Environmental Engineers stand at the threshold between natural environmental systems and human societies!

Environmental engineers are the technical professionals who identify and design solutions for environmental problems. They seek to shield the environment from the harmful effects of human activity, protect human populations from adverse environmental events such as floods and disease, and restore environmental quality for ecological and human well-being. Traditionally, environmental engineers provided safe drinking water, treated and properly disposed of wastes, maintained air quality, controlled water pollution, and remediated sites contaminated by hazardous substances. They continue to do these activities as well as monitor the quality of the air, water, and land and develop new, improved environmental control technologies.

Although many people are concerned about the state of our environment, environmental engineers understand how complicated environmental systems work. They develop molecular tools to track contaminants at very low levels in complex mixtures and genomic tools to characterize microbial diversity in unknown communities. Environmental engineers are the vital link between scientific discovery, technological development and the societal need for protecting human health and ecological integrity. More and more the emphasis of their work is shifting from managing wastes after they are generated, to altering production processes so to recover, recycle and reuse resources.

Historically, it was the sanitary and civil engineer who made cities livable for large populations. A crucial future need is to find ways to make both developing and post-industrial cities sustainable. Environmental engineers will be critical members of manufacturing teams where the design and production of goods are developed in full consideration of their environmental impacts during production, use and at the end of their useful life. Environmental engineers are working to improve energy efficiency in infrastructure design, enhance the development of renewable energy and restore the full services of ecosystems so there is less reliance on technology.

The field of environmental engineering, as well as environmental engineering education, is highly interdisciplinary. They involve traditional components such as mathematics, physics, chemistry, and engineering design. But, environmental engineering education also includes a range of other disciplines, including biology, microbiology, ecology, public health, material science, geology, meteorology, economics, political science, and computer science. To address the spectrum of issues facing the environment, environmental engineers are broadly educated, as well as technically trained.

So, You Want to be an Environmental Engineer
Association of Environmental Engineering and Science Professors
Undergraduate Curriculum – Total requirement = 48 courses

### Mathematics - 4 courses
- MATH 220, 224, 230
- MATH 234

### Basic Sciences - 4 courses
- CHEM 101, 102, 103 or
- CHEM 171/172 (Equivalent to CHEM 101/102/103)
- PHYSICS 135-2 (Recommended to complete PHYS 135-3 as an unrestricted elective)

#### General: Chemistry, Inorganic Chemistry, Phys Chemistry
#### Accelerated General: Inorganic Chemistry, Phys Chemistry

### Engineering Analysis and Computer Proficiency - 4 courses
- GEN_ENG 205-1, 2, 3, 4

### Design and Communication - 3 course units
- IDEA 106-1,2 (0.5 units each) and
- English 106-1,2 (0.5 units each); and
- One course from the following (1.0 units each)
  - Speech 102 or Speech 103

### Basic Engineering - 5 courses in at least 4 areas
- Thermodynamics
- Fluids and Solids
- Probability, Statistics, and Quality Control
- Systems Engineering & Analysis
- Numerical Methods (ECE 328) or ES_APPM 346 or
- Materials Science Basic Engrg list

### Social Sciences -- Humanities - 7 courses (see catalog for requirements)

### Unrestricted Electives - 5 courses

### Environmental Engineering Core Program - 16 courses (Required Core -- 12 courses)
- ENVR_SCI 201
- ENVR_SCI 202
- ENVR_SCI 203
- CHEM 210-1
- CIV_ENG 260
- CIV_ENG 340
- CIV_ENG 361
- CIV_ENG 363
- CIV_ENG 364
- CIV_ENG 365
- CIV_ENG 367
- CIV_ENG 370 (Capstone Design)

### Technical Electives - 4 Total with 2 from Required*
- TE Required List -- CHEM 210-2
  - BIO_SCI 210-1,2
  - CHEM_ENG (CBE) 275
  - CIV_ENG 346
  - CIV_ENG 355
  - CIV_ENG 360
  - CIV_ENG 395, 20
  - CIV_ENG 395, 21
  - CIV_ENG 440
  - CIV_ENG 441
  - CIV ENG 442
  - CIV ENG 444

Other courses may be accepted by petition

*Any 200-level or higher course in Engineering or WCAS (math or sciences)

400-level requires instructor permission and permission number
## BSEE Program in Environmental Engineering — *EXAMPLE* — 4-Year Program

<table>
<thead>
<tr>
<th>Freshman</th>
<th>FALL</th>
<th>WINTER</th>
<th>SPRING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MATH 220-0 Calculus I</td>
<td>MATH 224-0 Calculus II</td>
<td>MATH 230-0 Calculus III</td>
</tr>
<tr>
<td></td>
<td>CHEM 101/171* General Chemistry</td>
<td>CHEM 102/172 General Inorganic Chemistry</td>
<td>CHEM 103 (or ENVR_SCI 201* if CHEM 171 &amp; CHEM 172 are taken)</td>
</tr>
<tr>
<td></td>
<td>GEN_ENG 205-1 Engineering Analysis 1</td>
<td>GEN_ENG 205-2 Engineering Analysis 2</td>
<td>GEN_ENG 205-3 Engineering Analysis 3</td>
</tr>
<tr>
<td></td>
<td>H/UE or Speech</td>
<td>IDEA 106-1 &amp; ENGL 106-1# Engineering Design and Communications 1</td>
<td>IDEA 106-2 &amp; ENGL 106-2 # Engineering Design and Communications 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(ENVR_SCI 201*) Earth: An Habitable Planet (if schedule permits)</td>
</tr>
<tr>
<td>Sophomore</td>
<td>MATH 234</td>
<td>PHYSICS 135-2 General Physics</td>
<td>MECH_ENG 241 Fluid Mechanics</td>
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<tr>
<td></td>
<td>GEN_ENG 205-4</td>
<td>ENVR_SCI 202 Health of the Biosphere</td>
<td>ENVR_SCI 201 H/UE</td>
</tr>
<tr>
<td></td>
<td>CHEM 210-1</td>
<td>Basic Engineering I or Elective</td>
<td>CIV_ENG 260 Fund of Env. Engrg</td>
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<tr>
<td></td>
<td>ENVR_SCI 203</td>
<td>H/UE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(Applied Statistics) H/UE Thermodynamics</td>
<td>CIV_ENG 361 Basic Engineering I or Elective</td>
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<tr>
<td></td>
<td>Basic Engrg II</td>
<td>CIV_ENG 364 Environmental Applications II: Water</td>
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<tr>
<td></td>
<td>(Applied Statistics) H/UE Thermodynamics</td>
<td>H/UE</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHEM 342-1</td>
<td>CIV_ENG 365 Environmental Laboratory</td>
<td>CIV_ENG 340 Fluid Mechanics II</td>
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<td>CIV_ENG 363</td>
<td>H/UE</td>
<td>H/UE</td>
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<tr>
<td></td>
<td>H/UE</td>
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<tr>
<td>Junior</td>
<td>Basic Engrg II</td>
<td>Basic Engineering I or Elective</td>
<td>Basic Engrg III or Elective or H/UE Technical Elective</td>
</tr>
<tr>
<td></td>
<td>CHEM 342-1</td>
<td>CIV_ENG 364 Environmental Applications II: Water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CIV_ENG 363</td>
<td>H/UE</td>
<td>CIV_ENG 340 Fluid Mechanics II</td>
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<td></td>
<td>H/UE</td>
<td></td>
<td>H/UE</td>
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<tr>
<td>Senior</td>
<td>CIV_ENG 367</td>
<td>CIV_ENG 365 Environmental Laboratory</td>
<td>CIV_ENG 370 Environ. Engrg Design</td>
</tr>
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<td></td>
<td>Technical Elective</td>
<td>Speech or Tech</td>
<td>Technical Elective</td>
</tr>
<tr>
<td></td>
<td>H/UE</td>
<td>H/UE</td>
<td>H/UE</td>
</tr>
</tbody>
</table>

*Completion of CHEM 171 is equivalent to completion of CHEM 101 and CHEM 102.  
Basic Engineering Elective I: ECE 328 or ES_APPM 346 or one course from MAT_SCI Basic Engineering List.  
Basic Engineering Elective II: One course from Probability, Statistics and Quality Control List (CIV_ENG 306 recommended, when offered).  
H/UE: either Humanities/Social Sciences/Communications (9 courses) or Unrestricted Elective (5 courses).  
Technical Elective: 2 courses from limited list and 2 courses (200-level or above) from Tech or CAS math /science. Must include at least 1.0 units of design unless ENGG 106-1,2 are taken.

# IDEA 106-1,2 and ENGL 106-1,2 are each an 0.5 unit course. They are taught concurrently and jointly by a faculty member from each department. Students must complete both quarters of both courses to receive credit for them.

P/N Policy in Environmental Engineering—A maximum of two (2) courses which can be chosen from any of the sixteen (16) in the departmental curriculum can be taken P/N. Go to [http://www.mccormick.northwestern.edu/undergraduate/pass_fail.php](http://www.mccormick.northwestern.edu/undergraduate/pass_fail.php) for full McCormick policy.
An Option to Combine Academics \textit{WITH} Real-World Experience: The Northwestern University CO-Op Program

At Northwestern University, The Walter P. Murphy Cooperative Engineering Education Program (CO-OP) is a 5-year educational program which gives undergraduate students in engineering an opportunity to alternate periods of academic study with periods of full-time paid work—a real-world experience related to their academic degree and their professional goals. A CO-OP student completes 12 academic quarters in addition to industry experience—the time grid below.

The CO-OP program is accredited by ABET, and some or all of your CO-OP experience may count toward the experience required to become a licensed professional engineer, depending upon the state in which you apply after graduation.

You will receive an engineering degree from one of the best universities in the country PLUS one and one half years of engineering experience in industry. Because of its national standing, McCormick School of Engineering and Applied Science attracts Fortune 500 companies, as well as the best and fastest growing mid-size and small companies in the country.

The Employer Evaluations, which are completed each quarter that you work, serve as documentation of how you performed in the workplace and can complement your academic transcript for future employers and graduate schools. The Program provides a campus coordinator to work with you in all aspects of your participation in the CO-OP Program.

You will be registered in a non-credit course so that your CO-OP experience becomes part of your academic history; you are continuously enrolled at Northwestern while you are working on a CO-OP assignment. Therefore, you can remain covered by your family's health insurance and automobile insurance at student rates. In addition, your student loans do not go into repayment. Your experience is documented for future professional licensing.

It is important to note that you do not pay tuition or fees during the quarters that you are on a CO-OP assignment and registered in the CO-OP course. The Tuition Rebate Program assures that you pay the same amount of tuition that you would have paid if you went straight through in four years.

See Example Schedule on next page.
<table>
<thead>
<tr>
<th>YEAR</th>
<th>FALL</th>
<th>WINTER</th>
<th>SPRING</th>
<th>SUMMER</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRESH 1</td>
<td>Quarter 1 Same as Example 4-year BSEE Program 1st year</td>
<td>Quarter 2 Same as Example 4-year BSEE Program 1st year</td>
<td>Quarter 3 Same as Example 4-year BSEE Program 1st year</td>
<td>VACATION</td>
</tr>
<tr>
<td>SOPH 2</td>
<td>Quarter 4 Same as Example 4-year BSEE Program 2nd year</td>
<td>Quarter 5 Same as Example 4-year BSEE Program 2nd year</td>
<td>Quarter 6 Same as Example 4-year BSEE Program 2nd year</td>
<td>CO-OP</td>
</tr>
<tr>
<td>PRE-SENIOR 9</td>
<td>Quarter 9 CEE 367 Aquatic Chemistry Technical Elective H/UE</td>
<td></td>
<td>Quarter 10 Basic Engrg III Technical Elective CEE Fluid Mechanics II H/UE</td>
<td>CO-OP</td>
</tr>
<tr>
<td>SENIOR 4</td>
<td>CO-OP</td>
<td>Quarter 11 CEE 365 Environmental Laboratory Speech or Technical Elective H/UE</td>
<td>Quarter 12 CEE 370 Environ Engrg Capstone Design Technical Elective H/UE</td>
<td>DONE !!!</td>
</tr>
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</table>

Basic Engineering Elective I. ECE 328 or ES_APPM 346 or one course from MAT_SCI Basic Engineering List.
Basic Engineering Elective II One course from Probability, Statistics and Quality Control List. (CIV_ENG 306 recommended, when offered.)
Basic Engineering Elective III CIV_ENG 304 Civil and Environmental Engrg Systems Analysis or IE 326 Economics and Finance for Engineers.

H/UE; either Humanities/Social Sciences/Communications (9 courses) or Unrestricted Elective (5 courses).

Technical Elective: 2 courses from restricted list and 2 courses (200-level or above) from Tech or CAS (math/science). Must include at least 1.0 units of design unless ENGG 106-1, 2 are taken.
BS-MS Program in Environmental Engineering

Imagine being able to earn a bachelor's and a master's degree in the next four years. If you are talented, highly motivated to do graduate-level work, and have earned the advanced-placement credit to complete your bachelor's degree requirements in less than four years, you don't have to imagine it. You can do it in the combined BS / MS program.

The combined BS / MS lets you work simultaneously on your undergraduate and graduate degrees. If you are interested in the combined BS / MS program, talk with your departmental advisor at the end of your sophomore year about eligibility. During your junior year of undergraduate study, you apply to the Graduate School, submitting an outline of the course work you intend to complete for the BS and MS. Your department advisor will help you select the courses necessary to fulfill both degree requirements. The Graduate School will then review your credentials and make its admission decision.

If you are not a U.S. citizen, you may have difficulty in moving from a bachelor's degree program to a master's degree program in this fashion. If you are interested in the combined BS / MS program, talk with your departmental advisor at the end of your sophomore year about eligibility.

http://www.mccormick.northwestern.edu/prospective/honorscombinedprograms.html#BSMS

### BS-MS Program in Environmental Engineering in detail by course and units.

<table>
<thead>
<tr>
<th>Units</th>
<th>MATHEMATICS</th>
<th>ENGINEERING ANALYSIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MATH 214-1</td>
<td>ENGG 205-1</td>
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<tr>
<td>2</td>
<td>214-2</td>
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<tr>
<td>3</td>
<td>214-3</td>
<td>205-3</td>
</tr>
<tr>
<td>4</td>
<td>215</td>
<td>205-4</td>
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</table>

<table>
<thead>
<tr>
<th>BASIC SCIENCES</th>
<th>DESIGN &amp; COMMUNICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>Chem 101</td>
</tr>
<tr>
<td>10</td>
<td>102/171</td>
</tr>
<tr>
<td>11</td>
<td>103/172</td>
</tr>
<tr>
<td>12</td>
<td>Physics 135-2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>BASIC ENGINEERING</th>
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</thead>
<tbody>
<tr>
<td>16</td>
</tr>
<tr>
<td>17</td>
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<tr>
<td>18</td>
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<tr>
<td>19</td>
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<tr>
<td>20</td>
</tr>
</tbody>
</table>

| SOCIAL SCIENCES & HUMANITIES (7 with distribution requirements) |
| UNRESTRICTED ELECTIVES (5) |
| ENVIRONMENTAL ENGINEERING BS CORE (12) |
| 21-27 | |
| 28-32 | |
| 33 | ENVR SCI 201 | Earth: An Habitable Planet |
### 34-48  TECHNICAL ELECTIVES (4 with 2 from Following List)
CHEM 210-2,3; BIO SCI 210-1,2,3; CHEM_ENG (CBE) 275; CIV ENG 395-20, 395-22, 440*, 441*, 442*, 444*, Remaining two from any 200-level or higher course in Engineering, Mathematics or Science

### MS PORTION of BS-MS PROGRAM (9)

#### Required Core Courses (4)

<table>
<thead>
<tr>
<th>#</th>
<th>CIV ENG</th>
<th>361</th>
<th>Environmental Microbiology and Public Health</th>
</tr>
</thead>
<tbody>
<tr>
<td>49</td>
<td>CIV ENG</td>
<td>440</td>
<td>Environmental Transport Processes</td>
</tr>
<tr>
<td>50</td>
<td>CIV ENG</td>
<td>444</td>
<td>Physical/Chemical Processes in Environmental Control</td>
</tr>
<tr>
<td>51</td>
<td>CIV ENG</td>
<td>448</td>
<td>Biophysicochemical Processes in Environmental systems</td>
</tr>
<tr>
<td>52</td>
<td>CIV ENG</td>
<td>449-1,2,2</td>
<td>Environmental Laboratory Experience</td>
</tr>
</tbody>
</table>

**# #**

| CIV ENG | 467 | Advanced Environmental Chemistry |

( **#** Omit from MS portion of program if taken in the BS portion. )

( **# #** Omit from MS portion of program if CIV ENG 367 is taken in the BS portion. )

#### Specialization (3)

53-55  Student-initiated three course thematic specialization in some aspect of environmental engineering and science

#### Electives (2)

56-57  Two graduate courses in any of the following subjects(three if BS is not in environmental or civil engineering)

- Environmental Engineering and Science
- Applied Mathematics
- Biochemistry, Microbiology, and Cell Biology
- Chemical and Biological Engineering
- Chemistry
- Civil Engineering
- Geological Sciences
- Mechanical Engineering
- Public Health
Undergraduate Course Descriptions

200s = Undergraduates; 300s = Undergraduates per Prerequisites and Graduates; 400s = Graduates and Undergraduates with permission of instructor and permission number from the CEE Academic Coordinator, j-soule@northwestern.edu

ENVR_SCI 201 Earth: An Habitable Planet
Presents a broad description of Earth System Sciences focused on the physical, chemical, and biological processes that have made the planet habitable. The first area of focus is to retrace the evolution of the planet from the early ages, when the laws of physics and chemistry ruled, to the apparition of life and the homeostatic conditions that resulted. The second is to describe, and show how we can quantify, the major biogeochemical cycles that are key in this homeostatic equilibrium. The third component is to assess the impact of human activities that can lead to minor or major perturbations and the policy efforts that have been implemented for their control. Prerequisites: MATH 224; CHEM 103 or CHEM 172.

ENVR_SCI 202 The Health of the Biosphere
Three main foci in this course: 1. Understanding mathematics of population growth (economics of harvested populations, history and projections of human population growth, impacts of growth and increased resource use, etc); 2. Distilling important concepts from ecology and evolution (ecological interactions, trophic structure/energy flow, overhunting, diversity-stability relationship, etc.); 3. Applying environmental economics (cost-benefit analysis, the values of biodiversity and ecosystem function; destruction and fragmentation of habitats, etc. Prerequisites: MATH 224 or equivalent.

ENVR_SCI 203 Energy and the Environment: The Automobile
Using the automobile as example, this course provides an integrated study of fundamental chemistry (thermodynamics, atmospheric chemistry, free radical mechanisms of reaction), industrial production, energy use, and public policy from an environmental perspective. Prerequisites: MATH 224; CHEM 103 or CHEM 172.

Highly recommended by CEE Faculty -- GEN_ENG 220-1,2: Analytic and Computer Graphics (2-quarters)
Microcomputer-aided drawing (CAD) for graphical three-dimensional problem solving and presentation—2-Qtr course (.50 credit each quarter). Winter Quarter results in a “K” grade; Spring Quarter results in a Final Grade for the two quarters on a mandatory P/N only basis (Winter “K” is converted to a P at the end of the Spring Quarter).

CIV_ENG 212-0 Mechanics

CIV_ENG 216-0 Mechanics of Materials I
Analytical and experimental study of stresses and deformations and their application to the design of machine and structural elements subjected to static, dynamic, and repeated loads. Prerequisite: CIV_ENG 212 or GEN_ENG 205-2.

CIV_ENG 221-0 Theory of Structures I
Deflections of structures, energy concepts, idealization of structures, truss analysis, column stability, and influence lines. Introduction to indeterminate truss and frame analyses, slope-deflection analysis, and moment distribution. Portal method. Prerequisite: CIV_ENG 216.

CIV_ENG 222-0 Structural Steel Design
Rational basis of structural design. Design approach for structural steel components of a building system. Prerequisite: CIV_ENG 221.

MECH_ENG 241-0 Fluid Mechanics I

CIV_ENG 250-0 Introductory Soil Mechanics
Fundamental properties and behavior of soils as engineering materials. Origin of soils through the properties of soil components to the strength, permeability, and deformation of soil masses. Prerequisite: CIV_ENG 216, completion of MECH_ENG 141 is recommended.
**CIV ENG 260-0 Fundamentals of Environmental Engineering**
Mass and energy concepts applied to major issues facing environmental engineers: safe drinking water, surface water quality, ambient air quality, global atmosphere, managing solid and hazardous wastes. **Prerequisites:** CHEM 101 and MATH 224 (take concurrently).

**CIV ENG 302-0 Engineering Law**
The American legal system from an engineer’s perspective. Socratic-method analysis of statutory and case law. Contract, patent, corporation, antitrust, property, and environmental law. **Prerequisite:** Senior standing.

**CIV ENG 303-0 Environmental Law and Policy**
Offers an introduction to many important aspects of environmental law and policy. Covers a wide range of environmental topics, focusing on national environmental policy as implemented through major federal environmental statutes. **Prerequisite:** Junior or Senior standing.

**CIV ENG 304-0 Civil and Environmental Engineering Systems Analysis**
Explores problems that arise in planning and managing engineering projects/systems. Integrates methodological tools, often used in the management sciences, with applications in civil and environmental engineering—engineering economics, decision making under uncertainty (decision analysis and dynamic programming), and optimization (constrained optimization and linear programming). **Prerequisite:** Junior or Senior standing.

**CIV ENG 306-0 Uncertainty Analysis in Civil Engineering**
Probability, statistics, and decision theory. Discrete and continuous random variables, marginal and conditional distributions, moments, statistical model selection and significance tests, hypothesis testing, and elementary Bayesian decision theory. Application to problems in soil mechanics, water resources, transportation, and structures. **Prerequisite** Math 230-0

**CIV ENG 307-0 Microstructure of Cement-Based Materials**
Chemistry of the principal silicate and aluminate cements used in building and civil and environmental engineering. Emphasis on underlying science rather than on practical application. Experimental and theoretical aspects of cement chemistry; relationships between processing, microstructure, and properties. **Prerequisite** Permission of instructor.

**CIV ENG 314-0 Mechanics of Crustal Processes**
Application of elementary mechanics to geological processes of crustal deformation, including faulting, earthquake generation and deformation, and folding and coupling of fluid flow with deformation. **Prerequisite** Permission of instructor.

**CIV ENG 318-0 Mechanics of Fracture**
Stress concentration: analysis of the stress field near a crack tip; fracture modes; brittle and ductile fracture; fracture toughness; fracture criteria; fracture mechanics design; fatigue; dynamic effects. **Prerequisites:** CIV ENG 216 or GEN ENG 205-4.

**CIV ENG 319-0 Theory of Structures II**
Shear center, nonprismatic members, nonlinear materials, influence lines, Mueller-Breslau Principle, approximate methods of analysis, energy methods, stiffness matrix, and computer methods of analysis. **Prerequisite:** CIV ENG 221.

**CIV ENG 320-0 Structural Analysis**
Single and multiple degree of freedom systems subjected to period, seismic, and general loadings. Time history analysis of linear and nonlinear systems. Design methods for earthquakes. **Prerequisite:** CIV ENG 221.

**CIV ENG 321-0 Properties of Concrete**
Concrete as a composite material; relationship between constitutive laws and microstructure; failure theories, fracture; fatigue; strain rate effects; destructive and nondestructive testing; creep and shrinkage; chemistry of cement hydration; admixtures; aggregates; proportioning; new materials. **Prerequisite:** CIV ENG 216.

**CIV ENG 322-0 Structural Design**
Design criteria; planning and design aspects of structural systems for gravity and lateral loads; an integral part of the class is a total design project involving the analysis and design of a structure. **Prerequisite:** CIV ENG 222 or equivalent.

**CIV ENG 325-0 Reinforced Concrete**
Fundamentals of reinforced concrete theory and design. Analysis and design of beams, slabs, and columns. Concurrent familiarization with current building codes, specifications, and practices. **Prerequisite:** CIV ENG 221.
CIV_ENG 327-0 Finite Element Methods in Mechanics
Development of finite elements from variational principles and application to static stress analysis. Introduction to techniques for transient and generalized field problems. Computer implementation. Prerequisite: MECH_ENG 262, MATH 215, or CIV_ENG 216, and permission of instructor.

CIV_ENG 330-0 Construction Management
Techniques for coordinating decisions and actions of various parties in the design and construction of civil and environmental engineering projects. Delivery systems; preconstruction services; project planning; cost control and value engineering; bidding. Prerequisite: Senior standing in engineering, or permission of instructor.

CIV_ENG 332-0 Construction Estimating
Estimation of cost at different stages of design; conceptual estimating, quantity take-off of various elements, such as materials, labor, equipment. Prerequisite: CIV_ENG 330 or permission of instructor.

CIV_ENG 336-0 Project Scheduling
Project planning, scheduling, and control using CPM arrow and precedence networks; resource allocation and leveling; earned-value analysis, linear scheduling; PERT; hands-on experience in using computer tools. Prerequisite: CIV_ENG 330 or permission of instructor.

CIV_ENG 338-0 Public Infrastructure Management
Explores the complexity of managing public infrastructure facilities by means of a five-part interactive model of infrastructure management. Aims to impart a realistic appreciation of contemporary public infrastructure management policies and practices. Prerequisite: Senior standing.

CIV_ENG 340-0 Fluid Mechanics II
Civil engineering applications of fluid mechanics. Turbulent flow in pipes, pipe networks, and open channels. Water waves and coastal engineering. Prerequisite: MECH_ENG 241 or CHEM_ENG321 or permission of instructor.

CIV_ENG 352-0 Foundation Engineering
Application of soil mechanics to analysis and design of foundations and embankments. Settlement of structures, bearing capacities of shallow and deep foundations, earth pressures on retaining structures and slope stability. Prerequisite: CIV_ENG 250.

CIV_ENG 355-0 Engineering Aspects of Groundwater Flow
Applied aspects of groundwater flow and seepage, including Darcy’s law, parameter determination, aquifer test analysis, flow-net construction and application, modeling techniques, slope-stability analysis, drainage, and filter design. Prerequisite: MECH_ENG 241, CIV_ENG 340, and Pre-senior or senior standing.

CIV_ENG 356-0 Transport Processes in Porous Media
Transport processes in porous media, including unsaturated flow, flow in deformable porous media, convective transport of solutes with hydrodynamic dispersion effects and coupled flow phenomena with particular emphasis on electrokinetics. Prerequisite: CIV_ENG 355.

CIV_ENG 358-0 Airphoto Interpretation
Principles and practice of using aerial photographs to obtain information about natural features of the earth's surface, with emphasis on earth materials. Landforms, geological processes, rocks, and soils. Stereoscopic photographs, elements of photogrammetry. Prerequisite: Junior standing or permission of instructor.

CIV_ENG 361-0 Environmental Microbiology and Public Health
Basic principles of microbiology; etiology of infectious and noninfectious diseases; control of environmentally-based health hazards. Prerequisite: Junior standing.

CIV_ENG 362-0 Ethics, Engineering, and Environment
A broad introduction to ethics for scientists and engineers required to make both personal and professional ethical decisions that include complexity and issues of environment. Prerequisite: Junior standing.

CIV_ENG 363-0 Environmental Engineering Applications I: Air & Land
Nature and control of community air pollution. Sources, physical and chemical properties, and effects of major air pollutants; analytical measurements and monitoring of air pollutants; engineering and legislative control. Prerequisite: Junior standing.
CIV_ENG 364-0 Environmental Engineering Applications II: Water

CIV_ENG 365-0 Environmental Laboratory
Chemical and microbiological aspects of environmental engineering and science are explored through an integrated laboratory course. Junior standing.

CIV_ENG 367-0 Aquatic Chemistry
Chemical equilibria in natural waters. Development of the theoretical basis for the investigation of chemical behavior of aquatic systems emphasizing a problem-solving approach. Prerequisite: CHEM 103, or permission of instructor.

CIV_ENG 369-0 Industrial Ecology of Materials and Products
Will significantly increase student's knowledge of eco-design, sustainability, “green” design and products, environmentally friendly manufacturing, reuse of various materials, and recycling of metal, glass, plastic, and paper. Current practice and future trends.

CIV_ENG 370-0 Environmental Engineering Design (Capstone Design for BSEEs)
Culminating student team design experience in Environmental Engineering: decision-making in selection and implementation of environmental control measures, including evaluation of economic, social and environmental impacts of alternative proposed projects. Prerequisite: Senior standing in Civil and Environmental Engineering, or permission of instructor.

CIV_ENG 371-0 Introduction to Transportation Planning and Analysis
Analysis and design of solutions to transportation problems; introduction to selected operations research and statistical analysis techniques; extensive use of case studies in urban transportation, intercity passenger transport, and freight movements. Prerequisite: Junior standing in engineering or permission of instructor.

CIV_ENG 376-0 Transportation System Operations
Traffic flow theory; vehicle and human factors, capacity analysis; intersection performance and control; management and control of arterial streets and networks; neighborhood traffic restraint, urban transit operations. Operations concepts and theories applied to actual problems through laboratory practice. Prerequisite: Junior standing, and basic knowledge of calculus and statistics. Knowledge of MATLAB is desirable, but not required.

CIV_ENG 382-0 Infrastructure of Facilities and Systems (Capstone Design for BSCEs)
Culminating student team design experience in Civil Engineering, with overview of function, design, and operation of modern infrastructure systems, through lecture-discussions and weekly field trips to working systems. Prerequisite: Senior standing in Civil and Environmental Engineering, or permission of instructor.

CIV_ENG 395-0 Special Topics in Civil Engineering
Undergraduate level experimental courses.

CIV_ENG 398-1,2 Community-based Design
Year-long participation in two- or three-person team projects involving research, analysis, and/or design in the solution of environmental problems affecting primarily low-income communities. Grade assigned only on completion of both units. Prerequisite: Junior or senior standing in BSCE or BSEE and permission of instructor.

CIV_ENG 399-0 Projects
Special projects under faculty direction. Credit to be arranged. Each instructor has own section—student must obtain permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 411-0 Micromechanics
Mechanics of microstructures of materials, such as continuum theory of dislocations, inclusions, inhomogeneities, cracks, and composite materials. Unified eigenstrain method employed. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 413-0 Experimental Stress Analysis
Experimental techniques in measuring stress and strain. Strain gauge, photoelastic, brittle coating, and Moire techniques studies and applied with selected laboratory experiments. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).
CIV_ENG 414-1,2 Mechanics of Composite Materials I, II
Introduction to basic concepts: fabrication of composite materials, micromechanics, macromechanics of uni-directional lamina, failure theories, mechanics of multi-directional laminate, lamination theory, hydrothermal effects, interlaminar stresses, stress concentrations, structural design and optimization, and nondestructive evaluation. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 415-0 Theory of Elasticity
Notions of stress and strain. Basic equations of the linear theory of elastic media. Stress function and displacement potentials. Applications to specific classes of problems such as plane strain, contact stresses, and axisymmetric problems. Stress concentration. Singular states of stress. Dislocations and residual stresses. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 417-1 Mechanics of Continua I
Introduction to the mechanics of continuous media. Cartesian tensors; kinematics of deformable media; stress; balance laws; constitutive relations for selected solids and fluids. Prerequisites: GEN_ENG 205-2,3 or CIV_ENG 212 and MATH 240. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 417-2 Mechanics of Continua II
Kinematics of deformable media, thermodynamics and balance laws of continua, general theory of constitutive equations. Emphasis on large deformation theories; objective stress and deformation measures with applications in finite strain elasticity. Introduction to nonlinear and inelastic material behavior including applications in plasticity and viscoelasticity. Prerequisite: CIV_ENG 417-1 or equivalent. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 420 Advanced Structural Analysis
Solution of nonlinear equations for structures, shear center and center of twist of open and multicell cross sections, shear stresses in multicell closed cross sections, restrained warping torsion stresses. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 421 Prestressed Concrete
Principles of prestressed concrete. Prestressing systems, end anchorage, and loss of prestress. Analysis and design of sections for flexure, shear, bond, bearing, and deflection. Continuous beams, slab, tension, and compression members. Circular prestressing. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 422 Inelastic Analysis of Structures
Inelastic analysis of frames, plates, and shells. Plastic behavior and limit analysis theorems. Static and kinematic methods for calculating collapse loads. Yield surfaces for plates and shells, plastic potential flow law, and load capacity. Viscoelastic behavior and rheologic models. Creep of concrete and its effects in structures. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 423-0 Matrix Analysis of Structures
Use of matrix methods for analysis of articulated structural systems, geometric matrices, stability, analysis of geometrically nonlinear systems, introduction to the finite element method. Prerequisite: CIV_ENG 221. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 424 Stability of Structures
Buckling of perfect and imperfect columns, mathematical treatment of various types of stability problems and stability criteria, dynamic and static instability, and energy methods. Buckling of frames, trusses, and beams. Snap-through, elastic-plastic columns, creep buckling, and basic approach to buckling of two- and three-dimensional bodies. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).
CIV_ENG 426-1,2 Advanced Finite Element Methods I, II
Methods for treating material and geometric nonlinearities by finite elements; transient analysis: explicit and implicit time integration, partitioned methods, and stability; hybrid and mixed elements; finite elements for plates and shells; convergence, efficiency, and computer implementation. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 430 Cohesive Fracture and Scaling

CIV_ENG 435 Cost Engineering and Control
Application of cost engineering for construction companies and projects; time and cost integration; estimating process and bid preparation; labor estimates; accounting for equipment; cost-control concepts; changes and extras; claims. Prerequisites: IEMS 423 and IEMS 425 Prerequisite: Permission of instructor.

CIV_ENG 436 Construction Contracts and Dispute Resolutions

CIV_ENG 440-0 Environmental Transport Processes
Processes controlling transport and fate of dissolved and suspended substances in natural and engineered environmental systems. Mass balances, hydrodynamic transport, phase and mass transfers; the fate of reactive species in complex environmental systems. Prerequisites: PHYS 135-1,2 and CHEM_ENG 321, MECH_ENG 241, or equivalent. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 441-0 Methods in Microbial Complexity
Principles of microbial physiology and biochemistry applied to microorganisms of environmental interest. Prerequisite: CIV_ENG 367. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 442 Processes in Environmental Biotechnology
Theory and practice of microbiological processes used in pollution control: kinetics of suspended growth and fixed-film processes, activated sludge, biofilm processes, nitrogen and phosphorus removal, methanogenesis. Prerequisites: CIV_ENG 440, CIV_ENG 441, and CIV_ENG 467. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 444 Physical/Chemical Processes in Environmental Control
Theory and practice of separations and conversions in water quality and residuals management. Water quality, coagulation, adsorption, ion exchange, membranes, oxidation, sedimentation, flocculation, filtration. Prerequisite: CIV_ENG 367, CIV_ENG 440 or equivalent. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 445 Environmental Systems Laboratory
Mechanistic aspects of the performance of selected unit processes typically used in drinking water treatment: coagulation, filtration, reactor hydraulics, disinfection, chemical reaction and other physicochemical phenomena to elucidate parameters and conditions critical for controlling treatment effectiveness and efficiency. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 447-0 Biogeochemistry
The cycling of biogenic elements (C, N, S, Fe, Mn) in surficial environments is the focus of this course. Emphasis will be placed on microbial processes and isotopic signatures. Prerequisite: Permission from instructor.

CIV_ENG 448-0 Biophysicochemical Processes in Environmental Systems
Microbiological and engineering fundamentals of bioremediation, with emphasis on current and emerging technologies for major classes of environmental contaminants and contaminated sites. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).
CIV_ENG 449-1,2,3 Environmental Laboratory Experience
A combined year-long laboratory experience that is coupled to classroom learning. Three laboratory exercises will be conducted each quarter and these are designed to reinforce the fundamentals of environmental transport, chemistry and microbiology that are taught in the core curriculum. Students will learn how to make selected measurements, collect and analyze data, design experiments, and draw conclusions based on their observations. The labs will parallel materials presented in coursework and provide students with hand-on learning opportunity. In the fall, the labs will be focused on environmental chemistry and transport, in the winter, environmental microbiology and advanced environmental chemistry, and in the spring the labs will stress integration of these basic principles to look at the behavior of environmental systems. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 450-1,2,3 Soil Mechanics I, II, III

CIV_ENG 451-0 Engineering Properties of Soils
Determination and interpretation of engineering properties of soils. Laboratory testing procedures and methods of evaluation and control. Report writing. Prerequisite: CIV_ENG 250. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 453 Rock Mechanics
Engineering properties and behavior of rock masses. Shear strength of rock, in situ and laboratory tests of strength, rock fracture, three-dimensional geometry of joint systems, stability of rock masses, in situ stress determination, and deformability of rock masses. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 454 Constitutive Models for Soils
Numerical models of effective and total stress-strain response of soils; non-linear pseudo-elastic, elasto-plastic and bounding surface models; parameter identification and applications. Prerequisite: CIV_ENG 450-1 or Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 457-0 Environmental Geotechnics
Site characterization and geotechnical aspects of waste containment and remediation. Geological setting and the heterogeneous nature of soils. Design, testing, and quality control of geosynthetics. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 458 Soil Dynamics
Dynamics of soils and soil-foundation systems; nuclear weapons effects, earthquake response, vibrations of machine foundations, reactions due to impact equipment, industrial noise and blast effects, fatigue concepts, wave propagation and attenuation, blast-resistant construction, and linear and nonlinear systems. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 461 Soil Science for Environmental Engineering
Fundamental properties and behavior of soil systems, with emphasis on soil physics, soil chemistry, and soil microbiological and biochemical reactions applied to contaminant transport and fate. Includes laboratory experience with soil. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 467 Advanced Environmental Chemistry
Principles and applications needed to develop advanced problem-solving techniques in environmental chemistry. Major topics include applied thermodynamics, environmental organic chemistry, and problem solving for acid/base, complexation, precipitation/dissolution, and redox. Prerequisite: CIV_ENG 367. Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).
CIV_ENG 468 Chemical Speciation in Aquatic Systems
Advanced theories, computerized methods, and chemical tools for investigating the chemical speciation of natural waters. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 471-1,2 Transportation Systems Analysis I, II
Applications of optimization methods to the analysis, design, and operation of transportation logistics networks. Network equilibrium. Flow prediction in congested multi-commodity networks. Vehicle routing and fleet management. Dynamic and stochastic transportation network modeling. **Prerequisite:** IEMS 310 or equivalent background. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 479 Transportation Systems Planning and Management
Functional and structural description of transportation systems; characteristics of major U.S. transportation modes; transportation analysis, planning, problem-solving, and decision-making methods illustrated through urban, freight, and intercity case studies. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 480-1,2 Travel Demand Analysis and Forecasting I, II
Introduction and application of statistical, econometric, and marketing research techniques to study and forecast travel behavior. First Quarter: introduction to theory, analysis, and model development. Second Quarter: advanced theory, disaggregate choice models, and prediction methods. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 482 Evaluation and Decision-Making for Infrastructure Systems
Theories and methods of evaluation and choice from alternatives for transportation and other infrastructure projects and systems. Economic, quantitative, and judgmental methods for both a priori and before-and-after evaluation. Measurement, modeling, analysis, and presentation problems. **Prerequisite:** CIV_ENG 306. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 483 Infrastructure Systems Analysis
Quantitative techniques to develop prescriptive models that can be used to support efficient planning and management of civil infrastructure systems. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 495 Selected Topics in Civil Engineering
Graduate-level experimental courses. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 497 Selected Topics in Civil Engineering
Half-unit special courses under faculty direction. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 499 Projects
Special projects under faculty direction (1, 2, or 3 units). Each instructor has own section—student must obtain permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).
McCormick School’s Mission Statement – Excellence at All Levels

The Robert R. McCormick School of Engineering and Applied Science seeks excellence at all levels from its students, faculty, and staff. Our goal is to be a recognized world leader in science and technology-driven initiatives, such as materials and nanotechnology, bioengineering and biotechnology, infrastructure and critical infrastructure and systems. We aspire to be a world leader in societal-driven initiatives that positively impact our world. We actively collaborate with industry, governmental and peer institutions to assist us in accomplishing these goals.

Department of Civil and Environmental Engineering’s Undergraduate Programs

The McCormick School’s Mission Statement provides the foundation for articulating the Educational Objectives and Outcomes of the Department of Civil and Environmental Engineering’s (CEE) Bachelor of Science in Environmental Engineering program.

The Educational Objectives and Outcomes and how they meet ABET (Accrediting Board for Engineering and Technology) criteria “a-k” for Environmental Engineering is presented on the two following pages. Each year, the CEE Department uses a Program Enhancement Cycle to assess student learning and improve program outcomes.

<table>
<thead>
<tr>
<th>Bachelor of Science in Environmental Engineering (BSEE) Program of Study’s Educational Objectives</th>
<th>meeting ABET’s Criteria (a-k)</th>
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<tbody>
<tr>
<td><strong>BSEE Educational Objectives</strong></td>
<td><strong>ABET criteria (a-k)</strong></td>
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<tr>
<td>1. Excel in the engineering practice, research and management associated with the protection and conservation of ecological and human health.</td>
<td>(a) Ability to apply knowledge of mathematics, science, and engineering (including chemistry, physics, earth science, biological science, and fluid mechanics).</td>
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<td></td>
<td>(e) Ability to identify, formulate and solve engineering problems.</td>
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<td></td>
<td>(k) Ability to use the techniques, skills, and modern engineering tools necessary for professional engineering practice.</td>
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<td>BSEE Educational Objectives</td>
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<tr>
<td>(l) Understanding of concepts of professional practice and the roles and responsibilities of public institutions and private organizations pertaining to environmental engineering.*</td>
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<tr>
<td>2. Play key roles in the analysis of the behavior of complex natural and engineered environmental systems and design infrastructure in a sustainable way to meet societal needs.</td>
<td>(c) Ability to design a system, component, or process to meet desired needs. (d) Ability to function on multidisciplinary teams. (e) Ability to identify, formulate and solve engineering problems. (f) Understanding of professional and ethical responsibility. (h) Broad education necessary to understand the impact of engineering solutions in a global and societal context. (j) Knowledge of contemporary issues. (k) Ability to use the techniques, skills, and modern engineering tools necessary for professional engineering practice.</td>
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<tr>
<td>3. Apply their broad environmental engineering training to excel and become leaders in a diverse range of professions including engineering consulting, industry, medicine, law, government, and education.</td>
<td>(c) Ability to design a system, component, or process to meet desired needs. (e) Ability to identify, formulate and solve engineering problems. (f) Understanding of professional and ethical responsibility. (g) Ability to communicate effectively. (h) Broad education necessary to understand the impact of engineering solutions in a global and societal context. (i) Recognition of the need for, and an ability to engage in life-long learning. (k) Ability to use the techniques, skills, and modern engineering tools necessary for professional engineering practice.</td>
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<td>4. Think critically, behave ethically and consider the technical and social consequences of their work, especially as it affects the health, safety and environment of both ecological and human communities.</td>
<td>(f) Understanding of professional and ethical responsibility. (h) Broad education necessary to understand the impact of engineering solutions in a global and societal context. (i) Recognition of the need for, and an ability to engage in life-long learning. (j) Knowledge of contemporary issues. (k) Ability to use the techniques, skills, and modern engineering tools necessary for professional engineering practice.</td>
</tr>
<tr>
<td>5. Apply their knowledge creatively and innovatively throughout their careers to meet the challenges posed by a rapidly changing world.</td>
<td>(a) Ability to apply knowledge of mathematics, science, and engineering (including chemistry, physics, earth science, biological science, and fluid mechanics). (b) Ability to design and conduct experiments, as well as to critically analyze and interpret data in more than one major environmental engineering focus area. (d) Ability to function on multidisciplinary teams. (e) Ability to identify, formulate and solve engineering problems (g) Ability to communicate effectively. (i) Recognition of the need for, and ability to engage in life-long learning.</td>
</tr>
</tbody>
</table>

* Criterion “l” is an additional criterion specified by the American Academy of Environmental Engineers (AAEE).