

Civil Engineering

Bachelor of Science—BSCE—2009-2010

Civil and Environmental Engineering Department

www.civil.northwestern.edu

Civil Engineering serves the basic needs of society through construction and operation of the public infrastructure. Civil engineers research, plan, design, construct, manage, and maintain one-of-a-kind infrastructure systems such as roads, airports, tunnels, bridges, and seaports; residential, office, commercial, and manufacturing buildings; water supply and reclamation networks; and power generation and distribution facilities. Each system has unique characteristics that challenge the civil engineer to combine engineering knowledge with initiative and creativity to satisfy project objectives, protect the well-being of society, and meet budget constraints.

Civil Engineers must also explore the social, economic, managerial sciences, and collaborate with other experts and the public. The work of civil engineers may extend to biotechnology to support environmental restoration, and to materials science to develop new building materials. In addition, students at Northwestern learn about application and development of computer models and analytical and experimental methods to explore the response of infrastructure systems to normal and extreme stresses in advance of construction. Civil engineers use advanced sensors and communications devices to monitor performance of bridges, tunnels, buildings in real time, over long distances, and under extreme conditions.

Curriculum The civil engineering curriculum (accredited by the Accrediting Board for Engineering and Technology) is designed to satisfy a diversity of interests and professional goals. Students construct study plans suited to their unique interests, including extensive options for courses outside the engineering school to address the social and physical challenges of constructing and managing the nation's infrastructure.

- * Architectural Engineering and Design
- * Environmental Engineering
- * Geotechnics
- * Structural Engineering and Materials
- * Transportation Systems Analysis and Planning
- * Mechanics of Materials and Solids
- * Construction Management

After Northwestern Graduates of civil engineering enter a wide range of careers. City engineers may manage water and wastewater treatment facilities or devise traffic control plans. Engineers in structures and geotechnics design foundation and structures for billion dollar mega-projects such as subway systems, airports, and industrial complexes. Transportation engineers work for private carriers and units of federal, state, and local governments to plan and manage transit, highways, railroads, and airlines. Many civil engineers work in consulting firms, governmental agencies, and manufacturing firms. About half of civil engineering majors go on to graduate school, and about half of these enter graduate programs in other fields to expand their capabilities. **A Bachelor of Science in Civil Engineering** combined with an advanced degree in law, business, or biochemistry provides an excellent foundation for exciting careers in research, teaching, and development in university, industrial, and governmental settings.

Civil Engineering — BSCE — 2009-2010

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The Bachelor of Science in Civil Engineering (BSCE) degree is awarded upon satisfactory completion of the following 48-course curriculum. Of the 48 course requirements, 32 courses must follow the **McCormick School Basic Studies Program**; and 16 courses follow the **Civil and Environmental Engineering Department's (CEE) Civil Engineering Major**.

Most of the 48 courses must be satisfied by taking courses at Northwestern University (NU); however, a few of the requirements are sometimes satisfied by advanced placement upon entering NU and/or transfer credit from other universities. The last 23 courses must be taken while enrolled at NU and the last three quarters must be completed while the student is enrolled in The Robert R. McCormick School of Engineering and Applied Science (McC or McCormick).

McCormick School Basic Studies Program

(32 courses)

Engineering Analysis *(4 courses)*

GEN_ENG 205-1
GEN_ENG 205-2
GEN_ENG 205-3
GEN_ENG 205-4

Mathematics *(4 courses)*

MATH 220 Calculus I
MATH 224 Calculus II
MATH 230 Calculus III
MATH 234 Multiple Integration and Vector Calculus

Basic Sciences *(4 courses)*

PHYSICS 135-2 General Physics
CHEM 101 General Chemistry
CHEM 102 General Chemistry
CHEM 103 or PHYSICS 135-3. Successful completion of CHEM 171 and 172 is equivalent to completion of CHEM 101 and CHEM 102, and CHEM 103. Students may elect to complete a 5th Basic Science course as a part of the 16-course CEE departmental program.

Basic Engineering *(5 courses)*

Thermodynamics: MECH_ENG 220 or CHEM 342-1
Fluids and Solids: CIV_ENV 216 and MECH_ENG 241
Electrical Science: ECE 202 or 270, or MECH_ENG 233
Materials Science: 1 course from materials science, systems engineering and analysis, computer architecture and numerical analysis or computer programming.

Design and Communications *(3 course units)*: IDEA 106-1, 2 (0.5 units each) and English 106-1, 2 (0.5 units each); these half-courses are taught concurrently by a faculty member from Engineering and from English. In the Winter, the courses are IDEA 106-1 and ENGLISH 106-1. In the Spring, the courses are IDEA 106-2 and ENGLISH 106-2. In addition, all engineering students are required to complete one speaking course before graduation: GEN_CMN 102 or 103.

Social Science/Humanities *(7 courses)*: See Social Science/Humanities details.

Unrestricted Electives *(5 courses)*: Any course offered for credit by the University is acceptable for this category.

Note: The CEE faculty recommends the selection of GEN_ENG 220-1,2 Analytic and Computer Graphics (AutoCAD), as an unrestricted or technical elective. This course will help prepare you for CAPSTONE DESIGN in your Senior Year.

McCormick School Basic Studies Program

(continued)

Design and Communications Requirement

All freshman engineering students are required to complete a two-quarter course sequence in which they are introduced to the process of engineering design and concurrently to techniques for effective writing in the context of engineering reports as well as communications with clients and among team members. The sequence is taken during the winter and spring quarters of the freshman year.

In winter quarter, the student registers for IDEA 106-1 (0.5 units) and ENGLISH 106-1 (0.5 units), and these half-courses are taught concurrently by a faculty member from Engineering and from English. In spring, the courses are IDEA 106-2 and English 106-2. These courses may not be taken P/N.

In addition, all engineering students are required to complete one of the following speaking courses before graduation (higher level courses may be approved to satisfy this requirement on an individual basis):

GEN CMN 102-0	Public Speaking
GEN CMN 103-0	Analysis and Performance of Literature

Social Science-Humanities Requirement

Seven courses chosen according to either of the following two options:

Option A. At least two courses must be chosen in each of three areas:

- Social and Behavioral Science (SBS)
- Historical Studies and Values (HSV)
- Fine Arts, Language and Literature (FAL)

Of the seven courses, only three 100-level introductory courses may be presented and three courses must be thematically related to provide depth.

Option B. Five of the seven courses must clearly have a thematic relatedness. For breadth, no more than five courses may come from a single area.

The courses taken for a student's Social Science-Humanities Requirement must be approved in advance by the McCormick Humanities Panel. Foreign language study can be incorporated into the program, but should be started as early as possible, preferably in the Freshman year.

Details of the program are available in the theme listings. If you have misplaced your copy, a replacement copy can be obtained from the Undergraduate Engineering Office—McCormick L269.

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BSCE—CEE Departmental program

(16 courses)

Basic Civil Engineering (7 courses)

- CIV_ENV 221 Theory of Structures 1
- CIV_ENV 222 Structural Steel Design (offered Spring, Even Years or 325 by petition)
- CIV_ENV 325 Reinforced Concrete
- CIV_ENV 250 Introductory Soil Mechanics
- CIV_ENV 260 Fundamentals of Environmental Engineering
- CIV_ENV 330 Construction Management
- CIV_ENV 340 Fluid Mechanics II
- CIV_ENV 371 Introduction to Transportation Planning and Analysis
- or**
- CIV_ENV 376 Transportation Systems Operations

Mathematical Techniques and Science (MTS) (1 course from the list in the following paragraph; plus 1 course from the Approved List – Additional Mathematical Techniques and Science (MTS)).

One of the courses must be a calculus-based probability/statistics course such as IEMS 201, IEMS 202, MATH 310-1, MECH_ENG 359, STAT 210, STAT 330-1, STAT 302—however, the CEE faculty recommends the selection of CIV_ENV 306, Uncertainty Analysis in Civil Engineering.

Technical Electives (TE) (5 courses from Approved List TE).

Note: The CEE faculty recommends the selection of GEN_ENG 220-1,2, Analytic and Computer Graphics (AutoCAD) and IEMS 326 Economics and Finance for Engineers as either Technical or Unrestricted Electives.

Design and Synthesis (DS) (2 courses from Approved List DS).

Note: In addition to the required CIV_ENV 325 (222—offered Spring, Even Years—by petition), at least 2 additional course units of ABET-accredited design must be completed from the list of Design and Synthesis courses, one of which must be CIV_ENV 382 CAPSTONE DESIGN taken in the senior year. Transfer students who do not take IDEA 106-1,2 and GEN_ENG 205-1,2,3,4 require an additional 3.5 (i.e., 2.0 + 1.5) design units (see Approved List DS and/or your advisor).

Additional Guidelines

- (i) At least 10 of the 16 BSCE—CEE Departmental program courses must be CEE courses.
- (ii) The 16 departmental courses must have a cumulative GPA of 2.00 or higher.
- (iii) The P/N option may be used for a maximum of two courses, which can be chosen from any of the fifteen in the departmental curriculum other than 382 (required to be taken only in the senior year). However, no more than two courses in the departmental program may have grades of D. Courses taken abroad for a grade, but recorded by the Northwestern University Registrar as P/N, may be exempted from this requirement.
- (iv) The only courses in the 32 McC Basic Studies Program requirements that are eligible for P/N are the speech, 7 social science/humanities, and 5 unrestricted elective courses. No more than 8 courses with a grade of P will be accepted in satisfaction of the graduation requirements. Courses taken abroad for a grade, but recorded by the Northwestern University Registrar as a P, may be exempted from this requirement.
- (v) All students pursuing an ABET-accredited undergraduate engineering degree must accumulate a total of 18 course-credits of “Engineering Topics” in fulfillment of their degree. Several courses offered by

engineering departments of the McCormick School are classified as providing less than a full unit of credit in the category of "Engineering Topics." See your advisor.

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————— BSCE—CEE Departmental program —————

(continued)

Approved List — Additional Mathematical Techniques and Science (MTS)

Mathematical Techniques and Science

Note: One Science course from the list may be substituted for one of the two MTS courses.

Math Department - Any course 300 level or above.

Engineering

CIV_ENV 304	Civil and Environmental Engineering Systems Analysis
CIV_ENV 327	Finite Element Methods in Mechanics (offered Fall, Odd Years)
CIV_ENV 423 (1)	Matrix Analysis of Structures
EECS 310	Mathematical Foundations of Computer Science
EECS 328	Numerical Methods for Engineers
ENVR_SCI 201	Earth: A Habitable Planet
ENVR_SCI 202	Health of the Biosphere
ENVR_SCI 203	Energy and the Environment: The Automobile
IEMS 310	Operations Research
IEMS 313	Deterministic Models and Optimization
IEMS 315	Stochastic Models and Simulation
ES_APPM	Any course 300 level or above

(1) 400-level courses require Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

Science

Any course 200-level or above in Biological Sciences, Chemistry, Geological Sciences or Physics, plus CHEM 103 or PHYSICS 135-3, whichever is not used to satisfy the Basic Sciences requirement.

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(continued)

Approved List — Technical Electives (TE)

Technical Electives Supporting Student's Specialty

1. Any course, 200-level or above in the McCormick School or in the Weinberg College of Arts and Sciences, Departments of Astronomy, Biological Sciences, Chemistry, Geological Science, Physics, Mathematics, provided the course supports the student's field of specialty.
2. Economics—for students concentrating in Transportation, the following courses are approved electives.

ECON 310-1	Microeconomics I
ECON 354	Issues in Urban and Regional Economics
ECON 355	Transportation Economics and Public Policy
ECON 381-1, 2	Econometrics I and II
3. Kellogg—for students interested in the Kellogg Undergraduate Certificate

KELLG_FE 310-0	Principles of Finance (TE)
KELLG_FE 312-0	Investments (TE)
KELLG_FE 316-0	Topics in Financial Economics (a free elective)
KELLG_FE 314-0	Derivatives (TE)
KELLG_MA 320-0	Analytical Decision Modeling on Spreadsheets (TE)
KELLG_MA 322-0	Pricing (TE)
KELLG_MA 324-0	Operations and Supply Chain Strategy (TE and MTS)
4. Other courses from Weinberg College of Arts and Sciences or Kellogg may be approved upon petition.

Approved List — Design and Synthesis (DS)

Courses in Design and Synthesis

CIV_ENV 325	Reinforced Concrete
CIV_ENV 336	Project Scheduling
CIV_ENV 352	Foundation Engineering (offered Winter, Odd Years)
CIV_ENV 360	Environmental Impact Evaluation
CIV_ENV 382*	CAPSTONE DESIGN
CIV_ENV 395	Special Topics (must be design class)
CIV_ENV 399	Projects (must be design project)
CIV_ENV 421	Prestressed Concrete (Requires permission of instructor and a permission number from j-soule@northwestern.edu . Not offered every year.)

Many courses in other departments of the University may be used to satisfy the design requirement (other than the required CIV_ENV 382). The Dean of Undergraduate Affairs of McCormick maintains a listing of the design content (credit units) of all undergraduate courses offered by the school.

***Note** – Students entering in the 2007-2008 Academic Year are required by ABET (Accreditation Board for Engineering and Technology) to take CIV_ENV 382 CAPSTONE DESIGN in their senior year or petition for exemption.

HONORS PROGRAMS

Outstanding students in the BSCE—CEE Departmental program –may be selected for the following Undergraduate Honors Program.

Undergraduate Honors Program: A student with a good scholastic record can be admitted to the Undergraduate Honors Program any time during the junior or pre-senior year. A cumulative Grade Point Average of 3.50 or better is required at the time of admission to the Honors Program. Any student who is eligible will be notified by the Dean.

An honors student participating in the program must:

- (a) complete at least three units of approved advanced study (including courses normally accepted at the graduate level) with an average grade of B or better; and
- (b) complete an extended Independent Study (at least two quarters on the same topic) leading to an acceptable report.

A student wishing to participate must petition the Civil and Environmental Engineering faculty for approval. The petition must indicate the three units of advanced study and the faculty advisor for the independent study project.

Successful completion of the Undergraduate Honors Program will be entered on the student's transcript. Recognition will also be given in the graduation program. If a student's individually evaluated performance is judged not to meet the standards of success required for the Undergraduate Honors Program, the student will still receive course grades and credits as earned.

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Freshman / Sophomore Years

Freshman Year *(more or less common for all engineering students)*

Quarter 1	Quarter 2	Quarter 3
GEN_ENG 205-1	GEN_ENG 205-2	GEN_ENG 205-3
MATH 220-0	MATH 224-0	MATH 230-0
CHEM 101*	CHEM 102 *	Elective or CHEM 103 *
Elective #	IDEA 106-1 and ENGLISH 106-1	IDEA 106-2 and ENGLISH 106-2

Sophomore Year *(more or less common for all engineering students)*

Quarter 4	Quarter 5	Quarter 6
MATH 234-0	CIV_ENV 216-0	MECH_ENG 241
PHYSICS 135-2	PHYSICS 135-3 or Elective	Basic Engrg or Elective
GEN_ENG 205-4	Basic Engrg or Elective	CIV_ENV 260
Elective (Humanities)	Elective (Humanities)	Elective (Humanities)
	GEN_ENG 220-1**	GEN_ENG 220-2**

#One of the electives must satisfy the oral communications requirement (see Design and Communications Requirement).

*Successful completion of CHEM 171 is equivalent to completion of CHEM 101 and CHEM 102; CHEM 171 and 172 are equivalent to CHEM 101, 102, 103.

****Highly Recommended by CEE Faculty -- GEN ENG 220-1,2 is a 0.5 credit AutoCAD course that must be taken P/N both quarters to accumulate 1.0 units of credit as a Technical Elective after Spring Quarter grades are posted.**

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Example BSCE specialty concentration for Jr and Sr years

(Course offerings vary year to year. Consult your advisor)

- Architectural Engineering & Design concentration.** AE&D creates a pathway for students toward a professional architectural degree. Founded on engineering, the program expands the student experience to innovation and problem solving. The training focuses on logical methods of studying and developing solutions to architectural design problems. This science of design is necessary to the architect in order that resources be wisely deployed, teamwork be productive, and buildings be made expressive. The program prepares students as well for a creative role in an engineering profession, giving them experience in the creative process, disciplined and focused thinking, and organizational skills that get projects done.

<i>Quarter 7</i>	<i>Quarter 8</i>	<i>Quarter 9</i>
CIV_ENV Requirement— CIV_ENV 250	CIV_ENV Requirement— CIV_ENV 325	CIV_ENV Elective or Basic Engineering
CIV_ENV Requirement— CIV_ENV 221		CIV_ENV Requirement— CIV_ENV 340 CIV_ENV Elective— CIV_ENV 222 ¹
AE&D Fundamentals: Studio	AE&D: Intermediate Studio	AE&D: Advanced Studio
Elective (Humanities)	Elective (Humanities)	Elective (Humanities)

<i>Quarter 10</i>	<i>Quarter 11</i>	<i>Quarter 12</i>
CIV_ENV Requirement— CIV_ENV 371 or 376	CIV_ENV Elective	CIV_ENV Requirement— CIV_ENV 382 CAPSTONE DESIGN
CIV_ENV 395, 23 BIM/ Sustainable Building Systems	AE&D Integration Studio	CIV_ENV Elective— CIV_ENV 302
CIV_ENV Requirement— CIV_ENV 330	CIV_ENV Elective	Elective
Elective	CIV_ENV Elective	Elective

¹ CIV_ENV 222 recommended (offered Spring, Even Years)

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Example BSCE specialty concentration for Jr and Sr years

(Course offerings vary year to year. Consult your advisor)

2. **Environmental Engineering concentration** (see also the BS in Environmental Engineering program for suggested electives).

Quarter 7	Quarter 8	Quarter 9
CIV_ENV Requirement— CIV_ENV 250	CIV_ENV Elective or Basic Engineering	Basic Engineering
CIV_ENV Requirement— CIV_ENV 221	CIV_ENV Requirement— CIV_ENV 325	CIV_ENV Elective— CIV_ENV 222 ¹ CIV_ENV Requirement— CIV_ENV 340
CIV_ENV 363	CIV_ENV Elective— CIV_ENV 364	Math Techniques
Elective (Humanities)	Elective (Humanities)	Elective (Humanities)

Quarter 10	Quarter 11	Quarter 12
CIV_ENV Requirement— CIV_ENV 371 or 376	CIV_ENV Elective —CIV_ENV 361	Elective
CIV_ENV Elective— CIV_ENV 367	CIV_ENV Elective	CIV_ENV Requirement— CIV_ENV 382 (CAPSTONE DESIGN)
CIV_ENV Requirement— CIV_ENV 330	CIV_ENV Elective— CIV_ENV 365	Elective
Elective	Elective	Elective

Typical Electives in CIV_ENV: 302, 306, 355, 360, 361, 363, 364, 365, 367. Selected 400-level courses, such as 440, 441, and 444 may be taken with permission of the instructor, and a permission number from j-soule@northwestern.edu.

¹ CIV_ENV 222 recommended (offered Spring, Even Years)

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Example BSCE specialty concentration for Jr and Sr years
(continued)

3. **Geotechnics concentration.** This program is only an example.

<i>Quarter 7</i>	<i>Quarter 8</i>	<i>Quarter 9</i>
CIV_ENV Requirement— CIV_ENV 221	CIV_ENV Requirement— CIV_ENV 325	CIV_ENV Elective— CIV_ENV 222 CIV_ENV Requirement— CIV_ENV 340
CIV_ENV Requirement— CIV_ENV 250	CIV_ENV Elective	Basic Engineering or CIV_ENV Elective
Math Techniques ³	CIV_ENV Recommendation CIV_ENV 352 ¹	CIV_ENV Recommendation ²
Elective (Humanities)	Elective (Humanities)	Elective (Humanities)

<i>Quarter 10</i>	<i>Quarter 11</i>	<i>Quarter 12</i>
CIV_ENV Requirement— CIV_ENV 371 or 376	CIV_ENV Elective ²	CIV_ENV Requirement ¹
CIV_ENV Requirement— CIV ENG 330	CIV_ENV Elective	Elective or Math Techniques
CIV_ENV Elective ⁴	Elective	Elective ²
Elective ³	CIV_ENV Elective	CIV_ENV Requirement— CIV_ENV 382 (CAPSTONE DESIGN)

Typical Electives in CIV_ENV: 302, 306, 307, 327, 332, 336, 352, 355, 358. Selected graduate courses such as 413, 417, 423 and 451 may be taken with the permission of instructor and a permission number from j-soule@northwestern.edu.

¹ CIV_ENV 352 (offered Winter, Odd Years).

² CIV_ENV 222 (offered Spring, Even Years) or 355 (Spring, Odd Years).

³ CIV_ENV 306 recommended.

⁴ CIV_ENV 358, 413, or 417 recommended

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Example BSCE specialty concentration for Jr and Sr years

4. **Structural Engineering concentration** and/or **Mechanics of Materials and Solids concentration**: To qualify for future registration as a structural engineer in the State of Illinois, the courses 320, 325, and either 352 or 421 must be completed.

<i>Quarter 7</i>	<i>Quarter 8</i>	<i>Quarter 9</i>
CIV_ENV Requirement— CIV_ENV 221	Basic Engineering or Elective	Basic Engineering or Elective
CIV_ENV Requirement— CIV_ENV 250	CIV_ENV Requirement— CIV_ENV 325	CIV_ENV Elective— CIV_ENV 222 ² CIV_ENV Elective ¹
Math Techniques ⁴	CIV_ENV Elective ³	CIV_ENV Requirement— CIV_ENV 340
Elective (Humanities)	Elective (Humanities)	Elective (Humanities)

<i>Quarter 10</i>	<i>Quarter 11</i>	<i>Quarter 12</i>
CIV_ENV Requirement— CIV_ENV 371 or 376	CIV_ENV Elective	CIV_ENV Requirement
Math Techniques ⁴	CIV_ENV Elective ³	Elective ²
CIV_ENV Requirement 330	Elective	Elective ³
Elective	CIV_ENV Elective	CIV_ENV Requirement— CIV_ENV 382 (CAPSTONE DESIGN)

Typical Electives in Civil Engineering: 302, 306, 307, 319, 320, 321, 327, 332, 334, 336, 338, 352, (413, 417, 421, 423 with permission of the instructor and a permission number from j-soule@northwestern.edu). **Note**: CIV_ENV 421 may not be offered in some years. Students interested in solid mechanics are urged to choose from the following electives group CIV_ENV: 327, 413, 417.

¹ CIV_ENV 302 recommended.

² CIV_ENV 222 recommended (offered Spring, Even Years).

³ Recommended: CIV_ENV 319 (Winter, Even Years), 320 (Winter, Odd Years), 321 (Spring, Odd Years) or 352 (Winter, Odd Years).

⁴ CIV_ENV 306 recommended.

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Example BSCE specialty concentration for Jr and Sr years
(continued)

5. **Transportation Systems Analysis and Planning concentration**

<i>Quarter 7</i>	<i>Quarter 8</i>	<i>Quarter 9</i>
CIV_ENV Requirement— CIV_ENV 371 or 376	Basic Engineering (Thermodynamics)	Math Tech (CIV_ENV 304)
Math Techniques CIV_ENV 306	Tech Elective (ECON 310-1)	CIV_ENV Elective ¹
CIV_ENV Requirement— CIV_ENV 250	Basic Engineering (Electrical Science)	CIV_ENV Requirement— CIV_ENV 340 or Tech Elective
Humanities Elective	Humanities Elective	Humanities Elective

<i>Quarter 10</i>	<i>Quarter 11</i>	<i>Quarter 12</i>
CIV_ENV Requirement— CIV_ENV 221	CIV_ENV Requirement— CIV_ENV 325	CIV_ENV Requirement— CIV_ENV 340 or Tech Elective CIV_ENV Recommended— CIV_ENV 222 ¹
Tech Elective (IEMS 304)	CIV_ENV Elective	CIV_ENV Requirement— CIV_ENV 382 (Capstone Design)
CIV_ENV Elective CIV_ENV 376	Tech Elective (ECON 355)	Tech Elective
CIV_ENV Requirement— CIV ENV 330	Humanities Elective	Elective

Note: At least 9 of the courses above must be CEE departmental courses. Required Capstone Design Course, CIV_ENV 382, is offered only in spring quarter. Other suggested design electives include CIV_ENV 352, and 360.

¹ CIV_ENV 222 recommended (offered Spring, Even Years)

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Example BSCE specialty concentration for Jr and Sr years
(continued)

6. For students interested in BS in Civil Engineering with a **Construction Management concentration**.

<i>Quarter 7</i>	<i>Quarter 8</i>	<i>Quarter 9</i>
CIV_ENV Requirement—221	CIV_ENV Requirement— CIV_ENV 325	CIV_ENV Recommended— CIV_ENV 222 ¹
CIV_ENV Requirement— CIV_ENV 250	Basic Engineering or CIV_ENV Elective	Basic Engineering or CIV_ENV Elective
CIV_ENV 306	CIV_ENV Elective	CIV_ENV Requirement—340
Humanities Elective	Humanities Elective	Humanities Elective

<i>Quarter 10</i>	<i>Quarter 11</i>	<i>Quarter 12</i>
CIV_ENV Requirement— CIV_ENV 371 or 376	CIV_ENV Elective	CIV_ENV Elective— CIV_ENV 302
CIV_ENV Requirement— CIV_ENV 330	CIV_ENV Elective	CIV_ENV Requirement— CIV_ENV 382 (Capstone Design)
CIV_ENV 338 or Elective	CIV_ENV 336 or CIV_ENV Elective	CIV_ENV 332
Elective	Elective	Elective

Typical Electives in Civil Engineering: 319, 320, 321, 336, 338, 352, 355, 358, 360, 363, 364, 367. Selected graduate courses such as 413, 417-1, 423, 434, and 451 with permission of instructor and permission number from j-soule@northwestern.edu .

Note: CIV_ENV 332 and CIV_ENV 336 have CIV_ENV 330 as a prerequisite. CIV_ENV 319 is offered only in Winter, Even Years. CIV_ENV 320 and 352 are offered only in Winter, Odd Years. CIV_ENV 421 may not be offered in some years.

Typical Electives in Industrial Engineering: 306, 326, 340, 342

¹ CIV_ENV 222 recommended (offered Spring, Even Years)

An Option to Combine Academics 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 work place 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.

YEAR	FALL	WINTER	SPRING	SUMMER
FRESHMAN 1	Quarter 1 Same as non CO-OP student's 1st year	Quarter 2 Same as non CO-OP student's 1st year	Quarter 3 Same as non CO-OP student's 1st year	VACATION
SOPHOMORE 2	Quarter 4 Same as non CO-OP student's 2nd year	Quarter 5 Same as non CO-OP student's 2nd year	Quarter 6 Same as non CO-OP student's 2nd year	CO-OP
JUNIOR 3	Quarter 7 Same as non CO-OP student's 3rd year	Quarter 8 Same as non CO-OP student's 3rd year	CO-OP	CO-OP
PRE- SENIOR 9	Quarter 9 Same as non CO-OP student's 4th year	CO-OP	Quarter 10 Same as non CO-OP student's 3rd year	CO-OP
SENIOR 4	CO-OP	Quarter 11 Same as non CO-OP student's 4th year	Quarter 12 Same as non CO-OP student's 4th year	DONE !!!

Course Descriptions

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

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-Qrtr 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).

ENVR_SCI 201 Earth: A 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 mechanics of reaction), industrial production, energy use, and public policy from an environmental perspective. **Prerequisites:** MATH 224; CHEM 103 or CHEM 172.

CIV_ENV 212-0 Mechanics

Force systems, equivalence of force systems, & resultants. Equilibrium of a rigid body and systems. Kinematics and dynamics of a rigid body in plane motion. Work & energy relations for a rigid body in plane motion. **Prerequisites:** PHYS135-1 & registered in MATH 234.

CIV_ENV 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_ENV 212 or GEN_ENG 205-2.

CIV_ENV 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_ENV 216.

CIV_ENV 222-0 Structural Steel Design

Rational basis of structural design. Design approach for structural steel components of a building system. **Prerequisite:** CIV_ENV 221.

MECH_ENG 241-0 Fluid Mechanics I

Fundamentals of fluid mechanics. Properties and statics of fluids. Kinematics and dynamics of fluid motion - continuity, momentum, and energy equations. Dimensional analysis, flow in closed conduits. **Prerequisite:** GEN_ENG 205-4.

CIV_ENV 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_ENV 216, completion of MECH_ENG 141 is recommended.

CIV_ENV 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_ENV 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_ENV 303-0 Environmental Law and Policy

An introduction to many important and interesting aspects of environmental law and policy. A wide range of environmental topics are covered focusing on national environmental policy as implemented through major federal environmental statutes. **Prerequisite:** Junior or Senior standing.

CIV_ENV 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; MATH 224 or equivalent (calculus and probability).

CIV_ENV 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_ENV 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_ENV 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_ENV 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_ENV 221.

CIV_ENV 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_ENV 221

CIV_ENV 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_ENV 216.

CIV_ENV 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_ENV 221.

CIV_ENV 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_ENV 216, and permission of instructor.

CIV_ENV 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_ENV 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_ENV 330 and permission of instructor.

CIV_ENV 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_ENV 330 or permission of instructor.

CIV_ENV 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_ENV 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_ENV 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_ENV 250.

CIV_ENV 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_ENV 340, and Pre-senior or senior standing.

CIV_ENV 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_ENV 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_ENV 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_ENV 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_ENV 364-0 Environmental Engineering Applications II: Water

Engineering elements of water supply and water pollution abatement. Water quality standards, water and wastewater treatment processes, and the management of receiving waters to control pollution. **Prerequisite:** MECH_ENG 241 and CIV_ENV 340.

CIV_ENV 365-0 Environmental Laboratory

Chemical and microbiological aspects of environmental engineering and science are explored through an integrated laboratory course. Junior standing.

CIV_ENV 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_ENV 368 Sustainability: Issues and Actions, Near and Far

The purpose of this course is to explore the issues that motivate the design and engineering of sustainable resource use and development. Case studies and examples from both developed and developing economies are discussed/compared.

CIV_ENV 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_ENV 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_ENV 382-0 CAPSTONE DESIGN

Culminating student team design experience in Civil and Environmental Engineering, with overview of function, design, and operation of modern infrastructure systems. **Prerequisite:** Senior standing in Civil and Environmental Engineering, or permission of instructor.

CIV_ENV 395-0 Special Topics in Civil Engineering

Undergraduate level experimental courses.

CIV_ENV 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_ENV 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_ENV 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_ENV 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_ENV 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_ENV 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_ENV 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_ENV 212 and MATH 240. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 417-1 or equivalent. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 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_ENV 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_ENV 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_ENV 221. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 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_ENV 430 Cohesive Fracture and Scaling

Essentials of linear fracture mechanics. Nonlinear cohesive fracture of concrete, rock, composites, ice, and ceramics. Crack band model, and smeared cracking. Cohesive softening materials models. Nonlocal theories. Micromechanics and random particle systems. Scaling laws, size effect and brittleness. Weibull's statistical theory. Effects of environment, loading rate, and cycles. Stability of crack systems, crack spacings, and width. Effect of reinforcement and bond slip. Ductility of beams and frames. Localization of softening damage. Relevance to structural design. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 436 Construction Contracts and Dispute Resolutions

Contracts as part of the project delivery system. Components of a construction contract. Intended and unintended contract changes. Payment Process. Trade union influences. Negotiations. Alternative dispute resolution. Mechanics liens. Risk management through insurance. **Prerequisite:** CIV_ENV 330-0 or permission of instructor.

CIV_ENV 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 CEE's Academic Coordinator (j-soule@northwestern.edu).

CIV_ENV 441-0 Methods in Microbial Complexity

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

CIV_ENV 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_ENV 440, CIV_ENV 441, and CIV_ENV 467. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 367, CIV_ENV 440 or equivalent. **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:** Instructor permission/Permission Number from Academic Coordinator (j-soule@northwestern.edu).

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:** Instructor permission/Permission Number from Academic Coordinator (j-soule@northwestern.edu).

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

450-1: Shear strength of soils. Theory of consolidation. Problems of rate-independent and rate-dependent settlement. 450-2: Foundation engineering. Bearing capacity of shallow and deep foundations. Deformation of foundations. Effects of construction on performance. Case studies. 450-3: Earth and earth-supported structures. Earth pressures on walls. Design of retaining structures and supported excavations. Effects of construction on performance. Stability of slopes. Design of earth dams and embankments. Case studies. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 250. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 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_ENV 450-1 or **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 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_ENV 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 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:** Instructor permission/Permission Number from Academic Coordinator (j-soule@northwestern.edu).

CIV_ENV 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_ENV 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_ENV 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_ENV 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_ENV 306. **Prerequisite:** Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 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_ENV 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).

Design Content and Prerequisites for Courses in your Civil Engineering Major

Note: * Course offered only in odd-numbered calendar years; # Course offered only in even-numbered calendar years.

Course	Design Units	Prerequisites
CIV_ENV 212	(0)	PHYSICS 135-1, registration in MATH 234
CIV_ENV 216	(0.125)	CIV_ENV 212 or GEN_ENG 205-2
CIV_ENV 221	(0)	CIV_ENV 216
CIV_ENV 222	(1.0)	CIV_ENV 221
CIV_ENV 250	(0.25)	CIV_ENV 216, completion of MECH_ENG 241 is recommended
CIV_ENV 260	(0.25)	CHEM 101 and MATH 224-0 (concurrently)
CIV_ENV 302	(0.25)	Senior Standing
CIV_ENV 304	(0)	Jrs / Srs / MATH 224 or equivalent (calculus and probability)
CIV_ENV 306	(0)	MATH 230-0
CIV_ENV 307	(0.5)	Permission of Instructor
CIV_ENV 314	(0)	CIV_ENV 216, MATH 250, or GEN_ENG 205-4
CIV_ENV 319 #	(0)	CIV_ENV 221
CIV_ENV 320 *	(0.5)	CIV_ENV 221
CIV_ENV 321 *	(0)	CIV_ENV 216
CIV_ENV 325 #	(1.0)	CIV_ENV 221
CIV_ENV 327	(0.125)	MECH_ENG 262, MATH 215, or CIV_ENV 216. Permission of instructor
CIV_ENV 330	(0.5)	Senior standing in Engineering or Permission of Instructor
CIV_ENV 332	(0.25)	CIV_ENV 330 and permission of instructor.
CIV_ENV 336	(1.0)	CIV_ENV 330 and permission of instructor.
CIV_ENV 338	(0.5)	Senior standing.
CIV_ENV 340	(0.25)	BMD_ENG 270, CHEM_ENG 321, or MECH_ENG 241
CIV_ENV 349	(0)	Pre-senior or senior standing
CIV_ENV 352 *	(1.0)	CIV_ENV 250
CIV_ENV 355	(0.5)	Pre-senior or senior standing; CIV_ENV 340
CIV_ENV 358	(0.25)	Junior standing or permission of instructor.

CIV_ENV 360	(1.0)	Junior Standing
CIV_ENV 361	(0.25)	Junior Standing
CIV_ENV 363	(0.5)	Junior Standing
CIV_ENV 364	(0.5)	MECH_ENG 241, CIV_ENV 340 recommended
CIV_ENV 365	(0.125)	Junior Standing.
CIV_ENV 367	(0.125)	CHEM 103
CIV_ENV 371	0.25)	Junior Standing in engineering or permission of instructor
CIV_ENV 376	(0.75)	Junior Standing and basic knowledge of calculus and statistics. Knowledge of MATLAB is desirable, but not required.
CIV_ENV 382	(1.0)	Culminating student team design experience for all CEE Seniors.
CIV_ENV 395	(1.0 or varies)	Varies
CIV_ENV 398-1,2	(1.0)	Jr/Sr Standing in BSEE or BSCE <u>and</u> permission of instructor
CIV_ENV 399	(Varies)	Permission of instructor

NOTE

The following courses require permission of the instructor and a permission numbers from Academic Coordinator, j-soule@northwestern.edu

CIV_ENV 413	(0.25)	CIV_ENV 216
CIV_ENV 417-1	(0)	GEN_ENG 205-2,3 or CIV_ENV 212 and MATH 240
CIV_ENV 421	(1.0)	CIV_ENV 325
CIV_ENV 423	(0)	CIV_ENV 221
CIV_ENV 434	(0)	CIV_ENV 330
CIV_ENV 440	(0.25)	PHYSICS 135-2; MECH_ENG 241 or equivalent
CIV_ENV 441	(0.125)	CIV_ENV 367
CIV_ENV 446	(0)	CIV_ENV 367
CIV_ENV 451	(0.5)	CIV_ENV 250 or equivalent
CIV_ENV 457	(0.25)	Permission of Instructor

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 Civil Engineering program.

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

Bachelor of Science in Civil Engineering (BSCE) Educational Objectives and Program Outcomes

<i>BSCE Educational Objectives</i>	<i>BSCE Program Outcomes</i> <i>described with</i> Accrediting Board for Engineering and Technology (ABET)’s Criteria (a-k)
<p>A. Graduates employ their knowledge of science, mathematics, and engineering in civil and environmental engineering practice, research, and management as well as other professional fields such as law, medicine, finance and management.</p>	<p>(a) Ability to apply knowledge of mathematics, science, and engineering (including probability and statistics). (b) Ability to design and conduct experiments, as well as to analyze and interpret data in at least 4 recognized areas.* (e) Ability to identify, formulate and solve engineering problems in at least 4 recognized areas.* (k) Ability to use the techniques, skills, and modern engineering tools necessary for professional engineering practice.</p>
<p>B. Graduates become leaders in organizations that focus on advanced problem solving for complex systems in multidisciplinary settings.</p>	<p>(c) Ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability. (d) Ability to function on multidisciplinary teams. (e) ability to identify, formulate and solve engineering problems in at least 4 recognized areas.* (g) Ability to communicate effectively. (h) Ability to understand the impact of engineering solutions in a global, economic, environmental and societal context. (k) Ability to use the techniques, skills, and modern engineering tools necessary for professional engineering practice.</p>

<i>BSCE Educational Objectives</i>	<i>BSCE Program Outcomes</i> <i>described with</i> Accrediting Board for Engineering and Technology (ABET)'s Criteria (a-k)
C. Graduates play key roles in the process of constructing and managing local and global civil and environmental infrastructure systems	(d) Ability to function on multidisciplinary teams. (f) Understanding of professional and ethical responsibility. (g) Ability to communicate effectively. (h) Ability to understand the impact of engineering solutions in a global, economic, environmental and societal context. (j) Knowledge of contemporary issues.
D. Graduates are engaged in broadly conceived organizations that require a diversity of thought, creativity, and curiosity.	(d) Ability to function on multidisciplinary teams. (f) Understanding of professional and ethical responsibility. (g) Ability to communicate effectively. (h) Ability to understand the impact of engineering solutions in a global, economic, environmental and societal context. (i) Recognition of the need for, and an ability to engage in lifelong learning. (j) Knowledge of contemporary issues

Emboldened Outcomes are part of the *American Society of Civil Engineers (ASCE)* definition of Professional Practice: Procurement of work, bidding versus quality-based selection processes, how design professionals and construction professionals interact to construct a project, the importance of professional licensure and continuing education, and other professional practice issues. *ASCE recognized areas include Environment, Fluids, Geotechnics, Structures, and Transportation.