 631 | Fundamentals of Deterministic Digital Signal Processing | |
| ECES 640 | Genomic Signal Processing | |
| ECES 641 | Bioinformatics | |
| **Systems Courses** | | **6.0** |
| Choose 2 courses in robotics and autonomy from the perspective of full systems or use | | |
| ECE 603 | Computing and Control | |
| ECE 608 | Decision-Making for Robotics | |
| ECE 610 | Machine Learning & Artificial Intelligence | |
| ECE 612 | Applied Machine Learning Engineering | |
| ECES 511 | Fundamentals of Systems I | |
| ECES 512 | Fundamentals of Systems II | |
| ECES 513 | Fundamentals of Systems III | |
| ECES 561 | Medical Robotics I | |
| ECES 562 | Medical Robotics II | |
| MEM 572 | Mechanics of Robot Manipulators | |
| MEM 573 | Industrial Application of Robots | |
| **Core Components** | | |
| Take 1 course in each of the four disciplines critical to robotics | | |
| Perception | | 3.0 |
| ECE 609 | Mobile Sensing and Motion Planning | |
| ECE 687 | Pattern Recognition | |
| ECES 681 | Fundamentals of Computer Vision | |
| ECES 682 | Fundamentals of Image Processing | |
| ECET 512 | Wireless Systems | |
| ECET T580 | Special Topics in Telecommunications | |
| MEM 678 | Nondestructive Evaluation Methods | |
| Cognition and Behavior | | 3.0 |
| ECE 610 | Machine Learning & Artificial Intelligence | |
| ECE 612 | Applied Machine Learning Engineering | |
| ECE 617 | Reinforcement Learning | |
| ECE 686 | Cell & Tissue Image Analysis | |
| ECES 604 | Optimal Estimation & Stochastic Control | |
| ECES 631 | Fundamentals of Deterministic Digital Signal Processing | |
| Action | | 3.0 |
| ECES 511 | Fundamentals of Systems I | |
| ECES 512 | Fundamentals of Systems II | |
| ECES 513 | Fundamentals of Systems III | |
| MEM 530 | Aircraft Flight Dynamics & Control I | |
| MEM 666 | Advanced Dynamics I | |
| MEM 667 | Advanced Dynamics II | |
| MEM 668 | Advanced Dynamics III | |
| Control | | 3.0 |
| ECE 603 | Computing and Control | |
| ECE 612 | Applied Machine Learning Engineering (Cognition and Behavior) | |
| ECES 604 | Optimal Estimation & Stochastic Control | |
| ECES 642 | Optimal Control | |
| MEM 633 | Robust Control Systems I | |
| MEM 634 | Robust Control Systems II | |

| | | |
|---|---|---|
| MEM 635 | Robust Control Systems III | |
| MEM 636 | Theory of Nonlinear Control I | |
| MEM 637 | Theory of Nonlinear Control II | |
| MEM 638 | Theory of Nonlinear Control III | |
| MEM 733 | Applied Optimal Control I | |
| MEM 734 | Applied Optimal Control II | |
| MEM 735 | Advanced Topics in Optimal Control | |
| **Technical Focus Areas** ‡ | | **9.0** |
| Take 3 courses in a maximum of two core component areas listed above | | |
| **Transformational Electives** | | **6.0** |
| Choose 2 elective courses that promote the development of leadership, communication, and ethics | | |
| COM 610 | Theories of Communication and Persuasion | |
| EDGI 510 | Culture, Society & Education in Comparative Perspective | |
| EDGI 522 | Education for Global Citizenship, Sustainability, and Social Justice | |
| **Mastery** | | **6.0** |
| Thesis Option: A minimum of two terms of laboratory-based research (ECE 898) that leads to a publicly defended MS thesis. Students will be advised by a faculty member, and when applicable, a representative of industry or government sponsor. | | |
| Non-thesis Option: In lieu of the research and thesis, students will complete six credits of additional coursework in a Technical Focus Area. Graduate Co-op is encouraged for non-thesis students, but is not required. | | |
| **Total Credits** | | **226.5-229.5** |

*****

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 Courses (p. 5)

*******

Students who choose the Master's Thesis instead of Senior Design must replace ECE 491 [WI] , ECE 492 [WI] , ECE 493 [WI] credits with ECE elective credits.

†

2 classes or at least 6.0 credits at the 300-400 level from subject codes ECE, ECEC, ECEE, ECEL, ECEP, or ECES. Includes Special Topics in each code (T380, T480).

††

3 classes or at least 9.0 credits at the 400 level from subject codes ECE, ECEE, ECEP, or ECES. Includes Special Topics in each code (T480).

‡

Choose three courses from a maximum of two Core Component areas: Perception, Cognition and Behavior, Action, Control

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Environmental Engineering BS/MS

*Major: Environmental Engineering*
*Degree Awarded: Bachelor of Science in Environmental Engineering (BSENE) and Master of Science (MS)*
*Calendar Type: Quarter*
*Minimum Required Credits: 227.50*
*Co-op Options: Three Co-op (Five years)*

## About the Program

The BS/MS in Environmental Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can range up to 25% higher than those with BS degrees alone.

## Additional Information

For more information, visit the COE BS/MS program webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) or the Department of Civil, Architectural and Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/).

## 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** | | |
| BIO 141 | Essential Biology | 4.5 |
| CAEE 361 | Statistical Analysis of Engineering Systems | 3.0 |
| **Chemistry Requirements** | | |
| Select one of the following options: *** | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | |
| Select one of the following options: † | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: † | | 4.0-8.0 |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 |
| or ENVE 316 | Fundamentals of Environmental Biotechnology | |
| CAEE 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CHE 211 | Material and Energy Balances I | 4.0 |
| CHEM 241 | Organic Chemistry I | 4.0 |
| CHEM 242 | Organic Chemistry II | 4.0 |
| CIVE 240 | 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 (ENVS 501 counts toward this course) | |
| **Technical Electives** | | |
| Select 6.0 credits in the following subjects (200-499): †† | | 6.0 |
| Any AE (Architectural Engineering) course | | |
| Any BIO (Bioscience & Biotechnology) course | | |
| Any BMES (Biomedical Engineering & Sci) course | | |
| Any CHE (Chemical Engineering) couorse | | |
| Any CHEM (Chemistry) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any CS (Computer Science) course | | |
| Any ECE (Electircal & Computer Engr) course | | |
| Any ECEC (Elec & Comp Eng-Computers) course | | |
| Any ECEE (Elec & Computer Engr-Electroph) course | | |
| Any ECEP (Elec & Computer Engr-Power Eng) course | | |
| Any ECES (Elec & Computer Engr-Systems) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any ENVS (Environmental Science) course | | |
| Any GEO (Geoscience) course | | |
| Any INFO (Information Science & Systems) course | | |
| Any MATE (Materials Engineering) course | | |
| Any MATH (Mathematics) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| Any PHYS (Physics) course | | |
| Any SE (Software Engineering) course | | |
| Select 6.0 credits in the following subjects (300-499) †† | | 6.0 |
| Any AE (Architectural Engineering) course | | |

| | | |
|---|---|---|
| Any BIO (Bioscience & Biotechnology) course | | |
| Any BMES (Biomedical Engineering & Sci) course | | |
| Any BMES (Biomedical Engineering & Sci) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CHEM (Chemistry) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any CS (Computer Science) course | | |
| Any ECE (Electrical & Computer Engr) course | | |
| Any ECEC (Elec & Comp Eng-Computeres) course | | |
| Any ECEC (Elec & Computer Eng-Computers) course | | |
| Any ECEE (Elec & Computer Eng-Electroph) course | | |
| Any ECEP (Elec & Computer Eng-Power Eng) course | | |
| Any ECES (Elec & Computer Engr-Systems) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any ENVS (Environmental Science) course | | |
| Any GEO (Geoscience) course | | |
| Any INFO (Information Science & Systems) course | | |
| Any MATE (Materials Engineering) course | | |
| Any MATH (Mathematics) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| Any PHYS (Physics) course) | | |
| Any SE (Software Engineering) course | | |
| PBHL 305 | Women and Children: Health & Society | |
| PBHL 314 | Environmental and Occupational Health | |
| PBHL 317 | The World's Water | |
| PBHL 321 | Disease Outbreak Investigations | |
| PBHL 350 | Introduction to Urban Health | |
| PBHL 457 | Adapting to a Hotter Climate: Protecting Health of Vulnerable Populations | |
| **MASTERS DEGREE COURSES** | | |
| **Core Courses (15.0 credits)** | | |
| ENVE 660 | Chemical Kinetics in Environmental Engineering | 3.0 |
| ENVS 501 | Chemistry of the Environment (Counts as ENVS 401) | 3.0 |
| **Approved Statistics Course** | | |
| Select one of the courses below: | | 3.0-4.0 |
| BMES 510 | Biomedical Statistics | |
| ENVE 750 | Data-based Engineering Modeling | |
| ENVS 506 | Biostatistics | |
| **Approved Policy Course** | | |
| Select one of the courses below: | | 3.0 |
| CIVE 564 | Sustainable Water Resource Engineering | |
| ECON 616 | Public Finance and Cost Benefit Analysis | |
| PLCY 503 | Theory and Practice of Policy Analysis | |
| PLCY 504 | Methods of Policy Analysis | |
| **Approved Life Sciences course** | | |
| Select one of the courses below: | | 3.0 |
| ENVE 516 | Fundamentals of Environmental Biotechnology | |
| ENVS 511 | Evolutionary Ecology | |
| ENVS 530 | Aquatic Ecology | |
| **Specialization Courses** | | |
| Select one area from the list below to complete: ‡ | | 9.0-12.0 |
| **Environmental Treatment Processes** | | |
| ENVE 546 | Solid Waste Systems | |
| ENVE 661 | Env Engr Op-Chem & Phys | |
| ENVE 662 | Enviro Engr Unit Oper-Bio | |
| ENVE 665 | Hazardous Waste & Groundwater Treatment | |
| **Human Risks** | | |
| AE 550 | Indoor Air Quality | |
| or EOH 612 | Environmental Exposure Science | |
| ENVE 727 | Risk Assessment | |
| EOH 510 | Principles and Practice of Environmental and Occupational Health | |
| **Water Resources** | | |
| CIVE 564 | Sustainable Water Resource Engineering | |
| CIVE 664 | Open Channel Hydraulics | |
| or ENVE 681 | Analytical and Numerical Techniques in Hydrology | |
| CIVE 565 | Urban Ecohydraulics | |
| ENVE 571 | Environmental Life Cycle Assessment | |
| **Environmental Modeling** | | |
| ENVE 555 | Geographic Information Systems | |
| or ENVE 571 | Environmental Life Cycle Assessment | |
| ENVE 681 | Analytical and Numerical Techniques in Hydrology | |
| ENVE 750 | Data-based Engineering Modeling | |
| Approved Advanced Math Course | | |
| MEM 591 | Applied Engr Analy Methods I | |
| or CHE 502 | Mathematical Methods in Chemical Engineering | |
| or MATE 535 | Numerical Engineering Methods | |
| **Air Quality** | | |
| AE 550 | Indoor Air Quality | |
| EOH 510 | Principles and Practice of Environmental and Occupational Health | |
| ENVE 560 | Fundamentals of Air Pollution Control | |
| **Cognate Discipline Track** | | |
| Select 12.0 credits in the following subjects (500-699 level): ‡‡ | | 12.0 |
| Any AE (Architectural Engineering) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CHEC (Chemical Engineering Chemistry) course | | |
| Any CHEM (Chemistry) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any ENSS (Environmental Studies & Sustainability) course | | |
| Any ENVP (Environmental Policy) course | | |
| Any ENVS (Environmental Science) course | | |
| Any MATH (Mathematics) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| Electives or Thesis | | 9.0-6.0 |
| **Total Credits** | | **227.5-242.5** |

*****

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).

*******

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of an summer online preparatory courses available based on that score. Some students who select the MATH 116 & MATH 117 sequence may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

††

Or courses approved by ENVE advisor.

‡
Students must take 4 courses in an approved specialization, such as environmental treatment processes, human risks, water resources, environmental modeling, or air quality.

‡‡
Students must complete a course sequence of 12.0 credits aside from their specialization. This might include a second specialization course sequence or a sequence of elective courses as approved by the student's advisor and the departmental graduate advisor.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# 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.

A. Emin Aktan, PhD *(University of Illinois at Urbana-Champaign) John Roebling Professor of Infrastructure Studies*. Professor. Structural engineering; health monitoring of large infrastructure systems; infrastructure evaluation; intelligent systems.

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)*. Associate Teaching Professor. International infrastructure delivery; response to natural catastrophes; risk assessment and mitigation strategies; project management techniques.

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

Peter DeCarlo, PhD *(University of Colorado)*. Assistant Professor. Outdoor air quality, particulate matter size and composition instrumentation and measurements, source apportionment of ambient particulate matter, climate impacts of particulate matter.

Eugenia Ellis, RA, PhD *(Virginia Polytechnic State University)*. Associate Professor. Extended-care facilities design, research on spatial visualization, perception and imagination.

Patricia Gallagher, PhD *(Virginia Polytechnic Institute)*. Associate Professor. Soil mechanics; geoenvironmental; ground improvement; sustainability.

Patrick Gurian, PhD *(Carnegie-Mellon University)*. Associate 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 Professor and Department Head, Civil, Architectural and Environmental Engineering*. Professor. Control of human exposures to and risk assessment of pathogenic organisms; water and waste treatment; homeland security.

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

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) Dean of the College of Engineering and Distinguished Professor*. Biological processes and applications of nanotechnology in environmental systems.

L. James Lo, PhD *(University of Texas at Austin)*. Assistant Professor. Computational Fluid Dynamics (CFD) and airflow simulation; Indoor

Environmental Quality; Building control integration with building information management systems.

Roger Marino, PhD *(Drexel University)*. Associate Teaching Professor. Fluid mechanics; water resources; engineering education; land development.

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

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

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

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) Graduate Studies Advisor*. Associate Professor. Environmental remediation; contaminant and bacterial transport in porous media and bacterial response to dynamic environments.

Michael Ryan, PhD *(Drexel University)*. Assistant Teaching Professor. Microbial Source Tracking (MST); Quantitative Microbial Risk Assessment (QMRA); Dynamic Engineering Systems Modeling; Molecular Microbial Biology; Environmental Statistics; Engineering Economics; Microbiology

Christopher Sales, PhD *(University of California, Berkeley)*. Assistant Professor. Environmental microbiology and biotechnology; biodegradation of environmental contaminants; microbial processes for energy and resource recovery from waste.

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. Research in 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.

# Environmental Engineering BSENE / Materials Science and Engineering MSMSE

*Major: Environmental Engineering and Materials Science Engineering*
*Degree Awarded: Bachelor of Science in Environmental Engineering (BSENE) and Master of Science in Materials Science and Engineering (MSMSE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 227.5*
*Co-op Options: Three Co-ops (Five years)*

## 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.

## Additional Information

For more information, visit the COE BS/MS program webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/) or the Department of Civil, Architectural and Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/) and/or the Department of Materials Science and Engineering (https://drexel.edu/engineering/academics/departments/materials-science-engineering/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.4 and completion of 90 credits.

# 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 |
| **Chemistry Requirements** | | |
| Select one of the following options: [***] | | 3.5-7.5 |
| Option A: | | |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| Option B: | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| **Engineering (ENGR) 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 | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| MEM 210 | Introduction to Thermodynamics | 3.0 |
| **Mathematics Requirements** | | |
| Select one of the following options: [†] | | 4.0-10.0 |
| Option A: | | |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| Option B: | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II [‡] | |
| Option C: | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| CAEE 231 | Linear Engineering Systems | 3.0 |
| CAEE 232 | Dynamic Engineering Systems | 3.0 |
| **Physics Requirements** | | |
| Select one of the following options: [†] | | 4.0-8.0 |
| Option A: | | |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| Option B: | | |
| PHYS 101 | Fundamentals of Physics I | |
| 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 |
| or ENVE 316 | Fundamentals of Environmental Biotechnology | |
| CAEE 202 | Introduction to Civil, Architectural & Environmental Engineering | 3.0 |
| CAEE 203 | System Balances and Design in CAEE | 3.0 |
| CAEE 212 | Geologic Principles for Infrastructure & Environmental Engineering | 4.0 |
| or GEO 101 | Physical Geology | |
| CHE 211 | Material and Energy Balances I | 4.0 |
| CHEM 241 | Organic Chemistry I | 4.0 |
| CHEM 242 | Organic Chemistry II | 4.0 |
| CIVE 240 | 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** | | |
| Select 9.0 credits in the following subjects (200-499 level): [^] | | 9.0 |
| Any AE (Architectural Engineering) course | | |
| Any BIO (Bioscience & Biotechnology) course | | |
| Any BMES (Biomedical Engineering & Sci) course | | |
| Any CHE (Chemical Engineering) course | | |
| Any CHEM (Chemistry) course | | |
| Any CIVE (Civil Engineering) course | | |
| Any CS (Computer Science) course | | |
| Any ECE (Electrical & Computer Engr) course | | |
| Any ECEC (Elec & Comp Engr-Computers) course | | |
| Any ECEE (Elec & Computer Engr-Electroph) course | | |
| Any ECEP (Elec & Computer Engr-Power Eng) course | | |
| Any ECES (Elec & Computer Engr-Systems) course | | |
| Any ENVE (Environmental Engineering) course | | |
| Any ENVS (Environmental Science) course | | |
| Any GEO (Geoscience) course | | |
| Any INFO (Information Science & Systems) course | | |
| Any MATE (Materials Engineering) course | | |
| Any MATH (Mathematics) course | | |
| Any MEM (Mechanical Engr & Mechanics) course | | |
| Any PHYS (Physics) course | | |
| Any SE (Software Engineering) course | | |
| **Master's Degree Courses** | | |
| **Required Core Courses** | | |
| MATE 510 | Thermodynamics of Solids | 3.0 |
| MATE 512 | Introduction to Solid State Materials | 3.0 |
| **Select Four Additional Selected Core (SC) courses from the following:** | | **12.0** |
| MATE 501 | Structure and Properties of Polymers | |
| MATE 507 | Kinetics | |
| MATE 515 | Experimental Technique in Materials | |
| MATE 535 | Numerical Engineering Methods | |
| MATE 563 | Ceramics | |
| MATE 610 | Mechanical Behavior of Solids | |
| MATE 661 | Biomedical Materials I | |

| | |
|---|---|
| **(GR) Technical Electives** ^^ | **27.0** |
| **Total Credits** | **227.5-241.5** |

*

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).

***

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

†

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

^

There are a total of 12.0 credits of UG technical electives required, 9 credits should come should be selected from the list provided or courses approved by ENVE advisor. The other 3 credits with be shared with the GR Additional Selected Core Course (3.0 credits).

^^

Of the 27.0 (GR) technical elective credits, which may include up to 6.0 credits of MATE 897, at least 12.0 credits must be taken as Materials Science and Engineering (MATE) courses, while the rest may be taken within the College of Engineering, College of Arts and Sciences, or at other colleges if consistent with the student's plan of study (and given advance written approval by their advisor).
Any graduate-level course in a STEM field (Engineering, Physical Sciences, or Computing/Data), as approved by the MSE Graduate Advisor, excluding MATE 536 (Materials Seminar), MATE 503 (Introduction to Materials Engineering) and MATE 504 (Art of Being a Scientist).

‡

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# 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 Master of Science in Materials Science and Engineering (MSMSE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 225.5*
*Co-op Options: Three Co-op (Five years)*

## About the Program

The BS/MS in Materials Science and Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student’s undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gain research experience by working with faculty. Salaries for students with MS degrees can range up to 25% higher than those with BS degrees alone.

For more information, visit COE Special Programs (p. 5) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must have a cumulative GPA of at least 3.4 and have taken coursework sufficient to demonstrate a readiness to undertake 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 |
| **Technical Electives/Track Courses (Select one track) ** ** | | **3.0** |
| 6.0 credits of (GR) MATE Technical Electives count as 6.0 credits of (UG) Track Electives | | |
| **Materials for Energy** | | |
| CHE 431 | Fundamentals of Solar Cells | |
| CHE 432 | Electrochemical Engineering | |
| ECE 380 | Fundamentals of Power and Energy | |
| 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 480 | Solar Energy Engineering | |
| EET 320 | Renewable Energy Systems | |
| MATE 482 | Materials for Energy Storage | |
| MEM 415 | Fuel Cell Engines | |
| MEM 445 | Solar Energy Fundamentals | |
| **Materials for Sustainability** | | |
| CHE 430 | Introduction to Sustainable Engineering | |
| CHE 431 | Fundamentals of Solar Cells | |
| ECEP 380 | Introduction to Renewable Energy | |
| ECEP 480 | Solar Energy Engineering | |
| ENVE 316 | Fundamentals of Environmental Biotechnology | |
| ENVE 410 | Solid and Hazardous Waste | |
| ENVE 471 | Environmental Life Cycle Assessment | |
| MATE 476 | Recycling of Materials | |
| MATE 483 | Environmental Effects on Materials | |
| **Materials for Medical Technology** | | |
| BIO 201 | Human Physiology I | |
| BIO 311 | Biochemistry | |
| BMES 441 | Biomechanics I: Introduction to Biomechanics | |
| BMES 460 | Biomaterials I | |
| BMES 461 | Biomaterials II | |
| BMES 471 | Cellular and Molecular Foundations of Tissue Engineering | |
| BMES 472 | Developmental and Evolutionary Foundations of Tissue Engineering | |
| BMES 488 | Medical Device Development | |
| CHE 360 | BioProcess Principles | |
| CHE 461 | Principles of Colloid Science | |
| CHEM 371 | Chemistry of Biomolecules | |
| CHEM 375 | The Chemistry Behind Drugs: Fundamentals of Medicinal Chemistry | |
| MEM 424 | Biomechanics | |
| MEM 478 | Computer-Aided Tissue Engr | |
| **Manufacturing** | | |
| CHE 452 | Polymer Process Technology | |
| CHEM 242 | Organic Chemistry II | |
| CHEM 465 | Synthetic Polymer Chemistry | |
| CHEM 466 | Physical Chemistry of Polymers | |
| CHEM 467 | Polymer Chemistry III | |
| MEM 361 | Engineering Reliability | |
| MEM 417 | Introduction to Microfabrication | |
| MEM 427 | Finite Element Methods | |
| MEM 428 | Introduction to Composites I | |
| MEM 429 | Introduction to Composites II | |
| MEM 435 | Introduction to Computer-Aided Engineering | |
| MEM 436 | Introduction to Computer-Aided Manufacturing | |
| MEM 437 | Manufacturing Process I | |
| MEM 438 | Manufacturing Process II | |
| General Education Electives *** | | 12.0 |
| Business Elective (GE) † | | 4.0 |
| Free Electives | | 6.0 |
| Societal Impact Elective (GE) ‡ | | 4.0 |
| **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 |
| **Chemistry Requirements ^** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| CHEM 102 | General Chemistry II | 4.5 |
| CHEM 241 | Organic Chemistry I | 4.0 |
| **Engineering (ENGR) 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 210 | Introduction to Thermodynamics | 3.0 |
| or MEM 210 | Introduction to Thermodynamics | |
| ENGR 220 | Fundamentals of Materials | 4.0 |
| or MATE 220 | Fundamentals of Materials | |
| ENGR 231 | Linear Engineering Systems | 3.0 |
| or CAEE 231 | Linear Engineering Systems | |
| or ECE 231 | Linear Algebra and Matrix Computations | |
| or MATH 201 | Linear Algebra | |
| ENGR 232 | Dynamic Engineering Systems | 3.0 |
| or CAEE 232 | Dynamic Engineering Systems | |
| or ECE 232 | Solving Dynamic Systems | |
| or MATH 210 | Differential Equations | |
| **Mathematics Requirements ^^** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II § | |
| OR | | |
| MATH 121 | Calculus I | |
| MATH 122 | Calculus II | 4.0 |
| MATH 200 | Multivariate Calculus | 4.0 |
| **Physics Requirements ^^** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |

| | | |
|---|---|---|
| PHYS 101 | Fundamentals of Physics I | |
| 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 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 375 | Materials Selection for Industrial Applications | 3.0 |
| MATE 410 | Case Studies in Materials | 3.0 |
| MATE 455 | Biomedical Materials | 3.0 |
| MATE 460 | Engineering Computational Laboratory | 4.0 |
| MATE 475 | Materials Data Analysis | 3.0 |
| 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 Degree Courses** | | |
| **Required Core Courses:** | | |
| MATE 510 | Thermodynamics of Solids | 3.0 |
| MATE 512 | Introduction to Solid State Materials | 3.0 |
| Four additional Selected Core (SC) courses from the following: | | 12.0 |
| MATE 501 | Structure and Properties of Polymers | |
| MATE 507 | Kinetics | |
| MATE 515 | Experimental Technique in Materials | |
| MATE 535 | Numerical Engineering Methods | |
| MATE 563 | Ceramics | |
| MATE 610 | Mechanical Behavior of Solids | |
| MATE 661 | Biomedical Materials I | |
| Any additional related courses if approved by the graduate advisor. | | |
| Technical Electives (TE) ¶ | | 18.0 |
| **Thesis and Alternatives** | | **9.0** |
| 9.0 credits of MATE 898 (MS Thesis) or 9.0 credits of Technical Electives (TE). | | |
| **Total Credits** | | **225.5-239.5** |

*****

Co-op cycles for Materials Science & Engineering are only Spring/Summer.
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.

******

Specialization tracks allow upper-class students to focus on a specific area of materials science and engineering through selection of three technical elective courses (minimum 9.0 credits, though 6.0 credits must be shared with graduate courses). This tailored specialization combined with foundational materials knowledge and co-op experiences gives students a customized education to prepare them for their future career and/or graduate school. Students choose from four pre-determined specialization tracks or create their own track. In addition to the specific courses listed for each pre-determined track, other courses may be accepted subject to approval by the MSE advisor. The pre-determined tracks are:

- Materials for Energy
- Materials for Medical Technologies
- Materials for Sustainability
- Manufacturing and Materials Processing

*******

General Education Electives (p. 5)

†

Choose one of the approved Business Electives
(GE): ECON 201, ACCT 110, OPM 200, ORGB 300 [WI] or approved by MSE advisor.

‡

Choose one of the approved Societal Impact
Electives: SOC 244, SOC 346, SCTS 202, SCTS 205 or approved by MSE advisor.

**^**

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**^^**

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses based on that score.

**§**

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**±**

Students pursuing the non-thesis option must complete the undergraduate senior design sequence, in lieu of MATE 898 [WI] (MS Thesis). MSE students pursuing the thesis option are not required to take MATE 491 [WI] , MATE 492, MATE 493 [WI] , and are required to complete 9.0 credits of MATE 898 [WI] (MS thesis). In addition, these students need to complete an additional 8.0 credits of UG MATE Electives.

¶
Of the 18.0 technical elective credits, which may include up to 6.0 credits of MATE 897, at least 9.0 credits must be taken as Materials Science and Engineering (MATE) courses, while the rest may be taken within the College of Engineering, College of Arts and Sciences, or at other colleges if consistent with the student's plan of study (and given advance written approval by their advisor). At least 9.0 of these 18.0 technical electives must be exclusive of independent study courses or research credits. Any graduate-level course (500-999) in a STEM field (BIO, CAEE, CHE, CHEM, ECE, MATH, MEM, PHYS) as approved by the MSE graduate advisor, excluding MATE 536, MATE 503, and MATE 504

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Facilities

**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.

**Layered Solids Laboratory**
This laboratory contains a vacuum hot-press; creep testers, Ar-atmosphere glove-box, high-speed saw, and assorted high temperature furnaces; metallographic preparation facilities; high temperature closed-loop servo-hydraulic testing machines.

**Mechanical 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.

**Macromolecular Materials Laboratory**
This laboratory contains a hybrid rheometer, inert environment glove box, size exclusion chromatography with multi-angle laser light scattering, HPLC and RI detector & MALS, centrifuge, rotovapor, and vacuum oven used for developing innovative synthetic platforms to generate functional soft materials with complex macromolecular architectures.

**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 (ALD), chemical vapor deposition (CVD), 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 °C with mass spectrometer, Zeta potential analyzer; attrition mill, bath and probe sonicators, centrifuges; electro-spinning system for producing nano-fibers.

**Functional Inorganic Materials Synthesis Laboratory**
The laboratory contains equipment for the synthesis of inorganic and hybrid materials, including gas cabinets for $NH_3$ and $H_2$, a CVD furnace,

and spin-coater; UV-Vis spectrophotometer; and a photodegradation test station with Xe 1000 W lamp.

**Films and Heterostructures 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 to 400 K, up to 9 T fields; 2 tube furnaces; spectroscopic ellipsometer.

**Powder Processing Laboratory**
This laboratory contains vee blenders, ball-mills, sieve shaker + sieves for powder classification, several furnaces.

**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 high purity liquid chromatography (HPLC) system; refractometer; electro-spinning and touch-spinning systems for producing nanofibers.

**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.

**MSE Undergraduate Teaching Laboratory**
Contains an FTIR spectrometer, metallographic sample preparation, equipment, polymer 3D printers, polymer extruder and injection molder, Vickers hardness tester, inverted metallograph, multiple furnaces.

**Materials Characterization Core (MCC)**
The Department of Materials Science & Engineering relies on the Materials Characterization 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 high resolution and variable pressure field-emission scanning electron microscopes (SEMs) with Energy Dispersive Spectroscopy (EDS) for elemental analysis, Orientation Image Microscopy (OIM) for texture analysis, various *in-situ* and *in-operando* stages (cryo mat, heating, tensile, 3- and 4-point bending, and electrochemistry); two Transmission Electron Microscopes (TEMs) with STEM capability and TEM sample preparation equipment; a dual-beam focused ion beam (FIB) system for nano-characterization and nano fabrication; a Nanoindenter; an X-ray Photoelectron Spectrometer (XPS)/Electron Spectroscopy for Chemical Analysis (ESCA) system; X-Ray Diffractometers (XRD); and an X-ray microscope (NanoCT) with an *in-situ* tensile/compression temperature controlled stage.

More details of these instruments, information on how to access them, and instrument usage rates can be found at Drexel University's Materials Characterization Core webpage.

## 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.

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

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

Adam K. Fontecchio, PhD *(Brown University) Vice Dean, Graduate College*. Professor. Electro-optics; remote sensing; active optical elements; liquid crystal devices.

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.

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

Haviva M. Goldman, PhD *(City University of New York) Neurobiology and Anatomy*. Associate Professor. Understanding how the size and shape of whole bones, as well as the distribution quantity and quality of the mineralized tissue that forms the bone, reflect both evolutionary constraints of skeletal growth and development, and responsiveness to mechanical loading during life.

Lin Han, PhD *(Massachusetts Institute of Technology)*. Assistant Professor. Nanoscale structure-property relationships of biological materials, genetic and molecular origins soft joint tissue diseases, biomaterials under extreme conditions, coupling between stimulus-responsiveness and geometry.

Maher Harb, PhD *(University of Toronto)*. Assistant Professor. Solid state physics, ultrafast electron diffraction, time-resolved X-ray diffraction, ultrafast lasers, nanofabrication, nano/microfluidics, instrument development, vacuum technologies.

Haifeng Frank Ji, PhD *(Chinese Academy of Sciences)*. Professor. Chemistry Micromechancial sensors for biological and environmental applications; Nanomechanical drug screening technology.

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

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.

E. Caglan Kumbur, PhD *(Pennsylvania State University)*. Associate Professor. Mechanical Engineering and Mechanics 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.

Leslie Lamberson, PhD *(California Institute of Technology) P.C. Chou Assistant Professor of Mechanical Angineering*. Assistant Professor. Dynamic behavior of materials, dynamic fracture, damage micromechanics, active materials.

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

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*. Professor. Orthopedic biomaterials; acellular regenerative medicine, biomimetic proteoglycans; hydrogels.

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

Bahram Nabet, PhD *(University of Washington) Associate Dean for Special Projects, College of Engineering; Electrical and Computer Engineering*. Professor. Optoelectronics; fabrication and modeling; fiber optic devices; nanoelectronics; nanowires.

Giuseppe R. Palmese, PhD *(University of Delaware) Department Head, Chemical and Biological Engineering*. Professor. Reacting polymer systems; nanostructured polymers; radiation processing of materials; composites and interfaces.

Ekaterina Pomerantseva, PhD *(Moscow State University, Russia)*. Assistant 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) Graduate Advisor*. Associate Professor. Polysaccharide thin films and nanofibers.

Wan Y. Shih, PhD *(Ohio State University)*. Associate Professor. Piezoelectric microcantilever biosensors development, piezoelectric finger development, quantum dots development, tissue elasticity imaging, piezoelectric microcantilever force probes.

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.

Karl Sohlberg, PhD *(University of Delaware)*. Associate Professor. Chemistry Computational and theoretical materials-related chemistry: (1) complex catalytic materials; (2) mechanical and electrical molecular devices.

Jonathan E. Spanier, PhD *(Columbia University) Associate Dean, Strategic Planning, College of Engineering*. Professor. Light-matter interactions in electronic materials, including ferroelectric semiconductors, complex oxide thin film science; laster spectroscopy, including Raman scattering.

Kara Spiller, PhD *(Drexel University)*. Assistant Professor. Macrophage-biometerial interactions, drug delivery systems, and chronic would healing. Cell-biomaterial interactions, biomaterial design, and international engineering education.

Mitra Taheri, PhD *(Carnegie Mellon University) Hoeganeas Associate Professor of Metallurgy*. Associate 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.

Garritt Tucker, PhD *(Georgial Institute of Technology)*. Assistant Professor. Computational materials science and engineering; microstructural evolutiona nd material behavior in extreme environments; interfacial-driven processes for improving material functionality; multi-scale physics modeling.

Christopher Weinberger, PhD *(Stanford University)*. Assistant Professor. Mechanical Engineering and Mechanics Multiscale materials modeling of mechanical properties including DFT, atomistics, mesoscale and microscale FEM modeling.

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

Margaret Wheatley, PhD *(University of Toronto) John M. Reid Professor*. Ultrasound contrast agent development (tumor targeting and triggered drug delivery), controlled release technology (bioactive compounds), microencapsulated allografts (ex vivo  gene therapy) for spinal cord repair.

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.

Alan Lawley, PhD *(University of Birmingham, England)*. Professor Emeritus. Mechanical and physical metallurgy, powder metallurgy, materials engineering design, engineering education.

# Mechanical Engineering & Mechanics BS / Environmental Engineering MS

*Major: Mechanical Engineering & Mechanics and Environmental Engineering*
*Degree Awarded: Bachelor of Science (BS) and Master of Science (MS)*
*Calendar Type: Quarter*
*Minimum Required Credits: 226.0*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Mechanical Engineering and Environmental Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can range up to 25% higher than those with BS degrees alone.

For more information, visit COE Special Programs (p. 5) or the BS/MS webpage. (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/)

## 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 |
| COM 310 [WI] | Technical Communication | 3.0 |
| 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** ** | | **12.0** |
| **Free Electives** | | **6.0** |
| **Mathematics Requirements** *** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II † | |
| OR | | |
| MATH 121 | Calculus I | |
| 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** *** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| PHYS 201 | Fundamentals of Physics III | 4.0 |
| **Chemistry Requirements** ‡ | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| 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 Economics Requirements** | | |
| CIVE 240 | Engineering Economic Analysis | 3.0 |
| **Materials Requirements** | | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Mechanical Requirements** | | |
| MEM 201 | Foundations of Computer Aided Design | 3.0 |
| MEM 202 | Statics | 3.0 |
| MEM 210 | Introduction to Thermodynamics | 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 260 | Thinking Like a Mechanical Engineer | 3.0 |
| MEM 261 | Introduction to Mechatronics for Mechanical Engineers | 3.0 |
| MEM 310 | Thermodynamic Analysis I | 4.0 |
| MEM 311 | Thermal Fluid Science Laboratory | 2.0 |
| MEM 321 | Fluid Mechanics II | 4.0 |
| MEM 330 | Mechanics of Materials II | 4.0 |
| MEM 331 | Experimental Mechanics I | 2.0 |
| MEM 333 | Mechanical Behavior of Materials | 3.0 |
| MEM 345 | Heat Transfer | 4.0 |
| MEM 351 | Dynamic Systems Laboratory I | 2.0 |
| MEM 355 | Performance Enhancement of Dynamic Systems | 4.0 |
| MEM 360 | Numerical Methods in Mechanical Engineering Design | 3.0 |
| MEM 361 | Engineering Reliability | 3.0 |
| MEM 423 | Mechanics of Vibration | 4.0 |
| MEM 431 | Machine Design I | 3.0 |
| MEM 435 | Introduction to Computer-Aided Engineering | 4.0 |
| MEM 491 [WI] | Senior Design Project I | 3.0 |
| MEM 492 [WI] | Senior Design Project II | 3.0 |
| MEM 493 [WI] | Senior Design Project III | 3.0 |
| MEM Open Electives (Any two (2) MEM courses 300 level or higher) Please note ENVE 660 counts as one of these two courses. | | 3.0 |

| | | |
|---|---|---|
| COE Electives (Any one (1) College of Engineering course, including MEM courses, 300 level or higher.) Please Note ENVS 501 counts as course. | | |
| MATH Elective: Please Note: GR Cognate Discipline Course counts as UG MATH elective | | |
| **Master's Degree Requirements** | | |
| **Graduate Core Courses (15 Credits)** | | |
| ENVE 660 | Chemical Kinetics in Environmental Engineering | 3.0 |
| ENVS 501 | Chemistry of the Environment | 3.0 |
| **Approved Statistics Course** | | **3.0-4.0** |
| BMES 510 | Biomedical Statistics | |
| or ENVE 75 | Data-based Engineering Modeling | |
| or ENVS 50 | Biostatistics | |
| **Approved Policy Course** | | **3.0** |
| CIVE 564 | Sustainable Water Resource Engineering | |
| or ECON 61 | Public Finance and Cost Benefit Analysis | |
| or PLCY 50 | Theory and Practice of Policy Analysis | |
| or PLCY 50 | Methods of Policy Analysis | |
| **Approved Life Sciences Course** | | **3.0** |
| ENVE 516 | Fundamentals of Environmental Biotechnology | |
| or ENVS 51 | Evolutionary Ecology | |
| or ENVS 53 | Aquatic Ecology | |
| **Specialization Courses (select one area from below) ^** | | **9.0-12.0** |
| **Environmental Treatment Processes** | | |
| ENVE 546 | Solid Waste Systems | |
| & ENVE 661 | and Env Engr Op-Chem & Phys | |
| & ENVE 662 | and Enviro Engr Unit Oper-Bio | |
| & ENVE 665 | and Hazardous Waste & Groundwater Treatment | |
| **Human Risks** | | |
| AE 550 | Indoor Air Quality ^^ | |
| or EOH 612 | Environmental Exposure Science | |
| EOH 510 | Principles and Practice of Environmental and Occupational Health | |
| ENVE 727 | Risk Assessment | |
| **Water Resources** | | |
| CIVE 564 | Sustainable Water Resource Engineering | |
| & CIVE 565 | and Urban Ecohydraulics | |
| & ENVE 571 | and Environmental Life Cycle Assessment | |
| CIVE 664 | Open Channel Hydraulics ^^ | |
| or ENVE 68 | Analytical and Numerical Techniques in Hydrology | |
| **Environmental Modeling** | | |
| ENVE 555 | Geographic Information Systems ^^ | |
| or ENVE 57 | Environmental Life Cycle Assessment | |
| ENVE 681 | Analytical and Numerical Techniques in Hydrology | |
| & ENVE 750 | and Data-based Engineering Modeling | |
| Approved Advanced Math Course (select one of the following): | | |
| MEM 591 | Applied Engr Analy Methods I | |
| or CHE 502 | Mathematical Methods in Chemical Engineering | |
| or MATE 535 | Numerical Engineering Methods | |
| **Air Quality** | | |
| AE 550 | Indoor Air Quality | |
| & EOH 510 | and Principles and Practice of Environmental and Occupational | |
| & ENVE 560 | Health and Fundamentals of Air Pollution Control | |
| **Cognate Discipline Track §** | | **12.0** |
| CIVE 898 (MS Thesis) or Graduate Electives (Approved by the student's faculty advisor.) | | 6.0-9.0 |
| **Total Credits** | | **226.0-244.0** |

*****

Co-op cycles for BSMS students with a MS in ENE must be in the Spring/Summer.
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)

*******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses based on that score.

**†**

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

**‡**

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

**^**

Students must take 4 courses in an approved specialization, such as environmental treatment processes, human risks, water resources, environmental modeling, or air quality.

**^^**

One of these is required.

**§**

Students must complete a course sequence of 12.0 credits aside from their specialization. This might include a second specialization course sequence or a sequence of elective courses as approved by the student's advisor and the departmental graduate advisor in any of the following subjects: AE, CHE, CHEC, CHEM, CIVE, ENVE, ENSS, ENVP, ENVS, MATH, MEM (500-699).

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission

while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Mechanical Engineering BSME / Materials Science & Engineering MSMSE

*Major: Mechanical Engineering and Materials Science & Engineering*
*Degree Awarded: Bachelor of Science in Mechanical Engineering (BSME) and Master of Science in Materials Science & Engineering (MSMSE)*
*Calendar Type: Quarter*
*Minimum Required Credits: 229.0*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Mechanical Engineering with Materials Science and Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can range up to 25% higher than those with BS degrees alone.

For more information, visit COE Special Programs (p. 5) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## Admission Requirements

Students must demonstrate a readiness for graduate work, both in terms of academic performance and relevant preparatory undergraduate courses. Required are a cumulative GPA of 3.4 and a completion of 90.0 credits.

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COM 310 [WI] | Technical Communication | 3.0 |
| 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 ** | | 12.0 |
| **Mathematics Requirements *** ** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II | |
| OR | | |
| MATH 121 | Calculus I | |
| 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 *** ** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| PHYS 201 | Fundamentals of Physics III | 4.0 |
| **Chemistry Requirements †** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| 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 Economics Requirements** | | |
| CIVE 240 | Engineering Economic Analysis | 3.0 |
| **Materials Requirements** | | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Mechanical Requirements** | | |
| MEM 201 | Foundations of Computer Aided Design | 3.0 |
| MEM 202 | Statics | 3.0 |
| MEM 210 | Introduction to Thermodynamics | 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 260 | Thinking Like a Mechanical Engineer | 3.0 |
| MEM 261 | Introduction to Mechatronics for Mechanical Engineers | 3.0 |
| MEM 310 | Thermodynamic Analysis I | 4.0 |
| MEM 311 | Thermal Fluid Science Laboratory | 2.0 |
| MEM 321 | Fluid Mechanics II | 4.0 |
| MEM 330 | Mechanics of Materials II | 4.0 |
| MEM 331 | Experimental Mechanics I | 2.0 |
| MEM 333 | Mechanical Behavior of Materials | 3.0 |
| MEM 345 | Heat Transfer | 4.0 |
| MEM 351 | Dynamic Systems Laboratory I | 2.0 |
| MEM 355 | Performance Enhancement of Dynamic Systems | 4.0 |
| MEM 360 | Numerical Methods in Mechanical Engineering Design | 3.0 |

| | | |
|---|---|---|
| MEM 361 | Engineering Reliability | 3.0 |
| MEM 423 | Mechanics of Vibration | 4.0 |
| MEM 431 | Machine Design I | 3.0 |
| MEM 435 | Introduction to Computer-Aided Engineering | 4.0 |
| MEM 491 [WI] | Senior Design Project I ‡ | 3.0 |
| MEM 492 [WI] | Senior Design Project II ‡ | 3.0 |
| MEM 493 [WI] | Senior Design Project III ‡ | 3.0 |
| MEM or COE Elective (300+ or higher) | | |
| MEM Electives (Any 2 MEM Elective 300+ or higher) | | 3.0 |
| MATE 510 and MATE 512 count as 6.0 credits of COE and MEM Electives as shared coursework | | |
| Math Elective: Select one course from the following: | | 3.0 |
| MATH 291 | Complex and Vector Analysis for Engineers | |
| MATH 300 | Numerical Analysis I | |
| MATH 321 | Vector Calculus | |
| MATH 322 | Complex Variables | |
| MATH 323 | Partial Differential Equations | |
| Free Electives | | 6.0-8.0 |
| **Master's Degree Courses** | | |
| Required Core Courses: | | |
| MATE 510 | Thermodynamics of Solids | 3.0 |
| MATE 512 | Introduction to Solid State Materials | 3.0 |
| Four additional Selected Core (SC) courses from the following: | | 12.0 |
| MATE 501 | Structure and Properties of Polymers | |
| MATE 507 | Kinetics | |
| MATE 515 | Experimental Technique in Materials | |
| MATE 535 | Numerical Engineering Methods | |
| MATE 563 | Ceramics | |
| MATE 610 | Mechanical Behavior of Solids | |
| MATE 661 | Biomedical Materials I | |
| Any additional related courses if approved by the graduate advisor. | | |
| **Graduate Technical Electives** ^ | | **18.0** |
| **Thesis or Alternatives** | | **9.0** |
| 9.0 credits MATE 898 (MS thesis) or 9.0 credits of Technical Electives (TE). | | |
| **Total Credits** | | **229.0-245.0** |

*****

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).

*******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

CHEM sequence is determined by the student's Chemistry Placement Exam score and the completion of a summer online preparatory course available based on that score.

‡

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.

^

Of the 18.0 technical elective credits, which may include up to 6.0 credits of MATE 897, at least 9.0 credits must be taken as Materials Science and Engineering (MATE) courses, while the rest may be taken within the College of Engineering, College of Arts and Sciences, or at other colleges if consistent with the student's plan of study (and given advance written approval by their advisor). At least 9.0 of these 18.0 technical elective credits must be exclusive of independent study courses or research credits.
Any graduate-level course in a STEM field (Engineering, Physical Sciences, or Computing/Data), as approved by the MSE Graduate Advisor, excluding MATE 536 *Materials Seminar*, MATE 503 *Introduction to Materials Engineering*, and MATE 504 *The Art of Being a Scientist*.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# Mechanical Engineering & Mechanics BSME / MSME

*Major: Mechanical Engineering & Mechanics*
*Degree Awarded: Bachelor of Science in Mechanical Engineering (BSME) & Master of Science in Mechanical Engineering (MSME)*
*Calendar Type: Quarter*
*Minimum Required Credits: 229.0*
*Co-op Options: Three Co-ops (Five years)*

## About the Program

The BS/MS in Mechanical Engineering is an accelerated degree program that provides academically qualified students the opportunity to develop technical depth and breadth in their major and an additional complementary related area, earning two diplomas (BS and MS) within the typical duration of earning the bachelor's degree alone. A natural progression from the student's undergraduate courses, with the necessary technical prerequisite understanding and skills, prepares students for graduate-level studies. Students can still enjoy the benefits and rewards of the Drexel co-op experience and gaining research experience by working with research faculty. Salaries for students with MS degrees can range up to 25% higher than those with BS degrees alone.

For more information, visit COE Special Programs (p. 5) or the BS/MS webpage (https://drexel.edu/engineering/academics/undergraduate-programs/bs-ms-programs/).

## 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 3.7 cumulative GPA in the following seven courses (or their equivalent) presented in List #1 and at least one of the courses in List #2.

List #1:
- Introduction to Thermodynamics (MEM 210)
- Fundamentals of Materials (MATE 220)
- Linear Algebra (MATH 201)
- Differential Equations (MATH 210)
- Foundations of Computer Aided Design (MEM 201)
- Statics (MEM 202)
- Dynamics (MEM 238)

List #2:
- Fluid Mechanics I (MEM 220)
- Mechanics of Materials I (MEM 230)
- Introduction to Controls (MEM 255)
- Thermodynamic Analysis I (MEM 310)

## Degree Requirements

| | | |
|---|---|---|
| **General Education/Liberal Studies Requirements** | | |
| CIVC 101 | Introduction to Civic Engagement | 1.0 |
| COM 310 [WI] | Technical Communication | 3.0 |
| 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 ** | | 12.0 |
| **Mathematics Requirements *** ** | | **4.0-10.0** |
| MATH 105 & MATH 121 | Algebra, Functions, and Trigonometry and Calculus I | |
| OR | | |
| MATH 116 & MATH 117 | Calculus and Functions I and Calculus and Functions II † | |
| OR | | |
| MATH 121 | Calculus I | |
| 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 *** ** | | **4.0-8.0** |
| PHYS 100 & PHYS 101 | Preparation for Engineering Studies and Fundamentals of Physics I | |
| OR | | |
| PHYS 101 | Fundamentals of Physics I | |
| PHYS 102 | Fundamentals of Physics II | 4.0 |
| PHYS 201 | Fundamentals of Physics III | 4.0 |
| **Chemistry Requirements** | | **3.5-7.5** |
| CHEM 111 & CHEM 101 | General Chemistry I and General Chemistry I | |
| OR | | |
| CHEM 101 | General Chemistry I | |
| 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 Economics Requirements** | | |
| CIVE 240 | Engineering Economic Analysis | 3.0 |
| **Materials Requirements** | | |
| MATE 220 | Fundamentals of Materials | 4.0 |
| **Mechanical Requirements** | | |
| MEM 201 | Foundations of Computer Aided Design | 3.0 |
| MEM 202 | Statics | 3.0 |
| MEM 210 | Introduction to Thermodynamics | 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 260 | Thinking Like a Mechanical Engineer | 3.0 |
| MEM 261 | Introduction to Mechatronics for Mechanical Engineers | 3.0 |
| MEM 310 | Thermodynamic Analysis I | 4.0 |
| MEM 311 | Thermal Fluid Science Laboratory | 2.0 |
| MEM 321 | Fluid Mechanics II | 4.0 |
| MEM 330 | Mechanics of Materials II | 4.0 |
| MEM 331 | Experimental Mechanics I | 2.0 |
| MEM 333 | Mechanical Behavior of Materials | 3.0 |
| MEM 345 | Heat Transfer | 4.0 |
| MEM 351 | Dynamic Systems Laboratory I | 2.0 |
| MEM 355 | Performance Enhancement of Dynamic Systems | 4.0 |
| MEM 360 | Numerical Methods in Mechanical Engineering Design | 3.0 |
| MEM 361 | Engineering Reliability | 3.0 |
| MEM 423 | Mechanics of Vibration | 4.0 |
| MEM 431 | Machine Design I | 3.0 |
| MEM 435 | Introduction to Computer-Aided Engineering | 4.0 |

| | | |
|---|---|---|
| MEM 491 [WI] | Senior Design Project I ‡ | 3.0 |
| MEM 492 [WI] | Senior Design Project II ‡ | 3.0 |
| MEM 493 [WI] | Senior Design Project III ‡ | 3.0 |
| COE/MEM Elective (Any COE or MEM course 300 level or higher) - MATH 592 or MATH 593 satisfies this requirement | | 0.0 |
| MEM Electives (Any two MEM courses 300 level or higher.) | | 6.0-8.0 |
| Math Elective (Any 1 course from MATH 291, MATH 300, MATH 321, MATH 322, or MATH 323) | | |
| MEM 591 counts as 3.0 credits of UG Math Elective and 3.0 credits COE/MEM Elective as shared coursework | | |
| Free Electives | | 6.0-8.0 |
| **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: Heat Transfer | | |
| MEM 611 | Conduction Heat Transfer | |
| MEM 612 | Convection Heat Transfer | |
| or 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 | |
| **Core Area: Manufacturing** | | |
| MEM 619 | Microfluidics and Lab-on-a-Chip | |
| MEM 678 | Nondestructive Evaluation Methods | |
| MEM 679 | Data Analysis and Machine Learning for Science and Manufacturing | |
| MEM 687 | Manufacturing Processes I | |
| **Graduate Math Courses** | | |
| MEM 591 | Applied Engr Analy Methods I | 3.0 |
| Choose one of the following: | | 3.0 |
| MEM 592 | Applied Engr Analy Methods II | |
| MEM 593 | Applied Engr Analy Methods III | |
| Graduate Electives ^^ | | 27.0 |
| **Total Credits** | | **229.0-247.0** |

*****

Upon matriculation, students are assigned one of two co-op cycles: fall/winter or spring/summer. All ME/ME BS/MS students will be switched to the spring/summer co-op when they are admitted to the BS/MS program, if not already on that cycle.
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 Electives (p. 5)

*******

MATH and PHYS sequences are determined by the student's Calculus Placement Exam score and the completion of any summer online preparatory courses available based on that score.

†

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

‡

If a student chooses to pursue a graduate thesis in place of senior design, they will need to replace the 9.0 undergraduate credits from MEM 491 [WI] , MEM 492 [WI] , MEM 493 [WI] with 9.0 credits from 400+ level MEM courses.

**^**

Consult the Thermal and Fluid Sciences area advisor for other options.

**^^**

**Graduate Electives**

- Students can take all 9 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 courses 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 9 elective technical courses from MEM, they may take a maximum of 7 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 at the 600 level from these four 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.

†

Some students may need a one-credit concurrent practicum course depending on their calculus exam score and summer preparatory review participation.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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

Students should complete undergraduate requirements in four years then convert to graduate status in their final year.

A full-time, academically qualified undergraduate student may take up to 9.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This coursework may be counted to fulfill undergraduate degree requirements with departmental permission.

Students admitted to an accelerated degree program may take up to a total of 15.0 quarter credits of graduate coursework with departmental permission while in an undergraduate degree program. This graduate coursework must be counted to fulfill undergraduate degree requirements with departmental permission.

This graduate coursework may be used as Shared Credits toward an advanced degree. The course credits for each graduate course taken as an undergraduate student shall only be applied to one graduate degree with departmental permission.

Matriculated students should consult Drexel Central about maintaining Federal/State financial aid eligibility regarding graduate credits taken while in an undergraduate degree program.

# 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 | 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.

## Additional Information

For more information, contact the program head:
Simi Hoque, PhD
Professor
Civil, Architectural & Environmental Engineering
Email: sth55@drexel.edu (sth55@drexel.edu)

# Minor in Chemical Engineering

## About the Minor

Engineering students can obtain a minor in Chemical Engineering by taking 24.0 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 |
| **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 | | 5.0 |
| CHE 211 | Material and Energy Balances I | |
| CHE 220 | Computational Methods in Chemical Engineering I | |
| CHE 320 | Computational Methods in Chemical Engineering II | |
| CHE 331 | Separation Processes | |
| CHE 350 | Statistics and Design of Experiments | |
| CHE 351 [WI] | Chemical Engineering Laboratory I | |
| CHE 352 [WI] | Chemical Engineering Laboratory II | |
| CHE 360 | BioProcess Principles | |
| CHE 364 | Bioprocess Unit Operations | |
| CHE 371 | Engineering Economics and Professional Practice | |
| CHE 372 | Integrated Case Studies in Chemical Engineering | |
| CHE 430 | Introduction to Sustainable Engineering | |
| CHE 431 | Fundamentals of Solar Cells | |
| CHE 453 [WI] | Chemical Engineering Laboratory III | |
| CHE 460 | Biochemical Engineering | |
| CHE 464 | Process Dynamics and Control | |
| CHE 466 | Chemical Process Safety | |
| CHE I399 | Independent Study in Chemical Engineering | |
| CHE T480 | Special Topics in Chemical Engineering | |
| **Total Credits** | | **24.0** |

*****

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)

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 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 |
| ECE 350 | Introduction to Computer Organization | 3.0 |
| ECEC 201 | Advanced Programming for Engineers | 3.0 |
| ECEC 204 | Design with Microcontrollers | 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 as well as ECE 302. 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, environmental engineering, environmental science, architectural engineering, architecture, architectural studies, business and several related majors may select to pursue construction management as a minor area of study. Because construction is inherently related to design in many of these disciplines, the construction management minor can be a natural extension of their field of study.

The requirements for the minor include:

- Completion of a minimum of 25.0 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.

## Additional Information

For more information, visit the College of Engineering's Construction Management (https://drexel.edu/engineering/academics/departments/engineering-leadership-society/academic-programs/construction-management/) web page.

## 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 | 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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.
Non-ECE Majors can select from ECEC, ECEE, ECEP, ECES plus ECE 301, ECE 303, ECE 361, ECE 370, ECE 371, and ECE 380.
CE Majors can select from ECEE, ECEP, ECES plus ECE 370, ECE 371, and ECE 380 only.

## 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** | | |
| Select one of the following options: | | 12.0 |
| Option A: Management Track * | | |
| BLAW 201 | Business Law I | |
| CIVE 240 | Engineering Economic Analysis | |
| EGMT 465 | Introduction to Systems Engineering | |
| INDE 370 | Industrial Project Management | |
| Option B: 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 | |
| Option C: 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 | |
| Option D: 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** |

*

Substitutions may be made in any of these tracks with prior approval from the Department.

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 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 | Engineering Economic Analysis | 3.0 |
| PROJ 401 | Introduction to Project Management | 3.0-4.0 |
| or INDE 370 | Industrial Project Management | |
| 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 |
| or SYSE 401 | Introduction to Systems Engineering | |
| Select 2 courses 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** | | **26.0-27.0** |

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 Leadership and Society (https://drexel.edu/engineering/academics/departments/engineering-leadership-society/) 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 an 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 | 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 | |
| ENVE 727 | Risk Assessment | |
| **Human Factors** | | |
| Select two of the following: | | 6.0 |
| 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** | | **1.0** |

| | |
|---|---|
| One additional credit of coursework is required for the minor. This credit may come from 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. | |
| **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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 information about this minor, contact Patrick Gurian, PhD at pgurian@drexel.edu.

# 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.

## Additional Information

For more information, please visit the Civil, Architectural and Environmental Engineering Department (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/) web page.

## 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, or 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 | 3.0-4.0 |
| or INDE 370 | Industrial Project Management | |
| 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 Engineering Management | |
| INTB 200 | International Business | |
| INTB 332 | Multinational Corporations * | |
| INTB 334 | International Trade * | |
| INTB 336 | International Money and Finance * | |
| **Political Science/History** | | |
| 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 | |
| **Culture and Communications** | | |
| COM 360 | Strategic 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** | | **24.0-25.0** |

*****

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

The **Minor in Green Energy and Sustainability** empowers students with the technical knowledge and systems-level perspective needed to address one of the most critical challenges of our time: building a sustainable energy future. Designed for students interested in the intersection of technology, environmental responsibility, and energy innovation, this program offers a comprehensive foundation in renewable energy systems and sustainable industrial practices.

Students in this minor gain hands-on experience with real-world energy technologies, including solar energy, electric power conversion, and renewable energy systems. Emphasizing practical applications, the program equips students with the skills to analyze, design, and optimize energy infrastructure in a way that reduces environmental impact and enhances efficiency. Concepts such as energy storage, system integration, and circuit analysis are explored through the lens of sustainability and clean technology.

Beyond the technical core, students develop a broader understanding of the economic, societal, and environmental dimensions of energy. Courses in industrial energy systems and technology economics connect engineering decisions to business strategy and policy-making—key areas for emerging leaders in the green economy.

With the rapid rise of clean energy industries and increased demand for sustainable engineering solutions, this 24-credit minor is an excellent complement to majors in engineering, engineering technology, environmental science, and business. It prepares students for careers in renewable energy development, sustainable manufacturing, green infrastructure, and energy consulting—fields where innovation and environmental stewardship go hand in hand.

**Program Highlights**

- Explore cutting-edge renewable energy technologies including solar, wind, and energy conversion systems.
- Apply engineering principles through hands-on work with circuits, energy systems, and storage devices.
- Gain an interdisciplinary perspective on sustainability, economics, and energy policy.
- Understand the impact of energy solutions across industrial, environmental, and social contexts.

## 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 complete a minor in Materials Science and Engineering (MSE) by completing 25.0 credits selected 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 proposed 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.

## Facilities

**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.

**Layered Solids Laboratory**
This laboratory contains a vacuum hot-press; creep testers, Ar-atmosphere glove-box, high-speed saw, and assorted high temperature furnaces; metallographic preparation facilities; high temperature closed-loop servo-hydraulic testing machines.

**Mechanical 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.

**Macromolecular Materials Laboratory**
This laboratory contains a hybrid rheometer, inert environment glove box, size exclusion chromatography with multi-angle laser light scattering, HPLC and RI detector & MALS, centrifuge, rotovapor, and vacuum oven used for developing innovative synthetic platforms to generate functional soft materials with complex macromolecular architectures.

**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 (ALD), chemical vapor deposition (CVD), 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 °C with mass spectrometer, Zeta potential analyzer; attrition mill, bath and probe sonicators, centrifuges; electro-spinning system for producing nano-fibers.

**Functional Inorganic Materials Synthesis Laboratory**
The laboratory contains equipment for the synthesis of inorganic and hybrid materials, including gas cabinets for $NH_3$ and $H_2$, a CVD furnace, and spin-coater; UV-Vis spectrophotometer; and a photodegradation test station with Xe 1000 W lamp.

**Films and Heterostructures 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 to 400 K, up to 9 T fields; 2 tube furnaces; spectroscopic ellipsometer.

**Powder Processing Laboratory**
This laboratory contains vee blenders, ball-mills, sieve shaker + sieves for powder classification, several furnaces.

**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 high purity liquid chromatography (HPLC) system; refractometer; electro-spinning and touch-spinning systems for producing nanofibers.

**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.

**MSE Undergraduate Teaching Laboratory**
Contains an FTIR spectrometer, metallographic sample preparation, equipment, polymer 3D printers, polymer extruder and injection molder, Vickers hardness tester, inverted metallograph, multiple furnaces.

**Materials Characterization Core (MCC)**
The Department of Materials Science & Engineering relies on the Materials Characterization 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 high resolution and variable pressure field-emission scanning electron microscopes (SEMs) with Energy Dispersive Spectroscopy (EDS) for elemental analysis, Orientation Image Microscopy (OIM) for texture analysis, various *in-situ* and *in-operando* stages (cryo mat, heating, tensile, 3- and 4-point bending, and electrochemistry); two Transmission Electron Microscopes (TEMs) with STEM capability and TEM sample preparation equipment; a dual-beam focused ion beam (FIB) system for nano-characterization and nano fabrication; a Nanoindenter; an X-ray Photoelectron Spectrometer (XPS)/Electron Spectroscopy for Chemical Analysis (ESCA) system; X-Ray Diffractometers (XRD); and an X-ray microscope (NanoCT) with an *in-situ* tensile/compression temperature controlled stage.

More details of these instruments, information on how to access them, and instrument usage rates can be found at Drexel University's Materials Characterization Core webpage.

# 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.

## Additional Information

For more information, please visit the Department of Mechanical Engineering and Mechanics (https://drexel.edu/engineering/academics/departments/mechanical-engineering/) web page.

## 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 Engineering | |
| 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 321 | Fluid Mechanics II | |
| 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 | |
| **Total Credits** | | **24.0** |

# Minor in Robotics and Automation

## About the Minor

Robotics and Automation is a fast-evolving, multidisciplinary field at the intersection of electrical, mechanical, and computer engineering. As industries embrace the Fourth Industrial Revolution (Industry 4.0) and transition toward smart factories and cyber-physical systems, the demand for skilled professionals in robotics and automation continues to surge across manufacturing, logistics, healthcare, and energy sectors.

The **Minor in Robotics and Automation** offers students a dynamic and applied foundation in mechatronics, control systems, and industrial automation. This 25-credit program is ideal for students seeking to enhance their major with in-demand technical skills and hands-on experience in intelligent systems, process control, and programmable automation.

Students will explore the fundamentals of circuit analysis and digital electronics, delve into fluid power systems, and program industry-standard PLCs. Through practical learning and experiential lab-based coursework in **robotics and mechatronics**, students will design, simulate, and control robotic systems that integrate mechanical components, sensors, actuators, and embedded computing. Advanced robotics courses and simulation tools prepare students to optimize automated systems in real-world settings.

**Program Highlights**

- Gain a strong foundation in robotics, control systems, and intelligent automation.
- Develop technical fluency with PLCs, sensor integration, fluid power, and mechatronic systems.
- Use advanced simulation tools to model and optimize industrial automation scenarios.
- Train in a dedicated robotics lab with hands-on access to real-world industrial equipment.

- Prepare for high-growth careers in smart manufacturing, robotics engineering, and automation system design.

Whether you're majoring in mechanical, electrical, computer, or industrial engineering - or simply passionate about smart technologies - this minor offers a powerful edge. Graduates are well-positioned for careers in advanced manufacturing, automation system design, process control, robotics integration, and smart infrastructure.

## 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 applies 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 | 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 |
| or SYSE 401 | Introduction to Systems Engineering | |
| INDE 362 | Operations Research for Engineering I | 3.0 |
| SYSE 488 | Systems Engineering Analysis | 3.0 |
| Select 9.0 credits from list below: | | 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 | |
| INDE 370 | Industrial Project Management | |
| 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** |

## Additional Information

For more information about this minor, contact Robert Lazzaro at rsl@drexel.edu.

# 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*
*Calendar Type: Quarter*
*Expected Time to Completion: 1 year*
*Financial Aid Eligibility: Aid eligible*
*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 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. 150) and the Construction Science certificate (p. 150).

## Additional Information

For more information, view the College of Engineering's Construction Management (https://drexel.edu/engineering/academics/departments/engineering-leadership-society/academic-programs/construction-management/) webpage or contact your advisor here (https://drexel.edu/engineering/resources/for-students/student-advising-support/).

## 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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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*
*Calendar Type: Quarter*
*Expected Time to Completion: 1 year*
*Financial Aid Eligibility: Aid eligible*
*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 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 certificate combines building systems and codes with estimating and offers focused electives that enhance field knowledge.

## Admission Requirements

Successful completion of the Fundamentals of Construction Management certificate (p. 150).

## Additional Information

For more information, view the College of Engineering's Construction Management (https://drexel.edu/engineering/academics/departments/engineering-leadership-society/academic-programs/construction-management/) webpage or contact your advisor here (https://drexel.edu/engineering/resources/for-students/student-advising-support/).

## 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**

# Certificate in 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*
*Calendar Type: Quarter*
*Expected Time to Completion: 1 year*
*Financial Aid Eligibility: Aid eligible*
*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 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 as well as provide students the foundational knowledge for success in the construction industry.

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

## Additional Information

For more information, view the College of Engineering's Construction Management (https://drexel.edu/engineering/academics/departments/engineering-leadership-society/academic-programs/construction-management/) webpage or contact your advisor here (https://drexel.edu/engineering/resources/for-students/student-advising-support/).

## 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 (GCSP) 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 first 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 (http://engineeringchallenges.org/14384.aspx) 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 | Introduction 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 | |
| Culture and Communications. Select one course from the following: | | 3.0 |
| COM 360 | Strategic International Communication | |
| 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.

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 (https://drexel.edu/coas/academics/departments-centers/english-philosophy/university-writing-program/faculty-programs/#writing-intensive-list) 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 and program contacts, please visit the NAE Grand Challenges Scholars Program (https://drexel.edu/engineering/student-experience/leadership-research-programs/nae-grand-challenges-scholars-program/) webpage.

# Index


## A

Architectural Engineering ..... 6

Architectural Engineering BS / Construction Management MS ..... 85

Architectural Engineering, Mechanical Concentration BSAE / Architectural Engineering MSAE ..... 81

Architectural Engineering, Structural Concentration BSAE / Civil Engineering, Structural Track MS ..... 83

## C

Certificate in Construction Management Concepts ..... 149

Certificate in Construction Science ..... 150

Chemical Engineering ..... 13

Chemical Engineering BSCHE / Chemical Engineering MSCHE ..... 87

Chemical Engineering BSCHE / Materials Science & Engineering MSMSE ..... 89

Civil Engineering ..... 18

Civil Engineering BSCIV / Civil Engineering MSCE ..... 91

Civil Engineering BSCIV / Construction Management MS ..... 95

Civil Engineering BSCIV / Environmental Engineering MSENE ..... 97

Computer Engineering ..... 26

Computer Engineering BSCE / Computer Engineering MSCE ..... 101

Computer Engineering BSCE / Cybersecurity MS ..... 104

Computer Engineering BSCE / Electrical Engineering MSEE ..... 106

Computer Engineering BSCE / Machine Learning Engineering MSMLE 108

Computer Engineering BSCE / Robotics & Autonomy MSRA ..... 110

Construction Management ..... 36

## E

Electrical Engineering ..... 41

Electrical Engineering BS / Electrical Engineering MS ..... 117

Electrical Engineering BSEE / Computer Engineering MSCPE ..... 112

Electrical Engineering BSEE / Cybersecurity MS ..... 114

Electrical Engineering BSEE / Machine Learning Engineering MSMLE 118

Electrical Engineering BSEE / Robotics & Autonomy MSRA ..... 120

Engineering ..... 51

Engineering Policy Analysis Minor ..... 144

Engineering Technology BSET ..... 54

Engineering Undeclared ..... 79

Environmental Engineering ..... 56

Environmental Engineering BS/MS ..... 122

Environmental Engineering BSENE / Materials Science and Engineering MSMSE ..... 126

## F

Fundamentals of Construction Management ..... 150

## M

Materials Science & Engineering BS / Materials Science & Engineering MS ..... 128

Materials Science and Engineering ..... 63

Mechanical Engineering ..... 71

Mechanical Engineering & Mechanics BS / Environmental Engineering MS ..... 134

Mechanical Engineering & Mechanics BSME / MS ..... 138

Mechanical Engineering BSME / Materials Science & Engineering MSMSE ..... 136

Minor in Architectural Engineering ..... 140

Minor in Chemical Engineering ..... 141

Minor in Computer Engineering ..... 141

Minor in Construction Management ..... 142

Minor in Electrical Engineering ..... 142

Minor in Engineering Leadership ..... 143

Minor in Engineering Management ..... 143

Minor in Environmental Engineering ..... 145

Minor in Global Engineering ..... 145

Minor in Green Energy and Sustainability ..... 146

Minor in Materials Science and Engineering ..... 146

Minor in Mechanical Engineering and Mechanics ..... 148

Minor in Robotics and Automation ..... 148

Minor in Systems Engineering ..... 149

## N

NAE Grand Challenge Scholars Program ..... 151

## T

The College of Engineering ..... 3

## U

Undergraduate Programs ..... 6