Civil and Environmental Engineering

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For the Degree of Bachelor of Science in Civil Engineering

Civil engineering is a profession that applies the basic principles of science in conjunction with mathematical and computational tools to solve problems associated with developing and sustaining civilized life on our planet. Civil engineering works are generally one-of-a-kind projects; they are often grand in scale; and they usually require cooperation among professionals of many different disciplines. The completion of a civil engineering project involves the solution of technical problems in which uncertainty of information and myriad non-technical factors often play a significant role. Some of the most common examples of civil engineering works include bridges, buildings, dams, airports, highways, tunnels, and water distribution systems. Civil engineers are concerned with flood control, landslides, air and water pollution, and the design of facilities to withstand earthquakes and other natural hazards, in addition to protecting our environment for a sustainable future.

The civil engineering program comprises seven main areas (construction engineering and management, construction materials engineering, environmental engineering, geotechnical engineering, environmental hydrology and hydraulics, structural engineering, and transportation engineering) and three cross-cutting programs (sustainable and resilient infrastructure systems; energy, water, and environmental sustainability; and societal risk management). Although each area has its own special body of knowledge and engineering tools, they all rely on the same fundamental core principles. Civil engineering projects often draw expertise from many of these areas and programs.

CEE’s Program Education Objectives are to educate CEE students to:

1. Successfully enter the civil and environmental engineering profession as practicing engineers and consultants with prominent companies and organizations in diverse areas that include structural, transportation, geotechnical, materials, environmental, and hydrologic engineering; construction management; or other related or emerging fields.
2. Pursue graduate education and research at major research universities in civil and environmental engineering, and related fields.
3. Pursue professional licensure.
4. Advance to leadership positions in the profession.
5. Engage in continued learning through professional development.
6. Participate in and contribute to professional societies and community services.

Program Review and Approval

To qualify for the degree of Bachelor of Science in Civil Engineering, each student’s academic program plan must be reviewed by a standing committee of the faculty (the Program Review Committee) and approved by the Associate Head of Civil and Environmental Engineering in charge of undergraduate programs. This review and approval process ensures that individual programs satisfy the educational objectives and all of the requirements of the civil engineering program, that those programs do not abuse the substantial degree of flexibility that is present in the curriculum, and that the career interests of each student are cultivated and served.

Overview of Curricular Requirements

The curriculum requires 128 hours for graduation and is organized as follows.

Orientation and Professional Development

These courses introduce the opportunities and resources your college, department, and curriculum can offer you as you work to achieve your career goals. They also provide the skills to work effectively and successfully in the engineering profession.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 195</td>
<td>About Civil Engineering</td>
<td>1</td>
</tr>
<tr>
<td>CEE 495</td>
<td>Professional Practice</td>
<td>0</td>
</tr>
<tr>
<td>ENG 100</td>
<td>Engineering Orientation</td>
<td>0</td>
</tr>
<tr>
<td>Total Hours</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

1. External transfer students take ENG 300.

Foundational Mathematics and Science

These courses stress the basic mathematical and scientific principles upon which the engineering discipline is based.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 102</td>
<td>General Chemistry I</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 103</td>
<td>General Chemistry Lab I</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 104</td>
<td>General Chemistry II</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 105</td>
<td>General Chemistry Lab II</td>
<td>1</td>
</tr>
<tr>
<td>MATH 221</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 225</td>
<td>Introductory Matrix Theory</td>
<td>2</td>
</tr>
<tr>
<td>MATH 231</td>
<td>Calculus II</td>
<td>3</td>
</tr>
<tr>
<td>MATH 241</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>MATH 285</td>
<td>Intro Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 211</td>
<td>University Physics: Mechanics</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 212</td>
<td>University Physics: Elec &amp; Mag</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 213</td>
<td>Univ Physics: Thermal Physics</td>
<td>2</td>
</tr>
<tr>
<td>Total Hours</td>
<td></td>
<td>34</td>
</tr>
</tbody>
</table>

1. MATH 220 may be substituted, with four of the five credit hours applying toward the degree. MATH 220 is appropriate for students with no background in calculus.

Civil Engineering Technical Core

These courses stress fundamental concepts and basic laboratory techniques that comprise the common intellectual understanding of civil engineering.

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 201</td>
<td>Systems Engrg &amp; Economics</td>
<td>3</td>
</tr>
<tr>
<td>CEE 202</td>
<td>Engineering Risk &amp; Uncertainty</td>
<td>3</td>
</tr>
<tr>
<td>CS 101</td>
<td>Intro Computing: Engrg &amp; Sci</td>
<td>3</td>
</tr>
<tr>
<td>GE 101</td>
<td>Engineering Graphics &amp; Design</td>
<td>3</td>
</tr>
<tr>
<td>TAM 211</td>
<td>Statics</td>
<td>3</td>
</tr>
<tr>
<td>TAM 212</td>
<td>Introductory Dynamics</td>
<td>3</td>
</tr>
</tbody>
</table>

Information listed in this catalog is current as of 04/2016
Civil and Environmental Engineering

TAM 251  Introduction to Solid Mechanics  3
TAM 335  Introduction to Fluid Mechanics  4
Total Hours  25

Science Elective
This elective allows the student to gain additional depth in science. The course should be selected according to the requirements and recommendations for the selected area of study, which is subject to approval by the faculty Program Review Committee.

Science elective, selected in accord with recommendations for the chosen primary field in civil engineering as outlined in the Civil Engineering Undergraduate Handbook. 1

1 Civil Engineering Undergraduate Handbook (http://cee.illinois.edu/handbooks).

Civil Engineering Technical Electives
This course work is designed to give each student a broad background in the areas of civil engineering through the core courses and to allow each student to develop a focused program through advanced technical electives in chosen primary and secondary fields. There are seven areas of study which include:

- Construction Engineering and Management
- Construction Materials Engineering
- Environmental Engineering
- Environmental Hydrology and Hydraulic Engineering
- Geotechnical Engineering
- Structural Engineering
- Transportation Engineering

In addition to the areas of study, three cross-cutting programs can be chosen by students. They include:

- Sustainable and Resilient Infrastructure Systems
- Energy-Water-Environment Sustainability
- Societal Risk Management

The fundamental principles of civil engineering design and the behavior of civil engineering systems are emphasized throughout the course work. The specific choices of courses in this category are made through the submission of the Plan of Study, which is subject to approval by the faculty Program Review Committee.

Civil engineering technical courses, selected as follows, to at least include:

- Construction Engineering and Management
- Construction Materials Engineering
- Environmental Engineering
- Environmental Hydrology and Hydraulic Engineering
- Geotechnical Engineering
- Structural Engineering
- Transportation Engineering

Civil Engineering Core Courses
The courses that are required and recommended for the primary and secondary fields are listed in the Civil Engineering Undergraduate Handbook. Select at least 5 courses from the following list: 1

1 Civil Engineering Undergraduate Handbook (http://cee.illinois.edu/handbooks).

CEE 300  Behavior of Materials  4
CEE 310  Transportation Engineering  3
CEE 320  Construction Engineering  3
CEE 330  Environmental Engineering  3
CEE 340  Energy and Global Environment  3
CEE 350  Water Resources Engineering  3
CEE 360  Structural Engineering  3

CEE 380  Geotechnical Engineering  3
Primary Field Advanced Technical Electives. Select courses from approved lists for appropriate programs of study within the seven areas or three cross-cutting programs of civil engineering. Design experience is distributed in 200-level, 300-level, and 400-level CEE courses including integrated design courses. Course lists can be found in the Civil Engineering Undergraduate Handbook. 1

Secondary Field Advanced Technical Electives. Select courses from approved lists to complement the primary area and add breadth to the program of study. Course lists can be found in the Civil Engineering Undergraduate Handbook. 1

1 Civil Engineering Undergraduate Handbook (http://cee.illinois.edu/handbooks).

Liberal Education
The liberal education courses (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Liberal+Education+Electives) develop students' understanding of human culture and society, build skills of inquiry and critical thinking, and lay a foundation for civic engagement and lifelong learning.

ECON 102  Microeconomic Principles (Recommended)  3
or ECON 103  Macroeconomic Principles  3
Electives from the campus General Education Social and Behavioral Sciences list.  3
Electives from the campus General Education Humanities and the Arts list.  6
Electives either from a list approved by the college, or from the campus General Education lists for Social and Behavioral Sciences or Humanities and the Arts.  6

Total Hours  18

Students must also complete the campus cultural studies requirement by completing (i) one western/comparative culture(s) course and (ii) one non-western/U.S. minority culture(s) course from the General Education cultural studies lists. Most students select liberal education courses that simultaneously satisfy these cultural studies requirements. Courses from the western and non-western lists that fall into free electives or other categories may also be used satisfy the cultural studies requirements.

Composition
These courses teach fundamentals of expository writing.

RHET 105  Writing and Research  4
BTW 261  Principles Tech Comm (satisfies the Advanced Composition requirement)  3

Total Hours  7

Free Electives
These unrestricted electives, subject to certain exceptions as noted at the College of Engineering Advising Website (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Free+Electives?src=search), give the student the opportunity to explore any intellectual area of unique interest. This freedom plays a critical role in helping students to define research specialties or to complete minors.
Free electives. Additional unrestricted course work, subject to certain exceptions as noted at the College of Engineering advising Web site, so that there are at least 128 credit hours earned toward the degree.

**Suggested Sequence**

The schedule that follows is illustrative, showing the typical sequence in which courses would be taken by a student with no college course credit already earned and who intends to graduate in four years. Each individual’s case may vary, but the position of required named courses is generally indicative of the order in which they should be taken.

**First Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 195</td>
<td>About Civil Engineering</td>
</tr>
<tr>
<td>CHEM 102</td>
<td>General Chemistry I</td>
</tr>
<tr>
<td>CHEM 103</td>
<td>General Chemistry Lab I</td>
</tr>
<tr>
<td>ENG 100</td>
<td>Engineering Orientation</td>
</tr>
<tr>
<td>GE 101</td>
<td>Engineering Graphics Design</td>
</tr>
<tr>
<td>or RHET</td>
<td>or GE</td>
</tr>
<tr>
<td>MATH 221</td>
<td>Calculus I</td>
</tr>
<tr>
<td>Liberal education elective</td>
<td>3</td>
</tr>
<tr>
<td>Semester Hours</td>
<td>15-16</td>
</tr>
</tbody>
</table>

**Second Semester**

| CHEM 104 | General Chemistry II             | 3     |
| CHEM 105 | General Chemistry Lab II         | 1     |
| MATH 225 | Introductory Matrix Theory       | 2     |
| MATH 231 | Calculus II                      | 3     |
| PHYS 211 | University Physics: Mechanics    | 4     |
| or RHET | or GE                            | 105   |
| Writing and Research               | 4-3   |
| Liberal education elective        | 3     |
| Semester Hours                    | 17-16 |

**Second Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 201</td>
<td>Systems Engrg Economics</td>
</tr>
<tr>
<td>MATH 241</td>
<td>Calculus III</td>
</tr>
<tr>
<td>PHYS 212</td>
<td>University Physics: Elec Mag</td>
</tr>
<tr>
<td>TAM 211</td>
<td>Statics</td>
</tr>
<tr>
<td>Free elective</td>
<td>3</td>
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<tr>
<td>Semester Hours</td>
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<table>
<thead>
<tr>
<th>Second Semester</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 202</td>
<td>Engineering Risk Uncertainty</td>
</tr>
<tr>
<td>CS 101</td>
<td>Intro Computing: Engrg Sci</td>
</tr>
<tr>
<td>PHYS 213</td>
<td>Univ Physics: Thermal Physics</td>
</tr>
<tr>
<td>TAM 212</td>
<td>Introductory Dynamics</td>
</tr>
<tr>
<td>TAM 251</td>
<td>Introductory Solid Mechanics</td>
</tr>
<tr>
<td>Liberal education elective</td>
<td>3</td>
</tr>
<tr>
<td>Semester Hours</td>
<td>17</td>
</tr>
</tbody>
</table>

**Third Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 285</td>
<td>Intro Differential Equations</td>
</tr>
<tr>
<td>TAM 335</td>
<td>Introductory Fluid Mechanics</td>
</tr>
<tr>
<td>Civil engineering technical courses</td>
<td>6</td>
</tr>
<tr>
<td>Science elective</td>
<td>3</td>
</tr>
<tr>
<td>Semester Hours</td>
<td>16</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Second Semester</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>BTW 261</td>
<td>Principles Tech Comm</td>
</tr>
<tr>
<td>Civil engineering technical courses</td>
<td>10</td>
</tr>
<tr>
<td>Liberal education elective</td>
<td>3</td>
</tr>
<tr>
<td>Semester Hours</td>
<td>16</td>
</tr>
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</table>

**Fourth Year**

<table>
<thead>
<tr>
<th>First Semester</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 495</td>
<td>Professional Practice</td>
</tr>
<tr>
<td>Civil engineering technical courses</td>
<td>9</td>
</tr>
<tr>
<td>Liberal education electives</td>
<td>6</td>
</tr>
<tr>
<td>Semester Hours</td>
<td>15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second Semester</th>
<th>Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Civil engineering technical courses</td>
<td>10</td>
</tr>
<tr>
<td>Liberal education elective</td>
<td>3</td>
</tr>
<tr>
<td>Free elective</td>
<td>3</td>
</tr>
<tr>
<td>Semester Hours</td>
<td>16</td>
</tr>
</tbody>
</table>

| Total Hours                         | 129   |

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1. *Offered in the fall semester should be taken in the first or second semester of enrollment in Civil Engineering.*

2. *RHET 105 may be taken in the first or second semester of the first year as authorized. The alternative is GE 101.*

3. *MATH 220 may be substituted, with four of the five credit hours applying toward the degree. MATH 220 is appropriate for students with no background in calculus.*

4. *Liberal education electives (https://wiki.cites.illinois.edu/wiki/display/ugadvise/Liberal+Education+Electives) must include 6 hours of social & behavioral sciences and 6 hours of humanities & the arts course work from the campus General Education lists. ECON 102 or ECON 103 must be one of the social & behavioral sciences courses. The remaining 6 hours may be selected from a list maintained by the college, or additional course work from the campus General Education lists for social & behavioral sciences or humanities & the arts. Students must also complete the campus cultural studies requirement by completing (i) one western/comparative culture(s) course and (ii) one non-western/U.S. minority culture(s) course from the General Education cultural studies lists. Most students select liberal education courses that simultaneously satisfy these cultural studies requirements. Courses from the western and non-western lists that fall into free electives or other categories may also be used satisfy the cultural studies requirements.*

5. *Civil engineering technical courses are defined as core courses and advanced technical electives and must total 34 hours of credit. Five courses and a minimum of fifteen hours must be core courses as outlined in the Civil Engineering Undergraduate Handbook. (http://cee.illinois.edu/handbooks) Advanced technical electives are selected to correspond with chosen primary and secondary areas of emphasis in civil engineering as outlined in the Civil Engineering Undergraduate Handbook. (http://cee.illinois.edu/handbooks) A minimum of twelve and six hours must be taken for the primary and secondary areas, respectively.*
Courses

CEE 195  About Civil Engineering  credit: 1 Hour.
Civil engineering orientation including historical developments, education requirements, relation to science, professional practice, and specialties within the profession.

CEE 199  Undergraduate Open Seminar  credit: 1 to 5 Hours.
May be repeated.

CEE 201  Systems Engrg & Economics  credit: 3 Hours.
Introduction to the formulation and solution of civil engineering problems. Major topics: engineering economy, mathematical modeling, and optimization. Application of techniques, including classical optimization, linear and nonlinear programming, network theory, critical path methods, simulation, decision theory, and dynamic programming to a variety of civil engineering problems. Credit is not given for both CEE 201 and IE 310. Prerequisite: MATH 231; credit or concurrent registration in MATH 225.

CEE 202  Engineering Risk & Uncertainty  credit: 3 Hours.
Identification and modeling of non-deterministic problems in civil engineering design and decision making. Development of stochastic concepts and simulation models, and their relevance to real design and decision problems in various areas of civil engineering. Credit is not given for both CEE 202 and IE 300. Prerequisite: Recommended: Credit or concurrent registration in MATH 241.

CEE 300  Behavior of Materials  credit: 4 Hours.
Macroscopic mechanical behavior in terms of phenomena at the nanometer and micrometer levels for the three types of engineering materials (metals, ceramics, and polymers) with emphasis on specific materials used in civil engineering -- steel, rocks, clay, portland cement concrete, asphaltic concrete, and wood. Same as TAM 324. Credit is not given for both CEE 300 and either ME 330 or MSE 280. Prerequisite: Completion of Composition I general education requirement; CHEM 104; TAM 251.

CEE 310  Transportation Engineering  credit: 3 Hours.
Design, planning, operation, management, and maintenance of transportation systems; integrated multi-modal transportation systems (highways, air, rail, etc.); layout of highways, airports, and railroads with traffic flow models, capacity analysis, and safety. Design of facilities and systems with life cycle costing procedures and criteria for optimization. Prerequisite: TAM 251; credit or concurrent registration in CEE 202.

CEE 320  Construction Engineering  credit: 3 Hours.
Construction engineering processes: contracting and bonding, planning and scheduling, estimating and project control, productivity models, and construction econometrics. Prerequisite: CEE 201; credit or concurrent registration in CS 101 and CEE 202.

CEE 330  Environmental Engineering  credit: 3 Hours.
Sources, characteristics, transport, and effects of air and water contaminants; biological, chemical, and physical processes in water; atmospheric structure and composition; unit operations for air and water quality control; solid waste management; environmental quality standards. Prerequisite: CHEM 104.

CEE 340  Energy and Global Environment  credit: 3 Hours.
Introduction to evaluating multiple impacts of engineering decisions. Topics include mass and chemical balances; effects of engineered systems on local and global environment, health, and risk; economic, consumer, and social considerations; provision of conventional and renewable energy; and future projections. Design projects emphasize making appropriate decisions by quantifying total impact and evaluating social environment. Approved for both letter and S/U grading. Prerequisite: PHYS 211; PHSY 213; CEE 201 or IE 310; CEE 202, IE 300, or STAT 200; or permission of instructor. CEE students only.

CEE 350  Water Resources Engineering  credit: 3 Hours.
Quantitative aspects of water in the earth's environment and its engineering implications, including design and analysis of systems directly concerned with use and control of water; quantitative introduction to hydrology, hydraulic engineering, and water resources planning. Prerequisite: CEE 202; credit or concurrent registration in TAM 335 and CEE 201.

CEE 360  Structural Engineering  credit: 3 Hours.
Analysis, behavior, and design of trusses and framed structures under static loads; member forces in trusses, shear and moment diagrams, deflections, simple applications of the force method and slope-deflection; computer applications. Prerequisite: TAM 251.

CEE 380  Geotechnical Engineering  credit: 3 Hours.
Classification of soils, compaction in the laboratory and in the field, soil exploration, boring and sampling, permeability of soils, one-dimensional settlement analyses, strength of soil, and foundations. Prerequisite: TAM 251.

CEE 398  Special Topics  credit: 0 to 4 Hours.
Subject offerings of new and developing areas of knowledge in civil and environmental engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. Approved for letter and S/U grading. May be repeated in the same or separate terms if topics vary.

CEE 401  Concrete Materials  credit: 4 Hours.
Examination of the influence of constituent materials (cements, water, aggregates and admixtures) on the properties of fresh and hardened concrete, concrete mix design, handling and placement of concrete, and behavior of concrete under various types of loading and environment. Laboratory exercises utilize standard concrete test methods. Field trips are held during some scheduled laboratory sessions. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 300.

CEE 405  Asphalt Materials I  credit: 3 or 4 Hours.
Properties and control testing of bituminous materials, aggregates for bituminous mixtures, and analysis and design of asphalt concrete and liquid asphalt cold mixtures; structural properties of bituminous mixes; surface treatment design; recycling of mixtures. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

CEE 406  Pavement Design I  credit: 3 or 4 Hours.
Analysis, behavior, performance, and structural design of highway flexible and rigid pavements; climate factors, drainage, traffic loading analysis, and life cycle cost analysis. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

CEE 407  Airport Design  credit: 3 or 4 Hours.
Basic principles of airport facilities design to include aircraft operational characteristics, noise, site selection, land use compatibility, operational area, ground access and egress, terminals, ground service areas, airport capacity, and special types of airports. 3 undergraduate hours. 3 or 4 graduate hours.
CEE 408 Railroad Transportation Engineering credit: 3 or 4 Hours.
Principles and analysis of railroad transportation efficiency, economics, energy, and engineering; effect on production and markets. Railroad infrastructure; locomotive and rolling stock design, function, and operation. Computation of train speed, power, and acceleration requirements; railway traffic control and signaling. Quantitative analytical tools for rail-transportation decision-making and optimization. Field trip to observe railroad infrastructure, equipment and operations. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

CEE 409 Railroad Track Engineering credit: 3 or 4 Hours.
Railroad track engineering concepts including track component and system design, construction, evaluation, maintenance, load distribution, and wheel-rail interaction. Design and analysis tools for railroad track engineering and maintenance. Field trip to observe railroad track system and components. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

CEE 410 Railway Signaling & Control credit: 3 or 4 Hours.
Railway traffic control and signaling systems; train performance and scheduling tools; analysis of temporal and spatial separation of trains for safety and efficiency; train movement authority and operating rules, track circuit and wireless train position monitoring technology; interlocking design; railroad capacity modeling tools; economic analysis of traffic control system design, optimization, and selection. Field trip to observe signal system infrastructure and railway traffic operations control center. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

CEE 411 RR Project Design & Constr credit: 3 or 4 Hours.
Critical elements in the development and planning of railroad construction projects; project economic justification; route alternative analysis procedures; cost estimation; site civil design; computer-aided track design; surveying; construction management; construction procedures for typical railroad projects. Design project covering a typical railroad capital construction projects. Field trip to observe the construction of a railroad capital project. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

CEE 412 High-Speed Rail Engineering credit: 3 or 4 Hours.
Development, engineering, design and construction of high-speed rail (HSR) passenger transport systems with particular emphasis on the unique engineering elements of HSR technology. Key elements of HSR systems and subsystems including: core systems (trains, power, signal, communication and control), track system and civil infrastructure (earthwork, bridges, viaducts and tunnels). Also covered are basic design and construction of HSR stations and rolling stock maintenance facilities. 3 undergraduate hours. 4 graduate hours.

CEE 415 Geometric Design of Roads credit: 4 Hours.
Highway classification; analysis of factors in developing a transportation facility; highway geometrics design and safety standards; roadway design element; human factors in roadway design; roadway location principles; intersection, interchange, and ramp design; drainage factors. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 310.

CEE 416 Traffic Capacity Analysis credit: 3 or 4 Hours.
Fundamentals of traffic engineering; analysis of traffic stream characteristics; capacity of urban and rural highways; design and analysis of traffic signals and intersections; traffic control; traffic impact studies; traffic accidents. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

CEE 417 Urban Transportation Planning credit: 4 Hours.
Same as UP 430. See UP 430.

CEE 418 Public Transportation Systems credit: 3 or 4 Hours.
Transit systems basics, demand issues, design standards, economic and sustainability implications. Transit service planning for shuttle, corridor, and network systems, hybrid hierarchical systems, paratransit and demand-responsive services. Management of transit systems, fleet operations, and crew scheduling. Operational issues, vehicle movement, headway and schedule control. 3 undergraduate hours. 4 graduate hours. Prerequisite: CEE 310 or equivalent.

CEE 420 Construction Productivity credit: 3 or 4 Hours.
Application of scientific principles to the measurement and forecasting of productivity in construction engineering. Conceptual and mathematical formulation of labor, equipment, and material factors affecting productivity. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 320.

CEE 421 Construction Planning credit: 3 or 4 Hours.
Project definition; scheduling and control models; material, labor, and equipment allocation; optimal schedules; project organization; documentation and reporting systems; management and control. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 320.

CEE 422 Construction Cost Analysis credit: 3 or 4 Hours.
Application of scientific principles to costs and estimates of costs in construction engineering; concepts and statistical measurements of the factors involved in direct costs, general overhead costs, cost markups, and profits; the fundamentals of cost recording for construction cost accounts and cost controls. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 320.

CEE 424 Sustainable Const Methods credit: 4 Hours.
Identification of cutting edge sustainable construction materials, technologies, and project management strategies for use in the construction industry and evaluation of their potential to reduce the negative environmental impacts of construction activity. Examination of the current LEED for New Construction rating system, and case study analysis of highly successful recent “green construction projects” through student team assignments and presentations. Preparation for the LEED Green Associate professional licensing exam. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 320; two of CEE 420, CEE 421, or CEE 422.

CEE 430 Ecological Quality Engineering credit: 2 Hours.
Characteristics of rivers and lakes which affect the management of domestic and industrial wastewaters; chemical hazards assessment, surveillance and biomonitoring, and review of regulations governing effluents. 2 undergraduate hours. 2 graduate hours. Prerequisite: CEE 330.

CEE 434 Environmental Systems I credit: 3 Hours.
Introduction to the concepts and applications of environmental systems analysis. Application of mathematical programming and modeling to the design, planning, and management of engineered environmental systems, regional environmental systems, and environmental policy. Economic analysis, including benefit-cost analysis and management structures. Concepts of tradeoff, non-inferior sets, single- and multi-objective optimization. Practical application to case studies to convey an understanding of the complexity and data collection challenges of actual design practice. 3 undergraduate hours. 3 graduate hours. Prerequisite: CEE 201 and CEE 330.
CEE 437 Water Quality Engineering  credit: 3 Hours.
Fundamental theory underlying the unit processes utilized in the treatment of water for domestic and industrial usage, and in the treatment of domestic and industrial wastewaters. 3 undergraduate hours. 3 graduate hours. Prerequisite: CEE 330; credit or concurrent registration in TAM 335.

CEE 438 Science & Environmental Policy  credit: 3 Hours.
Environmental treaties, the role of science and scientists in managing the national and global environment, effective science communication, scientific assessments, and the use of quantitative tools to inform policy decisions. 3 undergraduate hours. 3 graduate hours. Prerequisite: CEE 202 or IE 300, STAT 400, or equivalent introductory probability and statistics course. Senior and Graduate students.

CEE 440 Fate Cleanup Environs Pollutant  credit: 4 Hours.
Investigation of the regulatory and technical issues affecting solid and hazardous waste management, with an emphasis on the principles governing the transport, fate, and remediation of solid and hazardous waste in the subsurface, including advection, dispersion, sorption, interphase mass transfer, and transformation reactions. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 330.

CEE 442 Environmental Engineering Principles, Physical  credit: 4 Hours.
Analysis of the physical principles which form the basis of many water and air quality-control operations; sedimentation, filtration, inertial separations, flocculation, mixing, and principles of reactor design; energy flows, thermal pollution, earth's energy balance. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 437.

CEE 443 Env Eng Principles, Chemical  credit: 4 Hours.
Application of principles of chemical equilibrium and chemical kinetics to air and water quality. Thermodynamics, kinetics, acid-base chemistry, complexation, precipitation, dissolution, and oxidation-reduction. Applications. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 437.

CEE 444 Env Eng Principles, Biological  credit: 4 Hours.
Application of principles of biochemistry and microbiology to air and water quality, wastes, and their engineering management; biological mediated changes in water and in domestic and industrial wastewater. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 443.

CEE 445 Air Quality Modeling  credit: 4 Hours.
Practical and advanced approaches to pollutant transport and fate in the environment with emphasis on air pollution modeling, including aspects of pollutant dispersion, chemical transformation, and loss. Gaussian plume, chemical mass balance, chemical reaction, grid and trajectory models. Evaluation of models and the development of efficient air quality management strategies. Applications with use of regulatory USEPA air quality models. Same as ATMS 425. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 330 and credit or concurrent registration in TAM 335; or ATMS 302.

CEE 446 Air Quality Engineering  credit: 4 Hours.
Description and application of chemical and physical principles related to air pollutants, aerosol mechanics, attenuation of light in the atmosphere, air quality regulation, generation of air pollutants, methods to remove gaseous and particulate pollutants from gas streams, and atmospheric dispersion. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 330; credit or concurrent registration in TAM 335.

CEE 447 Atmospheric Chemistry  credit: 4 Hours.
Same as ATMS 420. See ATMS 420.

CEE 449 Environmental Engineering Lab  credit: 3 Hours.
Traditional analysis tools and techniques in analysis, control, and design of natural and engineered environmental systems including air, water, wastewater, solid and hazardous waste, and ecological systems. 4 undergraduate hours. 3 graduate hours. Prerequisite: CEE 437 or CEE 446.

CEE 450 Surface Hydrology  credit: 3 Hours.
Descriptive and quantitative hydrology dealing with the distribution, circulation, and storage of water on the earth's surface; principles of hydrologic processes; methods of analysis and their applications to engineering and environmental problems. 3 undergraduate hours. 3 graduate hours. Prerequisite: CEE 350.

CEE 451 Environmental Fluid Mechanics  credit: 3 Hours.
Incompressible fluid mechanics with particular emphasis on topics in analysis and applications in civil engineering areas; principles of continuity, momentum and energy, kinematics of flow and stream functions, potential flow, laminar motion, turbulence, and boundary-layer theory. 3 undergraduate hours. 3 graduate hours. Prerequisite: TAM 335.

CEE 452 Hydraulic Analysis and Design  credit: 3 Hours.
Hydraulic analysis and design of engineering systems: closed conduits and pipe networks; hydraulic structures, including spillways, stilling basins, and embankment seepage; selection and installation of hydraulic machinery. 3 undergraduate hours. 3 graduate hours. Prerequisite: TAM 335.

CEE 453 Urban Hydrology and Hydraulics  credit: 4 Hours.
Hydraulic analysis and design of urban, highway, airport, and small rural watershed drainage problems; discussion of overland and drainage channel flows; hydraulics of storm-drain systems and culverts; determination of design flow; runoff for highways, airports, and urban areas; design of drainage gutters, channels, sewer networks, and culverts. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 350.

CEE 457 Groundwater  credit: 3 Hours.
Physical properties of groundwater and aquifers, principles and fundamental equations of porous media flow and mass transport, well hydraulics and pumping test analysis, role of groundwater in the hydrologic cycle, groundwater quality and contamination. 3 undergraduate hours. 3 graduate hours. Prerequisite: CEE 350 and TAM 335.

CEE 458 Water Resources Field Methods  credit: 4 Hours.
Scientific principles of measurement technologies and protocols used for water-resources measurements and experimental design of field-scale water-resources and environmental studies. Planning field studies; instruments and protocols for surface-water, and water-quality sampling; description of data quality. One-half-day laboratory field trips to streamflow monitoring stations and groundwater monitoring wells nearby. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 350.

CEE 460 Steel Structures I  credit: 3 Hours.
Introduction to the design of metal structures; behavior of members and their connections; theoretical, experimental, and practical bases for proportioning members and their connections. 3 undergraduate hours. No graduate credit. Prerequisite: CEE 360.

CEE 461 Reinforced Concrete I  credit: 3 Hours.
Strength, behavior, and design of reinforced concrete members subjected to moments, shear, and axial forces; emphasis on the influence of the material properties on behavior. 3 undergraduate hours. No graduate credit. Prerequisite: CEE 360.
CEE 462 Steel Structures II  credit: 3 or 4 Hours.
Metal members under combined loads; connections, welded and bolted; moment-resistant connections; plate girders, conventional behavior, and tension field action. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 460.

CEE 463 Reinforced Concrete II  credit: 3 or 4 Hours.
Strength, behavior, and design of indeterminate reinforced concrete structures, with primary emphasis on slab systems; emphasis on the strength of slabs and on the available methods of design of slabs spanning in two directions, with or without supporting beams. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 461.

CEE 465 Design of Structural Systems  credit: 3 Hours.
Examination of the whole structural design process including definition of functional requirements, selection of structural scheme, formulation of design criteria, preliminary and computer-aided proportioning, and analysis of response, cost, and value. 3 undergraduate hours. No graduate credit. Prerequisite: Credit in either CEE 460 or CEE 461 with concurrent registration in the other.

CEE 466 Masonry Structures  credit: 3 or 4 Hours.
Analysis, design, and construction of masonry structures. Mechanical properties of clay and concrete masonry units, mortar, and grout. Compressive, tensile, flexural, and shear behavior of masonry structural components. Strength and behavior of unreinforced bearing walls. Detailed design of reinforced masonry beams, columns, structural walls with and without openings, and complete lateral-force resisting building systems. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 461.

CEE 468 Prestressed Concrete  credit: 3 or 4 Hours.
Strength, behavior, and design of prestressed reinforced concrete members and structures, with primary emphasis on pretensioned, precast construction; emphasis on the necessary coordination between design and construction techniques in prestressing. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 461.

CEE 469 Wood Structures  credit: 3 or 4 Hours.
Mechanical properties of wood, stress grades, and working stresses; effects of strength-reducing characteristics, moisture content, and duration of loading and causes of wood deterioration; glued-laminated timber and plywood; behavior and design of connections, beams, and beam-columns; design of buildings and bridges; other structural applications: trusses, rigid frames, arches, and pole-type buildings; prismatic plates and hyperbolic paraboloids. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 460 or CEE 461.

CEE 470 Structural Analysis  credit: 4 Hours.
Direct stiffness method of structural analysis; fundamentals and algorithms; numerical analysis of plane trusses, grids and frames; virtual work and energy principles; finite element method for plane stress and plane strain. 4 undergraduate hours. 4 graduate hours. Credit is not given for both CEE 470 and ME 471. Prerequisite: CEE 360.

CEE 471 Structural Mechanics  credit: 3 or 4 Hours.
Beams under lateral load and thrust; beams on elastic foundations; virtual work and energy principles; principles of solid mechanics, stress and strain in three dimensions; static stability theory; torsion; computational methods. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MATH 285 and TAM 251.

CEE 472 Structural Dynamics I  credit: 3 or 4 Hours.
Analysis of the dynamic response of structures and structural components to transient loads and foundation excitation; single-degree-of-freedom and multi-degree-of-freedom systems; response spectrum concepts; simple inelastic structural systems; systems with distributed mass and flexibility. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 360, MATH 285, and TAM 212.

CEE 480 Foundation Engineering  credit: 3 Hours.
Analysis and design of foundations, bearing capacity and settlement of foundations; stability of excavations and slopes; ground movements due to construction; analysis and design of excavations, retaining walls, slopes, and underground structures in soil and rock. 3 undergraduate hours. No graduate credit. Prerequisite: CEE 380.

CEE 483 Soil Mechanics and Behavior  credit: 4 Hours.
Composition and structure of soil; water flow and hydraulic properties; stress in soil; compressibility behavior and properties of soils; consolidation and settlement analysis; shear strength of soils; compaction and unsaturated soils; experimental measurements. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 380.

CEE 484 Applied Soil Mechanics  credit: 4 Hours.
Application of soil mechanics to earth pressures and retaining walls, stability of slopes, foundations for structures, excavations; construction considerations; instrumentation. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 483.

CEE 491 Decision and Risk Analysis  credit: 3 or 4 Hours.
Development of modern statistical decision theory and risk analysis, and application of these concepts in civil engineering design and decision making; Bayesian statistical decision theory, decision tree, utility concepts, and multi-objective decision problems; modeling and analysis of uncertainties, practical risk evaluation, and formulation of risk-based design criteria, risk benefit trade-offs, and optimal decisions. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 202.

CEE 493 Sustainable Design Eng Tech  credit: 4 Hours.
Quantitative sustainable design (QSD) and how to navigate engineering decision-making. Economic (life cycle costing, techno-economic assessment) and environmental (life cycle assessment, LCA) sustainability assessments, and how to link these tools to design decisions under uncertainty. Design of engineered technologies individually and in teams, with special attention to water infrastructure and bioenergy production. Semester-long design project that includes components from two of the following three CEE sub-disciplines: environmental, hydraulic, geotechnical. 4 undergraduate hours. 4 graduate hours. Prerequisite: CEE 340 or Graduate Standing.

CEE 495 Professional Practice  credit: 0 Hours.
Series of lectures by outstanding authorities on the practice of civil engineering and its relations to economics, sociology, and other fields of human endeavor. 0 undergraduate hours. 0 graduate hours. Approved for S/U grading only.

CEE 497 Independent Study  credit: 1 to 16 Hours.
Individual investigations or studies of any phase of civil engineering selected by the student and approved by the department. 1 to 4 undergraduate hours. 1 to 16 graduate hours. May be repeated. Prerequisite: Consent of instructor.
CEE 498  Special Topics  credit: 1 to 4 Hours.
Subject offerings of new and developing areas of knowledge in civil and environmental engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. 1 to 4 undergraduate hours. 1 to 4 graduate hours. May be repeated in the same or separate terms if topics vary.