DREXEL UNIVERSITY
College of
Engineering

CATALOG
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UNDERGRADUATE

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Table of Contents

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)
- Chemical Engineering (BSCHE) (p. 17)
- Civil Engineering (BSCIV) (p. 24)
- Computer Engineering (BSCE) (p. 32)
- Construction Management (BSCMGT) (p. 42)
  - Real Estate Concentration (p. 46)
- Electrical Engineering (BSEE) (p. 50)
- Engineering (BSE) (p. 61)
- Engineering Technology (BSET) (p. 65)
  - Electrical Engineering Technology Concentration (http://catalog.drexel.edu/undergraduate/collegeofengineering/electricalengineeringtechnology/)
  - Industrial Engineering Technology Concentration (http://catalog.drexel.edu/undergraduate/collegeofengineering/industrialengineeringtechnology/)
  - Mechanical and Manufacturing Concentration (http://catalog.drexel.edu/undergraduate/collegeofengineering/engineeringtechnology/mechanicalandmanufacturingconcentration/)
  - Robotics and Automation Concentration (http://catalog.drexel.edu/undergraduate/collegeofengineering/engineeringtechnology/roboticsandautomationconcentration/)
- Environmental Engineering (BSENE) (p. 67)
- Materials Science and Engineering (BSMSE) (p. 74)
- Mechanical Engineering & Mechanics (BSME) (p. 84)

Undeclared Majors

- Engineering Undeclared (p. 93)

Accelerated Degree Programs

- Architectural Engineering - Mechanical Concentration (BSAE) / Architectural Engineering (MS) (p. 95)
- Architectural Engineering - Structural Concentration (BSAE) / Civil Engineering - Structural Track (MS (p. 100))
- Chemical Engineering (BSCHE) / Chemical Engineering (MSCHE) (p. 105)
- Chemical Engineering (BSCHE) / Materials Science Engineering (MSME) (p. 111)
- Civil Engineering (BSCIV) / Civil Engineering (MSCIV) (p. 115)
- Civil Engineering (BSCIV) / Environmental Engineering (MSENE) (p. 127)
- Computer Engineering (BSCE) / Computer Engineering (MSCE) (p. 133)
- Computer Engineering (BSCE) / Cybersecurity (MS) (p. 138)
- Computer Engineering (BSCE) / Electrical Engineering (MSEE) (p. 143)
- Computer Engineering (BSCE) / Machine Learning Engineering (MSMLE) (p. 147)
- Computer Engineering (BSCE) / Project Management (MS) (p. 151)
- Computer Engineering (BSCE) / Robotics & Autonomy (MSRA) (p. 154)
- Computer Engineering (BSCE) / Telecommunications Engineering (MSEET) (p. 159)
- Electrical Engineering (BSEE) / Computer Engineering (MSCPE) (p. 162)
- Electrical Engineering (BSEE) / Cybersecurity (MS) (p. 166)
- Electrical Engineering (BSEE) / Electrical Engineering (MS) (p. 171)
- Electrical Engineering (BSEE) / Machine Learning Engineering (MSMLE) (p. 176)
- Electrical Engineering (BSEE) / Robotics & Autonomy (MSRA) (p. 180)
- Electrical Engineering (BSEE) / Telecommunications Engineering (MSEET) (p. 185)
- Environmental Engineering (BSENE) / Environmental Engineering (MSENE) (p. 188)
- Environmental Engineering (BSENE) / Peace Engineering (MS) (p. 194)
- Materials Science & Engineering (BS) / Materials Science & Engineering (MSMSE) (p. 198)
- Mechanical Engineering & Mechanics (BSME) / Environmental Engineering (MSENE) (p. 206)
- Mechanical Engineering (BSME) / Materials Science & Engineering (MSMSE) (p. 216)
- Mechanical Engineering & Mechanics (BSME) / Mechanical Engineering & Mechanics (MSME) (p. 211)
- Mechanical Engineering (BSME) / Peace Engineering (MS) (p. 221)

Minors

- Architectural Engineering (p. 227)
- Chemical Engineering (p. 227)
- Computer Engineering (p. 228)
- Construction Management (p. 229)
- Electrical Engineering (p. 230)
- Engineering Leadership (p. 230)
- Engineering Management (p. 232)
- Engineering Policy Analysis (p. 232)
- Environmental Engineering (p. 234)
- Global Engineering (p. 234)
- Green Energy and Sustainability (p. 235)
- Materials Science and Engineering (p. 236)
- Mechanical Engineering and Mechanics (p. 238)
- Robotics and Automation (p. 239)
- Systems Engineering (p. 239)

Certificates

- Construction Management Concepts (p. 240)
- Construction Science (p. 241)
- Fundamentals of Construction Management (p. 242)
- NAE Grand Challenge Scholars Program (p. 243)

About the College

For more than 130 years, engineering has been the cornerstone of the University. From the start through today, the engineering programs have valued applied learning and exploration of emerging subjects aimed at perparing students to launch careers as innovators and solution-driven engineers. Through teaching the foundation sciences to exploration of the disciplines, faculty and industry experts guide students through the curriculum with emphasis of hands-on learning in classrooms, participation in research and 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 with opportunities to explore interests and find innovative solutions that promote economic development and improve the human-condition and our world. 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. 65) and Construction Management (p. 42).

Cooperative Education

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

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

About the Traditional Engineering Curriculum

Degree Requirements

The degree of Bachelor of Science in the engineering 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 advance credit (https://drexel.edu/~/media/Files/provost/policies/advanced-credit-crosswalks_2021-2022.ashx?la=en).

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
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0

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), Business Law (BLAW), Chinese (CHIN), Communication (COM), Criminology & Justice Studies (CJS), Culinary Arts (CULA), Dance (DANC), Economics (ECON), Education (EDUC), English (ENGL, except ENGL 101, ENGL 102, ENGL 103 & ENGL 105), Entertainment & Arts Management (EAM), Entrepreneurship (ENTP), Environmental Studies & Sustainability (ENSS), Film Studies (FMST), Finance (FIN), French (FREN), General Business (BUSN), German (GER), Global Studies (GST), Hebrew (HBRW), History (HIST), HNRS (Honors), Hotel & Restaurant Management (HRM), Humanities (HUM, except HUM 107 & HUM 108), Interior Design (INTR), International Business (INTB), Italian (ITAL), Japanese (JAPN), Jewish Studies (JWST), Korean (KOR), Language (LANG), 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), PPE (Philosophy, Politics & Economics), (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 (https://drexel.edu/provost/offices/undergrad-education/electives/), 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 Degrees Program

The Accelerated Degrees Program of the College of Engineering provides highly talented and strongly motivated students to progress toward their educational goals more quickly. 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 are most often ready to apply for the program late in their second year or early in their third, when they have shown readiness to tackle graduate-level coursework.

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.

A 5-year Plan of Study is key to fulfilling the requirement of completing both degrees at the same time. Interested students are encouraged to begin discussing their interest with their academic advisor after their first term at Drexel.

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.

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 study the principles of structural support and external cladding, building environmental systems, and project management and develop depth in at least one area.

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

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

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

Mission Statement

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

Program Educational Objectives

Architectural engineering graduates will become responsible professionals who analyze, design, construct, manage, or operate various types of buildings and their systems, and/or advance knowledge of the field.

Student Outcomes

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

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

Concentration Options

Mechanical Concentration (HVAC)

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

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

Structural Concentration

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

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

Digital Building Concentration

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

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

Additional Information

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

For more information about this major, contact the program 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 **		**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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
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 141	Architecture and Society I	3.0
ARCH 142	Architecture and Society II	3.0
ARCH 143	Architecture and Society III	3.0
ARCH 191	Studio 1-AE	3.0
ARCH 192	Studio 2-AE	3.0
CAE 491 [WI]	Senior Design Project I	3.0
CAE 492 [WI]	Senior Design Project II	3.0
CAE 493 [WI]	Senior Design Project III	3.0
CAEE 202	Introduction to Civil, Architectural & Environmental Engineering	3.0
CAEE 203	System Balances and Design in CAEE	3.0
CAEE 212	Geologic Principles for Infrastructure & Environmental Engineering	4.0
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		**29.0-34.0**
Students select one of the following concentrations for a total of 29.0-34.0 credits:		
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	
Three professional electives		

Structural Concentration	
CIVE 302	Structural Analysis I
CIVE 303	Structural Design I
CIVE 312	Soil Mechanics I
CIVE 315	Soil Mechanics II
CIVE 400	Structural Analysis II
CIVE 401	Structural Design II
CIVE 402	Structural Design III
MEM 238	Dynamics
Two 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
Three professional electives	
Total Credits	**190.0-209.0**

* 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.

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

BS Architectural Engineering, Mechanical Concentration

4 year, 1 co-op

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202		3.0 ARCH 191		3.0 AE 340		3.0 AE 220	3.5
ENGR 220		4.0 CAEE 203		3.0 ARCH 192		3.0 CIVE 250	4.0
ENGR 231 or CAEE 231		3.0 CIVE 240		3.0 CAEE 212		4.0 CIVE 330	4.0

MEM 202	3.0	ENGL 103 or 113	3.0	CIVE 320	3.0	General Education Elective†	3.0
PHYS 201	4.0	ENGR 210	3.0	MEM 230	4.0		
		ENGR 232 or CAEE 232	3.0				
	17		**18**		**17**		**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				
CIVE 302	4.0	CIVE 303	3.0				
MEM 345	4.0	General Education elective†	3.0				
Free elective	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	AE 430	3.0
ARCH 143	3.0	MEM 414	3.0	CAE 493	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
MEM 413	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).

BS Architectural Engineering, Mechanical Concentration

5 year, 3 co-op

First Year

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

Second Year

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

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
AE 340	3.0	AE 220	3.5	COOP EXPERIENCE		COOP EXPERIENCE	

ARCH 192	3.0	CIVE 250	4.0				
CAEE 212	4.0	CIVE 330	4.0				
CIVE 320	3.0	General Education elective†	3.0				
MEM 230	4.0						
	17		**14.5**		**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				
CIVE 302	4.0	CIVE 303	3.0				
MEM 345	4.0	General Education elective†	3.0				
Free 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	AE 430	3.0
ARCH 143	3.0	MEM 414	3.0	CAE 493	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
MEM 413	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).

BS Architectural Engineering, Structural Concentration

4 year, 1 co-op

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	ARCH 191	3.0	AE 340	3.0	AE 220	3.5
ENGR 220	4.0	CAEE 203	3.0	ARCH 192	3.0	CIVE 250	4.0
ENGR 231 or CAEE 231	3.0	CIVE 240	3.0	CAEE 212	4.0	CIVE 330	4.0
MEM 202	3.0	ENGL 103 or 113	3.0	CIVE 320	3.0	General Education Elective†	3.0
PHYS 201	4.0	ENGR 210	3.0	MEM 230	4.0		
		ENGR 232 or CAEE 232	3.0				
	17		**18**		**17**		**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				
CIVE 302	4.0	CIVE 303	3.0				
CIVE 312	4.0	MEM 238	4.0				
Free elective	3.0	General Education elective†	3.0				
	18		**17**		**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	CIVE 315	4.0	CIVE 402	3.0
CAE 491	3.0	CIVE 401	3.0	Professional elective†	3.0
CAEE 361	3.0	Professional Elective†	3.0	General Education elective†	3.0
CIVE 400	3.0	General Education elective†	3.0		
	15		**16**		**12**

Total Credits 195

* 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).

BS Architectural Engineering, Structural Concentration

5 year, 3 co-ops

First Year

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

Second Year

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

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
AE 340	3.0	AE 220	3.5	COOP EXPERIENCE		COOP EXPERIENCE	
ARCH 192	3.0	CIVE 250	4.0				
CAEE 212	4.0	CIVE 330	4.0				
CIVE 320	3.0	General Education Elective†	3.0				

MEM 230	4.0	Free 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				
CIVE 302	4.0	CIVE 303	3.0				
CIVE 312	4.0	MEM 238	4.0				
		General Education elective†	3.0				
	15		**17**		**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	CIVE 315	4.0	CIVE 402	3.0
CAE 491	3.0	CIVE 401	3.0	Professional elective†	3.0
CAEE 361	3.0	Professional Elective†	3.0	General Education elective†	3.0
CIVE 400	3.0	General Education elective†	3.0		
	15		**16**		**12**

Total Credits 195

* 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).

BS Architectural Engineering, Digital Building Concentration

4 year, one co-op

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	ARCH 191	3.0	AE 340	3.0	AE 220	3.5
ENGR 220	4.0	CAEE 203	3.0	ARCH 192	3.0	CIVE 250	4.0
ENGR 231 or CAEE 231	3.0	CIVE 240	3.0	CIVE 320	3.0	CIVE 330	4.0
MEM 202	3.0	ENGL 103 or 113	3.0	CAEE 212	4.0	General Education Elective†	6.0
PHYS 201***	4.0	ENGR 210	3.0	MEM 230	4.0		
		ENGR 232 or CAEE 232	3.0				
	17		**18**		**17**		**17.5**

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				
CIVE 302	4.0	CIVE 303	3.0				

Free elective	3.0	General Education Elective[†]	3.0				
General Education Elective[†]	3.0	Professional Elective[†]	3.0				
	17		**16**		**0**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits
AE 444	3.0	AE 410	3.0	AE 430	3.0
AE 455	3.0	CAE 492	3.0	CAE 493	3.0
ARCH 143	3.0	CMGT 467	4.0	CMGT 361	3.0
CAE 491	3.0	Professional Elective[†]	3.0	Professional elective[†]	3.0
CAEE 361	3.0				
	15		**13**		**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 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).

5 YR UG Co-op Digital Building Concentration

5 year, 3 co-ops

First Year

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

Second Year

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

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
AE 340	3.0	AE 220	3.5	COOP EXPERIENCE		COOP EXPERIENCE	
ARCH 192	3.0	CIVE 250	4.0				
CIVE 320	3.0	CIVE 330	4.0				
CAEE 212	4.0	General Education Electives[†]	6.0				
MEM 230	4.0						
	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				
CIVE 302	4.0	CIVE 303	3.0				

Free elective	3.0	General Education Elective†	3.0			
General Education Elective†	3.0	Professional elective†	3.0			
	17		**16**		**0**	**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
AE 444	3.0	AE 410	3.0	AE 430	3.0
AE 455	3.0	CAE 492	3.0	CAE 493	3.0
ARCH 143	3.0	CMGT 467	4.0	CMGT 361	3.0
CAE 491	3.0	Professional Elective†	3.0	Professional Elective†	3.0
CAEE 361	3.0				
	15		**13**		**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 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).

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. 95) and Architectural Engineering BS - Structural Concentration / Civil Engineering MS -Structural Track (p. 100).

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.

Civil, Architectural and Environmental Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Matthew Reichenbach, PhD *(University of Austin at Texas)*. Assistant Teaching Professor. Design and behavior of steel structures, bridge engineering, structural stability

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

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

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

Sharon Walker, PhD *(Yale University) Dean, College of Engineering*. Distinguished Professor. Water quality systems engineering

Michael Waring, PhD *(University of Texas at Austin) Department Head, Civil, Architectural, and Environmental Engineering*. 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)*. Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

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

Emeritus Faculty

A. Emin Aktan, PhD *(University of Illinois, Urbana-Champaign)*. Professor Emeritus. Health monitoring and management of large infrastructures with emphasis on health monitoring.

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

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

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

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

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

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

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, integrating practical engineering design and modern computational techniques throughout, and including 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 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

Program Educational Objectives

The Department of Chemical and Biological Engineering has four goals pertaining to student outcomes within a few years of graduation:

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

Student Outcomes*

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

Additional Information

*Adapted from The Engineering Accreditation Commission of ABET, www.abet.org (http://www.abet.org).

For more information about this program, 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	General Chemistry I	
& CHEM 101	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	
ENGR 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.

†† 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, 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, PHYS, SE, or CHE 360, CHE 373, CHE 451, 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	ENGR 220	4.0	CHE 351	2.5
						ENGL 103 or 113	3.0
	15		**16**		**15**		**16.5**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHE 331	3.0	CHE 352	2.5	COOP EXPERIENCE		COOP EXPERIENCE	
CHE 362	4.0	CHE 371	3.0				
CHEC 353	4.0	CHE 372	3.0				
CHEM 356	2.0	CHE Technical elective†	3.0				
BIO elective††	3.0-4.5	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. 18)

†† 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				
ENGR 220	4.0	CHE 351	2.5				
		ENGL 103 or 113	3.0				
	15		**16.5**		**0**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHE 331	3.0	CHE 352	2.5	COOP EXPERIENCE		COOP EXPERIENCE	
CHE 362	4.0	CHE 371	3.0				
CHEC 353	4.0	CHE 372	3.0				
CHEM 356	2.0	CHE Technical elective†	3.0				
BIO elective††	3.0-4.5	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		
General Education elective†	3.0		
	15.5		**12**

CHE Technical elective†	3.0		
		General Education elective†	3.0
	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. 18).

†† 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.

Chemical Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Emeritus Faculty

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

Civil Engineering BSCIV

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.

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

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

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

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

Mission Statement

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

Program Educational Objectives

Civil engineering graduates will become responsible professionals who analyze, design, construct, manage or operate built and natural infrastructure and systems, and/or will have advanced knowledge of the field.

Student Outcomes

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

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

Additional Information

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

For more information about this major, contact the program head:
Ivan Bartoli, PhD
Professor
Civil, Architectural and Environmental Engineering
ib77@drexel.edu

You can also view webpage for the BS in Civil Engineering (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/civil-engineering/) and the Department of Civil, Architectural and Environmental Engineering (https://drexel.edu/engineering/academics/departments/civil-architectural-environmental-engineering/).

Degree Requirements

General Education/Liberal Studies Requirements		
CIVC 101	Introduction to Civic Engagement	1.0
COOP 101	Career Management and Professional Development	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
or ENGL 111	English Composition I	
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
or ENGL 112	English Composition II	
ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
or ENGL 113	English Composition III	
UNIV E101	The Drexel Experience	1.0
General Education Requirements *		21.0
Free Electives		6.0
Foundation Requirements		
BIO 141	Essential Biology	4.5
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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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

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
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 †		9.0
Other Areas of Focus ††		9.0
Total Credits		**189.5-203.5**

* 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.

† 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 454
- 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.

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	BIO 141	4.5	VACATION	
COOP 101**	1.0	CIVC 101	1.0	ENGL 102 or 112	3.0		
ENGL 101 or 111	3.0	ENGR 131 or 132	3.0	ENGR 113	3.0		
ENGR 111	3.0	MATH 122	4.0	MATH 200	4.0		
MATH 121***	4.0	PHYS 101***	4.0	PHYS 102	4.0		
UNIV E101	1.0						
	15.5		**16.5**		**18.5**		**0**

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	CAEE 203	3.0	CAEE 212	4.0	CIVE 250	4.0
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0	CIVE 320	3.0	CIVE 330	4.0
ENGR 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	Free elective	3.0
PHYS 201	4.0	ENGR 210	3.0	General Education elective†††	3.0	General Education elective†	3.0
	17		**15**		**17**		**18**

Third Year

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

Fourth Year

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

Total Credits 189.5

* 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.

† 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 454
- 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.

††† General Education Requirements (p. 5).

5 year, 3 co-op

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	CAEE 203	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0				
ENGR 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	4.0	CIVE 250	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CIVE 320	3.0	CIVE 330	4.0				
ENVE 300	3.0	MEM 238	4.0				
MEM 230	4.0	Free elective	3.0				
General Education elective†††	3.0	General Education elective†††	3.0				
	17		**18**		**0**		**0**

Fourth Year

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

Fifth Year

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

Total Credits 189.5

* 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.

† 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 454
- 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.

††† General Education Requirements (p. 5).

Co-op/Career Opportunities

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

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

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

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

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

Facilities

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

Structural and Geotechnical Research Laboratory Facilities and Equipment

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

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

The **Woodring Laboratory** hosts a wide variety of geotechnical, geosynthetics, and materials engineering testing equipment. The geotechnical engineering testing equipment includes Geotac unconfined compression and a triaxial compression testing device, ring shear apparatus, constant rate of strain consolidometer, an automated incremental consolidometer, an automated Geotac direct shear device and a large-scale consolidometer (12” by 12” sample size). Other equipment includes a Fisher pH and conductivity meter as well as a Brookfield rotating viscometer. Electronic and

digital equipment include FLIR SC 325 infrared camera for thermal measurements, NI Function generators, acoustic emission sensors and ultrasonic transducers, signal conditioners, and impulse hammers for nondestructive testing.

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

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

Environmental Engineering Laboratory Facilities and Equipment

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

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

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

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

Computer Equipment and Software

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

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

Civil, Architectural and Environmental Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Matthew Reichenbach, PhD *(University of Austin at Texas)*. Assistant Teaching Professor. Design and behavior of steel structures, bridge engineering, structural stability

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

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

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

Sharon Walker, PhD *(Yale University) Dean, College of Engineering*. Distinguished Professor. Water quality systems engineering

Michael Waring, PhD *(University of Texas at Austin) Department Head, Civil, Architectural, and Environmental Engineering*. 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)*. Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

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

Emeritus Faculty

A. Emin Aktan, PhD *(University of Illinois, Urbana-Champaign)*. Professor Emeritus. Health monitoring and management of large infrastructures with emphasis on health monitoring.

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

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

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

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

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

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

Computer Engineering BSCE

Major: Computer Engineering
Degree Awarded: Bachelor of Science in Computer Engineering (BSCE)
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: 14.0901
Standard Occupational Classification (SOC) code: 15-1132; 15-1133; 15-1143; 17-2031

About the Program

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

Computer engineers design smaller, faster, and more reliable computers and digital systems, build computer networks to transfer data, embed microprocessors in larger physical systems such as cars and planes, work on theoretical issues in computing, and design large-scale software systems. Computer engineers may work in positions that apply computers in control systems, digital signal processing, telecommunications, and power systems, and may design very large-scale integration (VLSI) integrated circuits and systems.

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

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

Mission Statement

The ECE Department at Drexel University 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, www.abet.org (http://www.abet.org).

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

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	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
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 231	Linear Engineering Systems	3.0

ENGR 232	Dynamic Engineering Systems	3.0
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 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		**181.5-195.5**

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.

†† 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

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	CS 260	3.0	ECE 361	4.0
ECEC 201	3.0	CS 265	3.0	ECE 301	4.0	PHIL 315	3.0
ENGL 103	3.0	ECEC 204	3.0	ECE 350	3.0	CE Core elective	3.0
ENGR 231	3.0	ENGR 232	3.0	ECES 301	4.0	Free elective	3.0
MATH 221	3.0	PHYS 201	4.0			Science elective	3.0
	16		**16**		**14**		**16**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	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 181.5

* 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 or ECEC. Includes Special Topics in each code (T480).

5 year, 3 co-op

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 201	4.0	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	3.0	ENGR 232	3.0
				MATH 221	3.0	PHYS 201	4.0
	0		**0**		**16**		**16**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		CS 260	3.0	ECE 361	4.0
				ECE 301	4.0	PHIL 315	3.0
				ECE 350	3.0	CE Core elective	3.0
				ECES 301	4.0	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

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

Facilities

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

Research Laboratories at the ECE Department

Adaptive Signal Processing and Information Theory Research Group

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

Bioimage Laboratory

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

Data Fusion Laboratory

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

Drexel Network Modeling Laboratory

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

Drexel Power-Aware Computing Laboratory

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

Drexel University Nuclear Engineering Education Laboratory

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

Drexel VLSI Laboratory

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

Drexel Wireless Systems Laboratory

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

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

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

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

Ecological and Evolutionary Signal-processing and Informatics Laboratory

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

Electric Power Engineering Center

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

Electronic Design Automation Facility

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

Microwave-Photonics Device Laboratories

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

Music and Entertainment Technology Laboratory

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

NanoPhotonics+ Lab

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

Opto-Electro-Mechanical Laboratory

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

Plasma and Magnetics Laboratory

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

Power Electronics Research Laboratory

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

Testbed for Power-Performance Management of Enterprise Computing Systems

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

Computer Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Emeritus Faculty

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

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

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

Construction Management 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. While construction has traditionally been a very conservative industry, the increasing rate of technological development and competition in the industry serves to accelerate the development of new construction methods, equipment, materials, and management techniques. As a result of these forces, there is an increasing need for innovative and professionally competent construction professionals.

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

Students in Drexel's Construction Management program receive broad academic, technical, business, and construction management courses that are designed to produce well-rounded construction professionals 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

Additional Information

For additional information, visit the BS in Construction Management (https://drexel.edu/engineering/academics/undergraduate-programs/bachelors/construction-management/) program or the Construction Management (https://drexel.edu/engineering/academics/departments/engineering-leadership-society/)department website, or contact:

William Grogan
215.895.5943
wtg25@drexel.edu

Degree Requirements

English/Communication		
COM 230	Techniques of Speaking	3.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
or ENGL 111	English Composition I	
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
or ENGL 112	English Composition II	
ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
or ENGL 113	English Composition III	
Mathematics *		**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 CMGT	
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.

Potential Careers

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

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

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

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

Construction Management Faculty

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

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

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

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

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

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

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

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

Student Outcomes

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

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

Areas of Study

Telecommunications and Digital Signal Processing (DSP)

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

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

Electronics

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

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

Power and Systems/Control

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

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

Additional Information

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

For additional information, 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	
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 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
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 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
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		**181.5-195.5**

* 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.

†† 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

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

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	ECE elective††	3.0
				MATH 221	3.0	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

* 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

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	3.0
				ENGR 231	3.0	PHIL 315	3.0
				MATH 291	4.0	PHYS 201	4.0
	0		**0**		**17**		**16**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 301	4.0	ECE 361	4.0
				ECE 370	3.0	ECE 371	3.0
				ECES 301	4.0	ECE 380	3.0
				EE Core elective	3.0	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

* 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.

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‡ 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 (http://drexel.edu/ece/academics/undergrad/bs-ms/) page.

Facilities

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

Research Laboratories at the ECE Department

Adaptive Signal Processing and Information Theory Research Group

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

Bioimage Laboratory

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

Data Fusion Laboratory

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

Drexel Network Modeling Laboratory

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

Drexel Power-Aware Computing Laboratory

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

Drexel University Nuclear Engineering Education Laboratory

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

Drexel VLSI Laboratory

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

Drexel Wireless Systems Laboratory

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

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

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

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

Ecological and Evolutionary Signal-processing and Informatics Laboratory

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

Electric Power Engineering Center

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

Electronic Design Automation Facility

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

Microwave-Photonics Device Laboratories

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

Music and Entertainment Technology Laboratory

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

NanoPhotonics Laboratory

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

Opto-Electro-Mechanical Laboratory

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

Plasma and Magnetics Laboratory

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

Power Electronics Research Laboratory

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

Testbed for Power-Performance Management of Enterprise Computing Systems

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

Electrical Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Emeritus Faculty

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

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

Engineering 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

For students in year two and beyond.

About the Program

The Bachelor of Science in Engineering major is an interdisciplinary engineering major for students who do not intend to be practicing engineers. Students in the Bachelor of Science in Engineering major combine a rigorous engineering education in the College of Engineering with interdisciplinary studies in fields outside of engineering such as law, medicine, business, entrepreneurship, teaching, international studies, public policy, music, art, environmental studies, and more. The Bachelor of Science in Engineering major provides a strong grounding in the foundations of engineering, in quantitative skills, and in the analytic processes that engineers use in design of practical technology.

Drexel's Bachelor of Science in Engineering major was developed to provide students with educational and professional challenges not available in the traditional engineering curriculum.

Program Objectives

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

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

Additional Information

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

Degree Requirements

General Education/Liberal Studies Requirements		
CIVC 101	Introduction to Civic Engagement	1.0
COOP 101	Career Management and Professional Development	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
or ENGL 111	English Composition I	
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
or ENGL 112	English Composition II	

ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
or ENGL 113	English Composition III	
UNIV E101	The Drexel Experience	1.0
General Education Requirements [*]		24.0
Free Electives		24.0
Math and Science Requirements		
BIO 141	Essential Biology	4.5
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Core Curriculum Requirements		
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
Engineering Requirements		
Senior Design Sequence or Research Project		8.0
200+ Level Courses [**]		22.0
300+ Level Courses [**]		22.0
Technical Electives		
200+ Level Courses [***]		18.0
Total Credits		**181.5**

* General Education Requirements. (p. 5)

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

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

Sample Plan of Study

4 year, no co-op

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ENGL 103 or 113	3.0	ENGR 232	3.0	Two Engineering courses [**]	6.0	VACATION	
ENGR 231	3.0	Two Engineering courses [**]	7.0	General Education elective [**]	3.0		
PHYS 201	4.0	General Education elective [**]	3.0	Free elective	3.0		
Two Engineering courses [**]	7.0	Free elective [*]	4.0				
	17		**17**		**12**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
Two Engineering courses [**]	6.0	Two Engineering courses [**]	6.0	Two Engineering courses [**]	6.0	VACATION	

Technical elective	3.0	Technical elective	3.0	Technical elective	3.0		
General Education elective**	3.0	General Education elective**	3.0	General Education elective**	3.0		
Free elective	3.0	Free elective	3.0	Free elective	3.0		
	15		**15**		**15**		**0**

Fourth Year

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

Total Credits 181.5

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

** See degree requirements (p. 61).

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. 61).

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. 61).

Facilities

From the start of their freshman year, students learn to use the equipment they are likely to need in their careers such as oscilloscopes, signal generators, amplifiers, and power supplies. These skills make students more useful as co-op employees and give them a competitive advantage in their engineering careers.

Computer/Design Center

The Drexel curriculum boasts two types of lab experience: Instrumentation and Computer Design. Instrumentation Labs introduce Engineering majors to the sight, sound, and feel of equipment such as digital multimeters, power supplies, oscilloscopes, and waveform generators. The Computer Labs imbue these pre-engineers with knowledge of software which will be vital in today's work environment.

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

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

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

Engineering technology graduates go on to integrate electrical, mechanical, manufacturing, and industrial engineering disciplines to meet opportunities and technical challenges in robotics, healthcare, energy, transportation, communications, environmental protection, defense and homeland security and buildings and infrastructure. Engineering technology professionals are uniquely qualified to serve in a variety of functions requiring traditional and nontraditional technological skills. The program also prepares students for graduate study in a variety of fields, including engineering technology, engineering management, business administration, and healthcare.

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

The following concentrations are available under the Engineering Technology degree:

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

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

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

Mission

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

Engineering Technology Program Educational Objectives

Produces graduates who:

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

Engineering Technology Student Outcomes

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

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

Additional Information

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

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

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: 191.5
Co-op Options: Three Co-op (Five years); One Co-op (Four years)
Classification of Instructional Programs (CIP) code: 14.1401
Standard Occupational Classification (SOC) code: 17-2081

About the Program

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

Environmental engineers design systems, processes and policies to minimize the effect of human activities on the physical and living environment so that we can all live more healthy and sustainable lives. Environmental engineers work to meet human needs for resources in ways to minimize impact on the ecosystem and adverse effects on health. This field builds on other branches of engineering, especially civil, chemical and mechanical engineering. It also builds on information from many of the sciences, such as chemistry, physics, hydrology, geology, atmospheric science, and several specializations of biology (ecology, microbiology and biochemistry). Students who elect to study environmental engineering will become familiar with many of these areas because maintaining and improving the environment requires that problems be evaluated and solutions found using a multidisciplinary approach.

Mission

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

Program Educational Objectives

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

Student Outcomes

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

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

Additional Information

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

For more information about this major, contact the program head:
Charles Haas, PhD
LD Betz Professor of Environmental Engineering
Civil, Architectural & Environmental Engineering
haas@drexel.edu

You can also 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 ***		**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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
Environmental Engineering Requirements		
BIO 221	Microbiology	3.0
CAEE 202	Introduction to Civil, Architectural & Environmental Engineering	3.0
CAEE 203	System Balances and Design in CAEE	3.0
CAEE 212	Geologic Principles for Infrastructure & Environmental Engineering	4.0
CHE 211	Material and Energy Balances I	4.0
CHEM 230	Quantitative Analysis	4.0
CHEM 231 [WI]	Quantitative Analysis Laboratory	2.0
CHEM 241	Organic Chemistry I	4.0
CHEM 242	Organic Chemistry II	4.0
CIVE 240	Engineering Economic Analysis	3.0
CIVE 320	Introduction to Fluid Flow	3.0
CIVE 330	Hydraulics	4.0
CIVE 430	Hydrology	3.0
CIVE 431	Hydrology-Ground Water	3.0
ENVE 300	Introduction to Environmental Engineering	3.0
ENVE 302	Environmental Transport and Kinetics	3.0
ENVE 410	Solid and Hazardous Waste	3.0
ENVE 421	Water and Waste Treatment II	3.0
ENVE 422	Water and Waste Treatment Design	3.0
ENVE 435	Groundwater Remediation	3.0
ENVE 460	Fundamentals of Air Pollution Control	3.0

or ENVE 465	Indoor Air Quality	
ENVE 485	Professional Environmental Engineering Practice	1.0
ENVE 486	Environmental Engineering Processes Laboratory I	2.0
ENVE 487	Environmental Engineering Processes Laboratory II	2.0
ENVE 491 [WI]	Senior Project Design I	3.0
ENVE 492 [WI]	Senior Design Project II	3.0
ENVE 493 [WI]	Senior Design Project III	3.0
ENVS 230	General Ecology	3.0
ENVS 401	Chemistry of the Environment	3.0
Technical Electives		**12.0**
Total Credits		**191.5-205.5**

* 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.

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

Second Year

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

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 361	3.0	BIO 221	3.0	COOP EXPERIENCE		COOP EXPERIENCE	

CHEM 241	4.0	CHEM 242	4.0				
CIVE 430	3.0	General Education electives†	6.0				
ENVS 401	3.0	Technical elective	3.0				
General Education elective†	3.0						
	16		**16**		**0**		**0**

Fourth Year

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

Total Credits 191.5

* 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. 68).

5 year, 3 co-op

First Year

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

Second Year

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

Third Year

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

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 361	3.0	BIO 221	3.0	COOP EXPERIENCE		COOP EXPERIENCE	

CHEM 241	4.0	CHEM 242	4.0		
CIVE 430	3.0	General Education electives†	6.0		
ENVS 401	3.0	Technical elective	3.0		
General Education elective†	3.0				
	16		**16**	**0**	**0**

Fifth Year

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

Total Credits 191.5

* 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. 68).

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

Civil, Architectural and Environmental Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Matthew Reichenbach, PhD *(University of Austin at Texas)*. Assistant Teaching Professor. Design and behavior of steel structures, bridge engineering, structural stability

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

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

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

Sharon Walker, PhD *(Yale University) Dean, College of Engineering*. Distinguished Professor. Water quality systems engineering

Michael Waring, PhD *(University of Texas at Austin) Department Head, Civil, Architectural, and Environmental Engineering*. 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)*. Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

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

Emeritus Faculty

A. Emin Aktan, PhD *(University of Illinois, Urbana-Champaign)*. Professor Emeritus. Health monitoring and management of large infrastructures with emphasis on health monitoring.

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

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

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

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

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

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

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. A number of tracks allow upper-level students to focus their technical electives in areas of specialization, including:

- Materials for Energy
- Materials for Sustainability
- Materials for Medical Technology
- Manufacturing
- A Custom Track.

In addition, several required senior level courses emphasize the role and importance of materials selection and specification in design.

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 mentor. Students, generally working in small groups, synthesize information and knowledge from their courses to arrive at solutions to real-world engineering problems.

Examples of recent senior design project topics include:

- Fabrication of MXenes with Large Flakes
- Polymer/Metal Additive Manufacturing Materials Development
- Photoluminescent Nanocrystals as Photocatalysts
- Touchspinning of Chitosan Nanofibers
- Designing Compatibilizers for Upcycling Plastics
- Design of High Entropy Alloys via Physics-Informed Machine Learning
- Scaling-up a Topochemical Fluorination Reactor
- Quantum Materials Properties Characterization Using Computational Models
- Synthesis of MXenes from Novel MAX Phases
- Near-Infrared Photodetector for Future Use in an Imaging Wand
- Screening of MXenes for Photothermal Therapy
- 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
- Materials Discovery Through Machine Learning
- Photoluminescent Nanocrystals for Photodetectors
- Numerical Modeling of Selective Laser Melting via Finite Element Analysis
- Synthesis of MXenes Through Molten Salt Etching of MAX Phases
- Analysis of Electrospun Polyacrylonitrile Nanoyarn
- MXene-Polymer Nanocomposites *via* Thiol-Michael "Click" Chemistry

Mission Statement

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

Vision

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

Program Educational Objectives

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

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

Student Outcomes

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

1. an ability to apply, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, 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://www.abet.org/).

For additional information about this major, contact:

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

Degree Requirements

General Education/Liberal Studies Requirements		
CIVC 101	Introduction to Civic Engagement	1.0
COOP 101	Career Management and Professional Development *	1.0
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 Design and Manufacturing	
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
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
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
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		**186.5-200.5**

* 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.

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	3.0	General Education Electives†	6.0	PHIL 315	3.0
ENGR 220	4.0	ENGR 232	3.0	Technical Elective/Track Course††	3.0	Free Elective	3.0
ENGR 231	3.0	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		**16**		**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

* 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. 76).

†† 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	4.0	ENGR 210	3.0				
ENGR 231	3.0	ENGR 232	3.0				
PHYS 201	4.0	MATE 230	4.0				
Free Elective	3.0						
	18		**17**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
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

* 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, bicycles, railways).

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

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

Dual/Accelerated Degree

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.

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. Primarily through advance placement, credit by examination, flexibility of scheduling, and independent study, this “fast-track” makes it possible to complete both the undergraduate curriculum and master's level graduate studies in the five years required by the standard curriculum.

Bachelor’s/Master’s Accelerated Degree Program

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

For more information about this program, please visit the Department's BS/MS 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; a hot isostatic press (HIP) for materials consolidation and synthesis; laser scattering particle size analyzer; creep testers, Ar-filled glove-box, high-speed saw, and assorted high temperature furnaces; metallographic preparation facilities; high temperature closed-loop servo-hydraulic testing machines.

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, chemical vapor deposition, sublimation growth, and resistive thermal evaporation. Variable-temperature high-vacuum probe station and optical cryostats including high magnetic field, fixed and tunable-wavelength laser sources, several monochromators for luminescence and Raman scattering spectroscopy, scanning electron microscopy with electron beam lithography, and a scanning probe microscope.

Nanomaterials Laboratory
This laboratory contains instrumentation for synthesizing, testing and manipulation of nanomaterials carbon and two dimensional carbides under microscope, high-temperature autoclaves, Sievert’s apparatus; glove-boxes; high-temperature vacuum and other furnaces for the synthesis of nano-carbon coatings and nanotubes; tube furnaces for synthesis of carbides and nitrides; potentiostat/galvanostat for electrochemical testings; ultraviolet-visible (UV-VIS) spectrophotometry; Raman spectrometers; Differential scanning calorimeter (DSC) and thermogravimetric analyzer (TGA) up to 1500 °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
This laboratory contains gas cabinets and CVD furnaces for the synthesis of inorganic and hybrid materials for energy and environmental applications, including photocatalytic mixed anion materials, oxides and nitrides.

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 – 400K, up to 9 T fields; 2 tube furnaces.

Powder Processing Laboratory

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

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

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

X-ray Tomography Laboratory
This laboratory contains a high resolution X-ray micro-tomography instrument and a cluster of computers for 3D microstructure reconstruction; mechanical stage, a positioning stage and a cryostage for *in-situ* testing.

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 (TEM) 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.

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

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

Yong-Jie Hu, PhD *(Penn State University)*. Assistant Professor. Computational design and evaluation of mechanical, thermodynamic, and electronic properties using first-principles calculations, molecular dynamic simulations, the CALPHAD approach, multiscale modeling, and machine learning approaches.

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

Christopher Y. Li, PhD *(University of Akron) Graduate Advisor*. 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)*. Professor Emerita. Orthopedic biomaterials; acellular regenerative medicine, biomimetic proteoglycans; hydrogels.

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

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

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

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

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

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

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

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

Emeritus Faculty

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

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

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

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

Mechanical Engineering & Mechanics BSME

Major: Mechanical Engineering & Mechanics
Degree Awarded: Bachelor of Science in Mechanical Engineering (BSME)
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: 14.1901
Standard Occupational Classification (SOC) code: 17-2141

About the Program

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

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

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

Mission Statement

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

Program Educational Objectives

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

Student Outcomes

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

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

Additional Information

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

For additional information about this major, 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
COOP 101	Career Management and Professional Development *	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
or ENGL 111	English Composition I	
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
or ENGL 112	English Composition II	
ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
or ENGL 113	English Composition III	
HIST 285	Technology in Historical Perspective	4.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	1.0
General Education Requirements **		12.0
Mathematics Requirements ***		**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/Biology Requirements †		**3.5-7.5**
BIO 141	Essential Biology	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 Design Requirements		
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
Engineering Requirements		
ENGR 210	Introduction to Thermodynamics	3.0
Engineering Economics Requirements		
CIVE 240	Engineering Economic Analysis	3.0
Materials Requirements		
ENGR 220	Fundamentals of Materials	4.0
Mechanical Requirements		
MEM 201	Foundations of Computer Aided Design	3.0
MEM 202	Statics	3.0
MEM 220	Fluid Mechanics I	4.0
MEM 230	Mechanics of Materials I	4.0
MEM 238	Dynamics	4.0
MEM 255	Introduction to Controls	4.0
MEM 310	Thermodynamic Analysis I	4.0
MEM 311	Thermal Fluid Science Laboratory	2.0
MEM 331	Experimental Mechanics I	2.0
MEM 351	Dynamic Systems Laboratory I	2.0
MEM 333	Mechanical Behavior of Materials	3.0
MEM 345	Heat Transfer	4.0
MEM 355	Performance Enhancement of Dynamic Systems	4.0
MEM 361	Engineering Reliability	3.0
MEM 435	Introduction to Computer-Aided Design and Manufacturing	4.0
MEM 491 [WI]	Senior Design Project I	3.0
MEM 492 [WI]	Senior Design Project II	3.0
MEM 493 [WI]	Senior Design Project III	3.0
MEM Fundamental Courses. Select four of the following:		12.0-16.0
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 410	Thermodynamic Analysis II	
MEM 417	Introduction to Microfabrication	
MEM 423	Mechanics of Vibration	
MEM 431	Machine Design I	
MEM 437	Manufacturing Process I	
MEM 440	Thermal Systems Design	
MEM 458	Micro-Based Control Systems I	
MEM 459	Control Applications of DSP Microprocessors	
MEM Open Electives (Any two MEM courses 300 level or higher.)		6.0-8.0
COE Electives (Any 2 College of Engineering courses, including MEM courses, 300 level or higher.)		6.0-8.0
Math/Science Electives (300+ level MATH, PHYS, BIO, CHEM, CHEC, and ENVS.)		6.0-8.0
Free Electives		6.0-8.0
Electives or Optional Concentration ††		
Aerospace Concentration		
Select five courses (15.0 credits) from the list below:		
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 373	Space Systems Engineering I	
MEM 374	Space Systems Engineering II	

MEM 403	Gas Turbines & Jet Propulsion
MEM 405	Principles of Combustion I
MEM 406	Principles of Combustion II
MEM 420	Aerodynamics
MEM 423	Mechanics of Vibration
MEM 425	Aircraft Design & Performance
MEM 426	Aerospace Structures
MEM 427	Finite Element Methods
MEM 428	Introduction to Composites I
MEM 429	Introduction to Composites II
MEM 451	Orbital Mechanics
MEM 453	Aircraft Flight Dynamics & Control I
MEM 454	Aircarft Flight Dynamics & Control II
MEM 455	Introduction to Robotics
MEM 459	Control Applications of DSP Microprocessors
Energy Concentration	
Select five courses (15.0 credits) from the list below:	
AE 430	Control Systems for HVAC
CHE 431	Fundamentals of Solar Cells
ECEP 354	Energy Management Principles
ECEP 371	Introduction to Nuclear Engineering
ECEP 380	Introduction to Renewable Energy
ECEP 402	Theory of Nuclear Reactors
ECEP 403	Nuclear Power Plant Design & Operation
ECEP 406	Introduction to Radiation Health Principles
ECEP 411	Power Systems I
ECEP 422	Power Distribution Automation and Control
ECEP 480	Solar Energy Engineering
MEM 320	Fluid Dynamics I
MEM 330	Mechanics of Materials II
MEM 371	Introduction to Nuclear Engineering I
MEM 400	Internal Combustion Engines
MEM 402	Power Plant Design
MEM 403	Gas Turbines & Jet Propulsion
MEM 405 & MEM 406	Principles of Combustion I and Principles of Combustion II
MEM 410	Thermodynamic Analysis II
MEM 413 & MEM 414	HVAC Loads and HVAC Equipment
MEM 415	Fuel Cell Engines
MEM 445	Solar Energy Fundamentals
MEM 446 & MEM 447	Fundamentals of Plasmas I and Fundamentals of Plasmas II
MEM 448	Applications of Thermal Plasmas
MEM 449	Applications of Non-Thermal Plasmas
Total Credits	**189.5-215.5**

* 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).

*** 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.

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

Writing-Intensive Course Requirements

In order to graduate, all students must pass three writing-intensive courses after their freshman year. Two writing-intensive courses must be in a student's major. The third can be in any discipline. Students are advised to take one writing-intensive class each year, beginning with the sophomore

year, and to avoid “clustering” these courses near the end of their matriculation. Transfer students need to meet with an academic advisor to review the number of writing-intensive courses required to graduate.

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (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	BIO 141	4.5	VACATION	
ENGL 101 or 111	3.0	COOP 101***	1.0	ENGL 103 or 113	3.0		
ENGR 111	3.0	ENGL 102 or 112	3.0	ENGR 113	3.0		
MATH 121**	4.0	ENGR 131 or 132	3.0	MATH 200	4.0		
UNIV E101	1.0	MATH 122	4.0	PHYS 102	4.0		
		PHYS 101**	4.0				
	14.5		**19.5**		**18.5**		**0**

Second Year

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

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
MEM 311	2.0	MEM 351	2.0	COOP EXPERIENCE		COOP EXPERIENCE	
MEM 355	4.0	MEM 361	3.0				
MEM 345	4.0	Two MEM Fundamentals courses†	6.0				
MEM 435	4.0	General Education elective†	3.0				
MEM Fundamentals course†	3.0						
	17		**14**		**0**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits
MEM 491	3.0	MEM 492	3.0	MEM 493	3.0
General Education elective†	3.0	MEM elective (300+ or higher)†	3.0	MEM Elective (300+ higher)	3.0
MEM or College of Engineering elective (300+ or higher)	3.0	MEM or College of Engineering elective (300+ or higher)	3.0	General Education elective†	3.0
MEM Fundamentals course†	3.0	Math/Science course†	3.0	Free electives	3.0
Math/Science course†	3.0				
	15		**12**		**12**

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.

† See degree requirements (p. 85).

5 year, 3 co-op

First Year

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

Second Year

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

Third Year

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

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
MEM 311	2.0	MEM 351	2.0	COOP EXPERIENCE		COOP EXPERIENCE	
MEM 345	4.0	MEM 361	3.0				
MEM 355	4.0	Two MEM Fundamentals courses†	6.0				
MEM 435	4.0	General Education elective†	3.0				
MEM Fundamentals course†	3.0						
	17		**14**		**0**		**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
MEM 491	3.0	MEM 492	3.0	MEM 493	3.0
General Education elective†	3.0	MEM elective (300+ or higher)	3.0	Free elective	3.0
MEM or College of Engineering elective (300+ or higher)	3.0	MEM or College of Engineering elective (300+ or higher)	3.0	MEM Elective (300+ or higher)	3.0
MEM Fundamentals course†	3.0	Math/Science course†	3.0	General Education elective†	3.0
Math/Science course†	3.0				
	15		**12**		**12**

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.

† See degree requirements (p. 85).

Co-op/Career Opportunities

Mechanical engineers are employed in a growing number of areas, including aerospace, automotive, biomechanics, computer systems, electronic entertainment, energy, environmental, health care, manufacturing, nuclear technology, and utilities.

Most mechanical engineering graduates begin full-time employment immediately upon graduation. However, there are a number of graduates who go on to pursue master's and/or doctoral degrees in mechanical engineering. The graduate schools that Drexel's mechanical engineers have attended include Harvard, UC Berkeley, and the University of Pennsylvania.

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

Facilities

Instructional Laboratories

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

Specialized Laboratories

BIOMEMS Lab and Lab-on-a-Chip

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

Computer-aided Design Lab (CAD)

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

Theoretical and Applied Mechanics Group Laboratory (TAMG)

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

Electrochemical Energy Systems Laboratory (ECSL)

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

Multiscale Thermofluidics Lab

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

Biofabrication Laboratory

Utilizes cells or biologics as basic building blocks in which biological models, systems devices and products are manufactured. Biofabrication techniques encompass a broad range of physical, chemical, biological, and/or engineering process, with various applications in tissue science and engineering,

regenerative medicine, disease pathogeneses and drug testing studies, biochips and biosensors, cell printing, patterning and assembly, and organ printing.

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

The facilities at the Biofabrication Laboratory include:

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

Complex Fluids and Multiphase Transport Lab

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

Laboratory for Biological Systems Analysis

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

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

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

Biomechanics Laboratory
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.

Mechanical Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Emeritus Faculty

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

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

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

Albert S. Wang, PhD *(University of Delaware)*. Professor Emeritus. Treatment of damage evolution processes in multi-phased high-temperature materials, including ceramics and ceramic-matrix composites.

Engineering Undeclared

About the Program

The Engineering Undeclared program allows students to explore academic options and stay on track with credits and critical courses within the College of Engineering before declaring a major. With the help of an advisor, students can select courses based on their unique interests and goals. No later than the end of 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*MTY4NTYyNTIyMi42MzQuMS4xNjg1NjI4MzkyLjI4LjAuMA..) 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 Requirement	8.0		
UNIV E101	1.0	Major Requirement	4.5				
	14.5		**18.5**		**18.5**		**0**

Second Year

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

Third Year

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

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits
Senior Design	3.0	Senior Design	3.0	Senior Design	3.0
Math/Science course	3.0	Math/Science course	3.0	General Education Requirement	3.0
General Education Requirement	3.0	Major Requirements	6.0	Major Requirement	3.0
Major Requirement	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)
Classification of Instructional Programs (CIP) code: 14.0401
Standard Occupational Classification (SOC) code: 17-2199; 11-9041

About the Program

The BSAE/MS program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. 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 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		3.0
Foundation Requirements		
BIO 141	Essential Biology	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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
Major Requirements		
AE 220	Introduction to HVAC	3.5
AE 340	Architectural Illumination and Electrical Systems	3.0
AE 390	Architectural Engineering Design I	4.0
AE 391	Architectural Engineering Design II	4.0
ARCH 141	Architecture and Society I	3.0
ARCH 142	Architecture and Society II	3.0
ARCH 143	Architecture and Society III	3.0
ARCH 191	Studio 1-AE	3.0
ARCH 192	Studio 2-AE	3.0
CAE 491 [WI]	Senior Design Project I	3.0
CAE 492 [WI]	Senior Design Project II	3.0
CAE 493 [WI]	Senior Design Project III	3.0
CAEE 202	Introduction to Civil, Architectural & Environmental Engineering	3.0
CAEE 203	System Balances and Design in CAEE	3.0
CAEE 212	Geologic Principles for Infrastructure & Environmental Engineering	4.0
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
Professional Elective		3.0
Two Graduate Technical Electives count as 6.0 credits of Professional Electives		
400+ level courses in AE, ACCT, ARCH, BLAW, BMES, BUSN, CHE, CIVE, CMGT, ECE, ECON, CS, EGMT, ENVE, ENVR, FIN, INFO, INTB, MATE, MEM, MIS, MKTG, OPM or SE		
MASTER'S DEGREE COURSES		
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 †	**18.0**
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.

† 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 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

5 year, 3 co-op Co-Terminal

First Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 101	3.5	CHEM 102	4.5	COOP 101 or CIVC 101*	1.0	VACATION	
ENGL 101 or 111	3.0	CIVC 101 or COOP 101*	1.0	ENGL 103 or 113	3.0		
ENGR 111	3.0	ENGL 102 or 112	3.0	ENGR 113	3.0		
MATH 121	4.0	ENGR 131 or 132	3.0	MATH 200	4.0		
UNIV E101	1.0	MATH 122	4.0	PHYS 102	4.0		
		PHYS 101	4.0	(UG) General Education Requirement**	3.0		
	14.5		**19.5**		**18**		**0**

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	ARCH 191	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 231 or ENGR 231	3.0	CAEE 203	3.0				

ENGR 220	4.0	CAEE 232 or ENGR 232	3.0				
MEM 202	3.0	CIVE 240	3.0				
PHYS 201	4.0	ENGR 210	3.0				
		(UG) General Education Requirement**	3.0				
	17		**18**		**0**		**0**

Third Year

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

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
AE 390	4.0	AE 391	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CIVE 302	4.0	CIVE 303	3.0	(GR) Additional Elective	3.0		
MEM 345	4.0	(UG) Free Elective	3.0				
AE 550	3.0	(UG) General Education Requirement**	4.0				
(GR) Graduate Technical Elective (counts as UG Professional Elective as shared coursework)	3.0	AE 510	3.0				
		(GR) Graduate Technical Elective (counts as UG Professional Elective as shared coursework)	3.0				
	18		**20**		**3**		**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ARCH 141	3.0	ARCH 142	3.0	AE 430	3.0
CAE 491	3.0	CAE 492	3.0	ARCH 143	3.0
CAEE 361	3.0	MEM 414	3.0	BIO 141	4.5
MEM 413	3.0	(UG) Professional Elective	3.0	CAE 493	3.0
AE 544 (Counts as AE 444 as shared coursework)	3.0	(GR) Additional Electives	6.0	AE 551 or 552	3.0
(GR) Graduate Technical Elective	3.0			(GR) Additional Elective	3.0
	18		**18**		**19.5**

Total Credits 226

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

** General Education Requirements

Civil, Architectural and Environmental Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Matthew Reichenbach, PhD *(University of Austin at Texas)*. Assistant Teaching Professor. Design and behavior of steel structures, bridge engineering, structural stability

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

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

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

Sharon Walker, PhD *(Yale University) Dean, College of Engineering*. Distinguished Professor. Water quality systems engineering

Michael Waring, PhD *(University of Texas at Austin) Department Head, Civil, Architectural, and Environmental Engineering*. 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)*. Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

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

Emeritus Faculty

A. Emin Aktan, PhD *(University of Illinois, Urbana-Champaign)*. Professor Emeritus. Health monitoring and management of large infrastructures with emphasis on health monitoring.

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

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

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

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

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

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

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)
Classification of Instructional Programs (CIP) code: 14.0401
Standard Occupational Classification (SOC) code: 17-2199

About the Program

The program Architectural Engineering/Civil Engineering BSMS program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies, a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

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
Foundation Requirements		
BIO 141	Essential Biology	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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
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 141	Architecture and Society I	3.0
ARCH 142	Architecture and Society II	3.0
ARCH 143	Architecture and Society III	3.0
ARCH 191	Studio 1-AE	3.0
ARCH 192	Studio 2-AE	3.0
CAE 491 [WI]	Senior Design Project I	3.0
CAE 492 [WI]	Senior Design Project II	3.0
CAE 493 [WI]	Senior Design Project III	3.0
CAEE 202	Introduction to Civil, Architectural & Environmental Engineering	3.0
CAEE 203	System Balances and Design in CAEE	3.0
CAEE 212	Geologic Principles for Infrastructure & Environmental Engineering	4.0
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	
MASTER'S DEGREE COURSES		
Required Cross-Cutting Courses (12.0 credits)		
CIVE 605	Advanced Mechanics of Materials	3.0
CIVE 615	Infrastructure Condition Evaluation	3.0
or ENVE 555	Geographic Information Systems	
ENVE 571	Environmental Life Cycle Assessment	3.0
ENVE 750	Data-based Engineering Modeling	3.0
or ENVE 727	Risk Assessment	
Required Theme Courses (12.0 credits) ‡		
CIVE 701	Advanced Structural Analysis I	3.0
CIVE 702	Advanced Structural Analysis II	3.0
CIVE 703	Advanced Structural Analysis III	3.0
CIVE 708	Fundamentals of Structural Dynamics	3.0
Technical Elective Courses (21.0 credits)		**21.0**
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.		
AE 510	Intelligent Buildings	
AE 561	Airflow Simulation in Built Environment	
CIVE 510	Prestressed Concrete	
CIVE 512	Wood and Timber Design	
CIVE 520	Advanced Concrete Technology	
CIVE 531	Advanced Foundation Engineering	
CIVE 540	Forensic Structural Engineering	
CIVE 615	Infrastructure Condition Evaluation	
CIVE 704	Behavior and Stability of Structural Members I	
CIVE 705	Behavior and Stability of Structural Members II	
CIVE 711	Engineered Masonry I	
CIVE 714	Behavior of Concrete Structures I	
ENVE 555	Geographic Information Systems	
ENVE 727	Risk Assessment	
ENVE 750	Data-based Engineering Modeling	
MATH 520	Numerical Analysis I	
MATH 521	Numerical Analysis II	
MEM 591	Applied Engr Analy Methods I	
MEM 592	Applied Engr Analy Methods II	
MEM 660	Theory of Elasticity I	
MEM 663	Continuum Mechanics	
MEM 664	Introduction to Plasticity	
MEM 681	Finite Element Methods I	
MEM 682	Finite Element Methods II	
Electives or Thesis ^		
Total Credits		**231.0-245.0**

* 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)

*** 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.

‡ Must achieve grade of B or better.

^ 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

5 year, 3 co-op Co-Terminal

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ARCH 141	3.0	ARCH 191	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 202	3.0	CAEE 203	3.0	ENVE 571	3.0		
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0				
ENGR 220	4.0	CIVE 240	3.0				
MEM 202	3.0	ENGR 210	3.0				
PHYS 201	4.0	MEM 238	4.0				
	20		**19**		**3**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
AE 340	3.0	AE 220	3.5	COOP EXPERIENCE		COOP EXPERIENCE	
ARCH 192	3.0	CIVE 250	4.0	(GR) Graduate Elective	3.0		
CAEE 212	4.0	CIVE 330	4.0				
CAEE 361	3.0	(UG) General Education Requirement**	2.0				
CIVE 320	3.0	ENVE 727	3.0				
MEM 230	4.0	(GR) Graduate Elective	3.0				
	20		**19.5**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
AE 390	4.0	AE 391	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CIVE 302	4.0	ARCH 142	3.0	(GR) Graduate Elective (counts as UG Free Elective)	3.0		
CIVE 312	4.0	CIVE 303	3.0				
CIVE 605	3.0	CIVE 315	4.0				

CIVE 615 or ENVE 555	3.0 (GR) Graduate Electives (count as UG Professional Electives)	6.0	
	18	**20**	**3**	**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ARCH 143	3.0	CAE 492	3.0	BIO 141	4.5
AE 444	3.0	CIVE 401	3.0	CAE 493	3.0
CAE 491	3.0	(UG) General Education Requirements	6.0	CIVE 402	3.0
CIVE 400	3.0	CIVE 702	3.0	CIVE 703	3.0
(UG) General Education Requirement	4.0	CIVE 708	3.0	(GR) Graduate Elective	6.0
CIVE 701	3.0				
	19		**18**		**19.5**

Total Credits 231

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

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

Civil, Architectural and Environmental Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Matthew Reichenbach, PhD *(University of Austin at Texas)*. Assistant Teaching Professor. Design and behavior of steel structures, bridge engineering, structural stability

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

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

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

Sharon Walker, PhD *(Yale University) Dean, College of Engineering*. Distinguished Professor. Water quality systems engineering

Michael Waring, PhD *(University of Texas at Austin) Department Head, Civil, Architectural, and Environmental Engineering*. 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)*. Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

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

Emeritus Faculty

A. Emin Aktan, PhD *(University of Illinois, Urbana-Champaign)*. Professor Emeritus. Health monitoring and management of large infrastructures with emphasis on health monitoring.

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

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

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

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

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

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

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)
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, integrating practical engineering design and modern computational techniques throughout, and including 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 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.

The BS/MS program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary, 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. 17) 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	
ENGR 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.

†† 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, 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, PHYS, SE, or CHE 360, CHE 373, CHE 451, 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, PRMT, 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

5 year, 3 coop Co-Terminal

(Co-op cycle for Chemical Engineering is only spring/summer.)

First Year				
Fall	**Credits Winter**	**Credits Spring**	**Credits Summer**	**Credits**
CHEM 101	3.5 CHEM 102	4.5 ENGL 102 or 112	3.0 VACATION	
CIVC 101	1.0 COOP 101**	1.0 ENGR 113	3.0	
ENGL 101 or 111	3.0 ENGR 131 or 132	3.0 MATH 200	4.0	
ENGR 111	3.0 MATH 122	4.0 PHYS 102	4.0	

MATH 121	4.0	PHYS 101	4.0	(UG) General Education Elective*	3.0
UNIV E101	1.0				
(UG) General Education Elective*	3.0				
	18.5		**16.5**		**17**

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHE 211	4.0	CHE 212	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CHE 220	3.0	CHE 230	4.0				
CHEM 241	4.0	CHEM 242	4.0				
MATH 201	4.0	MATH 210	4.0				
(UG) Biology Elective***	3.0						
	18		**16**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHE 330	4.0	CHE 320	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CHE 341	4.0	CHE 342	4.0	(GR) Graduate Technical Elective†	3.0		
CHE 350	3.0	CHE 343	4.0				
CHEM 356	2.0	ENGL 103	3.0				
ENGR 220	4.0	(GR) Graduate Technical Elective†	3.0				
(GR) Graduate Free Elective	3.0						
	20		**17**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHE 331	3.0	CHE 351	2.5	COOP EXPERIENCE		COOP EXPERIENCE	
CHE 362	4.0	CHE 352	2.5	(GR) Graduate Technical Elective†	3.0	(GR) Graduate Thesis/ Non-Thesis†††	3.0
CHEC 353	4.0	CHE 371	3.0				
(UG) Education Elective*	3.0	CHE 372	3.0				
CHE 513	3.0	(UG) Technical Elective††	3.0				
(GR) Graduate Technical Elective†	3.0	(GR) Graduate Free Elective	3.0				
		(GR) Graduate Technical Elective†	3.0				
	20		**20**		**3**		**3**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CHE 453	2.5	CHE 472	3.0	CHE 466	3.0
CHE 464	3.0	(UG) General Education Elective*	3.0	CHE 473	3.0
CHE 471	4.0	(UG) Technical Electives††	6.0	(UG) General Education Elective*	3.0
(UG) General Education Elective*	3.0	CHE 525	3.0	(UG) Technical Elective††	3.0
CHE 502	3.0	(GR) Graduate Thesis/ Non-Thesis†††	3.0	CHE 543	3.0
(GR) Graduate Thesis/ Non-Thesis†††	3.0			CHE 554	3.0
	18.5		**18**		**18**

Total Credits 226.5

* General Education Requirements (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.

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

† 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, PRMT, PROJ, REAL, SYSE, PENG, MATH, PHYS, SE, or approved by CHE advisor.

†† 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, 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, PHYS, SE, or CHE 360, CHE 373, CHE 451, CHE 460, CHE 399-480, CHE I399, CHE T480, CHEM 230, CHEM 231 [WI] , CHEM 243, ENGR 370, or courses approved by CHE advisor.

††† 9.0 credits in one of:

- CHE 898 (thesis)
- CHE I799 (research)
- Graduate Major Technical Electives

Chemical Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Emeritus Faculty

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

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)
BS Classification of Instructional Programs (CIP) code: 14.0701
BS Standard Occupational Classification (SOC) code: 17-2041
MS Classification of Instructional Programs (CIP) code: 14:1801
MS Standard Occupational Classification (SOC) code: 17-2131

About the Program

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

The graduate program in Materials Science and Engineering aims to provide an education which encompasses both the breadth and depth of the most recent knowledge base in the materials science and engineering fields in a format suitable for individuals seeking careers in academia and/or industry.

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 3.4 and completion of 80 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	
ENGR 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.

† 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, 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, PHYS, SE, or CHE 360, CHE 373, CHE 451, 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

5 year, 3 coop Co-Terminal

First Year				
Fall	**Credits Winter**	**Credits Spring**	**Credits Summer**	**Credits**
CHEM 101	3.5 CHEM 102	4.5 ENGL 102 or 112	3.0 VACATION	
CIVC 101	1.0 COOP 101**	1.0 ENGR 113	3.0	
ENGL 101 or 111	3.0 ENGR 131 or 132	3.0 MATH 200	4.0	
ENGR 111	3.0 MATH 122	4.0 PHYS 102	4.0	
MATH 121	4.0 PHYS 101	4.0 (UG) General Education Elective*	3.0	
UNIV E101	1.0			
(UG) General Education Elective*	3.0			
	18.5	**16.5**	**17**	**0**
Second Year				
Fall	**Credits Winter**	**Credits Spring**	**Credits Summer**	**Credits**
CHE 211	4.0 CHE 212	4.0 COOP EXPERIENCE	COOP EXPERIENCE	
CHE 220	3.0 CHE 230	4.0		

CHEM 241	4.0	CHEM 242	4.0				
MATH 201	4.0	MATH 210	4.0				
Biology elective	3.0-4.5						
Choose one of the following:							
BIO 100, 101, 122, or 141							
	18-19.5		**16**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHE 330	4.0	CHE 320	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CHE 341	4.0	CHE 342	4.0	(GR) MATE Technical Elective (TE)	3.0	(GR) Technical Elective (TE)	3.0
CHE 350	3.0	CHE 343	4.0				
CHEM 356	2.0	ENGL 103 or 113	3.0				
ENGR 220	4.0	(GR) MATE Selected Core	3.0				
(GR) Technical Elective	3.0						
	20		**17**		**3**		**3**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHE 331	3.0	CHE 351	2.5	COOP EXPERIENCE		COOP EXPERIENCE	
CHEC 353	4.0	CHE 352	2.5	MATE 897 or (GR) MATE Technical Elective (TE)	3.0	MATE 897 or (GR) Technical Elective (TE)	3.0
CHE 362	4.0	CHE 371	3.0				
(UG) General Education Elective*	3.0	CHE 372	3.0				
(GR) MATE Selected Core	3.0	(UG) Technical Elective***	3.0				
(GR) MATE Technical Elective (TE)	3.0	MATE 510	3.0				
		(GR) MATE Selected Core	3.0				
	20		**20**		**3**		**3**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CHE 453	2.5	CHE 472	3.0	CHE 466	3.0
CHE 464	3.0	(UG) General Education Elective*	3.0	CHE 473	3.0
CHE 471	4.0	(UG) Technical Electives***	6.0	(UG) Technical Elective***	3.0
(UG) General Education Elective*	3.0	MATE 512	3.0	(UG) General Education Elective*	3.0
(GR) MATE Selected Core	3.0	MATE 898 (or (GR) Technical Elective (TE))	3.0	MATE 898 (or (GR) Technical Elective (TE))	3.0
MATE 898 (or (GR) Technical Elective (TE))	3.0				
	18.5		**18**		**15**

Total Credits 226.5-228

* General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

** Students doing BSCHE/MSMSE must be on a spring/summer co-op cycle.

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.

*** 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, 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, PHYS, SE, or CHE 360, CHE 373, CHE 451, 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.

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)
Classification of Instructional Programs (CIP) code: 14.0801
Standard Occupational Classification (SOC) code: 17-2051

About the Program

The Civil Engineering BSCIV / Civil Engineering MSCE program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies, a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

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 ***		**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	
ENGR 210	Introduction to Thermodynamics	3.0

ENGR 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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
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
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) ‡‡		**6.0**
CIVE 423	Engineering Ground Improvement	3.0
9 credits of GR Theme Courses as 9 credits of UG Professional Electives		
Master's Degree Courses		
Required Cross-Cutting Course (12 credits)		
CIVE 605	Advanced Mechanics of Materials ‡‡‡	3.0
ENVE 727	Risk Assessment	3.0
or CIVE 518	Natural Hazards and Infrastructure	
or ENVE 555	Geographic Information Systems	
MEM 591	Applied Engr Analy Methods I	3.0
MEM 592	Applied Engr Analy Methods II	3.0
Required Theme Course (18 credits) ‡‡‡		
CIVE 516	Geotechnical Site Investigation	3.0
CIVE 531	Advanced Foundation Engineering	3.0
CIVE 632	Advanced Soil Mechanics	3.0
CIVE 633	Lateral Earth Pressures and Retaining Structures	3.0

CIVE 635	Slope Stability and Landslides	3.0
CIVE 637	Seepage and Consolidation	3.0
Graduate Technical Elective Courses (15 credits)		**15.0**
These courses must be approved by the student's advisor and the graduate advisor.		
Select from any of the following that were not already counted for credit.		
CIVE 516	Geotechnical Site Investigation	
CIVE 518	Natural Hazards and Infrastructure	
CIVE 530	Geotechnical Engineering for Highways	
CIVE 531	Advanced Foundation Engineering	
CIVE 562	Introduction to Groundwater Hydrology	
CIVE 615	Infrastructure Condition Evaluation	
CIVE 632	Advanced Soil Mechanics	
CIVE 633	Lateral Earth Pressures and Retaining Structures	
CIVE 635	Slope Stability and Landslides	
CIVE 636	Engineering Ground Improvement	
CIVE 637	Seepage and Consolidation	
CIVE 640	Environmental Geotechnics	
CIVE 650	Geosynthetics in Civil Infrastructure	
CIVE 651	Geosynthetics in Waste Containment	
CIVE 730	Experimental Soil Mechanics I	
CIVE 731	Experimental Soil Mechanics II	
CIVE 732	Experimental Soil Mechanics III	
CIVE 737	Seismic Geotechnics	
CIVE 838	Soil Behavior	
CIVE 839	Geomechanics Modeling	
ENVE 555	Geographic Information Systems	
ENVE 727	Risk Assessment	
ENVE 750	Data-based Engineering Modeling	
MATH 520	Numerical Analysis I	
MATH 521	Numerical Analysis II	
MEM 591	Applied Engr Analy Methods I	
MEM 592	Applied Engr Analy Methods II	
MEM 660	Theory of Elasticity I	
MEM 663	Continuum Mechanics	
MEM 664	Introduction to Plasticity	
MEM 681	Finite Element Methods I	
MEM 682	Finite Element Methods II	
Thesis, Research Project, or additional Graduate Technical Electives (9 credits) †		
Total Credits		**225.5-239.5**

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 ***		**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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
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
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 Technical Electives count as 9 credits of UG Professional Electives		
Master's Degree Courses		
Required Cross-Cutting Courses (12 credits)		
CIVE 605	Advanced Mechanics of Materials ‡‡‡	3.0
CIVE 615	Infrastructure Condition Evaluation	3.0
or ENVE 555	Geographic Information Systems	

ENVE 571	Environmental Life Cycle Assessment	3.0
ENVE 727	Risk Assessment	3.0
or ENVE 750	Data-based Engineering Modeling	
Required Theme Courses (12 credits) ‡‡‡		
CIVE 701	Advanced Structural Analysis I	3.0
CIVE 702	Advanced Structural Analysis II	3.0
CIVE 703	Advanced Structural Analysis III	3.0
CIVE 708	Fundamentals of Structural Dynamics	3.0
Graduate Technical Elective Courses (21 credits)		**21.0**
These courses must be approved by the student's advisor and the graduate advisor.		
Select from any of the following that were not already counted for credit.		
AE 510	Intelligent Buildings	
AE 561	Airflow Simulation in Built Environment	
CIVE 510	Prestressed Concrete	
CIVE 512	Wood and Timber Design	
CIVE 520	Advanced Concrete Technology	
CIVE 531	Advanced Foundation Engineering	
CIVE 540	Forensic Structural Engineering	
CIVE 615	Infrastructure Condition Evaluation	
CIVE 704	Behavior and Stability of Structural Members I	
CIVE 705	Behavior and Stability of Structural Members II	
CIVE 711	Engineered Masonry I	
CIVE 714	Behavior of Concrete Structures I	
ENVE 555	Geographic Information Systems	
ENVE 727	Risk Assessment	
ENVE 750	Data-based Engineering Modeling	
MATH 520	Numerical Analysis I	
MATH 521	Numerical Analysis II	
MEM 591	Applied Engr Analy Methods I	
MEM 592	Applied Engr Analy Methods II	
MEM 660	Theory of Elasticity I	
MEM 663	Continuum Mechanics	
MEM 664	Introduction to Plasticity	
MEM 681	Finite Element Methods I	
MEM 682	Finite Element Methods II	
Thesis, Research Project, or additional Graduate Technical Electives (9 credits) ††		
Total Credits		**225.5-239.5**

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 ***		**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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
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
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 Technical Electives count as 9 credits of UG Professional Electives		
Master's Degree Courses		
Required Cross-Cutting Course (12 credits)		
CIVE 615	Infrastructure Condition Evaluation	3.0
or ENVE 555	Geographic Information Systems	
CIVE 664	Open Channel Hydraulics ‡‡‡	3.0
ENVE 571	Environmental Life Cycle Assessment	3.0
ENVE 727	Risk Assessment	3.0
or ENVE 750	Data-based Engineering Modeling	
Required Theme Course (12 credits) ‡‡‡		
CIVE 565	Urban Ecohydraulics	3.0

CIVE 567	Watershed Analysis	3.0
or ENVE 681	Analytical and Numerical Techniques in Hydrology	
ENVE 665	Hazardous Waste & Groundwater Treatment	3.0
or CIVE 564	Sustainable Water Resource Engineering	
ENVS 501	Chemistry of the Environment	3.0
Graduate Technical Elective Courses (21 credits)		**21.0**
These courses must be approved by the student's advisor and the graduate advisor.		
Select from any of the following that were not already counted for credit.		
CIVE 562	Introduction to Groundwater Hydrology	
CIVE 564	Sustainable Water Resource Engineering	
CIVE 567	Watershed Analysis	
CIVE 615	Infrastructure Condition Evaluation	
ENVE 555	Geographic Information Systems	
ENVE 660	Chemical Kinetics in Environmental Engineering	
ENVE 661	Env Engr Op-Chem & Phys	
ENVE 665	Hazardous Waste & Groundwater Treatment	
ENVE 727	Risk Assessment	
ENVE 750	Data-based Engineering Modeling	
Thesis, Research Project, or additional Graduate Technical Electives (9 credits) ††		
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

*** 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.

‡‡ 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.

†† 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

5 year, 3 co-op: Geotechnical Graduate Track

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	CAEE 203	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0				
ENGR 220	4.0	CIVE 240	3.0				
MEM 202	3.0	ENGR 210	3.0				
PHYS 201	4.0	(UG) General Education Elective†	3.0				
	17		**15**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 212	4.0	CIVE 250	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 361	3.0	CIVE 330	4.0	(GR) Graduate Technical Elective	3.0		
CIVE 320	3.0	MEM 238	4.0				
ENVE 300	3.0	ENVE 555, 727, or CIVE 518†††	3.0				
MEM 230	4.0	(GR) Graduate Technical Elective	3.0				
CIVE 605†††	3.0						
	20		**18**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CIVE 302	4.0	CIVE 303	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CIVE 312	4.0	CIVE 315	4.0	(GR) Graduate Technical Elective	3.0		
CIVE 430	3.0	CIVE 375	3.0				
(UG) General Education Elective†	3.0	(UG) General Education Elective†	3.0				
MEM 591†††	3.0	MEM 592†††	3.0				
(GR) Graduate Technical Elective	3.0	(GR) Graduate Technical Elective	3.0				
	20		**19**		**3**		**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CAE 491	3.0	CAE 492	3.0	CAE 493	3.0
CIVE 477	2.0	CIVE 478	1.0	CIVE 423	3.0
(UG) General Education Electives†	6.0	(UG) Free Electives	6.0	(UG) General Education Electives†	6.0
CIVE 531 (counts as (UG) Professional Elective)	3.0	CIVE 516‡	3.0	CIVE 635 (counts as (UG) Professional Elective)	3.0
CIVE 632‡	3.0	CIVE 633 (counts as (UG) Professional Elective)	3.0	CIVE 637‡	3.0

(GR) Technical Elective	3.0	(GR) Professional Elective	3.0				
	20		**19**		**18**		

Total Credits 225.5

* 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.

** 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.

† General Education Requirements (p. 5)

†† 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.

††† Graduate Cross-Cutting Courses
CIVE 605, ENVE 727 or ENVE 555 or CIVE 518, MEM 591, and MEM 592

‡ Graduate Theme Courses
CIVE 516, CIVE 531, CIVE 632, CIVE 633, CIVE 635, and CIVE 637

5 year, 3 co-op: Structural Graduate Track

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	CAEE 203	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0				
ENGR 220	4.0	CIVE 240	3.0				
MEM 202	3.0	ENGR 210	3.0				
PHYS 201	4.0	(UG) General Education Electives†	6.0				
	17		**18**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 212	4.0	CIVE 250	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 361	3.0	CIVE 330	4.0	ENVE 571	3.0		
CIVE 320	3.0	MEM 238	4.0				
ENVE 300	3.0	ENVE 727 or 750	3.0				
MEM 230	4.0	(GR) Graduate Technical Elective***	3.0				
(GR) Graduate Technical Elective***	3.0						
	20		**18**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CIVE 302	4.0	CIVE 303	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CIVE 312	4.0	CIVE 315	4.0	(GR) Graduate Technical Elective	3.0		
CIVE 430	3.0	CIVE 375	3.0				
(UG) General Education Elective†	3.0	(UG) General Education Elective†	3.0				
CIVE 605	3.0	(GR) Graduate Technical Elective counts as (UG) Professional Elective	3.0				
CIVE 615 or ENVE 555	3.0	(GR) Graduate Technical Elective	3.0				
	20		**19**		**3**		**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CAE 491	3.0	CAE 492	3.0	CAE 493	3.0
CIVE 400	3.0	CIVE 401	3.0	CIVE 402	3.0
CIVE 477	2.0	CIVE 478	1.0	(UG) General Education Electives†	6.0
(UG) General Education Elective†	3.0	(UG) Free Electives	6.0	(GR) Graduate Technical Elective counts as (UG) Professional Elective	3.0
(GR) Graduate Technical Elective counts as (UG) Professional Elective	3.0	CIVE 702	3.0	CIVE 703	3.0
CIVE 701	3.0	CIVE 708	3.0		
	17		**19**		**18**

Total Credits 225.5

* 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.

** 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.

† General Education Requirements

5 year, 3 co-op: Water Resources Graduate Track

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	CAEE 203	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0				
ENGR 220	4.0	CIVE 240	3.0				
MEM 202	3.0	ENGR 210	3.0				

PHYS 201	4.0	(UG) General Education Elective†	3.0				
	17		**15**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 212	4.0	CIVE 250	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 361	3.0	CIVE 330	4.0	ENVE 571	3.0		
CIVE 320	3.0	MEM 238	4.0				
ENVE 300	3.0	ENVE 727 or 750	3.0				
MEM 230	4.0	(GR) Graduate Technical Elective	3.0				
(GR) Graduate Technical Elective	3.0						
	20		**18**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CIVE 302	4.0	CIVE 303	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CIVE 312	4.0	CIVE 315	4.0	(GR) Graduate Technical Elective counts as (UG) Professional Elective	3.0		
CIVE 430	3.0	CIVE 375	3.0				
(UG) General Education Elective†	3.0	(UG) General Education Elective†	3.0				
CIVE 615 or ENVE 555	3.0	(GR) Graduate Technical Electives counts as (UG) Professional Electives	6.0				
CIVE 664	3.0						
	20		**19**		**3**		**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CAE 491	3.0	CAE 492	3.0	CAE 493	3.0
CIVE 477	2.0	CIVE 478	1.0	(UG) General Education Electives†	6.0
(UG) General Education Electives†	6.0	(UG) Free Electives	6.0	(UG) Professional Elective	3.0
(UG) Professional Elective	3.0	(UG) Professional Elective	3.0	ENVE 665 or CIVE 564	3.0
CIVE 567 or ENVE 681	3.0	CIVE 565	3.0	(GR) Graduate Technical Elective	3.0
ENVS 501	3.0	(GR) Graduate Technical Elective	3.0		
	20		**19**		**18**

Total Credits 225.5

* 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.

† General Education Requirements

Civil, Architectural and Environmental Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Matthew Reichenbach, PhD *(University of Austin at Texas)*. Assistant Teaching Professor. Design and behavior of steel structures, bridge engineering, structural stability

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

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

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

Sharon Walker, PhD *(Yale University) Dean, College of Engineering*. Distinguished Professor. Water quality systems engineering

Michael Waring, PhD *(University of Texas at Austin) Department Head, Civil, Architectural, and Environmental Engineering*. 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)*. Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

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

Emeritus Faculty

A. Emin Aktan, PhD *(University of Illinois, Urbana-Champaign)*. Professor Emeritus. Health monitoring and management of large infrastructures with emphasis on health monitoring.

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

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

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

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

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

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

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)
BS Classification of Instructional Programs (CIP) code: 14.0801
BS Standard Occupational Classification (SOC) code: 17-2051
MS Classification of Instructional Programs (CIP) code: 14.1401
MS Standard Occupational Classification (SOC) code: 17-2081

About the Program

The program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. Their undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies, a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved. The American Society of Civil Engineers publishes the Journal of Environmental Engineering, so these are recognized as 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 ***		**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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
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
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 †		9.0
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 616	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 to complete) ††		**9.0-12.0**
Environmental Treatment Processes:		
ENVE 546 & ENVE 661 & ENVE 662 & ENVE 665	Solid Waste Systems and Env Engr Op-Chem & Phys and Enviro Engr Unit Oper-Bio 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 & CIVE 565 & ENVE 571	Sustainable Water Resource Engineering and Urban Ecohydraulics and Environmental Life Cycle Assessment	
CIVE 664	Open Channel Hydraulics ††††	
or ENVE 681	Analytical and Numerical Techniques in Hydrology	
Environmental Modeling:		
ENVE 555	Geographic Information Systems ††††	
or ENVE 571	Environmental Life Cycle Assessment	
ENVE 681 & ENVE 750	Analytical and Numerical Techniques in Hydrology 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 & EOH 510 & ENVE 560	Indoor Air Quality and Principles and Practice of Environmental and Occupational Health and Fundamentals of Air Pollution Control	
Cognate Discipline Track †††		**12.0**
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.

† Professional Electives:

- AE 400-level and above (Special Topics on a case by case basis)
- CIVE 400-level and above
- ENVE 400-level and above
- CMGT 361, CMGT 362, CMGT 461, CMGT 463, CMGT 451, CMGT 467

†† 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 in any of the following subjects: AE, CHE, CHEC, CHEM, CIVE, ENVE, ENSS, ENVP, ENVS, MATH, MEM (500-699).

‡ 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

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	ENGL 102 or 112	3.0	ENGL 103 or 113	3.0		
MATH 121	4.0	ENGR 131 or 132	3.0	ENGR 113	3.0		
UNIV E101	1.0	MATH 122	4.0	MATH 200	4.0		
		PHYS 101	4.0	PHYS 102	4.0		
	14.5		**19.5**		**19.5**		**0**

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	CAEE 203	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0				
ENGR 220	4.0	CIVE 240	3.0				
MEM 202	3.0	ENGR 210	3.0				
PHYS 201	4.0	(UG) General Education Elective**	3.0				
	17		**15**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 212	4.0	CIVE 250	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 361	3.0	CIVE 330	4.0	(GR) Graduate Policy Course††	3.0		
CIVE 320	3.0	MEM 238	4.0				
ENVE 300	3.0	(GR) Graduate Life Science†††	3.0				
MEM 230	4.0	(GR) Graduate Elective***	3.0				

(GR) Graduate Statistics Course[†]	3.0						
	20		**18**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CIVE 302	4.0	CIVE 303	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CIVE 312	4.0	CIVE 315	4.0	(GR) Graduate Elective[***]	3.0		
CIVE 430	3.0	CIVE 375	3.0				
(UG) General Education Elective[**]	3.0	(UG) General Education Elective[**]	3.0				
ENVS 501	3.0	ENVE 660	3.0				
(GR) Graduate Elective[***]	3.0	(GR) Graduate Elective[***]	3.0				
	20		**19**		**3**		**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CAE 491	3.0	CAE 492	3.0	CAE 493	3.0
CIVE 477	2.0	CIVE 478	1.0	(UG) General Education Elective[**]	6.0
(UG) General Education Electives[***]	6.0	(UG) Free Electives	6.0	(UG) Professional Elective[‡]	3.0
(UG) Professional Elective[‡]	3.0	(UG) Professional Elective[‡]	3.0	(GR) Graduate Elective[***]	3.0
(GR) Graduate Elective[***]	3.0	(GR) Graduate Elective[***]	3.0	(GR) Graduate Elective[***]	3.0
(GR) Graduate Elective[***]	3.0	(GR) Graduate Elective[***]	3.0		
	20		**19**		**18**

Total Credits 225.5

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** **Graduate Electives:**

One Specialization Track:

- Environmental Treatment Processes: ENVE 546 , ENVE 661, , ENVE 662, ENVE 665
- Human Risks: , EOH 612, ENVE 727 , and AE 550or EOH 510
- Water Resources:CIVE 564 , CIVE 565, ENVE 571, and CIVE 664 or ENVE 681
- Environmental Modeling: ENVE 555 or ENVE 571, ENVE 681 or ENVE 750, and one advanced MATH course (MEM 591, CHE 502 or MATE 535)
- Air Quality: AE 550, EOH 510, ENVE 560

One Cognate Sequence:

- 4-course coherent sequence in addition to the specialization, either in environmental engineering, environmental science, or related STEM field. Advisor must approve of courses chosen.

† Approved Statistics Course
BMES 510 or ENVE 750 or ENVS 506

†† Approved Policy Course
CIVE 564 or ECON 616 or PLCY 503 or PLCY 504

††† Approved Life Sciences Course
ENVE 516 or ENVS 511 or ENVS 530

‡ Professional Electives:

- AE 400-level and above (Special Topics on a case by case basis)
- CIVE 400-level and above
- ENVE 400-level and above
- CMGT 361, CMGT 362, CMGT 461, CMGT 463, CMGT 451, CMGT 467

Civil, Architectural and Environmental Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Matthew Reichenbach, PhD *(University of Austin at Texas)*. Assistant Teaching Professor. Design and behavior of steel structures, bridge engineering, structural stability

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

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

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

Sharon Walker, PhD *(Yale University) Dean, College of Engineering*. Distinguished Professor. Water quality systems engineering

Michael Waring, PhD *(University of Texas at Austin) Department Head, Civil, Architectural, and Environmental Engineering*. 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)*. Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

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

Emeritus Faculty

A. Emin Aktan, PhD *(University of Illinois, Urbana-Champaign)*. Professor Emeritus. Health monitoring and management of large infrastructures with emphasis on health monitoring.

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

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

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

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

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

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

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: 226.5
Co-op Options: Three Co-ops (Five years)
Classification of Instructional Programs (CIP) code: 14.0901
Standard Occupational Classification (SOC) code: 15-1132; 15-1133; 15-1143; 17-2031

About the Program

The BS/MS in Computer Engineering is an accelerated degree program that gives academically qualified ECE students the opportunity to receive two diplomas (BS and MS) at the same time, graduating within the typical duration of earning the bachelor's degree alone. 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. An additional benefit of pursuing the BS/MS at Drexel's College of Engineering is the possibility of receiving a BS degree in one discipline and a MS degree in the same or related discipline.

For more information, visit COE Special Programs 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

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	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		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):		3.0-4.0
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		**226.5-227.5**

* 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, PRMT, 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

5 year, 3 coop Co-Terminal

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 201	4.0	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	3.0	ENGR 232	3.0				
MATH 221	3.0	PHYS 201	4.0				
(UG) Free Elective	3.0	(UG) Free Elective	3.0				
	19		**19**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CS 260	3.0	ECE 361	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
ECE 301	4.0	PHIL 315	3.0	(GR) Graduate Elective§	3.0		
ECE 350	3.0	(UG) CE Core Elective***	3.0				
ECES 301	4.0	(UG) Free Elective	3.0				
(UG) General Education Elective**	3.0	(UG) Science Elective	3.0				
(GR) Graduate Elective§	3.0	Any course in BIO, CHEM or PHYS					
		(GR) Graduate Elective§	3.0				
	20		**19**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 303		3.0 (UG) ECE Elective[†]		3.0 COOP EXPERIENCE		COOP EXPERIENCE	
MATH 291		4.0 (UG) Free Electives		6.0 (GR) Graduate Elective[§]		3.0 (GR) Graduate Elective[§]	3.0
(UG) ECE Elective[†]		3.0 (UG) General Education Elective[**]		3.0			
(UG) Free Elective		3.0 (GR) Graduate ECEC Courses[‡]		6.0			
(GR) Graduate ECEC Courses[‡]		6.0					
	19		**18**		**3**		**3**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491		3.0 ECE 492		3.0 ECE 493	3.0
(UG) ECE 400+ Elective[††]		3.0 (UG) ECE 400+ Elective[††]		3.0 (UG) ECE 400+ Elective[††]	3.0
(UG) Free Elective		3.0 (UG) Free Elective		3.0 (UG) Free Elective	3.0
(UG) General Education Elective[**]		3.0 (UG) General Education Elective[**]		3.0 (UG) General Education Elective[**]	3.0
(GR) Graduate ECEC Courses[‡]		6.0 (GR) Graduate ECEC Course[‡]		3.0 (GR) General ECE Courses[‡]	6.0
		(GR) General ECE Course[‡]		3.0	
	18		**18**		**18**

Total Credits 226.5

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (p. 5)

*** Choose one of the following: ECE 370, ECE 371, or ECE 380

† ECE Electives: 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).

†† ECE 400+ Electives: 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.

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

Computer Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Emeritus Faculty

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

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

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

Computer Engineering 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: 226.5
Co-op Options: Three Co-ops (Five years)
BS Classification of Instructional Programs (CIP) code: 14.0901
BS Standard Occupational Classification (SOC) code: 15-1132
MS Classification of Instructional Programs (CIP) code: 11.1003
MS Standard Occupational Classification (SOC) code: 15-1122

About the Program

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

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 Special Programs (p. 5) 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; with minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, and ECEC 201.

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	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
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 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
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 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 612	Knowledge-based Agents	
CS 613	Machine Learning	
CS 621	Approximation Algorithms	
CS 630	Cognitive Systems	
CS 643	Advanced Operating Systems	
CS 645	Network Security	
CS 647	Distributed Systems Software	
CS 650	Program Generation and Optimization	
CS 695	Research Rotations in Cybersecurity	
CS 741	Computer Networks II	
CS 751	Database Theory	
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	Information Retrieval Systems	
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		**226.5-240.5**

* 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

5 year, 3 coop Co-terminal

First Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 101	3.5	COOP 101 or CIVC 101*	1.0	CIVC 101 or COOP 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	3.0	ENGR 232	3.0
				MATH 221	3.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**19**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		CS 260	3.0	ECE 361	4.0
INFO 725	3.0			ECE 301	4.0	PHIL 315	3.0
				ECE 350	3.0	(UG) CE Core elective***	3.0
				ECES 301	4.0	(UG) Free Elective	3.0

				(UG) General Education Elective**	3.0	(UG) Science elective (Any BIO, CHEM or PHYS course)	3.0
				INFO 517	3.0	SE 578	3.0
	3		**0**		**20**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE elective†	3.0
(GR) Non-Track Technical Elective	3.0	(GR) Track Technical Elective	3.0	MATH 291	4.0	(UG) Free electives	6.0
				(UG) ECE elective†	3.0	(UG) General Education elective**	3.0
				(UG) Free elective	3.0	(GR) Non-Track Technical Elective	3.0
				(GR) Track Technical Electives	6.0	(GR) Track Technical Elective	3.0
	3		**3**		**19**		**18**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level elective††	3.0	(UG) ECE 400-level elective††	3.0
(UG) Free elective	3.0	(UG) Free elective	3.0	(UG) Free elective	3.0
(UG) General Education elective**	3.0	(UG) General Education elective**	3.0	(UG) General Education elective**	3.0
(GR) Non-Track Technical Elective	3.0	(GR) Track Technical Electives	6.0	(GR) Track Technical electives	6.0
(GR) Track Technical Elective	3.0				
	18		**18**		**18**

Total Credits 226.5

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)

*** CE Core Elective: Choose one of the following: ECE 370, ECE 371, or ECE 380

† 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).

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)
BS Classification of Instructional Programs (CIP) code: 14.0901
BS Standard Occupational Classification (SOC) code: 15-1132
MS Classification of Instructional Programs (CIP) code: 14.1001
MS Standard Occupational Classification (SOC) code: 17-2071

About the Program

The Computer Engineering undergraduate degree program is designed to provide our students with breadth in engineering, the sciences, mathematics, and the humanities, as well as depth in both software and hardware disciplines appropriate for a computer engineer. It embodies the philosophy and

style of the Drexel Engineering Curriculum and will develop the student's design and analytical skills. In combination with the co-op experience, it opens to the student opportunities in engineering practice, advanced training in engineering or in other professions, and an entry to business and administration.

The 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 in six general areas: (1) computer engineering; (2) control, robotics, and intelligent systems; (3) electrophysics; (4) image and signal processing and interpretation; (5) power engineering and energy; and (6) telecommunications and networking.

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 80.0 credits, with a minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, and ECEC 201.

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	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		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		**226.5**

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.

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

5 year, 3 coop Co-Terminal

First Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
CHEM 101	3.5 COOP 101 or CIVC 101*	1.0 CIVC 101 or COOP 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	3.0	ENGR 232	3.0
				MATH 221	3.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**19**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		CS 260	3.0	ECE 361	4.0
(GR) Graduate Elective[§]	3.0			ECE 301	4.0	PHIL 315	3.0
				ECE 350	3.0	(UG) CE Core elective[***]	3.0
				ECES 301	4.0	(UG) Free elective	3.0
				(UG) General Education Elective[**]	3.0	(UG) Science elective	3.0
				(GR) Graduate Elective[§]	3.0	Any BIO, CHEM or PHYS course	
						(GR) General ECE course[‡‡]	3.0
	3		**0**		**20**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE Elective[†]	3.0
(GR) Graduate Elective[§]	3.0	(GR) Graduate Elective[§]	3.0	MATH 291	4.0	(UG) Free Electives	6.0
				(UG) ECE Elective[†]	3.0	(UG) General Education Elective[**]	3.0
				(UG) Free Elective	3.0	(GR) Electrical Eng Course[‡]	3.0
				(GR) Electrical Eng Courses[‡]	6.0	(GR) General ECE Course[‡‡]	3.0
	3		**3**		**19**		**18**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
(UG) ECE 400-level Elective[††]	3.0	(UG) ECE 400-level Elective[††]	3.0	(UG) ECE 400-level Elective[††]	3.0
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0
(UG) General Education Elective[**]	3.0	(UG) General Education Elective[**]	3.0	(UG) General Education Elective[**]	3.0
(GR) Electrical Eng Courses[‡]	6.0	(GR) Electrical Eng Course[‡]	3.0	(GR) Electrical Eng Course[‡]	3.0
		(GR) Graduate Elective[§]	3.0	(GR) General ECE Course[‡‡]	3.0
	18		**18**		**18**

Total Credits 226.5

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

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)

*** CE Core Elective: Choose one of the following: ECE 370, ECE 371, or ECE 380

† 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.

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: 226.5
Co-op Options: Three Co-ops (Five years)
BS Classification of Instructional Programs (CIP) code: 14.0901
BS Standard Occupational Classification (SOC) code: 15-1132
MS Classification of Instructional Programs (CIP) code: 14.0903
MS Standard Occupational Classification (SOC) code: 15-1132

About the Program

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

The 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 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 80.0 credits, with minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, and ECEC 201.

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	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		**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		**226.5**

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, PRMT, 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

5 year, 3 coop Co-Terminal

First Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 101	3.5	COOP 101 or CIVC 101*	1.0	CIVC 101 or COOP 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	3.0	ENGR 232	3.0
				MATH 221	3.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**19**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		CS 260	3.0	ECE 361	4.0
(GR) Signal Processing Course	3.0			ECE 301	4.0	PHIL 315	3.0
				ECE 350	3.0	(UG) CE Core Elective***	3.0
				ECES 301	4.0	(UG) Free Elective	3.0
				(UG) General Education Elective**	3.0	(UG) Science Elective	3.0
				(GR) Engineering Elective	3.0	Any BIO, CHEM or PHYS course	
						(GR) Aligned Mathematical Theory Course	3.0
	3		**0**		**20**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE Elective†	3.0
(GR) Applications Course	3.0	ECE 610	3.0	MATH 291	4.0	(UG) Free Electives	6.0
				(UG) ECE Elective†	3.0	(UG) General Education Elective**	3.0
				(UG) Free Elective	3.0	ECE 612	3.0
				ECE 687	3.0	(GR) Aligned Mathematical Theory Course	3.0
				ECES 521	3.0		
	3		**3**		**19**		**18**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0
(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0
(GR) Engineering Elective	3.0	(GR) Transformational Elective	3.0	(GR) Engineering Elective	3.0
(GR) Transformational Elective	3.0	(GR) Thesis or Alternative	3.0	(GR) Thesis or Alternative	3.0
	18		**18**		**18**

Total Credits 226.5

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

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)

*** CE Core Elective: Choose one of the following: ECE 370, ECE 371, or ECE 380

† 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).

Computer Engineering BS / Project Management MS

Major: Computer Engineering and Project Management
Degree Awarded: Bachelor of Science in Computer Engineering (BSCE) and Master of Science in Project Management (MSPROJ)
Calendar Type: Quarter
Minimum Required Credits: 226.5
Co-op Options: Three Co-op (Five years)
BS Classification of Instructional Programs (CIP) code: 14.0901
BS Standard Occupational Classification (SOC) code: 15-1132; 15-1133; 15-1143; 17-2031
MS Classification of Instructional Programs (CIP) code: 52.0211
MS Standard Occupational Classification (SOC) code: 11-9199

About the Program

Although most of the students in the Project Management MS are mid-level working professionals, many College of Engineering students have completed at least 1 co-op experience to sufficiently provide a professional background to make meaningful contributions to the courses in the program. The BSCE students students nteract with project management professionals who are currently in industry which will serve them well in future co-ops and when they enter the workplace.

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

Admission Requirements

Students must have a cumulative GPA of at least 3.2; be classified as a 3rd year (pre-junior) student and have completed at least completed at least 1 co-op experience or have at least one year of professional experience. We will also require students to submit an essay discussing the following:

- Why they are pursuing a BS in Computer Engineering (BSCE) / MS in Project Management (MJPROJ)
- How they feel having a BSCE/MSPROJ will set them apart from their peers in future co-ops/career choice

Degree Requirements

General Education/Liberal Studies Requirements		
CIVC 101	Introduction to Civic Engagement	1.0
COOP 101	Career Management and Professional Development *	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
or ENGL 111	English Composition I	
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
or ENGL 112	English Composition II	
ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
or ENGL 113	English Composition III	
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	1.0
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	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
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 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
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 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: 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 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 and/or ECEC 400+ Electives ††		9.0
Free Electives		27.0
MASTER'S DEGREE COURSES		
Core Courses		
PROJ 501	Introduction to Project Management	3.0
PROJ 502	Project Planning & Scheduling	3.0
PROJ 510	Project Quality Management	3.0
PROJ 515	Project Estimation & Cost Management	3.0
PROJ 520	Project Risk Assessment & Management	3.0
PROJ 530	Managing Multiple Projects	3.0
PROJ 535	International Project Management	3.0
PROJ 540	Project Procurement Management	3.0
PROJ 601	Project Leadership	1.5
PROJ 602	Project Teamwork	1.5
PROJ 645	Project Management Tools	3.0

Capstone Project		
PROJ 695	Capstone Project in Project Management	3.0
Graduate Electives †††		**12.0**
Total Credits		**226.5-240.5**

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

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** 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.

† 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).

††† Students should use electives to increase project management, creativity, communication, or leadership skills or to develop areas of specialization. Any appropriate graduate course offered in the University can serve as an elective if the student has sufficient background to take the course. In addition, the program will offer its own elective courses including special topics (PROJ T580; PROJ T680; or PROJ T780). Qualified students may also pursue independent study (PROJ I599; PROJ I699; or PROJ I799) for elective credit in special cases.

Writing-Intensive Course Requirements

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

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (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

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 201	4.0	CS 265	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
ECEC 201	3.0	ECEC 204	3.0				
ENGL 103 or 113	3.0	ENGR 232	3.0				
ENGR 231	3.0	PHYS 201	4.0				
MATH 221	3.0	Communications Elective	3.0				
(UG) Free Elective	3.0	COM 230 or 310					
		(UG) Free Elective	3.0				
	19		**19**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CS 260	3.0	ECE 361	4.0	COOP EXPERIENCE		COOP EXPERIENCE	

ECE 301	4.0	PHIL 315	3.0	PROJ 515	3.0	PROJ 510	3.0
ECE 350	3.0	(UG) CE Core Elective	3.0				
ECES 301	4.0	ECE 370, 371, or 380					
(UG) General Education Elective**	3.0	(UG) Free Elective	3.0				
PROJ 501	3.0	(UG) Science Elective: Any BIO, PHYS or CHEM course	3.0				
		PROJ 502	3.0				
	20		**19**		**3**		**3**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 303	3.0	(UG) ECE Elective***	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
MATH 291	4.0	(UG) Free Elective	6.0	PROJ 535	3.0	GR Graduate Elective†	3.0
(UG) ECE Elective***	3.0	(UG) General Education Elective**	3.0				
(UG) Free Elective	3.0	PROJ 530	3.0				
PROJ 520	3.0	PROJ 540	3.0				
(GR) Graduate Elective†	3.0						
	19		**18**		**3**		**3**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
(UG) ECE Elective (400+ level)****	3.0	(UG) ECE Elective (400+ level)****	3.0	(UG) ECE Elective (400+ level)****	3.0
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0
(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0
PROJ 645	3.0	PROJ 602	1.5	PROJ 695	3.0
PROJ 601	1.5	(GR) Graduate Elective†	3.0	(GR) Graduate Elective†	3.0
	16.5		**16.5**		**18**

Total Credits 226.5

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

** General Education Requirements (http://catalog.drexel.edu/undergraduate/collegeofengineering/#generaleducationrequirementstext)

*** 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).

† Students should use graduate electives to increase project management, creativity, communication, or leadership skills or to develop areas of specialization. Any appropriate graduate course offered in the University can serve as an elective if the student has sufficient background to take the course. In addition, the program will offer its own elective courses including special topics (PROJ T580; PROJ T680; or PROJ T780). Qualified students may also pursue independent study (PROJ I599; PROJ I699; or PROJ I799) for elective credit in special cases.

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: 226.5
Co-op Options: Three Co-ops (Five years)
BS Classification of Instructional Programs (CIP) code: 14.0901
BS Standard Occupational Classification (SOC) code: 15-1132
MS Classification of Instructional Programs (CIP) code: 14.4201
MS Standard Occupational Classification (SOC) code: 11-9041

About the Program

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

The 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 80.0 credits, with a minimum grade of B in the following courses: ECE 200, ECE 201, ECE 105, and ECEC 201.

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	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		**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 521	Probability & Random Variables	
MATH 504	Linear Algebra & Matrix Analysis	
MATH 510	Applied Probability and Statistics I	
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	
Systems Courses		**6.0**
Choose 2 courses in robotics and autonomy from the perspective of full systems or use		
CS 510	Introduction to Artificial Intelligence	
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 571	Introduction to Robot Technology	
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 687	Pattern Recognition	
ECES 681	Fundamentals of Computer Vision	
ECES 682	Fundamentals of Image Processing	
ECET 512	Wireless Systems	
ECET T580	Special Topics in ECET	
MEM 678	Nondestructive Evaluation Methods	
Cognition and Behavior Course		3.0

CS 510	Introduction to Artificial Intelligence	
CS 583	Introduction to Computer Vision	
CS 613	Machine Learning	
CS 630	Cognitive Systems	
ECE 610	Machine Learning & Artificial Intelligence	
ECE 612	Applied Machine Learning Engineering	
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 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		**226.5**

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

5 year, 3 coop Co-Terminal

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
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	3.0	ENGR 232	3.0
				MATH 221	3.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**19**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		CS 260	3.0	ECE 361	4.0
(GR) Systems Course‡	3.0			ECE 301	4.0	PHIL 315	3.0
				ECE 350	3.0	(UG) CE Core Elective***	3.0
				ECES 301	4.0	(UG) Free Elective	3.0
				(UG) General Education Elective**	3.0	(UG) Science Elective	3.0
				(GR) Foundation Course	3.0	Any BIO, CHEM or PHYS course	
						(GR) Systems Course	3.0
	3		**0**		**20**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE Elective†	3.0
(GR) Technical Focus Course	3.0	(GR) Technical Focus Course	3.0	MATH 291	4.0	(UG) Free Electives	6.0
				(UG) ECE Elective†	3.0	(UG) General Education Elective**	3.0
				(UG) Free Elective	3.0	(GR) Core Cognition & Behavior Course	3.0
				(GR) Core Perception Course	3.0	(GR) Transformational Elective	3.0
				(GR) Foundation Course	3.0		
	3		**3**		**19**		**18**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0

(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0		
(GR) Core Action Course	3.0	(GR) Thesis or Alternative	3.0	(GR) Technical Focus Course	3.0		
(GR) Core Control Course	3.0	(GR) Transformational Elective	3.0	(GR) Thesis or Alternative	3.0		
	18		**18**		**18**		

Total Credits 226.5

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

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)

*** CE Core Elective: Choose one of the following: ECE 370, ECE 371, or ECE 380

† 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).

Computer Engineering BSCE / Telecommunications Engineering MSEET

Major: Computer Engineering and Telecommunications Engineering
Degree Awarded: Bachelor of Science in Computer Engineering (BSCE) and Master of Science in Telecommunications Engineering (MSEET)
Calendar Type: Quarter
Minimum Required Credits: 226.5
Co-op Options: Three Co-ops (Five years)
BS Classification of Instructional Programs (CIP) code: 14.0901
BS Standard Occupational Classification (SOC) code: 15-1132
MS Classification of Instructional Programs (CIP) code: 14.1001
MS Standard Occupational Classification (SOC) code: 15-1143

***Note*: New students are no longer being accepted into this program.**

About the Program

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

The MS in Electrical and Telecommunications Engineering combines the expertise of its faculty in electrical and computer engineering, business, information systems, and humanities. Through its interdisciplinary approach, Drexel's Telecommunications Engineering program trains and nurtures the complete telecommunications engineer.

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, with a minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, and ECEC 201.

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	3.0
CS 265	Advanced Programming Tools and Techniques	3.0
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		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		
Telecommunications Engineering Courses (ECET 500-level or higher)		6.0
Telecommunications Electives [‡]		15.0
General ECE courses [‡‡]		9.0
Graduate Electives [§]		15.0
Total Credits		**226.5**

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 from ECEE, ECEC, ECES, and ECET.

‡‡ 500-level or higher courses from ECEC, ECEE, ECEP, ECES, ECET, and ECE.

§ 500-level or higher courses from ECEC, ECEE, ECEP, ECES, ECET, ECE, AE, CHE, CIVE, CMGT, EGMT, ENGR, ENVE, ET, MATE, MEM, PROJ, PRMT, SYSE, BMES, MATH, PHYS, CHEM, BIO, OPR, and 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

5 year, 3 coop Co-Terminal

First Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 101	3.5	COOP 101 or CIVC 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	3.0	ENGR 232	3.0
				MATH 221	3.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**19**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		CS 260	3.0	ECE 361	4.0
(GR) Graduate Elective§	3.0			ECE 301	4.0	PHIL 315	3.0
				ECE 350	3.0	(UG) CE Core Elective***	3.0
				ECES 301	4.0	(UG) Free Elective	3.0
				(UG) General Education Elective**	3.0	(UG) Science Elective	3.0
				(GR) Graduate Elective§	3.0	Any BIO, CHEM or PHYS course	

						(GR) General ECE Course‡‡	3.0
	3		**0**		**20**		**19**
Fourth Year							
Fall	**Credits**	**Winter**	**Credits**	**Spring**	**Credits**	**Summer**	**Credits**
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE Elective†	3.0
(GR) Graduate Elective§	3.0	(GR) Graduate Elective§	3.0	MATH 291	4.0	(UG) Free Electives	6.0
				(UG) ECE Elective†	3.0	(UG) General Education Elective**	3.0
				(UG) Free Elective	3.0	(GR) ECET Course	3.0
				(GR) ECET Course	3.0	(GR) General ECE Course‡‡	3.0
				(GR) Telecom Elective Course‡	3.0		
	3		**3**		**19**		**18**
Fifth Year							
Fall	**Credits**	**Winter**	**Credits**	**Spring**	**Credits**		
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0		
(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0		
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0		
(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0		
(GR) General ECE Course‡‡	3.0	(GR) Graduate Elective§	3.0	(GR) Telecom Elective Courses‡	6.0		
(GR) Telecom Elective Courses‡	3.0	(GR) Telecom Elective Course‡	3.0				
	18		**18**		**18**		

Total Credits 226.5

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

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)

*** CE Core Elective: Choose one of the following: ECE 370, ECE 371, or ECE 380

† 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 from ECEE, ECEP, ECES, and ECET.

‡‡ 500-level or higher courses from ECEC, ECEE, ECEP, ECES, ECET, and ECE.

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

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)
BS Classification of Instructional Programs (CIP) code: 14.1001
BS Standard Occupational Classification (SOC) code: 17-2071
MS Classification of Instructional Programs (CIP) code: 14.0901
MS Standard Occupational Classification (SOC) code: 15-1132

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

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 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 80.0 credits, with a minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, ENGR 231, and ENGR 232.

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
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		3.0
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
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**

* 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, PRMT, 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

5 year, 3 coop Co-Terminal

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	3.0
				ENGR 231	3.0	PHIL 315	3.0
				MATH 291	4.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**20**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 301	4.0	ECE 361	4.0
(GR) Graduate Elective‡‡	3.0			ECE 370	3.0	ECE 371	3.0
				ECES 301	4.0	ECE 380	3.0
				(UG) EE Core Elective***	3.0	(UG) Free Elective	3.0
				(UG) General Education Elective**	3.0	(UG) Science Elective	3.0
				(GR) Graduate Elective‡‡	3.0	Any BIO, CHEM, or PHYS	
						(GR) Graduate Elective‡‡	3.0
	3		**0**		**20**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE elective†	3.0
(GR) Graduate Elective‡‡	3.0	(GR) Graduate Elective‡‡	3.0	MATH 221	3.0	(UG) Free Electives	6.0
				(UG) Free Elective	3.0	(UG) General Education Elective**	3.0
				(UG) General Education Elective**	3.0	(GR) Graduate CPE Courses	6.0
				(GR) Graduate CPE Courses	6.0		
	3		**3**		**18**		**18**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0
(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0

(GR) Graduate CPE Courses	6.0	(GR) General ECE Course‡	3.0	(GR) General ECE Courses‡	6.0		
		(GR) Graduate CPE Course	3.0				
	18		**18**		**18**		

Total Credits 226.5

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

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

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

** General Education Electives (p. 5)

*** Choose one of CS 260, CS 265, or ECE 350

† 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 500-999 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, PRMT, SYSE, BMES, MATH, PHYS, CHEM, BIO, OPR, or CS.

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)
BS Classification of Instructional Programs (CIP) code: 14.1001
BS Standard Occupational Classification (SOC) code: 17-2071
MS Classification of Instructional Programs (CIP) code: 11.1003
MS Standard Occupational Classification (SOC) code: 15-1122

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

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 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 80.0 credits, with a minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, ENGR 231, and ENGR 232.

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	
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 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
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 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
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 612	Knowledge-based Agents	
CS 613	Machine Learning	
CS 621	Approximation Algorithms	
CS 630	Cognitive Systems	
CS 643	Advanced Operating Systems	
CS 645	Network Security	
CS 647	Distributed Systems Software	
CS 650	Program Generation and Optimization	
CS 695	Research Rotations in Cybersecurity	
CS 741	Computer Networks II	
CS 751	Database Theory	
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	Information Retrieval Systems
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		**226.5-240.5**

* 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.

†† 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

5 year, 3 coop Co-Terminal

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 201	4.0	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	3.0				

ENGR 231	3.0	PHIL 315	3.0				
MATH 291	4.0	PHYS 201	4.0				
(UG) Free Elective	3.0	(UG) Free Elective	3.0				
	20		**19**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 301	4.0	ECE 361	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
ECE 370	3.0	ECE 371	3.0	INFO 725	3.0		
ECES 301	4.0	ECE 380	3.0				
(UG) EE Core Elective***	3.0	(UG) Free Elective	3.0				
(UG) General Education Elective**	3.0	(UG) Science Elective	3.0				
INFO 517	3.0	Any BIO, CHEM or PHYS					
		SE 578	3.0				
	20		**19**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 303	3.0	(UG) ECE Elective†	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
MATH 221	3.0	(UG) Free Electives	6.0	(GR) Non-Track Tech Elective	3.0	(GR) Track Tech Elective	3.0
(UG) ECE Elective†	3.0	(UG) General Education Elective**	3.0				
(UG) Free Elective	3.0	(GR) Track Tech Elective	3.0				
(GR) Track Tech Electives	6.0	(GR) Non-Track Tech Elective	3.0				
	18		**18**		**3**		**3**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Electives††	3.0
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0
(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0
(GR) Track Tech Elective	3.0	(GR) Track Tech Electives	6.0	(GR) Track Tech Electives	6.0
(GR) Non-Track Tech Elective	3.0				
	18		**18**		**18**

Total Credits 226.5

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

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

** General Education Electives (p. 5)

*** Choose one of CS 260, CS 265, or ECE 350

† 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).

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)
Classification of Instructional Programs (CIP) code: 14.1001
Standard Occupational Classification (SOC) code: 17-2071

About the Program

The BS/MS in Electrical Engineering is an accelerated degree program that gives academically qualified ECE students the opportunity to receive two diplomas (BS and MS) at the same time, graduating within the typical duration of earning the bachelor's degree alone. 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. An additional benefit of pursuing the BS/MS at Drexel's College of Engineering is the possibility of receiving a BS degree in one discipline and a MS degree in the same or related discipline.

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 3.30 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
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective: Any BIO, PHYS or CHEM course		3.0
Professional Requirements		
ECE 101	Electrical and Computer Engineering in the Real World	1.0
ECE 105	Programming for Engineers II	3.0
ECE 200	Digital Logic Design	4.0
ECE 201	Foundations of Electric Circuits I	4.0

ECE 301	Foundations of Electric Circuits II	4.0
ECE 303	ECE Laboratory	3.0
ECE 361	Probability and Data Analytics for Engineers	4.0
ECE 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
Choose one of CS 260, CS 265, or ECE 350		
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**

* 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, PRMT, 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

5 year, 3 coop Co-Terminal

First Year

Fall	Credits Winter	Credits Spring	Credits Summer	Credits
CHEM 101	3.5 CIVC 101 or COOP 101*	1.0 COOP 101 or CIVC 101*	1.0 VACATION	
ECE 101	1.0 ECE 200	4.0 ECE 105	3.0	

ENGL 101 or 111	3.0	ENGR 131 or 132	3.0	ENGL 102 or 112	3.0		
ENGR 111	3.0	MATH 122	4.0	ENGR 113	3.0		
MATH 121	4.0	PHYS 101	4.0	MATH 200	4.0		
UNIV E101	1.0			PHYS 102	4.0		
	15.5		**16**		**18**		**0**

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 201	4.0	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	3.0				
ENGR 231	3.0	PHIL 315	3.0				
MATH 291	4.0	PHYS 201	4.0				
(UG) Free Elective	3.0	(UG) Free Elective	3.0				
	20		**19**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 301	4.0	ECE 361	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
ECE 370	3.0	ECE 371	3.0	(GR) Graduate Elective‡‡	3.0		
ECES 301	4.0	ECE 380	3.0				
(UG) EE Core Elective***	3.0	(UG) Free Elective	3.0				
(UG) General Education Elective**	3.0	(UG) Science Elective: Any BIO, PHYS or CHEM course	3.0				
(GR) Graduate Elective‡‡	3.0	(GR) General ECE Course§	3.0				
	20		**19**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ECE 303	3.0	(UG) ECE Elective†	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
MATH 221	3.0	(UG) Free Electives	6.0	(GR) Graduate Elective‡‡	3.0	(GR) Graduate Elective‡‡	3.0
(UG) ECE Elective†	3.0	(UG) General Education Elective**	3.0				
(UG) Free Elective	3.0	(GR) Graduate EE Course‡	3.0				
(GR) Graduate EE Courses‡	6.0	(GR) General ECE Course§	3.0				
	18		**18**		**3**		**3**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
400-level ECE Elective††	3.0	400-level ECE Elective††	3.0	400-Level ECE Elective††	3.0
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0
(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0
(GR) Graduate EE Courses‡	6.0	(GR) Graduate EE Course‡	3.0	(GR) General ECE Course§	3.0
		(GR) Graduate Elective‡‡	3.0	(GR) Graduate EE Course‡	3.0
	18		**18**		**18**

Total Credits 226.5

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.
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)

*** Choose one of CS 260, CS 265, or ECE 350

† 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 course in ECEE, ECEP, ECES, and/or ECET
‡‡ 500+ courses in the following areas: AE, BIO, BMES, CHE, CHEM, CIVE, CMGT, CS, ECE, ECEC, ECEE, ECEP, ECES, ECET, EGMT, ENGR, ENVE, ET, MATE, MATH, MEM, OPR, PHYS, PROJ, PRMT, SYSE
§ 500+ level course in ECE, ECEC, ECEE, ECEP, ECES, and/or ECET

Electrical Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Emeritus Faculty

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

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

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)
BS Classification of Instructional Programs (CIP) code: 14.1001
BS Standard Occupational Classification (SOC) code: 17-2071
MS Classification of Instructional Programs (CIP) code: 14.0903
MS Standard Occupational Classification (SOC) code: 15-1132

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

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 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 80.0 credits, with a minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, ENGR 231, and ENGR 232.

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
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		3.0
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
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**

* 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, PRMT, 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

5 year, 3 coop Co-Terminal

First Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 101	3.5	COOP 101 or CIVC 101*	1.0	CIVC 101 or COOP 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	3.0
				ENGR 231	3.0	PHIL 315	3.0
				MATH 291	4.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**20**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 301	4.0	ECE 361	4.0
(GR) Signal Processing Course	3.0			ECE 370	3.0	ECE 371	3.0
				ECES 301	4.0	ECE 380	3.0
				(UG) EE Core Elective***	3.0	Science Elective	3.0
				(UG) General Education Elective**	3.0	Any BIO, CHEM or PHYS course	
				(GR) Engineering Elective§§	3.0	(UG) Free elective	3.0
						(GR) Aligned Mathematical Theory Course	3.0
	3		**0**		**20**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE Elective†	3.0
(GR) Applications Course	3.0	ECE 610	3.0	MATH 221	3.0	(UG) Free Electives	6.0
				(UG) ECE Elective†	3.0	(UG) General Education Elective**	3.0
				(UG) Free Elective	3.0	ECE 612	3.0
				ECE 687	3.0	(GR) Aligned Mathematical Theory Course	3.0
				ECES 521	3.0		
	3		**3**		**18**		**18**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0
(UG) ECE 400-level elective††	3.0	(UG) ECE 400-level elective††	3.0	(UG) ECE 400-level elective††	3.0
(UG) Free elective	3.0	(UG) Free elective	3.0	(UG) Free elective	3.0
(UG) General Education elective**	3.0	(UG) General Education elective**	3.0	(UG) General Education elective**	3.0
(GR) Engineering Elective	3.0	(GR) Thesis or alternative	3.0	(GR) Engineering Elective	3.0
(GR) Transformational Elective	3.0	(GR) Transformational Elective	3.0	(GR) Thesis or alternative	3.0
	18		**18**		**18**

Total Credits 226.5

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

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

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

** General Education Requirements (p. 5)

*** Choose one of CS 260, CS 265, or ECE 350

† 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).

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)
BS Classification of Instructional Programs (CIP) code: 14.1001
BS Standard Occupational Classification (SOC) code: 17-2071
MS Classification of Instructional Programs (CIP) code: 14.4201
MS Standard Occupational Classification (SOC) code: 11-9041

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

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 80.0 credits, with a minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, ENGR 231, and ENGR 232.

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
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		3.0
Choose any BIO, CHEM, or PHYS		
Professional Requirements		
ECE 101	Electrical and Computer Engineering in the Real World	1.0
ECE 105	Programming for Engineers II	3.0
ECE 200	Digital Logic Design	4.0
ECE 201	Foundations of Electric Circuits I	4.0
ECE 301	Foundations of Electric Circuits II	4.0
ECE 303	ECE Laboratory	3.0
ECE 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
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 521	Probability & Random Variables	
MATH 504	Linear Algebra & Matrix Analysis	
MATH 510	Applied Probability and Statistics I	
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	
Systems Courses		**6.0**
Choose 2 courses in robotics and autonomy from the perspective of full systems or use		
CS 510	Introduction to Artificial Intelligence	
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 571	Introduction to Robot Technology	
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 687	Pattern Recognition	
ECES 681	Fundamentals of Computer Vision	
ECES 682	Fundamentals of Image Processing	
ECET 512	Wireless Systems	
ECET T580	Special Topics in ECET	
MEM 678	Nondestructive Evaluation Methods	
Cognition and Behavior		3.0
CS 510	Introduction to Artificial Intelligence	
CS 583	Introduction to Computer Vision	
CS 613	Machine Learning	
CS 630	Cognitive Systems	
ECE 610	Machine Learning & Artificial Intelligence	
ECE 612	Applied Machine Learning Engineering	
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 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	
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**

* 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

5 year, 3 coop Co-Terminal

First Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 101	3.5	COOP 101 or CIVC 101*	1.0	CIVC 101 or COOP 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	3.0
				ENGR 231	3.0	PHIL 315	3.0
				MATH 291	4.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**20**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 301	4.0	ECE 361	4.0
(GR) Systems Course	3.0			ECE 370	3.0	ECE 371	3.0
				ECES 301	4.0	ECE 380	3.0
				(UG) EE Core Elective	3.0	(UG) Free Elective	3.0
				(UG) General Education Elective**	3.0	Science Elective	3.0
				(GR) Foundation Course	3.0	Any BIO, CHEM or PHYS course	
						(GR) Systems Course	3.0
	3		**0**		**20**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE Elective†	3.0
(GR) Technical Focus Course	3.0	(GR) Technical Focus Course	3.0	MATH 221	3.0	(UG) Free Electives	6.0
				(UG) ECE Elective†	3.0	(UG) General Education Elective**	3.0
				(UG) Free Elective	3.0	(GR) Core Cognition & Behavior Course	3.0
				(GR) Core Perception Course	3.0	(GR) Transformational Elective	3.0
				(GR) Foundation Course	3.0		
	3		**3**		**18**		**18**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ECE 491***	3.0	ECE 492***	3.0	ECE 493***	3.0
(UG) ECE 400+ Elective††	3.0	(UG) ECE 400+ Elective††	3.0	(UG) ECE 400+ Elective††	3.0
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0
(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0
(GR) Core Action Course	3.0	(GR) Thesis or alternative	3.0	(GR) Technical Focus Course	3.0
(GR) Core Control Course	3.0	(GR) Transformational Elective	3.0	(GR) Thesis or alternative	3.0
	18		**18**		**18**

Total Credits 226.5

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

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

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

** 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 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).

Electrical Engineering BSEE / Telecommunications Engineering MSEET

Major: Electrical Engineering and Telecommunications Engineering
Degree Awarded: Bachelor of Science in Electrical Engineering (BSEE) and Master of Science in Telecommunications Engineering (MSEET)
Calendar Type: Quarter
Minimum Required Credits: 226.5
Co-op Options: Three Co-ops (Five years)
Classification of Instructional Programs (CIP) code: 14.1001
Standard Occupational Classification (SOC) code: 17-2071

***Note*: New students are no longer being accepted into this program.**

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

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, with a minimum grade of B in the following courses: ECE 105, ECE 200, ECE 201, ENGR 231, and ENGR 232.

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
ENGR 232	Dynamic Engineering Systems	3.0
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 221	Discrete Mathematics	3.0
MATH 291	Complex and Vector Analysis for Engineers	4.0
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Science Elective		3.0
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
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		
Telecommunications Engineering (500+ level ECET) Courses		6.0
Telecommunications Engineering Elective Courses ‡		15.0
General ECE Courses ‡‡		9.0
Graduate Electives §		15.0
Total Credits		**226.5**

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

** General Education 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).

‡ 500-level or higher courses from ECEC, ECEE, ECES, and ECET

‡‡ 500-level or higher courses from ECEC, ECEE, ECEP, ECES, ECET, and ECE

§ 500-level or higher courses from ECEC, ECEE, ECEP, ECES, ECET, ECE, AE, CHE, CIVE, CMGT, EGMT, ENGR, ENVE, ET, MATE, MEM, PROJ, PRMT, SYSE, BMES, MATH, PHYS, CHEM, BIO, OPR, and 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

5 year, 3 coop Co-Terminal

First Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 101	3.5	COOP 101*	1.0	CIVC 101 or ECE 200	1.0	VACATION	
ECE 101	1.0	ECE 200 or CIVC 101	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	3.0
				ENGR 231	3.0	PHIL 315	3.0
				MATH 291	4.0	PHYS 201	4.0
				(UG) Free Elective	3.0	(UG) Free Elective	3.0
	0		**0**		**20**		**19**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 301	4.0	ECE 361	4.0
(GR) Graduate Elective§	3.0			ECE 370	3.0	ECE 371	3.0
				ECES 301	4.0	ECE 380	3.0
				(UG) EE Core Elective***	3.0	(UG) Free Elective	3.0
				(UG) General Education Elective**	3.0	(UG) Science Elective	3.0
				(GR) Graduate Elective§	3.0	Any BIO, CHEM or PHYS course	
						(GR) General ECE Course‡‡	3.0
	3		**0**		**20**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ECE 303	3.0	(UG) ECE Elective†	3.0
(GR) Graduate Elective§	3.0	(GR) Graduate Elective§	3.0	MATH 221	3.0	(UG) Free Electives	6.0
				(UG) ECE Elective†	3.0	(UG) General Education Elective**	3.0
				(UG) Free Electives	3.0	(GR) ECET Course	3.0
				(GR) ECET Course	3.0	(GR) General ECE Course‡‡	3.0

				(GR) Telecommunications Elective‡	3.0		
	3		**3**		**18**		**18**
Fifth Year							
Fall	**Credits**	**Winter**	**Credits**	**Spring**	**Credits**		
ECE 491	3.0	ECE 492	3.0	ECE 493	3.0		
(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0	(UG) ECE 400-level Elective††	3.0		
(UG) Free Elective	3.0	(UG) Free Elective	3.0	(UG) Free Elective	3.0		
(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0		
(GR) Telecommunications Electives‡	6.0	(GR) Graduate Elective§	3.0	(GR) General ECE Course‡‡	3.0		
		(GR) Telecommunications Elective‡	3.0	(GR) Telecommunications Elective‡	3.0		
	18		**18**		**18**		

Total Credits 226.5

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

* Co-op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

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

** General Education Electives (p. 5)

*** Choose one of CS 260, CS 265, or ECE 350

† 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 or higher courses from ECEC, ECEE, ECES, and ECET

‡‡ 500-level or higher courses from ECEC, ECEE, ECEP, ECES, ECET, and ECE

§ 500-level or higher courses from ECEC, ECEE, ECEP, ECES, ECET, ECE, AE, CHE, CIVE, CMGT, EGMT, ENGR, ENVE, ET, MATE, MEM, PROJ, PRMT, SYSE, BMES, MATH, PHYS, CHEM, BIO, OPR, and CS

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)
Classification of Instructional Programs (CIP) code: 14.1401
Standard Occupational Classification (SOC) code: 17-2081

About the Program

The Environmental Engineering BS/MS program allows students to develop technical depth and breadth in their professional and related area, which enhances their professional productivity, whether in industry or as they proceed to the PhD. The undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies—a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

Additional Information

For more information, visit COE Special Programs (p. 5), 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
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	
ENGR 210	Introduction to Thermodynamics	3.0
ENGR 220	Fundamentals of Materials	4.0
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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
Environmental Engineering Requirements		
BIO 221	Microbiology	3.0
CAEE 202	Introduction to Civil, Architectural & Environmental Engineering	3.0
CAEE 203	System Balances and Design in CAEE	3.0
CAEE 212	Geologic Principles for Infrastructure & Environmental Engineering	4.0
CAEE 361	Statistical Analysis of Engineering Systems	3.0
CHE 211	Material and Energy Balances I	4.0
CHEM 230	Quantitative Analysis	4.0
CHEM 231 [WI]	Quantitative Analysis Laboratory	2.0
CHEM 241	Organic Chemistry I	4.0
CHEM 242	Organic Chemistry II	4.0
CIVE 240	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 [††]		**6.0**
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		**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 616	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 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 ‡‡		12.0
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.

†† Technical electives:

- 300+ level courses in MATH, PHYS, BIO, GEO, CHEM, CHEC, and ENVS (excluding MATH 310, MATH 311 and MATH 312)
- 300+ level CoE courses including MEM 202 and CIVE 250 (excluding MEM 361, ECE 361)

‡ 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 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

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	CAEE 203	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0				
CIVE 240	3.0	ENGR 210	3.0				

ENGR 220	4.0	ENVS 230	3.0				
PHYS 201	4.0	PHIL 315	3.0				
(UG) General Education Requirement	3.0						
	20		**15**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 212	4.0	CHEM 241	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 361	3.0	CIVE 330	4.0	(GR) Graduate Elective	3.0		
CHE 211	4.0	CIVE 431	3.0				
CIVE 320	3.0	ENVE 302	3.0				
ENVE 300	3.0	(GR) Graduate Policy Course	3.0				
(GR) Graduate Elective	3.0	(GR) Graduate Statistics Course	3.0				
	20		**20**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 230	4.0	ENVE 410	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CHEM 231	2.0	(UG) General Education Requirements**	9.0	(GR) Graduate Elective	3.0		
CHEM 242	4.0	ENVE 660	3.0				
CIVE 430	3.0	(GR) Graduate Elective	3.0				
ENVS 501 (Counts as ENVS 401)	3.0						
(GR) Graduate Life Science	3.0						
	19		**18**		**3**		**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
BIO 221	3.0	ENVE 421	3.0	ENVE 422	3.0
ENVE 460 or 465	3.0	ENVE 486	2.0	ENVE 435	3.0
ENVE 485	1.0	ENVE 492	3.0	ENVE 487	2.0
ENVE 491	3.0	(UG) Technical Elective	3.0	ENVE 493	3.0
(UG) Technical Elective	3.0	(GR) Graduate Electives	6.0	(UG) General Education Requirement**	3.0
(GR) Graduate Electives	6.0			(GR) Graduate Electives	6.0
	19		**17**		**20**

Total Credits 227.5

* Co-Op cycles may vary. Students are assigned a co-op cycle (fall/winter, spring/summer, summer-only) based on their co-op program (4-year, 5-year) and major.

** General Education Requirements (p. 5)

Civil, Architectural and Environmental Engineering Faculty

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Matthew Reichenbach, PhD *(University of Austin at Texas)*. Assistant Teaching Professor. Design and behavior of steel structures, bridge engineering, structural stability

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

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

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

Sharon Walker, PhD *(Yale University) Dean, College of Engineering*. Distinguished Professor. Water quality systems engineering

Michael Waring, PhD *(University of Texas at Austin) Department Head, Civil, Architectural, and Environmental Engineering*. 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)*. Professor. Architectural engineering; Building Energy Efficiency; Intelligent Building; Net-zero Building; and Indoor Air Quality.

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

Emeritus Faculty

A. Emin Aktan, PhD *(University of Illinois, Urbana-Champaign)*. Professor Emeritus. Health monitoring and management of large infrastructures with emphasis on health monitoring.

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

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

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

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

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

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

Environmental Engineering BSENE / Peace Engineering MS

Major: Environmental Engineering and Peace Engineering
Degree Awarded: Bachelor of Science in Environmental Engineering (BSENE) and Master of Science in Peace Engineering (MS)
Calendar Type: Quarter
Minimum Required Credits: 230.5
Co-op Options: Three Co-ops (Five years)
Classification of Instructional Programs (CIP) code: 14.1401
Standard Occupational Classification (SOC) code: 17-2081

About the Program

This program integrates peacebuilding into standard engineering curricula, expanding the role that engineers may play in addressing complex technical and sociopolitical challenges. It allows environmental engineering students to incorporate conflict sensitivity into their curriculum and gain skills and contextual knowledge necessary to consider the systems-level effects of environmental engineering projects on peace, social justice and equity.

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 3.0 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
General Education Requirements **		12.0
A Graduate Social Dimension course will count as 3.0 credits of General Education Requirements as shared coursework		
Engineering Core Courses		
BIO 141	Essential Biology	4.5
CAEE 361	Statistical Analysis of Engineering Systems	3.0
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 (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
ENGR 220	Fundamentals of Materials	4.0
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
CAEE 231	Linear Engineering Systems	3.0
or ENGR 231	Linear Engineering Systems	
CAEE 232	Dynamic Engineering Systems	3.0
or ENGR 232	Dynamic Engineering Systems	
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
Environmental Engineering Requirements		
BIO 221	Microbiology	3.0
CAEE 202	Introduction to Civil, Architectural & Environmental Engineering	3.0
CAEE 203	System Balances and Design in CAEE	3.0
CAEE 212	Geologic Principles for Infrastructure & Environmental Engineering	4.0
CHE 211	Material and Energy Balances I	4.0
CHEM 230	Quantitative Analysis	4.0
CHEM 231 [WI]	Quantitative Analysis Laboratory	2.0
CHEM 241	Organic Chemistry I	4.0
CHEM 242	Organic Chemistry II	4.0
CIVE 240	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 ‡‡		**6.0**
ENVE 727 and ENVE 750 count as 6.0 credits of Technical Electives as shared coursework		
Master's Degree Courses		
Core Peacebuilding Requirements		
PENG 501	Peace Engineering Seminar - Fall	1.0
PENG 502	Peace Engineering Seminar - Winter	1.0
PENG 503	Peace Engineering Seminar - Spring	1.0
PENG 545	Introduction to Peacebuilding for Engineers	3.0
PENG 550	Conflict Management for Engineers	3.0

PENG 560	Peacebuilding Skills	3.0
Core Engineering Requirements		
ENVE 727	Risk Assessment	3.0
PROJ 501	Introduction to Project Management	3.0
SYSE 540	Systems Engineering for Peacebuilding	3.0
Research Methods		
CAEE 501	Community-Based Design	3.0
ENVE 750	Data-based Engineering Modeling	3.0
SCTS 502	Research Methods	3.0
Experiential Learning		
PENG 600	Peace Engineering Experiential Learning	6.0
Social Dimensions of Conflict Electives †		**6.0**
Technical Focus Sequences ††		**6.0**
Total Credits		**230.5-244.5**

* 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). Please note that the total number of required General Education credits of 12 is different from the required 15 credits in BS Environmental Engineering program, since these 3 credits are shared with the MS Peace Engineering program.

*** 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.

‡‡ Any 300-499 level courses from AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ENVE, ENVS, MATE, MATH, MEM, PHYS, or SE. CIVE 250 is also allowed. The following courses duplicate content in required courses and will not be accepted: MATH 310, MATH 311, MATH 410, ECE 361, BMES 310, MEM 361, and CHE 350.

† **Social Dimensions of Conflict Electives**
Students must complete a minimum of six credits, at the graduate level, from the following approved courses.

- **Science, Technology and Society electives:** SCTS 501, SCTS 570, SCTS 571, SCTS 615, SCTS 620, SCTS 641, SCTS 645,
- **Politics electives:** PSCI 510, PSCI 553, ENVP 552
- **Education electives**: EDGI 550, EDGI 533, EDGI 536

†† **Technical Focus Sequences**
Students must complete one sequence of at least 2 courses (6 credits) from the following approved sequences.

- **Systems Analysis**: SYSE 688, SYSE 690, EGMT 660
- **Software Development**: CS 502, SE 575, SE 576
- **Machine Learning and AI**: CS 510, CS 613, CS 610
- **Information Security**: INFO 517, INFO 712, INFO 710
- **Database Management**: INFO 605, INFO 606, INFO 607
- **Information Retrieval**: INFO 605, INFO 624, INFO 633
- **Data Mining**: INFO 605, INFO 634, INFO 633
- **Web and Mobile Development**: INFO 552, INFO 655
- **Game Design**: DIGM 505, DIGM 506
- **Serious gaming**: DIGM 530, DIGM 531
- **Interactivity:** DIGM 520, DIGM 521
- **WASH:** CIVE 564, CIVE 567, CIVE 561
- **Power Systems and Distribution:** ECEP 501, ECEP 502, ECEP 601

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

5 year, 3 coop Co-Terminal

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 202	3.0	CAEE 203	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CAEE 231 or ENGR 231	3.0	CAEE 232 or ENGR 232	3.0				
CAEE 361	3.0	ENGR 210	3.0				
CIVE 240	3.0	ENVS 230	3.0				
ENGR 220	4.0	PHIL 315	3.0				
PHYS 201	4.0						
	20		**15**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CAEE 212	4.0	BIO 221	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
CHE 211	4.0	CHEM 241	4.0	PENG 560	3.0		
CIVE 320	3.0	CIVE 330	4.0				
ENVE 300	3.0	CIVE 431	3.0				
PENG 545	3.0	ENVE 302	3.0				
(GR) Social Dimension elective	3.0	PENG 550	3.0				
	20		**20**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 230	4.0	CHEM 231	2.0	COOP EXPERIENCE		COOP EXPERIENCE	
CHEM 242	4.0	ENVE 410	3.0	PENG 600	3.0	PENG 600	3.0
CIVE 430	3.0	(UG) General Education elective**	3.0				
ENVS 401	3.0	(UG) Technical Elective***	3.0				
ENVE 750 (counts as UG Technical elective)	3.0	ENVE 727 (counts as UG Technical elective)	3.0				
PROJ 501	3.0	(GR) Technical Focus Course	3.0				
	20		**17**		**3**		**3**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
ENVE 465 or 460	3.0	ENVE 421	3.0	ENVE 422	3.0
ENVE 485	1.0	ENVE 486	2.0	ENVE 435	3.0
ENVE 491	3.0	ENVE 492	3.0	ENVE 487	2.0
(UG) General Education elective**	3.0	(UG) General Education elective**	3.0	ENVE 493	3.0
(UG) Technical Elective***	3.0	PENG 502	1.0	(UG) General Education elective**	3.0
PENG 501	1.0	SCTS 502	3.0	CAEE 501	3.0

SYSE 540	3.0	(GR) Social Dimension elective (counts as UG General Education Elective)	3.0	PENG 503	1.0
(GR) Technical Focus Course	3.0				
	20		**18**		**18**

Total Credits 230.5

* 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)

*** Any 300-499 level courses from AE, BIO, BMES, CHE, CHEM, CIVE, CS, ECE, ENVE, ENVS, MATE, MATH, MEM, PHYS, or SE. CIVE 250 is also allowed. The following courses duplicate content in required courses and will not be accepted: MATH 310, MATH 311, MATH 410, ECE 361, BMES 310, MEM 361, and CHE 350.

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)
Classification of Instructional Programs (CIP) code: 14.1801
Standard Occupational Classification (SOC) code: 17-2131

About the Program

The Materials Science and Engineering BS/MS program allows students to develop both technical depth and breadth in their professional and related areas, which enhances their professional productivity, whether in industry or as they proceed to a PhD program. Their undergraduate courses provide the necessary technical pre-requisite understanding and skills for graduate studies, a natural progression. Because the technical concepts of engineering are common, an MS in a related discipline is readily achieved.

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 Design and Manufacturing	
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
ENGR 220	Fundamentals of Materials	4.0
ENGR 231	Linear Engineering Systems	3.0
ENGR 232	Dynamic Engineering Systems	3.0
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
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.

** General Education Electives (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, 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

**** 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.

† 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

5 year, 3 coop: Non-thesis option

First Year				
Fall	**Credits Winter**	**Credits Spring**	**Credits Summer**	**Credits**
CHEM 101§	3.5 CHEM 102	4.5 COOP 101*	1.0 VACATION	
ENGL 101 or 111	3.0 CIVC 101	1.0 ENGL 102 or 112	3.0	

ENGR 111	3.0	ENGR 131 or 132	3.0	ENGR 113	3.0		
MATH 121[§§]	4.0	MATH 122	4.0	MATH 200	4.0		
UNIV E101	1.0	PHYS 101[§§]	4.0	PHYS 102	4.0		
(UG) General Education Elective[**]	3.0			(UG) General Education Elective[**]	3.0		
	17.5		**16.5**		**18**		**0**

Second Year

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

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
MATE 214	4.0	MATE 245	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
MATE 240	4.0	MATE 280	4.0	(GR) Technical Elective (TE)[‡]	3.0	(GR) Technical Elective (TE)[‡]	3.0
MATE 355	3.0	MATE 315	4.5				
MATE 370	3.0	(UG) Societal Impact Elective (GE)[¶]	4.0				
(UG) Business Elective (GE)[****]	4.0	(GR) MATE Selected Core Course	3.0				
	18		**19.5**		**3**		**3**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEC 353	4.0	MATE 345	4.5	COOP EXPERIENCE		COOP EXPERIENCE	
MATE 366	4.5	MATE 351	4.0	MATE 897 (or (GR) MATE Technical Elective)	3.0	MATE 897 (or (GR) Technical Elective (TE))	3.0
MATE 455	3.0	MATE 375	3.0				
(UG) Free Elective	3.0	PHIL 315	3.0				
(GR) Technical Elective (TE)[‡]	3.0	MATE 510	3.0				
	17.5		**17.5**		**3**		**3**

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	(UG) General Education Elective[**]	3.0	(UG) General Education Elective[**]	3.0
(GR) MATE Selected Core Course	3.0	MATE 512	3.0	(UG) Track Elective	3.0
(GR) MATE Technical Elective (counts as (UG) Track Elective)[***]	3.0	(GR) MATE Technical Elective (counts as (UG) Track Elective)[***]	3.0	(GR) MATE Selected Core Course	3.0
(GR) Technical Elective (TE)[‡]	3.0	(GR) MATE Selected Core Course	3.0	(GR) Technical Elective (TE)[‡]	3.0
	18		**18**		**18**

Total Credits 225.5

* 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.

** General Education 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, 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

**** 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 advisor.

† Students pursuing the non-thesis option must complete the undergraduate senior design sequence, in lieu of MATE 898 [WI] (MS Thesis).

‡ 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

5 year, 3 coop: Thesis option

First Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEM 101	3.5	CHEM 102	4.5	COOP 101*	1.0	VACATION	
ENGL 101 or 111	3.0	CIVC 101	1.0	ENGL 102 or 112	3.0		
ENGR 111	3.0	ENGR 131 or 132	3.0	ENGR 113	3.0		
MATH 121	4.0	MATH 122	4.0	MATH 200	4.0		
UNIV E101	1.0	PHYS 101	4.0	PHYS 102	4.0		
(UG) General Education Elective**	3.0			(UG) General Education Elective**	3.0		
	17.5		**16.5**		**18**		**0**

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
BIO 107	3.0	CHEM 241	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
BIO 108	1.0	ENGL 103	3.0				
ENGR 220	4.0	ENGR 210	3.0				
ENGR 231	3.0	ENGR 232	3.0				
PHYS 201	4.0	MATE 230	4.0				
(UG) Free Elective	3.0						
	18		**17**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
MATE 214	4.0	MATE 245	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
MATE 240	4.0	MATE 280	4.0	(GR) Technical Elective (TE)‡	3.0	(GR) Technical Elective (TE)‡	3.0
MATE 355	3.0	MATE 315	4.5				
MATE 370	3.0	(UG) Societal Impact Elective (GE)¶	4.0				
(UG) Business Elective (GE)****	4.0	(GR) MATE Selected Core Course	3.0				
	18		**19.5**		**3**		**3**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
CHEC 353	4.0	MATE 345	4.5	COOP EXPERIENCE		COOP EXPERIENCE	
MATE 366	4.5	MATE 351	4.0	MATE 897	3.0	MATE 897	3.0
MATE 455	3.0	MATE 375	3.0				
(UG) Free Elective	3.0	PHIL 315	3.0				
(GR) Technical Elective (TE)‡	3.0	MATE 510	3.0				
	17.5		**17.5**		**3**		**3**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CHE 350	3.0	MATE 475	3.0	MATE 410	3.0
MATE 460	4.0	(UG) General Education Elective**	3.0	(UG) General Education Elective**	3.0
(UG) MSE Elective†	2.0	(UG) MSE Elective†	3.0	(UG) MSE Elective†	3.0

MATE 898†	3.0 MATE 512	3.0 (UG) Track Elective	3.0
(GR) MATE Selected Core Course	3.0 MATE 898†	3.0 MATE 898†	3.0
(GR) MATE Technical Elective (counts as (UG) Track Elective)***	3.0 (GR) MATE Technical Elective (counts as (UG) Track Elective)***	3.0 (GR) MATE Selected Core Course	3.0
	18	**18**	**18**

Total Credits 225.5

* 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.

** General Education 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, 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

**** 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.

† 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

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; a hot isostatic press (HIP) for materials consolidation and synthesis; laser scattering particle size analyzer; creep testers, Ar-filled glove-box, high-speed saw, and assorted high temperature furnaces; metallographic preparation facilities; high temperature closed-loop servo-hydraulic testing machines.

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, chemical vapor deposition, sublimation growth, and resistive thermal evaporation. Variable-temperature high-vacuum probe station and optical cryostats including high magnetic field, fixed and tunable-wavelength laser sources, several monochromators for luminescence and Raman scattering spectroscopy, scanning electron microscopy with electron beam lithography, and a scanning probe microscope.

Nanomaterials Laboratory
This laboratory contains instrumentation for synthesizing, testing and manipulation of nanomaterials carbon and two dimensional carbides under microscope, high-temperature autoclaves, Sievert's apparatus; glove-boxes; high-temperature vacuum and other furnaces for the synthesis of nano-carbon coatings and nanotubes; tube furnaces for synthesis of carbides and nitrides; potentiostat/galvanostat for electrochemical testings; ultraviolet-visible (UV-VIS) spectrophotometry; Raman spectrometers; Differential scanning calorimeter (DSC) and thermogravimetric analyzer (TGA) up to 1500 °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
This laboratory contains gas cabinets and CVD furnaces for the synthesis of inorganic and hybrid materials for energy and environmental applications, including photocatalytic mixed anion materials, oxides and nitrides.

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 – 400K, up to 9 T fields; 2 tube furnaces.

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

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

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

X-ray Tomography Laboratory
This laboratory contains a high resolution X-ray micro-tomography instrument and a cluster of computers for 3D microstructure reconstruction; mechanical stage, a positioning stage and a cryostage for *in-situ* testing.

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 (TEM) 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.

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

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

Yong-Jie Hu, PhD *(Penn State University)*. Assistant Professor. Computational design and evaluation of mechanical, thermodynamic, and electronic properties using first-principles calculations, molecular dynamic simulations, the CALPHAD approach, multiscale modeling, and machine learning approaches.

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

Christopher Y. Li, PhD *(University of Akron) Graduate Advisor*. 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)*. Professor Emerita. Orthopedic biomaterials; acellular regenerative medicine, biomimetic proteoglycans; hydrogels.

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

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

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

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

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

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

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

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

Emeritus Faculty

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

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

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

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

Mechanical Engineering & Mechanics 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: 225.5
Co-op Options: Three Co-ops (Five years)
BS Classification of Instructional Programs (CIP) code: 14.1901
BS Standard Occupational Classification (SOC) code: 17-2141
MS Classification of Instructional Programs (CIP) code: 14.1401
MS Standard Occupational Classification (SOC) code: 17-2081

About the Program

This 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. Students' 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.

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
COOP 101	Career Management and Professional Development *	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
or ENGL 111	English Composition I	
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
or ENGL 112	English Composition II	
ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
or ENGL 113	English Composition III	
HIST 285	Technology in Historical Perspective	4.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	1.0
General Education Requirements **		**12.0**
Mathematics Requirements ***		**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/Biology Requirements †		**3.5-7.5**
BIO 141	Essential Biology	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 Design Requirements		
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
Engineering Requirements		
ENGR 210	Introduction to Thermodynamics	3.0
Engineering Economics Requirements		
CIVE 240	Engineering Economic Analysis	3.0

Materials Requirements		
ENGR 220	Fundamentals of Materials	4.0
Mechanical Requirements		
MEM 201	Foundations of Computer Aided Design	3.0
MEM 202	Statics	3.0
MEM 220	Fluid Mechanics I	4.0
MEM 230	Mechanics of Materials I	4.0
MEM 238	Dynamics	4.0
MEM 255	Introduction to Controls	4.0
MEM 310	Thermodynamic Analysis I	4.0
MEM 311	Thermal Fluid Science Laboratory	2.0
MEM 331	Experimental Mechanics I	2.0
MEM 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 361	Engineering Reliability	3.0
MEM 435	Introduction to Computer-Aided Design and Manufacturing	4.0
MEM 491 [WI]	Senior Design Project I	3.0
MEM 492 [WI]	Senior Design Project II	3.0
MEM 493 [WI]	Senior Design Project III	3.0
MEM Fundamental Courses: Select four of the following:		**12.0**
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 410	Thermodynamic Analysis II	
MEM 417	Introduction to Microfabrication	
MEM 423	Mechanics of Vibration	
MEM 431	Machine Design I	
MEM 437	Manufacturing Process I	
MEM 440	Thermal Systems Design	
MEM 458	Micro-Based Control Systems I	
MEM 459	Control Applications of DSP Microprocessors	
MEM Open Electives (Any two MEM courses 300 level or higher)		6.0
COE Electives (Any 2 College of Engineering courses, including MEM courses, 300 level or higher.)		
Two Graduate Electives count as 6.0 credits in UG COE Electives as shared coursework		
Math/Science Electives (300+ level MATH, PHYS, BIO, CHEM, CHEC, and ENVS)		3.0
Graduate Elective counts as 3.0 credits of UG Math/Science Electives as shared coursework		
Free Electives		6.0
Electives or Optional Concentration [††]		
Aerospace Concentration		
Select five courses (15.0 credits) from the list below:		
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 373	Space Systems Engineering I	
MEM 374	Space Systems Engineering II	
MEM 403	Gas Turbines & Jet Propulsion	
MEM 405	Principles of Combustion I	
MEM 406	Principles of Combustion II	
MEM 420	Aerodynamics	
MEM 423	Mechanics of Vibration	
MEM 425	Aircraft Design & Performance	
MEM 426	Aerospace Structures	
MEM 427	Finite Element Methods	
MEM 428	Introduction to Composites I	
MEM 429	Introduction to Composites II	
MEM 451	Orbital Mechanics	
MEM 453	Aircraft Flight Dynamics & Control I	
MEM 454	Aircarft Flight Dynamics & Control II	
MEM 455	Introduction to Robotics	
MEM 459	Control Applications of DSP Microprocessors	
Energy Concentration		
Select five courses (15.0 credits) from the list below:		

AE 430	Control Systems for HVAC	
CHE 431	Fundamentals of Solar Cells	
ECEP 354	Energy Management Principles	
ECEP 371	Introduction to Nuclear Engineering	
ECEP 380	Introduction to Renewable Energy	
ECEP 402	Theory of Nuclear Reactors	
ECEP 403	Nuclear Power Plant Design & Operation	
ECEP 406	Introduction to Radiation Health Principles	
ECEP 411	Power Systems I	
ECEP 422	Power Distribution Automation and Control	
ECEP 480	Solar Energy Engineering	
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 371	Introduction to Nuclear Engineering I	
MEM 400	Internal Combustion Engines	
MEM 402	Power Plant Design	
MEM 403	Gas Turbines & Jet Propulsion	
MEM 405 & MEM 406	Principles of Combustion I and Principles of Combustion II	
MEM 410	Thermodynamic Analysis II	
MEM 413 & MEM 414	HVAC Loads and HVAC Equipment	
MEM 415	Fuel Cell Engines	
MEM 445	Solar Energy Fundamentals	
MEM 446 & MEM 447	Fundamentals of Plasmas I and Fundamentals of Plasmas II	
MEM 448	Applications of Thermal Plasmas	
MEM 449	Applications of Non-Thermal Plasmas	
Master's Degree Requirements		
Graduate Core Courses		
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 616	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 below) †††		**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	
EOH 510	Principles and Practice of Environmental and Occupational Health	
ENVE 727	Risk Assessment	
Water Resources		
CIVE 564	Sustainable Water Resource Engineering	
CIVE 565	Urban Ecohydraulics	
ENVE 571	Environmental Life Cycle Assessment	
CIVE 664	Open Channel Hydraulics ‡	
or ENVE 681	Analytical and Numerical Techniques in Hydrology	

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 (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	Principles and Practice of Environmental and Occupational Health	
ENVE 560	Fundamentals of Air Pollution Control	
Cognate Discipline Track ‡‡		**12.0**
CIVE 898 (MS Thesis) or Graduate Electives		9.0-6.0
Total Credits		**225.5-240.5**

* 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.

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

††† 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

5 year, 3 coop Co-Terminal

First Year				
Fall	**Credits Winter**	**Credits Spring**	**Credits Summer**	**Credits**
CHEM 101	3.5 CHEM 102	4.5 BIO 141	4.5 VACATION	
ENGL 101 or 111	3.0 COOP 101*	1.0 CIVC 101	1.0	
ENGR 111	3.0 ENGL 102 or 112	3.0 ENGL 103 or 113	3.0	
MATH 121	4.0 ENGR 131 or 132	3.0 ENGR 113	3.0	
UNIV E101	1.0 MATH 122	4.0 MATH 200	4.0	
	PHYS 101	4.0 PHYS 102	4.0	
	14.5	**19.5**	**19.5**	**0**
Second Year				
Fall	**Credits Winter**	**Credits Spring**	**Credits Summer**	**Credits**
ENGR 220	4.0 CIVE 240	3.0 COOP EXPERIENCE	COOP EXPERIENCE	

MATH 201	4.0	ENGR 210	3.0				
MEM 202	3.0	MATH 210	4.0				
PHYS 201	4.0	MEM 201	3.0				
(UG) Free Elective	3.0	MEM 238	4.0				
		(UG) General Education Elective	3.0				
	18		**20**	**0**			**0**

Third Year

Fall	**Credits**	**Winter**	**Credits**	**Spring**	**Credits**	**Summer**	**Credits**
HIST 285	4.0	MEM 220	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
MEM 230	4.0	MEM 255	4.0	(GR) Elective	3.0		
MEM 310	4.0	MEM 331	2.0				
ENVS 501	3.0	MEM 333	3.0				
(GR) Elective	3.0	(GR) Elective	3.0				
	18		**16**		**3**		**0**

Fourth Year

Fall	**Credits**	**Winter**	**Credits**	**Spring**	**Credits**	**Summer**	**Credits**
MEM 311	2.0	MEM 351	2.0	COOP EXPERIENCE		COOP EXPERIENCE	
MEM 345	4.0	MEM 361	3.0	(GR) Elective	3.0		
MEM 355	4.0	PHIL 315	3.0				
MEM 435	4.0	(UG) MEM Fundamental Electives	6.0				
(UG) General Education Elective	3.0	ENVE 660 (counts as UG COE Elective)	3.0				
(GR) Core	3.0	(GR) Core	3.0				
	20		**20**		**3**		**0**

Fifth Year

Fall	**Credits**	**Winter**	**Credits**	**Spring**	**Credits**
MEM 491	3.0	MEM 492	3.0	MEM 493	3.0
(UG) MEM Fundamental Electives	6.0	(UG) General Education Elective	3.0	(UG) Free Elective	3.0
CIVE 898 (or Graduate Elective)	3.0	(UG) MATH/SCI Elective	3.0	(UG) General Education Elective	3.0
(GR) Elective (counts as UG COE Elective)	3.0	(UG) MEM Open Elective	3.0	(UG) MEM Open Elective	3.0
(GR) Life Science Course (counts as UG MATH/SCI Elective)	3.0	CIVE 898 (or Graduate Elective)	3.0	CIVE 898 (or Graduate Elective)	3.0
		(GR) Elective	3.0	(GR) Elective	3.0
	18		**18**		**18**

Total Credits 225.5

* 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.

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: 225.5
Co-op Options: Three Co-ops (Five years)
Classification of Instructional Programs (CIP) code: 14.1901
Standard Occupational Classification (SOC) code: 17-2141

About the Program

The BSME/MSME program allows students to develop technical depth and breadth in their professional and related area which enhances their professional productivity, whether in industry or as they proceed to the PhD. Their undergraduate courses provide the necessary technical prerequisite understanding and skills for the graduate studies—a natural progression. Because the technical concepts of engineering are common, the MS in a related discipline is readily achieved.

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 3.5 cumulative GPA in the following seven courses (or their equivalent): *Introduction to Thermodynamics* (ENGR 210), *Fundamentals of Materials* (ENGR 220), *Linear Algebra* (MATH 201), *Differential Equations* (MATH 210), *Foundations of Computer Aided Design* (MEM 201), *Statics* (MEM 202), and *Dynamics* (MEM 238).

Degree Requirements

General Education/Liberal Studies Requirements		
CIVC 101	Introduction to Civic Engagement	1.0
COOP 101	Career Management and Professional Development *	1.0
ENGL 101	Composition and Rhetoric I: Inquiry and Exploratory Research	3.0
or ENGL 111	English Composition I	
ENGL 102	Composition and Rhetoric II: Advanced Research and Evidence-Based Writing	3.0
or ENGL 112	English Composition II	
ENGL 103	Composition and Rhetoric III: Themes and Genres	3.0
or ENGL 113	English Composition III	
HIST 285	Technology in Historical Perspective	4.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	1.0
General Education Requirements **		12.0
Mathematics Requirements		
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 201	Linear Algebra	4.0
MATH 210	Differential Equations	4.0
Physics Requirements		
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Chemistry/Biology Requirements		
BIO 141	Essential Biology	4.5
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
Engineering Design Requirements		
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
Engineering Requirements		
ENGR 210	Introduction to Thermodynamics	3.0
Engineering Economics Requirements		
CIVE 240	Engineering Economic Analysis	3.0
Materials Requirements		
ENGR 220	Fundamentals of Materials	4.0
Mechanical Requirements		
MEM 201	Foundations of Computer Aided Design	3.0
MEM 202	Statics	3.0
MEM 220	Fluid Mechanics I	4.0
MEM 230	Mechanics of Materials I	4.0
MEM 238	Dynamics	4.0
MEM 255	Introduction to Controls	4.0
MEM 310	Thermodynamic Analysis I	4.0
MEM 311	Thermal Fluid Science Laboratory	2.0
MEM 331	Experimental Mechanics I	2.0
MEM 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 361	Engineering Reliability	3.0
MEM 435	Introduction to Computer-Aided Design and Manufacturing	4.0
MEM 491 [WI]	Senior Design Project I ***	3.0
MEM 492 [WI]	Senior Design Project II ***	3.0
MEM 493 [WI]	Senior Design Project III ***	3.0
MEM Fundamental Courses. Select four of the following:		12.0
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 410	Thermodynamic Analysis II	
MEM 417	Introduction to Microfabrication	
MEM 423	Mechanics of Vibration	
MEM 431	Machine Design I	
MEM 437	Manufacturing Process I	
MEM 440	Thermal Systems Design	
MEM 458	Micro-Based Control Systems I	
MEM 459	Control Applications of DSP Microprocessors	
MEM Open Electives (Any two MEM courses 300 level or higher.)		6.0
COE Electives (Any 2 College of Engineering courses, including MEM courses, 300 level or higher.)		
Two Graduate Electives count as 6.0 credits of COE Electives as shared coursework		
Math/Science Electives (300+ level MATH, PHYS, BIO, CHEM, CHEC, and ENVS.)		3.0
Graduate Elective counts as 3.0 credits of Math/Science Electives as shared coursework		
Free Electives		6.0
Electives or Optional Concentration †		
Aerospace Concentration		
Select five courses from the list below:		
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 373	Space Systems Engineering I	
MEM 374	Space Systems Engineering II	
MEM 403	Gas Turbines & Jet Propulsion	
MEM 405	Principles of Combustion I	
MEM 406	Principles of Combustion II	
MEM 420	Aerodynamics	
MEM 423	Mechanics of Vibration	
MEM 425	Aircraft Design & Performance	
MEM 426	Aerospace Structures	
MEM 427	Finite Element Methods	
MEM 428	Introduction to Composites I	
MEM 429	Introduction to Composites II	
MEM 451	Orbital Mechanics	
MEM 453	Aircraft Flight Dynamics & Control I	
MEM 454	Aircarft Flight Dynamics & Control II	
MEM 455	Introduction to Robotics	
MEM 459	Control Applications of DSP Microprocessors	
Energy Concentration		
Select five courses from the list below:		
AE 430	Control Systems for HVAC	
CHE 431	Fundamentals of Solar Cells	
ECEP 354	Energy Management Principles	
ECEP 371	Introduction to Nuclear Engineering	
ECEP 380	Introduction to Renewable Energy	
ECEP 402	Theory of Nuclear Reactors	
ECEP 403	Nuclear Power Plant Design & Operation	
ECEP 406	Introduction to Radiation Health Principles	
ECEP 411	Power Systems I	
ECEP 422	Power Distribution Automation and Control	
ECEP 480	Solar Energy Engineering	
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 371	Introduction to Nuclear Engineering I	
MEM 400	Internal Combustion Engines	

MEM 402	Power Plant Design	
MEM 403	Gas Turbines & Jet Propulsion	
MEM 405 & MEM 406	Principles of Combustion I and Principles of Combustion II	
MEM 410	Thermodynamic Analysis II	
MEM 413 & MEM 414	HVAC Loads and HVAC Equipment	
MEM 415	Fuel Cell Engines	
MEM 445	Solar Energy Fundamentals	
MEM 446 & MEM 447	Fundamentals of Plasmas I and Fundamentals of Plasmas II	
MEM 448	Applications of Thermal Plasmas	
MEM 449	Applications of Non-Thermal Plasmas	
Master's Degree Requirements		
Graduate Core Courses		**12.0**
Select 2 courses in each of 2 Core Areas:		
Core Area: Mechanics		
Subject Area: Solid Mechanics		
MEM 660	Theory of Elasticity I	
MEM 663	Continuum Mechanics	
Subject Area: Advanced Dynamics		
MEM 666	Advanced Dynamics I	
MEM 667	Advanced Dynamics II	
Core Area: Thermal & Fluid Sciences		
Subject Area: Advanced Thermodynamics ††		
MEM 601	Statistical Thermodynamics I	
MEM 602	Statistical Thermodynamics II	
Subject Area: Heat Transfer		
MEM 611	Conduction Heat Transfer	
MEM 612	Convection Heat Transfer	
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	
Subject Area: Real-Time Microcomputer Control		
MEM 639	Real Time Microcomputer Control I	
MEM 640	Real Time Microcomputer Control II	
Graduate Math Courses		
MEM 591	Applied Engr Analy Methods I	3.0
MEM 592	Applied Engr Analy Methods II	3.0
MEM 593	Applied Engr Analy Methods III	3.0
Graduate Electives ‡		24.0
Total Credits		**225.5**

* 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)

*** 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.

† Students may choose to do a concentration in either Aerospace or Energy. Concentrations consist of 15.0 concentration credits and do not add additional credits to the program.

†† Consult the Thermal and Fluid Sciences area advisor for other options.

‡ **Graduate Electives**

- Students can take all 8 electives from MEM graduate courses.
- Any MEM graduate course is eligible to serve as electives. This includes those core courses that you do not use as core 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 8 elective technical courses from MEM, they may take a maximum of 4 non-MEM courses.
- Each non-MEM course to be used as technical elective needs be approved by listing it on the Plan of Study (GR-1 form) and the Graduate Advisor signing the form to approve it.
- To ensure you will receive the MSME degree, please consult with the Graduate Advisor before taking non-MEM graduate courses.
- Graduate courses at the 60- 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.

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

5 year, 3 coop Co-Terminal

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ENGR 220	4.0	ENGR 210	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
MATH 201	4.0	MATH 210	4.0				
MEM 202	3.0	MEM 201	3.0				
PHYS 201	4.0	MEM 238	4.0				
(UG) General Education Elective**	3.0	(UG) General Education Elective**	4.0				
	18		**18**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
MEM 230	4.0	MEM 220	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
MEM 310	4.0	MEM 255	4.0				
PHIL 315	3.0	MEM 331	2.0				
(UG) General Education Elective**	3.0	MEM 333	3.0				
(GR) Graduate Core Course	3.0	(GR) Graduate Core Course	3.0				

(GR) Graduate Elective (counts as UG COE Elective)†	3.0	(GR) Graduate Elective (counts as UG COE Elective)†	3.0				
	20		**19**		**0**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
MEM 311	2.0	MEM 351	2.0	COOP EXPERIENCE		COOP EXPERIENCE	
MEM 345	4.0	MEM 361	3.0				
MEM 355	4.0	(UG) MEM Fundamental Electives	6.0				
MEM 435	4.0	(UG) General Education Elective**	3.0				
(GR) Graduate Core Course	3.0	(GR) Graduate Core Course	3.0				
(GR) Graduate Elective†	3.0	(GR) Graduate Elective	3.0				
	20		**20**		**0**		**0**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CIVE 240	3.0	MEM 492***	3.0	HIST 285	4.0
MEM 491***	3.0	(UG) Free Elective	3.0	MEM 493***	3.0
(UG) Math/Science Elective	3.0	(UG) General Education Elective**	2.0	(UG) MEM Open Elective	3.0
(UG) MEM Fundamental Elective	3.0	(UG) MEM Fundamental Elective	3.0	MEM 593	3.0
MEM 591	3.0	(UG) MEM Open Elective	3.0	(GR) Graduate Elective†	3.0
(GR) Graduate Elective†	3.0	MEM 592	3.0	(GR) Graduate Elective (counts as UG Math/ Science Elective)	3.0
		(GR) Graduate Elective†	3.0		
	18		**20**		**19**

Total Credits 225.5

* 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 Requirements (p. 5)

*** If a student chooses to pursue a graduate thesis in place of senior design, they will need to replace the eight (8.0) undergraduate credits from MEM 491 [WI] , MEM 492 [WI] , MEM 493 [WI] with eight (8.0) credits from 400+ level MEM courses.

† **Graduate Electives:**

- Students can take all 8 electives from MEM graduate courses.
- Any MEM graduate course is eligible to serve as electives. This includes those core courses that you do not use as core 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 8 elective technical courses from MEM, they may take a maximum of 4 non-MEM courses.
- Each non-MEM course to be used as technical elective needs be approved by listing it on the Plan of Study (GR-1 form) and the Graduate Advisor signing the form to approve it.
- To ensure you will receive the MSME degree, please consult with the Graduate Advisor before taking non-MEM graduate courses.
- Graduate courses 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.

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: 228.5
Co-op Options: Three Co-ops (Five years)
BS Classification of Instructional Programs (CIP) code: 14.1901
BS Standard Occupational Classification (SOC) code: 17-2141
MS Classification of Instructional Programs (CIP) code: 14.1801
MS Standard Occupational Classification (SOC) code: 17-2131

About the Program

Drexel's Department of Mechanical Engineering and Mechanics (MEM) prides itself on providing its undergraduate students with a comprehensive program of courses, laboratories, design projects, and co-op experiences. The 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).

The graduate program in Materials Science & Engineering aims to provide an education which encompasses the most recent knowledge base in the materials science and engineering fields in a format suitable for individuals seeking careers in academia and/or industry.

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 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	
HIST 285	Technology in Historical Perspective	4.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	1.0
General Education Requirements **		12.0
Mathematics Requirements		
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 201	Linear Algebra	4.0
MATH 210	Differential Equations	4.0
Physics Requirements		
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Chemistry/Biology Requirements		
BIO 141	Essential Biology	4.5
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
Engineering Design Requirements		
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
Engineering Requirements		
ENGR 210	Introduction to Thermodynamics	3.0
Engineering Economics Requirements		
CIVE 240	Engineering Economic Analysis	3.0
Materials Requirements		
ENGR 220	Fundamentals of Materials	4.0

Mechanical Requirements		
MEM 201	Foundations of Computer Aided Design	3.0
MEM 202	Statics	3.0
MEM 220	Fluid Mechanics I	4.0
MEM 230	Mechanics of Materials I	4.0
MEM 238	Dynamics	4.0
MEM 255	Introduction to Controls	4.0
MEM 310	Thermodynamic Analysis I	4.0
MEM 311	Thermal Fluid Science Laboratory	2.0
MEM 331	Experimental Mechanics I	2.0
MEM 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 361	Engineering Reliability	3.0
MEM 435	Introduction to Computer-Aided Design and Manufacturing	4.0
MEM 491 [WI]	Senior Design Project I ***	3.0
MEM 492 [WI]	Senior Design Project II ***	3.0
MEM 493 [WI]	Senior Design Project III ***	3.0
MEM Fundamental Courses. Select four of the following:		12.0
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 410	Thermodynamic Analysis II	
MEM 417	Introduction to Microfabrication	
MEM 423	Mechanics of Vibration	
MEM 431	Machine Design I	
MEM 437	Manufacturing Process I	
MEM 440	Thermal Systems Design	
MEM 458	Micro-Based Control Systems I	
MEM 459	Control Applications of DSP Microprocessors	
MEM Open Electives (Any two MEM courses 300 level or higher.)		6.0
COE Electives (Any 2 College of Engineering courses, including MEM courses, 300 level or higher.)		
MATE 510 and MATE 512 count as 6.0 credits of COE Electives as shared coursework		
Math/Science Electives (300+ level MATH, PHYS, BIO, CHEM, CHEC, and ENVS.)		6.0
Free Electives		6.0
Electives or Optional Concentration †		
Aerospace Concentration		
Select five courses (15.0 credits) from the list below:		
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 373	Space Systems Engineering I	
MEM 374	Space Systems Engineering II	
MEM 403	Gas Turbines & Jet Propulsion	
MEM 405	Principles of Combustion I	
MEM 406	Principles of Combustion II	
MEM 420	Aerodynamics	
MEM 423	Mechanics of Vibration	
MEM 425	Aircraft Design & Performance	
MEM 426	Aerospace Structures	
MEM 427	Finite Element Methods	
MEM 428	Introduction to Composites I	
MEM 429	Introduction to Composites II	
MEM 451	Orbital Mechanics	
MEM 453	Aircraft Flight Dynamics & Control I	
MEM 454	Aircarft Flight Dynamics & Control II	
MEM 455	Introduction to Robotics	
MEM 459	Control Applications of DSP Microprocessors	
Energy Concentration		
Select five courses (15.0 credits) from the list below:		
AE 430	Control Systems for HVAC	
CHE 431	Fundamentals of Solar Cells	
ECEP 354	Energy Management Principles	

ECEP 371	Introduction to Nuclear Engineering	
ECEP 380	Introduction to Renewable Energy	
ECEP 402	Theory of Nuclear Reactors	
ECEP 403	Nuclear Power Plant Design & Operation	
ECEP 406	Introduction to Radiation Health Principles	
ECEP 411	Power Systems I	
ECEP 422	Power Distribution Automation and Control	
ECEP 480	Solar Energy Engineering	
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 371	Introduction to Nuclear Engineering I	
MEM 400	Internal Combustion Engines	
MEM 402	Power Plant Design	
MEM 403	Gas Turbines & Jet Propulsion	
MEM 405 & MEM 406	Principles of Combustion I and Principles of Combustion II	
MEM 410	Thermodynamic Analysis II	
MEM 413 & MEM 414	HVAC Loads and HVAC Equipment	
MEM 415	Fuel Cell Engines	
MEM 445	Solar Energy Fundamentals	
MEM 446 & MEM 447	Fundamentals of Plasmas I and Fundamentals of Plasmas II	
MEM 448	Applications of Thermal Plasmas	
MEM 449	Applications of Non-Thermal Plasmas	
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		**228.5**

* 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).

*** 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.

† Students may choose to do a concentration in either Aerospace or Energy. Concentrations consist of 15.0 concentration credits, and do not add additional credits to the program.

†† 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 (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

5 year, 3 coop Co-Terminal

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
ENGR 220	4.0	ENGR 210	3.0	COOP EXPERIENCE		COOP EXPERIENCE	
MATH 201	4.0	MATH 210	4.0				
MEM 202	3.0	MEM 201	3.0				
PHYS 201	4.0	MEM 238	4.0				
(UG) General Education Elective[**]	3.0	(UG) General Education Elective[**]	4.0				
	18		**18**		**0**		**0**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
MEM 230	4.0	MEM 220	4.0	COOP EXPERIENCE		COOP EXPERIENCE	
MEM 310	4.0	MEM 255	4.0	(GR) Graduate MATE Technical Elective[***]	3.0		
PHIL 315	3.0	MEM 331	2.0				
(UG) General Education Elective[**]	3.0	MEM 333	3.0				
(GR) Graduate Technical Elective[***]	3.0	(GR) Graduate MATE Tech Elective[***]	3.0				
		(GR) Graduate SC Core Course	3.0				
	17		**19**		**3**		**0**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
MEM 311	2.0	MEM 351	2.0	COOP EXPERIENCE		COOP EXPERIENCE	
MEM 345	4.0	MEM 361	3.0	(GR) Graduate Tech Elective[***]	3.0	(GR) Graduate Tech Elective[***]	3.0
MEM 355	4.0	(UG) MEM Fundamental Courses	6.0				
MEM 435	4.0	(UG) Free Elective	3.0				
(GR) Graduate MATE Tech Elective[***]	3.0	MATE 510 (counts as UG COE Elective)	3.0				
(GR) Graduate SC Core Course	3.0	(GR) Graduate SC Core Course	3.0				
	20		**20**		**3**		**3**

Fifth Year					
Fall	**Credits**	**Winter**	**Credits**	**Spring**	**Credits**
CIVE 240	3.0	MEM 492	3.0	HIST 285	4.0
MEM 491	3.0	(UG) General Education Elective**	2.0	MEM 493	3.0
(UG) Math/Science Elective	3.0	(UG) Math/Science elective	3.0	(UG) Free Elective	3.0
(UG) MEM Fundamental Course	3.0	(UG) MEM Open Elective	3.0	(UG) MEM Open Elective	3.0
MATE 898 (or (GR) Tech Elective)	3.0	(UG) MEM Fundamental Course	3.0	MATE 898 (GR) Tech Elective	3.0
(GR) Graduate SC Core Course	3.0	MATE 512 (counts as UG COE Elective)	3.0		
		MATE 898 (or (GR) Tech Elective)	3.0		
	18		**20**		**16**

Total Credits 228.5

* 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 Electives (p. 5)

*** 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 (Art of Being a Scientist).

Mechanical Engineering BSME / Peace Engineering MS

Major: Mechanical Engineering and Peace Engineering
Degree Awarded: Bachelor of Science in Mechanical Engineering (BSME) and Master of Science in Peace Engineering (MS)
Calendar Type: Quarter
Minimum Required Credits: 231.5
Co-op Options: Three Co-ops (Five years)
BS Classification of Instructional Programs (CIP) code: 14.1901
BS Standard Occupational Classification (SOC) code: 17-2141
MS Classification of Instructional Programs (CIP) code: 14.1401
MS Standard Occupational Classification (SOC) code: 17-2081

About the Program

This program integrates peacebuilding into standard engineering curricula, expanding the role that engineers may play in addressing complex technical and sociopolitical challenges. It allows Mechanical Engineering undergraduate students to incorporate conflict sensitivity into their curriculum and gain skills and contextual knowledge necessary to consider the systems-level effects of mechanical engineering projects and designs on peace, social justice, and equity.

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 3.0 and a 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	
HIST 285	Technology in Historical Perspective	4.0
PHIL 315	Engineering Ethics	3.0
UNIV E101	The Drexel Experience	1.0
General Education Requirements [**]		12.0
Mathematics Requirements		
MATH 121	Calculus I	4.0
MATH 122	Calculus II	4.0
MATH 200	Multivariate Calculus	4.0
MATH 201	Linear Algebra	4.0
MATH 210	Differential Equations	4.0
Physics Requirements		
PHYS 101	Fundamentals of Physics I	4.0
PHYS 102	Fundamentals of Physics II	4.0
PHYS 201	Fundamentals of Physics III	4.0
Chemistry/Biology Requirements		
BIO 141	Essential Biology	4.5
CHEM 101	General Chemistry I	3.5
CHEM 102	General Chemistry II	4.5
Engineering Design Requirements		
ENGR 111	Introduction to Engineering Design & Data Analysis	3.0
ENGR 113	First-Year Engineering Design	3.0
ENGR 131	Introductory Programming for Engineers	3.0
or ENGR 132	Programming for Engineers	
Engineering Requirements		
ENGR 210	Introduction to Thermodynamics	3.0
Engineering Economics Requirements		
CIVE 240	Engineering Economic Analysis	3.0
Materials Requirements		
ENGR 220	Fundamentals of Materials	4.0
Mechanical Requirements		
MEM 201	Foundations of Computer Aided Design	3.0
MEM 202	Statics	3.0
MEM 220	Fluid Mechanics I	4.0
MEM 230	Mechanics of Materials I	4.0
MEM 238	Dynamics	4.0
MEM 255	Introduction to Controls	4.0
MEM 310	Thermodynamic Analysis I	4.0
MEM 311	Thermal Fluid Science Laboratory	2.0
MEM 331	Experimental Mechanics I	2.0
MEM 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 361	Engineering Reliability	3.0
MEM 435	Introduction to Computer-Aided Design and Manufacturing	4.0
MEM 491 [WI]	Senior Design Project I [***]	3.0
MEM 492 [WI]	Senior Design Project II [***]	3.0
MEM 493 [WI]	Senior Design Project III [***]	3.0
MEM Fundamental Courses. Select four of the following:		12.0
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 410	Thermodynamic Analysis II	
MEM 417	Introduction to Microfabrication	
MEM 423	Mechanics of Vibration	
MEM 431	Machine Design I	
MEM 437	Manufacturing Process I	
MEM 440	Thermal Systems Design	

MEM 458	Micro-Based Control Systems I	
MEM 459	Control Applications of DSP Microprocessors	
MEM Open Electives (Any two MEM courses 300 level or higher.)		6.0
COE Electives (Any 2 College of Engineering courses, including MEM courses, 300 level or higher)		
ENVE 750 and SYSE 540 count as 6.0 credits of COE Electives as shared coursework		
Math/Science Electives (300+ level MATH, PHYS, BIO, CHEM, CHEC, and ENVS.)		6.0
Free Electives		6.0
Electives or Optional Concentration †		
Aerospace Concentration		
Select five courses from the list below:		
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 373	Space Systems Engineering I	
MEM 374	Space Systems Engineering II	
MEM 403	Gas Turbines & Jet Propulsion	
MEM 405	Principles of Combustion I	
MEM 406	Principles of Combustion II	
MEM 420	Aerodynamics	
MEM 423	Mechanics of Vibration	
MEM 425	Aircraft Design & Performance	
MEM 426	Aerospace Structures	
MEM 427	Finite Element Methods	
MEM 428	Introduction to Composites I	
MEM 429	Introduction to Composites II	
MEM 451	Orbital Mechanics	
MEM 453	Aircraft Flight Dynamics & Control I	
MEM 454	Aircarft Flight Dynamics & Control II	
MEM 455	Introduction to Robotics	
MEM 459	Control Applications of DSP Microprocessors	
Energy Concentration		
Select five courses from the list below:		
AE 430	Control Systems for HVAC	
CHE 431	Fundamentals of Solar Cells	
ECEP 354	Energy Management Principles	
ECEP 371	Introduction to Nuclear Engineering	
ECEP 380	Introduction to Renewable Energy	
ECEP 402	Theory of Nuclear Reactors	
ECEP 403	Nuclear Power Plant Design & Operation	
ECEP 406	Introduction to Radiation Health Principles	
ECEP 411	Power Systems I	
ECEP 422	Power Distribution Automation and Control	
ECEP 480	Solar Energy Engineering	
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 371	Introduction to Nuclear Engineering I	
MEM 400	Internal Combustion Engines	
MEM 402	Power Plant Design	
MEM 403	Gas Turbines & Jet Propulsion	
MEM 405 & MEM 406	Principles of Combustion I and Principles of Combustion II	
MEM 410	Thermodynamic Analysis II	
MEM 413 & MEM 414	HVAC Loads and HVAC Equipment	
MEM 415	Fuel Cell Engines	
MEM 445	Solar Energy Fundamentals	
MEM 446 & MEM 447	Fundamentals of Plasmas I and Fundamentals of Plasmas II	
MEM 448	Applications of Thermal Plasmas	
MEM 449	Applications of Non-Thermal Plasmas	
Master's Degree Requirements		
Core Peacebuilding Requirements		**12.0**
PENG 501	Peace Engineering Seminar - Fall	

PENG 502	Peace Engineering Seminar - Winter	
PENG 503	Peace Engineering Seminar - Spring	
PENG 545	Introduction to Peacebuilding for Engineers	
PENG 550	Conflict Management for Engineers	
PENG 560	Peacebuilding Skills	
Core Engineering Requirements		**9.0**
ENVE 727	Risk Assessment	
PROJ 501	Introduction to Project Management	
SYSE 540	Systems Engineering for Peacebuilding	
Research Methods		**9.0**
CAEE 501	Community-Based Design	
ENVE 750	Data-based Engineering Modeling	
SCTS 502	Research Methods	
Experiential Learning		**6.0**
PENG 600	Peace Engineering Experiential Learning	
Social Dimensions of Conflict Electives ††		**6.0**
Technical Focus Sequences ‡		**6.0**
Total Credits		**231.5**

* 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)

*** 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.

† Students may choose to do a concentration in either Aerospace or Energy. Concentrations consist of 15.0 concentration credits and do not add additional credits to the program.

†† **Social Dimensions of Conflict Electives**
Students must complete a minimum of 6.0 credits, at the graduate level, from the following approved courses.
- **Science, Technology and Society electives:** SCTS 501, SCTS 570, SCTS 571, SCTS 615, SCTS 620, SCTS 641, SCTS 645
- **Politics electives:** ENVP 552, PSCI 510, PSCI 553
- **Education electives**: EDGI 533, EDGI 536, EDGI 550

‡ **Technical Focus Sequences**
Students must complete one sequence of at least 2 courses (6.0 credits) from the following approved sequences.
- **Systems Analysis**: SYSE 688, SYSE 690, EGMT 660
- **Software Development**: CS 502, CS 575, CS 576
- **Machine Learning and AI**: CS 510, CS 613, CS 610
- **Information Security**: INFO 517, INFO 712, INFO 710
- **Database Management**: INFO 605, INFO 606, INFO 607
- **Information Retrieval**: INFO 605, INFO 624, INFO 633
- **Data Mining**: INFO 605, INFO 634, INFO 633
- **Web and Mobile Development**: INFO 552, INFO 655
- **Game Design**: DIGM 505, DIGM 506
- **Serious gaming**: DIGM 530, DIGM 531
- **Interactivity:** DIGM 520, DIGM 521
- **WASH:** CIVE 564, CIVE 567, CIVE 561
- **Power Systems and Distribution:** ECEP 501, ECEP 502, ECEP 601

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

5 year, 3 coop Co-Terminal

First Year

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

Second Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		ENGR 220	4.0	ENGR 210	3.0
				MATH 201	4.0	MATH 210	4.0
				MEM 202	3.0	MEM 201	3.0
				PHYS 201	4.0	MEM 238	4.0
				(UG) General Education Requirement**	3.0	(UG) Free Elective	3.0
						(UG) General Education Requirement**	3.0
	0		**0**		**18**		**20**

Third Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		HIST 285	4.0	MEM 220	4.0
(GR) Social Dimensions Elective†	3.0			MEM 230	4.0	MEM 255	4.0
				MEM 310	4.0	MEM 331	2.0
				PENG 545	3.0	MEM 333	3.0
				PHIL 315	3.0	PENG 550	3.0
						(GR) Social Dimensions Elective†	3.0
	3		**0**		**18**		**19**

Fourth Year

Fall	Credits	Winter	Credits	Spring	Credits	Summer	Credits
COOP EXPERIENCE		COOP EXPERIENCE		MEM 311	2.0	MEM 351	2.0
PENG 600	3.0	PENG 600	3.0	MEM 345	4.0	MEM 361	3.0
				MEM 355	4.0	(UG) MEM Fundamental Electives	6.0
				MEM 435	4.0	(GR) Technical Focus Courses††	6.0
				PROJ 501	3.0		
				SYSE 540 (counts as UG COE Elective)	3.0		
	3		**3**		**20**		**17**

Fifth Year

Fall	Credits	Winter	Credits	Spring	Credits
CIVE 240	3.0	MEM 492***	3.0	MEM 493***	3.0
MEM 491***	3.0	(UG) Math/Science Elective	3.0	(UG) Free Elective	3.0
(UG) General Education Requirement**	3.0	(UG) MEM Elective	3.0	(UG) General Education Requirement**	3.0
(UG) Math/Science Elective	3.0	(UG) MEM Fundamental Elective	3.0	(UG) MEM Elective	3.0

(UG) MEM Fundamental Elective	3.0 ENVE 727	3.0 CAEE 501	3.0
ENVE 750 (counts as UG COE Elective)	3.0 PENG 502	1.0 PENG 503	1.0
PENG 501	1.0 SCTS 502	3.0 PENG 560	3.0
	19	**19**	**19**

Total Credits 231.5

* 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)

*** 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.

† **Social Dimensions of Conflict Electives**

Students must complete a minimum of 6.0 credits, at the graduate level, from the following approved courses.

- **Science, Technology and Society electives:** SCTS 501, SCTS 570, SCTS 571, SCTS 615, SCTS 620, SCTS 641, SCTS 645
- **Politics electives:** ENVP 552, PSCI 510, PSCI 553
- **Education electives**: EDGI 533, EDGI 536, EDGI 550

†† **Technical Focus Sequences**

Students must complete one sequence of at least 2 courses (6.0 credits) from the following approved sequences.

- **Systems Analysis**: SYSE 688, SYSE 690, EGMT 660
- **Software Development**: CS 502, CS 575, CS 576
- **Machine Learning and AI**: CS 510, CS 613, CS 610
- **Information Security**: INFO 517, INFO 712, INFO 710
- **Database Management**: INFO 605, INFO 606, INFO 607
- **Information Retrieval**: INFO 605, INFO 624, INFO 633
- **Data Mining**: INFO 605, INFO 634, INFO 633
- **Web and Mobile Development**: INFO 552, INFO 655
- **Game Design**: DIGM 505, DIGM 506
- **Serious gaming**: DIGM 530, DIGM 531
- **Interactivity:** DIGM 520, DIGM 521
- **WASH:** CIVE 564, CIVE 567, CIVE 561
- **Power Systems and Distribution:** ECEP 501, ECEP 502, ECEP 601

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 CHE	
CHE T480	Special Topics in CHE	
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)

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, architectural engineering, architecture, and business may select to pursue Construction Management as a minor area of study. Because construction is inherently related to design in these disciplines, the Construction Management minor can be a natural extension of each field of study.

The requirements for the minor include:

- Completion of a minimum of 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, view the College of Engineering's Construction Management (https://drexel.edu/engineering/academics/departments/engineering-leadership-society/academic-programs/construction-management/) web page or contact:

William Grogan
Email: wtg25@drexel.edu
Phone: 215.895.5943

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: Students must choose one of the following elective tracks. Substitutions may be made in any of these tracks with prior approval from the Department.		**12.0**
Management Track		
BLAW 201	Business Law I	
CIVE 240	Engineering Economic Analysis	
EGMT 465	Introduction to Systems Engineering	
PROJ 401	Introduction to Project Management	
Entrepreneurship Track		
ENTP 210 [WI]	Leading Start-Ups *	
ENTP 215	Building Entrepreneurial Teams *	
ENTP 329	Entrepreneurship & New Technologies *	
ENTP 370	Global Entrepreneurship *	
ENTP 385	Innovation in Established Companies *	
Leadership Track		
ORGB 300 [WI]	Organizational Behavior	
ORGB 400	Team Development and Leadership	
ORGB 420	Negotiations and Conflict Resolution	
PROJ 403	Essentials of Project Leadership and Teamwork	
Technology Track		
MGMT 201	Introduction to Technology Innovation Management	
MGMT 301	Designing Innovative Organizations	
MGMT 302	Competing in Technology Industries	
MGMT 364	Technology Management	
SYSE 488	Systems Engineering Analysis	
Optional (these courses may be substituted for any of the above elective options)		
EGMT 295	Survey of Mentorship	
EGMT 296	Survey of Leadership	
Total Credits		**24.0**

* ENTP 101 is a prerequisite for all ENTP courses, but it will not count towards the Minor in Engineering Leadership.

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	4.0
EGMT 404 [WI]	Introduction to Engineering Management Communications	3.0
EGMT 462	Introduction to Engineering Management	3.0
or MEM 462	Introduction to Engineering Management	
EGMT 465	Introduction to Systems Engineering	3.0
Complete 2 classes from the list below		**7.0**
ECON 201	Principles of Microeconomics	
ECON 202	Principles of Macroeconomics	
ENTP 329	Entrepreneurship & New Technologies	
Other courses accepted with Director approval		
Total Credits		**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.

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, 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 EGMT	
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

This minor program aims to familiarize students with recent technological developments in renewable energy technologies and sustainability, as well as to conduct experimental work in these areas.

Students will explore the principles, characteristics, and operation of various renewable energy sources, storage devices, and energy conversion systems. In addition, this minor is designed to encourage students to enhance their knowledge of the fields of sustainability and green energy technologies so they may be able to expand their skills and career opportunities.

The Minor in Green Energy and Sustainability has a broad audience, created to give students both breadth and depth in this field with focus on technologies and their societal, economic, and environmental impact with emphasis on the manufacturing industry.

Program Requirements

ECEP 480	Solar Energy Engineering	3.0
EET 201	Circuit Analysis I	4.0
EET 202	Circuit Analysis II	4.0
EET 320	Renewable Energy Systems	3.0
EET 322	Energy Conversion	4.0
INDE 240	Technology Economics	3.0
INDE 420	Industrial Energy Systems	3.0
Total Credits		**24.0**

Additional Information

For more information on the Green Energy and Sustainability minor, please contact Gerry Willis at gtm23@drexel.edu or 215.895.6253.

Minor in Materials Science and Engineering

About the Minor

In addition to the core engineering curriculum and the courses required for majors in chemical, civil, architectural and environmental, electrical, or mechanical engineering, engineering students from other majors can complete a minor in Materials Science and Engineering (MSE) by completing 25.0 credits from the courses listed below.

Program Requirements

Required Courses		
MATE 230	Fundamentals of Materials II	4.0
Select six (at least 21.0 credits) of the following:		21.0
MATE 214	Introduction to Polymers *	
MATE 240	Thermodynamics of Materials	
MATE 245	Kinetics of Materials	
MATE 280	Advanced Materials Laboratory	
MATE 341	Defects in Solids	
MATE 351	Electronic and Photonic Properties of Materials	
MATE 355	Structure and Characterization of Crystalline Materials	
MATE 370	Mechanical Behavior of Solids **	
MATE 455	Biomedical Materials	
Total Credits		**25.0**

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

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

Note: Only one of the pre-requisites (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 pre-requisite 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 pre-requisite 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 pre-requisites since some may be included in the list above and some may be from other departments. Courses taken outside of the MSE department as pre-requisites do not count towards the 25.0 credits required for the minor. They may, however, be used as technical or free electives in students' home departments. Students pursuing the minor in Materials Science and Engineering are also encouraged to select a Senior Design topic that relates to the field of materials.

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; a hot isostatic press (HIP) for materials consolidation and synthesis; laser scattering particle size analyzer; creep testers, Ar-filled glove-box, high-speed saw, and assorted high temperature furnaces; metallographic preparation facilities; high temperature closed-loop servo-hydraulic testing machines.

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, chemical vapor deposition, sublimation growth, and resistive thermal evaporation. Variable-temperature high-vacuum probe station and optical cryostats including high magnetic field, fixed and tunable-wavelength laser sources, several monochromators for luminescence and Raman scattering spectroscopy, scanning electron microscopy with electron beam lithography, and a scanning probe microscope.

Nanomaterials Laboratory
This laboratory contains instrumentation for synthesizing, testing and manipulation of nanomaterials carbon and two dimensional carbides under microscope, high-temperature autoclaves, Sievert's apparatus; glove-boxes; high-temperature vacuum and other furnaces for the synthesis of nano-carbon coatings and nanotubes; tube furnaces for synthesis of carbides and nitrides; potentiostat/galvanostat for electrochemical testings; ultraviolet-visible (UV-VIS) spectrophotometry; Raman spectrometers; Differential scanning calorimeter (DSC) and thermogravimetric analyzer (TGA) up to 1500 °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
This laboratory contains gas cabinets and CVD furnaces for the synthesis of inorganic and hybrid materials for energy and environmental applications, including photocatalytic mixed anion materials, oxides and nitrides.

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 – 400K, up to 9 T fields; 2 tube furnaces.

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

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

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

X-ray Tomography Laboratory
This laboratory contains a high resolution X-ray micro-tomography instrument and a cluster of computers for 3D microstructure reconstruction; mechanical stage, a positioning stage and a cryostage for *in-situ* testing.

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 (TEM) 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.

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 Design and Manufacturing	
Select three of the following:		8.0
Laboratories		
MEM 311	Thermal Fluid Science Laboratory	
MEM 331	Experimental Mechanics I	
MEM 351	Dynamic Systems Laboratory I	
Recommended Electives		
MEM 320	Fluid Dynamics I	
MEM 330	Mechanics of Materials II	
MEM 361	Engineering Reliability	
MEM 410	Thermodynamic Analysis II	
MEM 420	Aerodynamics	
MEM 423	Mechanics of Vibration	
MEM 425	Aircraft Design & Performance	
MEM 430	Advanced Stress Analysis	
MEM 437	Manufacturing Process I	
MEM 438	Manufacturing Process II	
MEM 440	Thermal Systems Design	
MEM 453	Aircraft Flight Dynamics & Control I	
MEM 455	Introduction to Robotics	
MEM 458	Micro-Based Control Systems I	
MEM 459	Control Applications of DSP Microprocessors	
MEM 462 [WI]	Introduction to Engineering Management	
Total Credits		**24.0**

Writing-Intensive Course Requirements

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

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (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 Robotics and Automation

About the Minor

Robotics and Automation Engineering has evolved around several engineering and technology fields such as electrical, mechanical, and electro-mechanical, as well as electronics engineering. It merges the fundamental principles of electrical hardware and sensor usage with pneumatics, hydraulics, computer programming and instrumentation science, and related applications.

The Minor in Robotics and Automation (ROBT) introduces students to mechatronics engineering and prepares them for automation-related careers in process control, manufacturing, computerized hardware/software integration, and sustainable automated systems. It allows students to engage in real-life, industrial processes related to automation in an industrial robotics laboratory setting.

Program Requirements

EET 201	Circuit Analysis I	4.0
EET 205	Digital Electronics	4.0
EET 319	PLC Fundamentals	4.0
INDE 350	Industrial Engineering Simulation	3.0
MET 205	Robotics and Mechatronics	3.0
MET 209	Fluid Power	4.0
MET 310	Advanced Robotics and Mechatronics	3.0
Total Credits		**25.0**

Additional Information

For more information on the Robotics and Automation minor, please contact Gerry Willis at gtm23@drexel.edu or 215-895-6253.

Minor in Systems Engineering

About the Minor

Systems engineering is a set of processes and tools used to guide the engineering of large scale systems. Unlike traditional engineering which may focus on very specific technical components, systems engineers focus on the entirety of a system to ensure it is run efficiently and effectively. The minor will prepare undergraduate students for the current demands of industry and provide them with the opportunity to achieve a formal education in systems engineering.

The Minor in Systems Engineering is designed for students in the College of Engineering and School of Biomedical Engineering who are interested in the management of large, complex systems. It leads to careers in a wide range of industries, such as aerospace, communications, healthcare, manufacturing, and transportation.

The opportunity to pursue a minor in systems engineering will be offered to students who meet the following conditions:

- Minimum 3.0 cumulative GPA
- Upper level students (sophomores, juniors, pre-juniors, and seniors)
- Student in the College of Engineering or the School of Biomedical Engineering

Core Requirements		
CIVE 240	Engineering Economic Analysis	3.0
EGMT 462	Introduction to Engineering Management	3.0
or MEM 462	Introduction to Engineering Management	
EGMT 465	Introduction to Systems Engineering	3.0
INDE 362	Operations Research for Engineering I	3.0
SYSE 488	Systems Engineering Analysis	3.0
Complete 9 credits of courses from the following list		**9.0**
ECES 356	Theory of Control	
ECES 444	Systems and Control I	
INDE 350	Industrial Engineering Simulation	

INDE 365	Systems Analysis Methods I
INDE 366	Systems Analysis Methods II
MEM 355	Performance Enhancement of Dynamic Systems
SYSE 530	Systems Engineering Design
SYSE 531	Systems Architecture Development
SYSE 532	Software Systems Engineering
SYSE 533	Systems Integration and Test
Total Credits	**24.0**

Writing-Intensive Course Requirements

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

A "WI" next to a course in this catalog may indicate that this course can fulfill a writing-intensive requirement. For the most up-to-date list of writing-intensive courses being offered, students should check the Writing Intensive Course List (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 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 program from Drexel’s Construction Management program.

Developed at the request of two contractors' associations—the General Building Contractors Association and the Contractors Association of Eastern Pennsylvania—this certificate is suitable for those who have undergraduate degrees in other fields but wish to work in the construction industry, along with those who are already employed in the industry but seek career advancement or updated training.

The Construction Management Concepts certificate focuses on construction contracts, specifications, and practices with regard to business law and liability. The certificate also covers value engineering and construction planning, scheduling, and network systems, as well as the communications required for project control and claims prevention.

Admission Requirements

Successful completion of the Fundamentals of Construction Management certificate (p. 242) and the Construction Science certificate (p. 241).

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:

William Grogan
Email: wtg25@drexel.edu

Phone: 215.895.5943

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 program from Drexel’s Construction Management program.

Developed at the request of two contractors' associations—the General Building Contractors Association and the Contractors Association of Eastern Pennsylvania—this certificate is suitable for those who have undergraduate degrees in other fields but wish to work in the construction industry, along with those who are already employed in the industry but seek career advancement or updated training.

Admission Requirements

Successful completion of the Fundamentals of Construction Management certificate (p. 242).

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:

William Grogan
Email: wtg25@drexel.edu
Phone: 215.895.5943

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 program from Drexel's Construction Management program.

The undergraduate certificate in the Fundamentals of Construction Management is designed to fill the training needs of industry leaders.

Developed at the request of two contractors' associations—the General Building Contractors Association and the Contractors Association of Eastern Pennsylvania—this certificate is suitable for those who have undergraduate degrees in other fields but wish to work in the construction industry along with those who are already employed in the industry but seek career advancement or updated training.

Admission Requirements

High school diploma or GED

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:

William Grogan
Email: wtg25@drexel.edu
Phone: 215.895.5943

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