Department of Civil and Environmental Engineering

135 Kaufman Hall
757-683-3753
http://www.odu.edu/cee

Mujde Erten-Unal, Interim Chair
Isao Ishibashi, Graduate Program Director

Department Description

The Civil and Environmental Engineering Department offers a variety of master's and doctoral degrees. The Department's graduate programs are structured to accommodate both the full-time and part-time students. Most of the graduate courses are offered in evenings, and many are offered at a distance. The available specialty areas include coastal, geotechnical, structural, transportation, and water resources engineering in Civil Engineering and a variety of sub-fields in Environmental Engineering. Distance learning master's degree programs in coastal engineering and environmental engineering are also available.

List of Degrees and Certificates

• Master of Engineering - Civil Engineering
• Master of Science, Engineering - Civil Engineering
• Master of Engineering - Environmental Engineering
• Master of Science, Engineering - Environmental Engineering
• Doctor of Philosophy, Engineering - Civil and Environmental Engineering
• Doctor of Engineering - Civil and Environmental Engineering
• Graduate Certificate in Coastal Engineering
• Advanced Engineering Certificate in Energy Systems

Master's Degrees

In this rapidly changing technological world, graduate degrees are highly desirable and most often master’s degrees are required to hold professional civil and environmental engineering positions in the industry, and in federal, state and municipal government agencies. The department’s graduate programs are designed to educate the technological leaders of the future in civil and environmental engineering, and are structured to accommodate both full-time and part-time students. The specialty areas include coastal, geotechnical, structural, transportation, and water resources engineering in civil engineering, and sub-fields in environmental engineering including water quality, water and wastewater treatment, hydrologic processes, water resources, environmental engineering microbiology, air quality, hazardous and solid waste, biofuels, nutrient cycling, and pollution prevention. For additional information, please request a departmental handbook from the graduate program director. Distance learning master degree programs in Coastal Engineering (MS) and Environmental Engineering (MS and ME) are available with/without allowed transfer credits.

Admission Information

Civil and Environmental master's degree applicants must have a bachelor's degree, preferably, in civil or environmental engineering with a strong background in mathematics and physical sciences. Each applicant must submit an essay of 500 words or less describing personal and academic goals, professional objectives, preparation for graduate study, and how the chosen program will help the applicant achieve these goals and objectives. Two letters of recommendation must be submitted from former or current professors, or employment supervisors. Regular admission to a master’s program generally requires an undergraduate GPA of 3.0 or higher on a 4.0 scale. Applicants with a lower undergraduate GPA may be considered for regular or provisional admission on the basis of successful engineering work experience or other credentials demonstrating potential for success in the graduate program. The submission of Graduate Record Examination (GRE) is required unless the applicant holds an ABET accredited engineering degree from an institution in the USA. TOEFL (or IELTS) is required for all applicants whose native language is not English unless their BS degrees are from USA institutions. Provisional admission may also be possible for applicants with a bachelor’s degree in a field other than the applicant’s intended graduate program. In such cases there will be pre-requisite course requirements. Provisional admission may be given to those applicants who do not hold a bachelor’s degree in civil or environmental engineering; however, these students will be required to complete undergraduate course work in addition to the graduate program requirements. Potential prerequisite courses are listed below.

Potential Prerequisite Courses for M.S. and M.E., Civil Engineering (other than Transportation Engineering Emphasis):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 211</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 212</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 312</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 231N</td>
<td>University Physics I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 232N</td>
<td>University Physics</td>
<td>4</td>
</tr>
<tr>
<td>CS 150</td>
<td>Problem Solving and Programming I</td>
<td>4</td>
</tr>
<tr>
<td>or CEE 305</td>
<td>Civil and Environmental Computations</td>
<td>4</td>
</tr>
<tr>
<td>CEE 204</td>
<td>Statics</td>
<td>3</td>
</tr>
<tr>
<td>MAE 205</td>
<td>Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>CEE 220</td>
<td>Mechanics of Deformable Bodies</td>
<td>3</td>
</tr>
<tr>
<td>CEE 310</td>
<td>Structures I</td>
<td>3</td>
</tr>
<tr>
<td>CEE 323</td>
<td>Soil Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>CEE 330</td>
<td>Hydromechanics</td>
<td>3</td>
</tr>
<tr>
<td>CEE 340</td>
<td>Hydraulics and Water Resources</td>
<td>3</td>
</tr>
<tr>
<td>CEE 410</td>
<td>Concrete Design</td>
<td>3</td>
</tr>
</tbody>
</table>

Potential Prerequisites Courses for M.S. & M.E., Civil Engineering (Transportation Engineering Emphasis):

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 211</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 212</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 312</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>STAT 306</td>
<td>Introductory Statistics</td>
<td>3</td>
</tr>
<tr>
<td>PHYS 231N</td>
<td>University Physics I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 232N</td>
<td>University Physics</td>
<td>4</td>
</tr>
<tr>
<td>CS 150</td>
<td>Problem Solving and Programming I</td>
<td>4</td>
</tr>
<tr>
<td>or CEE 305</td>
<td>Civil and Environmental Computations</td>
<td>4</td>
</tr>
</tbody>
</table>

Potential Prerequisite Courses for M.S. & M.E., Environmental Engineering:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 211</td>
<td>Calculus I</td>
<td>4</td>
</tr>
<tr>
<td>MATH 212</td>
<td>Calculus II</td>
<td>4</td>
</tr>
<tr>
<td>MATH 307</td>
<td>Ordinary Differential Equations</td>
<td>3</td>
</tr>
<tr>
<td>MATH 312</td>
<td>Calculus III</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 231N</td>
<td>University Physics I</td>
<td>4</td>
</tr>
<tr>
<td>PHYS 232N</td>
<td>University Physics</td>
<td>4</td>
</tr>
<tr>
<td>CHEM 121N</td>
<td>Foundations of Chemistry I Lecture</td>
<td>3</td>
</tr>
<tr>
<td>CHEM 122N</td>
<td>Foundations of Chemistry I Laboratory</td>
<td>1</td>
</tr>
<tr>
<td>CHEM 123N</td>
<td>Foundations of Chemistry II Lecture</td>
<td>3</td>
</tr>
<tr>
<td>CS 150</td>
<td>Problem Solving and Programming I</td>
<td>4</td>
</tr>
</tbody>
</table>
or CEE 305 Civil and Environmental Computations
CEE 330 Hydromechanics 3
CEE 340 Hydraulics and Water Resources 3
CEE 350 Environmental Pollution and Control 3

**Civil Engineering and Environmental Engineering**

**Graduate Course Requirements (except Transportation Engineering Emphasis):**

The graduate courses applicable towards a master’s degree in the Department of Civil and Environmental Engineering are grouped into various categories listed below. The required number of the credit hours from these categories for the Master of Science (M.S.) and the Master of Engineering (M.E.) degrees in Civil Engineering (except for the transportation engineering concentration) and in Environmental Engineering are summarized in Table CEE-1 and CEE-2, respectively. Note that for the M.S. option students must pass an oral thesis defense examination. For the M.E. project option students must pass an oral project defense examination. For the M.E. course option, student must pass an oral (for civil engineering) or written (for environmental engineering) comprehensive examination at the end of all course work.

**Category A – Upper level courses in Civil Engineering**

CEE 710 Structural Dynamics 3
CEE 711 Finite Element Analysis 3
CEE 712 Advanced Reinforced Concrete 3
CEE 713 Prestressed Concrete 3
CEE 714 Advanced Structural Analysis 3
CEE 715 Engineering Optimization I * 3
CEE 717 Bridge Structures Design 3
CEE 719 Inelastic Structures 3
CEE 720 Structural Stability 3
CEE 721 Plates 3
CEE 722 Cluster Parallel Computing 3
CEE 723 Seismic Design of Steel Structures 3
CEE 724 Retrofitting Methods for Bridges and Buildings 3
CEE 725 Smart Structures * 3
CEE 726 Green Buildings * 3
CEE 730 Advanced Foundation Engineering 3
CEE 731 Advanced Soil Mechanics 3
CEE 732 Engineering Behavior of Soils 3
CEE 733 Soil Dynamics 3
CEE 741 Open Channel Flow * 3
CEE 747 Groundwater Flow * 3
CEE 761 Water Resources Processes and Analysis Methods * 3
CEE 770 Transportation Safety 3
CEE 771 Transportation Operations II 3
CEE 772 Intelligent Transportation Systems 3
CEE 773 Transportation Planning 3
CEE 774 Transportation Network Flow Models 3
CEE 775 Transportation Network Algorithms 3
CEE 776 Simulation in Transportation Networks 3
CEE 777 Discrete Choice Theory and Modeling in Transportation 3
CEE 782 Design of Coastal Structures 3
CEE 787 Dredging and Beach Engineering 3
CEE 788 Coastal Hydrodynamics and Sediment Processes * 3
CEE 789 Computational Environmental Fluid Dynamics 3

**Category B – Upper level courses in Environmental Engineering**

CEE 650 Pollution Prevention 3
CEE 659 Carbon-Free Clean Energy 3
CEE 715 Engineering Optimization I * 3
CEE 726 Green Buildings * 3
CEE 741 Open Channel Flow * 3
CEE 747 Groundwater Flow * 3
CEE 751 Physicochemical Treatment Processes (Env. Engr. Core Course) 3
CEE 752 Biological Wastewater Treatment (Env. Engr. Core Course) 3
CEE 753 Advanced Processes for Water and Wastewater Treatment 3
CEE 754 Environmental Engineering Microbiology 3
CEE 755 Water Quality Management (Env. Engr. Core Course) 3
CEE 756 Water Quality Modeling 3
CEE 761 Water Resources Processes and Analysis Methods * 3
CEE 762 Aquatic Chemistry in Environmental Engineering (Env. Engr. Core Course) 3
CEE 788 Coastal Hydrodynamics and Sediment Processes * 3

**Category C – Lower level courses in Civil & Environmental Engineering**

CEE 514 Masonry Structures Design 3
CEE 515 Steel Structures Design 3
CEE 516 Wood Structures Design 3
CEE 530 Foundation Engineering 3
CEE 531 Earth Structures Design with Geosynthetics 3
CEE 532 Introduction to Earthquake Engineering 3
CEE 533 Geomaterials Stabilization 3
CEE 540 Hydraulic Engineering 3
CEE 546 Urban Stormwater Hydrology 3
CEE 547 Groundwater Hydraulics 3
CEE 550 Water Distribution and Wastewater Collection System Design 3
CEE 552 Air Quality 3
CEE 554 Hazardous Waste Treatment 3
CEE 558 Sustainable Development 3
CEE 559 Biofuels Engineering 3
CEE 560 Advanced Analytical Techniques in Environmental Engineering 3
CEE 571 Transportation Operations I 3
CEE 582 Introduction to Coastal Engineering 3

**Category D – Other graduate courses**

Graduate level courses offered from other departments. These courses must be related to the program of study and must be approved by the student's academic advisor.

**MATH or STAT Category**

CEE 700 Civil and Environmental Engineering Experimental Design 3
CEE 701 Applied Mathematics for Civil and Environmental Engineering or a graduate level MATH or STAT course.

* Double listings in A and B categories.
### Table CEE-1. Required Course Distributions for M.S. and M.E., Civil Engineering (except for Transportation Engineering Emphasis)

#### M.S. - Thesis Option

<table>
<thead>
<tr>
<th>Category</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>12</td>
</tr>
<tr>
<td>A, B, C, or D</td>
<td>9</td>
</tr>
<tr>
<td>MATH/STAT</td>
<td>3</td>
</tr>
<tr>
<td>Thesis</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30*</td>
</tr>
</tbody>
</table>

#### M.E. - Project Option

<table>
<thead>
<tr>
<th>Category</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15</td>
</tr>
<tr>
<td>A, B, C, or D</td>
<td>9</td>
</tr>
<tr>
<td>MATH/STAT</td>
<td>3</td>
</tr>
<tr>
<td>Project</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30*</td>
</tr>
</tbody>
</table>

#### M.E. - Course Option

<table>
<thead>
<tr>
<th>Category</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>18</td>
</tr>
<tr>
<td>A, B, C, or D</td>
<td>9</td>
</tr>
<tr>
<td>MATH/STAT</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30**</td>
</tr>
</tbody>
</table>

* For M.S. and M.E. Project options, no more than 9 credit hours can be at 500 level.

** For M.E. Course option, no more than 12 credit hours can be at 500 level.

### Civil Engineering Graduate Course Requirements (in Transportation Engineering Emphasis):

The department offers Master of Science (M.S.) and Master of Engineering (M.E.) degrees in Civil Engineering with concentration in Transportation Engineering. Table CEE-3 summarizes the requirements for the M.S. and M.E. degrees in the Transportation Engineering concentration. Note that for the M.S. option students must pass an oral thesis defense examination. For the M.E. project option students must pass an oral project defense examination. For the M.E. course option, student must pass an oral comprehensive examination at the end of all course work.

### Table CEE-3. Required Course Distributions for M.S. and M.E., Civil Engineering – Transportation Engineering Emphasis

#### M.S. - Thesis Option

<table>
<thead>
<tr>
<th>Category</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Courses</td>
<td>6</td>
</tr>
<tr>
<td>Upper-Level Transportation Electives</td>
<td>6</td>
</tr>
<tr>
<td>Graduate Statistic Course</td>
<td>3</td>
</tr>
<tr>
<td>Other Electives</td>
<td>9</td>
</tr>
<tr>
<td>Thesis</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30*</td>
</tr>
</tbody>
</table>

#### M.E. - Project Option

<table>
<thead>
<tr>
<th>Category</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Courses</td>
<td>6</td>
</tr>
<tr>
<td>Upper-Level Transportation Electives</td>
<td>6</td>
</tr>
<tr>
<td>Graduate Statistic Course</td>
<td>3</td>
</tr>
<tr>
<td>Other Electives</td>
<td>12</td>
</tr>
<tr>
<td>Project</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30*</td>
</tr>
</tbody>
</table>

#### M.E. - Course Option

<table>
<thead>
<tr>
<th>Category</th>
<th>Credit Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Core Courses</td>
<td>6</td>
</tr>
<tr>
<td>Upper-Level Transportation Electives</td>
<td>9</td>
</tr>
<tr>
<td>Graduate Statistic Course</td>
<td>3</td>
</tr>
<tr>
<td>Other Electives</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>30**</td>
</tr>
</tbody>
</table>

* Note: For M.S. and M.E. Project options, no more than 9 credit hours can be at 500 level.

** For M.E. Course Option, no more than 12 credits can be at the 500 level.

### Courses in Transportation Engineering Emphasis

#### Core Courses
- CEE 571 Transportation Operations I (and)
- CEE 773 Transportation Planning (or)
- CEE 777 Discrete Choice Theory and Modeling in Transportation

#### Upper-level Transportation Electives
- CEE 770 Transportation Safety
- CEE 771 Transportation Operations II
- CEE 772 Intelligent Transportation Systems
- CEE 773 Transportation Planning
- CEE 774 Transportation Network Flow Models
- CEE 775 Transportation Network Algorithms
Ph.D. program. Submission of GRE scores is required except for applicants with at least one of the following: previous master’s degree, professional experience or other credentials demonstrating potential for success. Applicants with a lower GPA may be considered for provisional admission on the basis of successful engineering work in their master program. A master’s degree or equivalent in engineering or a related field is required for college-level teaching and employment in research institutions. Doctoral degrees in civil engineering and environmental engineering are required for all applicants whose mother languages are not English unless their master (or BS) degrees are from USA institutions.

Degree Requirements

Ph.D. program requires minimum 24 credits of course works and 24 credit hours of dissertation research work. Three fifths (3/5) of these courses (15 credit hours) shall be from 800-level courses as required by the University.

Doctor of Engineering

The Department offers a Doctoral of Engineering program (D.Eng.) with concentration in Civil and Environmental Engineering in accordance with the D.Eng. program criteria and requirements specified for the Batten College of Engineering and Technology in this catalog.

Graduate Certificate in Coastal Engineering

In order to provide the opportunity for practicing civil/coastal engineers to further their knowledge and to become more competent in their profession, the Department offers a non-degree Coastal Engineering Certificate. Refer to the Batten College of Engineering and Technology page for details.

Advanced Engineering Certificate in Energy Systems

The certificate program provides an opportunity to students in STEM fields and industry personnel with undergraduate degree in STEM fields to learn about energy systems or pursue job markets in energy industries. Refer to the Batten College of Engineering and Technology page for details.

CIVIL AND ENVIRONMENTAL ENGINEERING Courses

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 514</td>
<td>Masonry Structures Design</td>
<td>3</td>
</tr>
<tr>
<td>CEE 515</td>
<td>Steel Structures Design</td>
<td>3</td>
</tr>
<tr>
<td>CEE 516</td>
<td>Wood Structures Design</td>
<td>3</td>
</tr>
</tbody>
</table>

Doctor of Philosophy, Engineering

Doctoral degrees in civil engineering and environmental engineering are required for college-level teaching and employment in research institutions. Many leading industries and agencies also seek well-trained doctoral graduates. The specialty areas include coastal, geotechnical, structural, transportation, and water resources engineering in Civil Engineering and a variety of sub-fields in Environmental Engineering including water quality, waste, biofuels, nutrient cycling, and pollution prevention.

Admission Requirements

A master’s degree or equivalent in engineering or a related field is required for admission to the Ph.D. program, however, exceptionally well qualified students can be admitted to Ph.D. program directly without a master’s degree. Each applicant must submit an essay of 500 words or less describing personal and academic goals, professional objectives, preparation for graduate study, and how the chosen program will help the applicant achieve these goals and objectives. Two letters of recommendation are required.

Least one of these must be submitted from former or current professors, and one could be from employment supervisor. Regular admission to a Ph.D. program generally requires a GPA of 3.5 or higher on a 4.0 scale in their master program. Applicants with a lower GPA may be considered for regular or provisional admission on the basis of successful engineering work experience or other credentials demonstrating potential for success in the Ph.D. program. Submission of GRE scores is required except for applicants who hold an ABET accredited engineering degree from an institution in the USA or a graduate engineering degree from an institution of which the undergraduate degree is ABET accredited in the USA. TOEFL (or IELTS) are required for all applicants whose mother languages are not English unless their master (or BS) degrees are from USA institutions.

Statistics Course

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 700</td>
<td>Civil and Environmental Engineering</td>
</tr>
<tr>
<td></td>
<td>Experimental Design</td>
</tr>
</tbody>
</table>

Other Elective Courses

see table below

Thesis/Project

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 699</td>
<td>Thesis</td>
</tr>
<tr>
<td>CEE 698</td>
<td>Master’s Project</td>
</tr>
</tbody>
</table>

Other Approved Electives

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 552</td>
<td>Air Quality</td>
<td>3</td>
</tr>
<tr>
<td>CEE 558</td>
<td>Sustainable Development</td>
<td>3</td>
</tr>
<tr>
<td>CEE 715</td>
<td>Engineering Optimization I</td>
<td>3</td>
</tr>
<tr>
<td>ENMA 600</td>
<td>Cost Estimating and Financial Analysis</td>
<td>3</td>
</tr>
<tr>
<td>ENMA 603</td>
<td>Operations Research</td>
<td>3</td>
</tr>
<tr>
<td>ENMA 717</td>
<td>Cost Engineering</td>
<td>3</td>
</tr>
<tr>
<td>ENMA 724</td>
<td>Risk Analysis</td>
<td>3</td>
</tr>
<tr>
<td>MSIM 601</td>
<td>Introduction to Modeling and Simulation</td>
<td>3</td>
</tr>
<tr>
<td>MSIM 751</td>
<td>Advanced Analysis for Modeling and Simulation</td>
<td>3</td>
</tr>
<tr>
<td>PADM 634</td>
<td>Regional Planning</td>
<td>3</td>
</tr>
<tr>
<td>PADM 721</td>
<td>Transportation Policy</td>
<td>3</td>
</tr>
<tr>
<td>PORT 611</td>
<td>International Maritime Transport</td>
<td>3</td>
</tr>
<tr>
<td>PORT 612</td>
<td>Port Operations and Management</td>
<td>3</td>
</tr>
<tr>
<td>PORT 614</td>
<td>Port Planning and Economics</td>
<td>3</td>
</tr>
<tr>
<td>PSYC 870</td>
<td>Human Factors Psychology</td>
<td>3</td>
</tr>
<tr>
<td>STAT 531</td>
<td>Theory of Statistics</td>
<td>3</td>
</tr>
<tr>
<td>STAT 532</td>
<td>Sampling Theory</td>
<td>3</td>
</tr>
<tr>
<td>STAT 535</td>
<td>Design and Analysis of Experiments</td>
<td>3</td>
</tr>
<tr>
<td>STAT 537</td>
<td>Applied Regression and Time Series</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Analysis</td>
<td></td>
</tr>
<tr>
<td>STAT 549</td>
<td>Nonparametric Statistics</td>
<td>3</td>
</tr>
</tbody>
</table>

Department of Civil and Environmental Engineering
CEE 540. Hydraulic Engineering. 3 Credits.
Hydraulic transients; flow control structures; computer analysis of hydraulic systems; design of pipelines, open channels and culverts. Prerequisites: CEE 340.

CEE 546. Urban Stormwater Hydrology. 3 Credits.
Storm rainfall analysis, design rainfall hyetographs, runoff calculation procedures, detention basins, use of mathematical models to analyze and design urban storm drainage systems. Prerequisites: CEE 340.

CEE 547. Groundwater Hydraulics. 3 Credits.
Description of well hydraulics in single and multiple well systems. Determination of aquifer parameters from pumping tests. Use of computer models to determine drawdowns due to multiple well systems. Prerequisites: CEE 340.

CEE 550. Water Distribution and Wastewater Collection System Design. 3 Credits.
Design of water distribution systems, sanitary sewer systems and appurtenances. Prerequisites: CEE 330. Pre- or corequisite: CEE 340.

CEE 552. Air Quality. 3 Credits.
Study of air quality management standards and regulations and pollutant dynamics. Design and operation of emission control equipment for mobile and stationary sources of air pollution. Prerequisites: CEE 350.

CEE 554. Hazardous Waste Treatment. 3 Credits.
Study of sources, generation rates and characteristics of hazardous wastes and their regulation, handling, and design of treatment and disposal facilities. Prerequisites: CEE 350.

CEE 555. Sustainable Development. 3 Credits.
Overview of social, economical, technical environmental aspects of regional, national and international efforts to achieve sustainable development. Discussion of the integration of industrial activity and ecological concerns utilizing principles of zero emissions, pollution prevention and design for the environment. Prerequisites: permission of instructor.

CEE 559. Biofuels Engineering. 3 Credits.
Course covers the overview of renewable energy sources; fundamentals of biofuels; biomass and types of biomass (e.g., woody biomass, forest residues, agricultural residues, energy crops); composition of lignocellulosic (cellulose, hemicellulose, and lignin); biomass conversion technologies; thermochemical, supercritical water, and biochemical conversion processes; types of biofuels from biomass; liquid fuels (bioethanol, bio-oil, biocrude, and hydrocarbons); gaseous fuels (synthesis gas, hydrogen, biodiesel); solid fuels (biochar, torrefied biomass); biodiesel from vegetable oils, algae to biofuels; value-added processing of biofuel residues; economic and environmental assessments; policies and future R&D. Prerequisite: permission of the instructor.

CEE 560. Advanced Analytical Techniques in Environmental Engineering. 3 Credits.
The objective of this class is to introduce students to the analytical, experimental, and process engineering techniques that are utilized to support decision making in environmental engineering.

CEE 571. Transportation Operations I. 3 Credits.
This is the first course in transportation operations and traffic flow theory. Topics include traffic engineering studies, capacity analysis, intersection control, traffic flow models, shockwave analysis, signal warrant analysis, and safety analysis. Course includes applications of modeling and simulation to isolated intersections. Prerequisite: CEE 370.

CEE 574. Transportation Data Analytics. 3 Credits.
This course presents the basic techniques for transportation data analytics. It will discuss statistical modeling, prominent algorithms, and visualization approaches to analyze both small- and large-scale data sets generated from transportation systems. Practices of using different data for various real-world traffic/transportation applications and decision making will also be discussed. Prerequisites: Basic probability and statistics (e.g., STAT 330); any programming language such as C, Python or Java is beneficial but not required.

CEE 582. Introduction to Coastal Engineering. 3 Credits.
Classical small amplitude wave theory, wave transformations in shallow water, shoaling, refraction, diffraction, reflection, breaking. Wave induced near shore currents and sediment transport processes. Alternatives to mitigate coastal erosion processes. Introduction to coastal structures. Prerequisites: permission of the instructor.

CEE 595. Topics in Civil and Environmental Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in civil and/or environmental engineering. Prerequisites: Permission of the instructor.

CEE 650. Pollution Prevention. 3 Credits.

CEE 659. Carbon-Free Clean Energy. 3 Credits.
The course presents an overview of carbon-free energy sources (nuclear, wind, solar, hydropower, and geothermal). The current status, conversion processes, economics, and environmental issues of these forms of energy will be discussed.

CEE 667. Cooperative Education. 1-3 Credits.
Available for pass/fail grading only. May be repeated for credit. Student participation for credit based on the academic relevance of the work experience, criteria, and evaluative procedures as formally determined by the department and Career Development Services prior to the semester in which the work experience is to take place. Prerequisites: approval by the department and Career Development Services in accordance with the policy for granting credit for cooperative education programs.

CEE 668. Internship. 1-3 Credits.
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career-related experience. Prerequisites: approval by department and Career Development Services.

CEE 669. Practicum. 1-3 Credits.
Academic requirements will be established by the department and will vary with the amount of credit desired. Allows students an opportunity to gain short duration career-related experience. Prerequisites: approval by department and Career Development Services.

CEE 695. Topics in Civil and Environmental Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in civil and/or environmental engineering. Prerequisites: Permission of the instructor.

CEE 697. Independent Study in Civil and Environmental Engineering. 1-3 Credits.
Individual analytical, experimental and/or design study selected by the student. Approved and supervised by the advisor. Prerequisites: permission of the instructor.

CEE 698. Master’s Project. 1-3 Credits.
Individual project, investigation under the direction of the student’s major professor.

CEE 699. Thesis. 1-6 Credits.
Research leading to the Master of Science thesis.

CEE 700. Civil and Environmental Engineering Experimental Design. 3 Credits.
Graduate-level overview of engineering experimental design and analysis with emphasis on statistical methods; practical and proper statistical methods applicable to multidisciplinary, real-world civil and environmental engineering problems.
CEE 701. Applied Mathematics for Civil and Environmental Engineers. 3 Credits.
An examination of numerical and approximate mathematical methods for civil and environmental engineers with applications; finite-difference and finite-integral techniques for single and simultaneous ordinary differential equations; classical and finite-difference solutions of partial differential equations such as heat, wave, Laplace, and plate equation; and finite element applications selected from geotechnical, environmental, hydraulics/water resources, ocean, transportation, and structural engineering.

CEE 710. Structural Dynamics. 3 Credits.
Free and forced vibration of discrete and continuous systems; elastic and inelastic response of structures under dynamic loads.

CEE 711. Finite Element Analysis. 3 Credits.
To provide an understanding of the finite element method (FEM) as derived from an integral formulation perspective. To demonstrate the solutions of 1-D and 2-D continuum mechanics problems such as solid mechanics, fluid mechanics and heat transfer.

CEE 712. Advanced Reinforced Concrete. 3 Credits.
Ultimate-strength theory, yield line methods, limit design, and other relevant advanced topics in the theory and design of concrete structures.

CEE 713. Prestressed Concrete. 3 Credits.
Analysis and design of prestressed concrete members and structures. Shrinkage, creep and losses, shear, bond and anchorages are discussed.

CEE 714. Advanced Structural Analysis. 3 Credits.
Elastic analysis of framed structures using matrix and numerical techniques.

CEE 715. Engineering Optimization I. 3 Credits.
Formulation and solution algorithms for Linear Programming (LP) problems. Unconstrained and constrained nonlinear programming (NLP) problems. Optimum solution for practical engineering systems. (Cross-listed with MAE 715 and MAE 815).

CEE 717. Bridge Structures Design. 3 Credits.
Design of steel, concrete, and composite bridges using modern techniques and current specifications. Prerequisites: CEE 410 and CEE 415/CEE 515 or equivalent.

CEE 719. Inelastic Structures. 3 Credits.
Inelastic analysis and behavior of framed structures.

CEE 720. Structural Stability. 3 Credits.
Fundamentals of elastic and inelastic stability of beams, columns and frames.

CEE 721. Plates. 3 Credits.
Classical and modern methods for the solution of plates of various shapes and boundary conditions, continuous and axially loaded plates and plates on elastic supports. Design examples.

CEE 722. Cluster Parallel Computing. 3 Credits.
Detailed numerical step-by-step procedures to exploit parallel and sparse computation under MPI (Message, Passing, Interface) computer environments are explained. Large-scale engineering/science applications are emphasized. Simultaneous linear equations are discussed.

CEE 723. Seismic Design of Steel Structures. 3 Credits.
Analysis and design of steel structures under seismic loading conditions, introduction to design specifications for steel structures. Prerequisites: CEE 310 or equivalent.

CEE 724. Retrofitting Methods for Bridges and Buildings. 3 Credits.
Retrofitting methods for bridges and buildings combined with related advanced structural analysis and design techniques. Prerequisites: CEE 310 or equivalent.

CEE 725. Smart Structures. 3 Credits.
This course covers structural systems integrated with sensing, data processing, and control devices, which control and reduce the vibration of structures. Students will learn about basic theories of smart structures, smart materials, sensors, structural health monitoring (SHM) as well as their application to civil infrastructures.

CEE 726. Green Buildings. 3 Credits.
This course covers fundamental concepts in design, construction and operation of Green Buildings, including introduction to Green Buildings rating systems and assessment of energy consumption in buildings.

CEE 730. Advanced Foundation Engineering. 3 Credits.
Advanced analysis and design of shallow and deep foundations and retaining structures. Prerequisites: CEE 430/CEE 530.

CEE 731. Advanced Soil Mechanics. 3 Credits.
Detailed study of shear strength of soils and its application to slope stability and embankment design and analysis. Advanced laboratory shear tests are included. Prerequisites: CEE 323.

CEE 732. Engineering Behavior of Soils. 3 Credits.
Detailed study of physiochemical behavior of soils, fabric, rheology, effective stress path, and their applications to various geotechnical engineering problems. Prerequisites: CEE 323.

CEE 733. Soil Dynamics. 3 Credits.
Study of soil behavior under dynamic loadings. Laboratory and field techniques for determining soil properties and liquefaction potential. Design examples. Prerequisites: CEE 323.

CEE 734. Marine/Offshore Geotechnology. 3 Credits.
Understand the dynamic nature of the offshore environment and the available in-situ geotechnical tools to investigate and characterize offshore soils. Study static and dynamic behavior of marine sediments. Design different types of foundation systems such as suction bucket, pile-supported, and gravity base foundations for different offshore structures.

CEE 741. Open Channel Flow. 3 Credits.
Momentum and energy principles, design of open channels, use of mathematical models for flow calculations in rivers, introduction to unsteady open channel flow. Prerequisites: CEE 340.

CEE 747. Groundwater Flow. 3 Credits.

CEE 751. Physicochemical Treatment Processes. 3 Credits.
Physical and chemical processes used in the treatment of water and waste water are covered. Separation, isolation and reaction processes are characterized as well as reactor engineering. Prerequisites: CEE 350.

CEE 752. Biological Wastewater Treatment. 3 Credits.
The use of microorganisms to treat domestic and industrial waste waters for organics and nutrient removal are studied. Characteristics of individual waste water components and the appropriate treatment processes to remove these components are covered. Prerequisites: CEE 350.

CEE 753. Advanced Processes for Water and Wastewater Treatment. 3 Credits.
Theory, operation and application of advanced water and waste water treatment systems, including land application, dissolved solids, organic contaminant and nutrient removal processes. Emphasis on system development for waste water reclamation/recycling. Prerequisites: CEE 751 and CEE 752.

CEE 754. Environmental Engineering Microbiology. 3 Credits.
A lecture and laboratory course dealing with the study of the principles and applications of microbiology in waste water treatment, water treatment, stream self-purification and their effects in environmental engineering. Prerequisites: CEE 350.

CEE 755. Water Quality Management. 3 Credits.
Characterization of water quality in natural systems and the human activities that result in contaminant input to these systems are studied. Management practices for minimizing contaminant input and for restoring contaminated waters are discussed.

CEE 756. Water Quality Modeling. 3 Credits.
Formulation of mathematical equations to describe the fate and transport of aqueous contaminants in dynamic surface water systems. Use of water quality computer models to predict various contamination scenarios. Prerequisites: MATH 307, CEE 340, CEE 350 or permission of the instructor.
CEE 761. Water Resources Processes and Analysis Methods. 3 Credits.
This course examines interactive hydrologic processes in water resource; modifications of climate change to these processes; and modern simulation and systematic analysis methods incorporating the modifications into practices of water resource planning, utilization, protection, and engineering.

CEE 762. Aquatic Chemistry in Environmental Engineering. 3 Credits.
Chemical reactions in natural and engineered systems are studied with emphasis placed on developing kinetic expressions and assessing chemical equilibrium. Kinetic and equilibrium expressions are applied to engineering problems to predict the reaction time and products of specific reactions. Prerequisites: CHEM 123N.

CEE 770. Transportation Safety. 3 Credits.
This course focuses on major transportation safety issues including transportation safety goals, safety of various transportation modes, identification of problematic locations, selection of safety countermeasures and their evaluation, safety data and modeling issues. Prerequisite: CEE 471/CEE 571.

CEE 771. Transportation Operations II. 3 Credits.
This is the second course in transportation operations and traffic flow theory. Topics covered include design of progressive signal systems, queuing theory, car following models, and applications of microscopic traffic simulation to corridor studies. Prerequisite: CEE 471/CEE 571.

CEE 772. Intelligent Transportation Systems. 3 Credits.
This course examines how ITS can be used to enhance mobility and safety. The topics covered in the course include systems engineering approach to ITS, traveler response to technologies and information, ITS planning and evaluation, and ITS deployment and operational performance. Prerequisite: CEE 370.

CEE 773. Transportation Planning. 3 Credits.
This course covers transportation planning processes that include policy direction, transportation data, travel demand forecasting models, and decision-making/stakeholders issues.

CEE 774. Transportation Network Flow Models. 3 Credits.
This course provides a rigorous introduction to transportation network modeling, with special emphasis on network equilibrium problems. Topics include: elementary graph theory, shortest path problem nonlinear optimization, optimization of univariate functions, deterministic and stochastic user equilibrium. Prerequisite: CEE 370 or equivalent.

CEE 775. Transportation Network Algorithms. 3 Credits.
Fundamental models and algorithms in optimization, stochastic modeling and parallel computing will be discussed and illustrated with transportation applications.

CEE 776. Simulation in Transportation Networks. 3 Credits.

CEE 777. Discrete Choice Theory and Modeling in Transportation. 3 Credits.
This course will provide the student with an understanding of the theory and models that are capable of analyzing discrete choices. While the first part of the course covers topics including data assembly, preliminary descriptive analysis, and multivariate regression methods, the second part of the course focuses extensively on discrete econometric models such as binary logit, multinomial logit, mixed logit/probit, ordered response, count, and multiple-discrete continuous choice models. Methods of model estimation with particular emphasis on maximum likelihood and composite likelihood approaches will also be discussed. Prerequisites: Graduate student status.

CEE 782. Design of Coastal Structures. 3 Credits.
Nonlinear wave theories; wave forces on slender piles and seawalls; design of rubble mound structures; design philosophy, initial costs, maintenance costs, optimized design using stochastic methods; design of renourished beaches. Advanced alternative solutions for shore protection. Prerequisites: CEE 482/CEE 582.

CEE 787. Dredging and Beach Engineering. 3 Credits.
Types of dredges, factors affecting dredge performance; hydraulic dredges (cutter, hopper) and mechanical dredges systems (bucket, clamshell, etc.); shoaling rate determination; inlet sand bypassing systems; beach renourishment schemes. Design of beach renourishment/projects. Prerequisites: CEE 330.

CEE 788. Coastal Hydrodynamics and Sediment Processes. 3 Credits.
This course focuses on the hydrodynamics of the coastal environment and reviews waves, low-frequency motions, and coastal responses, including sediment processes and beach evolution. Specific topics to be covered include: review of linear wave theory; introduction to nonlinear waves; wave-averaged motions and radiation stresses; wave and current boundary layers; wave setup, longshore current, rip current, undertow, and nearshore circulation; wave dissipation mechanisms; and fluid-sediment interaction. An introduction to cohesive sediments, sediment concentration and transport models, and beach morphology will also be addressed. Prerequisites: CEE 482/CEE 582.

CEE 789. Computational Environmental Fluid Dynamics. 3 Credits.

CEE 795. Topics in Civil and Environmental Engineering. 1-3 Credits.
Special topics of interest with emphasis placed on recent developments in civil and/or environmental engineering. Prerequisites: Permission of the instructor.

CEE 797. Independent Study. 1-3 Credits.

CEE 800. Civil and Environmental Engineering Experimental Design. 3 Credits.
Graduate-level overview of engineering experimental design and analysis with emphasis on statistical methods: practical and proper statistical methods applicable to multidisciplinary, real-world civil and environmental engineering problems.

CEE 801. Applied Mathematics for Civil and Environmental Engineers. 3 Credits.
An examination of numerical and approximate mathematical methods for civil and environmental engineers with applications; finite-difference and finite-integral techniques for single and simultaneous ordinary differential equations; classical and finite-difference solutions of partial differential equations such as heat, wave, Laplace, and plate equation; and finite element applications selected from geotechnical, environmental, hydraulics/water resources, ocean, transportation, and structural engineering.

CEE 810. Structural Dynamics. 3 Credits.
Free and forced vibration of discrete and continuous systems; elastic and inelastic response of structures under dynamic loads.

CEE 811. Finite Element Analysis. 3 Credits.
To provide an understanding of the finite element method (FEM) as derived from an integral formulation perspective. To demonstrate the solutions of (1-D and 2-D) continuum mechanics problems such as solid mechanics, fluid mechanics and heat transfer.

CEE 812. Advanced Reinforced Concrete. 3 Credits.
Ultimate-strength theory, yield line methods, limit design, and other relevant advanced topics in the theory and design of concrete structures.

CEE 813. Prestressed Concrete. 3 Credits.
Analysis and design of prestressed concrete members and structures. Shrinkage, creep and losses, shear, bond and anchorages are discussed.

CEE 814. Advanced Structural Analysis. 3 Credits.
Elastic analysis of framed structures using matrix and numerical techniques.

CEE 815. Engineering Optimization I. 3 Credits.
Formulation and solution algorithms for Linear Programming (LP) problems. Unconstrained and constrained nonlinear programming (NLP) problems. Optimum solution for practical engineering systems. (Cross-listed with MAE 715/MAE 815).
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEE 817</td>
<td>Bridge Structures Design</td>
<td>3</td>
</tr>
<tr>
<td>CEE 819</td>
<td>Inelastic Structures</td>
<td>3</td>
</tr>
<tr>
<td>CEE 820</td>
<td>Structural Stability</td>
<td>3</td>
</tr>
<tr>
<td>CEE 821</td>
<td>Plates</td>
<td>3</td>
</tr>
<tr>
<td>CEE 822</td>
<td>Cluster Parallel Computing</td>
<td>3</td>
</tr>
<tr>
<td>CEE 823</td>
<td>Seismic Design of Steel Structures</td>
<td>3</td>
</tr>
<tr>
<td>CEE 824</td>
<td>Retrofitting Methods for Bridges and Buildings</td>
<td>3</td>
</tr>
<tr>
<td>CEE 825</td>
<td>Smart Structures</td>
<td>3</td>
</tr>
<tr>
<td>CEE 826</td>
<td>Green Buildings</td>
<td>3</td>
</tr>
<tr>
<td>CEE 830</td>
<td>Advanced Foundation Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CEE 831</td>
<td>Advanced Soil Mechanics</td>
<td>3</td>
</tr>
<tr>
<td>CEE 832</td>
<td>Engineering Behavior of Soils</td>
<td>3</td>
</tr>
<tr>
<td>CEE 833</td>
<td>Soil Dynamics</td>
<td>3</td>
</tr>
<tr>
<td>CEE 834</td>
<td>Marine/Offshore Geotechnology</td>
<td>3</td>
</tr>
<tr>
<td>CEE 841</td>
<td>Open Channel Flow</td>
<td>3</td>
</tr>
<tr>
<td>CEE 847</td>
<td>Groundwater Flow</td>
<td>3</td>
</tr>
<tr>
<td>CEE 851</td>
<td>Physicochemical Treatment Processes</td>
<td>3</td>
</tr>
<tr>
<td>CEE 852</td>
<td>Biological Wastewater Treatment</td>
<td>3</td>
</tr>
<tr>
<td>CEE 853</td>
<td>Advanced Processes for Water and Wastewater</td>
<td>3</td>
</tr>
<tr>
<td>CEE 854</td>
<td>Environmental Engineering Microbiology</td>
<td>3</td>
</tr>
<tr>
<td>CEE 855</td>
<td>Water Quality Management</td>
<td>3</td>
</tr>
<tr>
<td>CEE 856</td>
<td>Water Quality Modeling</td>
<td>3</td>
</tr>
<tr>
<td>CEE 857</td>
<td>Water Resources Processes and Analysis Methods</td>
<td>3</td>
</tr>
<tr>
<td>CEE 861</td>
<td>Transportation Safety</td>
<td>3</td>
</tr>
<tr>
<td>CEE 867</td>
<td>Transportation Operations II</td>
<td>3</td>
</tr>
<tr>
<td>CEE 872</td>
<td>Intelligent Transportation Systems</td>
<td>3</td>
</tr>
</tbody>
</table>

**CEE 817. Bridge Structures Design, 3 Credits.**
Design of steel, concrete, and composite bridges using modern techniques and current specifications. Prerequisites: CEE 410 and CEE 415/CEE 515 or equivalent.

**CEE 819. Inelastic Structures, 3 Credits.**
Inelastic analysis and behavior of framed structures.

**CEE 820. Structural Stability, 3 Credits.**
Fundamentals of elastic and inelastic stability of beams, columns and frames.

**CEE 821. Plates, 3 Credits.**
Classical and modern methods for the solution of plates of various shapes and boundary conditions, continuous and axially loaded plates and plates on elastic supports. Design examples.

**CEE 822. Cluster Parallel Computing, 3 Credits.**
Detailed numerical step-by-step procedures to exploit parallel and sparse computation under MPI (Message, Passing, Interface) computer environments are explained. Large-scale engineering/science applications are emphasized. Simultaneous linear equations are discussed.

**CEE 823. Seismic Design of Steel Structures, 3 Credits.**
Analysis and design of steel structures under seismic loading conditions, introduction to design specifications for steel structures. Prerequisites: CEE 310 or equivalent.

**CEE 824. Retrofitting Methods for Bridges and Buildings, 3 Credits.**
Retrofitting methods for bridges and buildings combined with related advanced structural analysis and design techniques. Prerequisites: CEE 310 or equivalent.

**CEE 825. Smart Structures, 3 Credits.**
This course covers structural systems integrated with sensing, data processing, and control devices, which control and reduce the vibration of structures. Students will learn about basic theories of smart structures, smart materials, sensors, structural health monitoring (SHM) as well as their application to civil infrastructures.

**CEE 826. Green Buildings, 3 Credits.**
This course covers fundamental concepts in design, construction and operation of Green Buildings, including introduction to Green Buildings rating systems and assessment of energy consumption in buildings.

**CEE 830. Advanced Foundation Engineering, 3 Credits.**
Advanced analysis and design of shallow and deep foundations and retaining structures. Prerequisites: CEE 430/CEE 530.

**CEE 831. Advanced Soil Mechanics, 3 Credits.**
Detailed study of shear strength of soils and its application to slope stability and embankment design and analysis. Advanced laboratory shear tests are included. Prerequisites: CEE 323.

**CEE 832. Engineering Behavior of Soils, 3 Credits.**
Detailed study of physiochemical behavior of soils, fabric, rheology, effective stress path, and their applications to various geotechnical engineering problems. Prerequisites: CEE 323.

**CEE 833. Soil Dynamics, 3 Credits.**
Study of soil behavior under dynamic loadings. Laboratory and field techniques for determining soil properties and liquefaction potential. Design examples. Prerequisites: CEE 323.

**CEE 834. Marine/Offshore Geotechnology, 3 Credits.**
Understand the dynamic nature of the offshore environment and the available in-situ geotechnical tools to investigate and characterize offshore soils. Study static and dynamic behavior of marine sediments. Design different types of foundation systems such as suction bucket, pile-supported, and gravity base foundations for different offshore structures.

**CEE 841. Open Channel Flow, 3 Credits.**
Momentum and energy principles, design of open channels, use of mathematical models for flow calculations in rivers, introduction to unsteady open channel flow. Prerequisites: CEE 340.

**CEE 847. Groundwater Flow, 3 Credits.**

**CEE 851. Physicochemical Treatment Processes, 3 Credits.**
Physical and chemical processes used in the treatment of water and waste water are covered. Separation, isolation and reaction processes are characterized as well as reactor engineering. Prerequisites: CEE 350.

**CEE 852. Biological Wastewater Treatment, 3 Credits.**
The use of microorganisms to treat domestic and industrial waste waters for organics and nutrient removal are studied. Characteristics of individual waste water components and the appropriate treatment processes to remove these components are covered. Prerequisites: CEE 350.

**CEE 853. Advanced Processes for Water and Wastewater Treatment, 3 Credits.**
Theory, operation and application of advanced water and waste water treatment systems, including land application, dissolved solids, organic contaminant and nutrient removal processes. Emphasis on system development for waste water reclamation/recycling. Prerequisites: CEE 751 and CEE 752.

**CEE 854. Environmental Engineering Microbiology, 3 Credits.**
A lecture and laboratory course dealing with the study of the principles and applications of microbiology in waste water treatment, waste water treatment, stream self-purification and their effects in environmental engineering. Prerequisites: CEE 350.

**CEE 855. Water Quality Management, 3 Credits.**
Characterization of water quality in natural systems and the human activities that result in contaminant input to these systems are studied. Management practices for minimizing contaminant input and for restoring contaminated waters are discussed.

**CEE 856. Water Quality Modeling, 3 Credits.**
Formulation of mathematical equations to describe the fate and transport of aqueous contaminants in dynamic surface water systems. Use of water quality computer models to predict various contamination scenarios. Prerequisites: MATH 307, CEE 340, CEE 350 or permission of the instructor.

**CEE 861. Water Resources Processes and Analysis Methods, 3 Credits.**
This course examines interactive hydrologic processes in water resource; modifications of climate change to these processes; and modern simulation and systematic analysis methods incorporating the modifications into practices of water resource planning, utilization, protection, and engineering.

**CEE 862. Aquatic Chemistry in Environmental Engineering, 3 Credits.**
Chemical reactions in natural and engineered systems are studied with emphasis placed on developing kinetic expressions and assessing chemical equilibrium. Kinetic and equilibrium expressions are applied to engineering problems to predict the reaction time and products of specific reactions. Prerequisites: CHEM 123N.

**CEE 870. Transportation Safety, 3 Credits.**
This course focuses on major transportation safety issues including transportation safety goals, safety of various transportation modes, identification of problematic locations, selection of safety countermeasures and their evaluation, safety data and modeling issues. Prerequisite: CEE 471/ CEE 571.

**CEE 871. Transportation Operations II, 3 Credits.**
This is the second course in transportation operations and traffic flow theory. Topics covered include design of progressive signal systems, queuing theory, car following models, and applications of microscopic traffic simulation to corridor studies. Prerequisite: CEE 471/CEE 571.

**CEE 872. Intelligent Transportation Systems, 3 Credits.**
This course examines how ITS can be used to enhance mobility and safety. The topics covered in the course include systems engineering approach to ITS, traveler response to technologies and information, ITS planning and evaluation, and ITS deployment and operational performance. Prerequisite: CEE 370.
CxEE 873. Transportation Planning. 3 Credits.
This course covers transportation planning processes that include policy
direction, transportation data, travel demand forecasting models, and
decision-making/stakeholders issues.

CxEE 874. Transportation Network Flow Models. 3 Credits.
This course provides a rigorous introduction to transportation network
modeling, with special emphasis on network equilibrium problems.
Topics include: elementary graph theory, shortest path problem nonlinear
optimization, optimization of univariate functions, deterministic and
stochastic user equilibrium.

CxEE 875. Transportation Network Algorithms. 3 Credits.
Fundamental models and algorithms in optimization, stochastic modeling
and parallel computing will be discussed and illustrated with transportation
applications.

CxEE 876. Simulation in Transportation Networks. 3 Credits.
Principles of simulation modeling. Microscopic, mesoscopic and
macroscopic traffic simulation models. Driver behavior in networks.
Calibration and validation of traffic simulation models. Traffic simulation
software.

CxEE 877. Discrete Choice Theory and Modeling in Transportation. 3
Credits.
This course will provide the student with an understanding of the theory and
models that are capable of analyzing discrete choices. While the first part
of the course covers topics including data assembly, preliminary descriptive
analysis, and multivariate regression methods, the second part of the course
focuses extensively on discrete econometric models such as binary logit,
multinomial logit, mixed logit/probit, ordered response, count, and multiple-
discrete continuous choice models. Methods of model estimation with
particular emphasis on maximum likelihood and composite likelihood
approaches will also be discussed. Prerequisites: Graduate student standing.

CxEE 882. Design of Coastal Structures. 3 Credits.
Nonlinear wave theories; wave forces on slender piles and seawalls; design
of rubblemound structures; design philosophy, initial costs, maintenance
costs, optimized design using stochastic methods; design of renourished
beaches. Advanced alternative solutions for shore protection. Prerequisites:
CEE 482/CEE 582.

CxEE 887. Dredging and Beach Engineering. 3 Credits.
Types of dredges, factors affecting dredge performance; hydraulic dredges
(cutter, hopper) and mechanical dredges systems (bucket, clamshell,
etc.); shoaling rate determination; inlet sand bypassing systems; beach
renourishment schemes. Design of beach renourishment/projects.
Prerequisites: CEE 330.

CxEE 888. Coastal Hydrodynamics and Sediment Processes. 3 Credits.
This course discusses the hydrodynamics of the coastal environment and
reviews waves, low-frequency motions, and coastal responses, including
sediment processes and beach evolution. Specific topics to be covered
include: review of linear wave theory; introduction to nonlinear waves;
wave-averaged motions and radiation stresses; wave and current boundary
layers; wave setup, longshore current, rip current, undertow, and nearshore
circulation; wave dissipation mechanisms; and fluid-sediment interaction.
An introduction to cohesive sediments, sediment concentration and transport
models, and beach morphology will also be addressed. Prerequisites:
CEE 482/CEE 582.

CxEE 889. Computational Environmental Fluid Dynamics. 3 Credits.
Fluid dynamics conservation laws as transport phenomena. Classical,
finite-difference models for advection, diffusion and combined fluid flows.
Explicit and implicit schemes to solve unsteady, free-surface fluid flow and
diffusion (dispersion) problems in one and multi-dimensions. Turbulence
models. Prerequisites: CEE 330.

CxEE 892. Doctor of Engineering Project. 1-12 Credits.
Directed individual study applying advanced level technical knowledge
to identify, formulate, and solve a complex, novel problem in Civil and
Environmental Engineering.