Department of Civil and Environmental Engineering

C. Sunny Jiang, Department Chair
E4130 Engineering Gateway
949-824-5333
http://www.eng.uci.edu/dept/cee

Overview
Civil Engineering is described as the art of sustainably harnessing the natural environment to meet human needs. The success of this endeavor is evident all around us. The arid plain which greeted the early settlers in Southern California has been transformed into a thriving regional community largely by the application of civil engineering.

The goal of the Civil Engineering curriculum is to prepare graduates for a career in practice, research, or teaching. At the undergraduate level a common core of fundamental subjects is provided, and students are required to specialize in their senior year. Specializations are offered in General Civil Engineering, Environmental Hydrology and Water Resource Engineering, Structural Engineering, and Transportation Systems Engineering. Graduate opportunities are in three major thrust areas: structural analysis, design, and reliability; transportation systems engineering; and water resources and environmental engineering.

The career opportunities in civil engineering are varied. Graduates may look forward to long-term careers in major corporations, public bodies, the military, private consulting firms, or to being self-employed in private practice. History has shown a civil engineering education to be a good ground for many administrative and managerial positions.

Environmental Engineering involves designing environmental protection or remediation strategies for multiple resources—water, air, and soil, often with combinations of physical, chemical, and biological treatment methods in the context of a complex regulatory framework.

The goal of the Environmental Engineering curriculum is to prepare graduates with a strong basic science background, particularly in chemistry and biology, and to provide students with a broad exposure to several environmental engineering science disciplines. Courses relating to transport processes, water quality control, air quality control, and process design are included in the core.

Career opportunities in environmental engineering are diverse. Graduates generally find careers related to pollution control and the remediation of air, water, and soil environments.

On This Page:
- Civil Engineering
- Environmental Engineering

Undergraduate Major in Civil Engineering

Program Educational Objectives: Graduates of the Civil Engineering program will (1) establish a Civil Engineering career in industry, government, or academia and achieve professional licensure as appropriate; (2) demonstrate excellence and innovation in engineering problem solving and design in a global and societal context; (3) commit to lifelong learning and professional development to stay current in technology and contemporary issues; and (4) take on increasing levels of responsibility and leadership in technical and/or managerial roles. (Program educational objectives are those aspects of engineering that help shape the curriculum; achievement of these objectives is a shared responsibility between the student and UCI.)

The curriculum provides the opportunity to obtain a firm foundation in engineering science and to develop the techniques of analysis and design, which are basic for the successful practitioner. Emphasis is placed on developing problem-solving skills.

Admissions

High School Students: See School Admissions information.

Transfer Students: Preference will be given to junior-level applicants with the highest grades overall, and who have satisfactorily completed the following required courses: two years of approved calculus, one year of calculus-based physics with laboratories (mechanics, electricity and magnetism), completion of lower-division writing, one year of general chemistry (with laboratory), one course in introductory programming, statics, and engineering graphics. For course equivalency specific to each college, see assist.org.

Students are encouraged to complete as many of the lower-division degree requirements as possible prior to transfer. Students who enroll at UCI in need of completing lower-division coursework may find that it will take longer than two years to complete their degrees. For further information, contact The Henry Samueli School of Engineering at 949-824-4334.
Requirements for the B.S. in Civil Engineering

All students must meet the University Requirements.
All students must meet the School Requirements.

Major Requirements

Mathematics and Basic Science Courses:

<table>
<thead>
<tr>
<th>Course</th>
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</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1A</td>
<td>General Chemistry</td>
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<tr>
<td>or</td>
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</tr>
<tr>
<td>ENGR 1A</td>
<td>General Chemistry for Engineers</td>
</tr>
<tr>
<td>CHEM 1B</td>
<td>General Chemistry</td>
</tr>
<tr>
<td>ENGRCEE 11</td>
<td>Methods II: Probability and Statistics</td>
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</tr>
</tbody>
</table>

One basic science elective selected from any Biological Science or Earth Systems Science course with approved GE II designation.

Lower-Division Technical Elective:

Select one course from two of the sections:

Section A:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGR 7A-7B</td>
<td>Introduction to Engineering I</td>
</tr>
<tr>
<td></td>
<td>and Introduction to Engineering II</td>
</tr>
</tbody>
</table>

Section B:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1LE</td>
<td>Accelerated General Chemistry Lab</td>
</tr>
<tr>
<td>CHEM 1C-1LC</td>
<td>General Chemistry</td>
</tr>
<tr>
<td></td>
<td>and General Chemistry Laboratory</td>
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</tbody>
</table>

Section C:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
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<tbody>
<tr>
<td>EECS 70A</td>
<td>Network Analysis I</td>
</tr>
<tr>
<td>ENGR 54</td>
<td>Principles of Materials Science and Engineering</td>
</tr>
<tr>
<td>ENGRMAE 80</td>
<td>Dynamics</td>
</tr>
<tr>
<td>ENGRMAE 91</td>
<td>Introduction to Thermodynamics</td>
</tr>
</tbody>
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Engineering Topics Courses:

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>ENGRCEE 20</td>
<td>Introduction to Computational Problem Solving</td>
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<td>ENGRCEE 21</td>
<td>Computational Problem Solving</td>
</tr>
<tr>
<td>ENGRCEE 30</td>
<td>Statics</td>
</tr>
<tr>
<td>ENGRCEE 81A</td>
<td>Civil Engineering Practicum I</td>
</tr>
<tr>
<td>ENGRCEE 81B</td>
<td>Civil Engineering Practicum II</td>
</tr>
<tr>
<td>ENGRCEE 110</td>
<td>Methods III: Modeling, Economics, and Management</td>
</tr>
<tr>
<td>ENGRCEE 111</td>
<td>Methods IV: Systems Analysis and Decision-Making</td>
</tr>
<tr>
<td>ENGRCEE 121</td>
<td>Transportation Systems I: Analysis and Design</td>
</tr>
<tr>
<td>ENGRCEE 130</td>
<td>Soil Mechanics</td>
</tr>
<tr>
<td>ENGRCEE 130L</td>
<td>Soil Mechanics Laboratory</td>
</tr>
<tr>
<td>ENGRCEE 150</td>
<td>Mechanics of Materials</td>
</tr>
<tr>
<td>ENGRCEE 150L</td>
<td>Mechanics of Materials Laboratory</td>
</tr>
<tr>
<td>ENGRCEE 151A</td>
<td>Structural Analysis</td>
</tr>
<tr>
<td>ENGRCEE 151C</td>
<td>Reinforced Concrete Design</td>
</tr>
<tr>
<td>ENGRCEE 160</td>
<td>Environmental Processes</td>
</tr>
<tr>
<td>ENGRCEE 170</td>
<td>Introduction to Fluid Mechanics</td>
</tr>
</tbody>
</table>
**ENGRCEE 171**  Water Resources Engineering  
**ENGRCEE 181A-181B-181C**  Senior Design Practicum I and Senior Design Practicum II and Senior Design Practicum III  

**Engineering Professional Topics Courses:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECON 20A-20B</td>
<td>Basic Economics I and Basic Economics II</td>
</tr>
<tr>
<td>ENGR 190W</td>
<td>Communications in the Professional World</td>
</tr>
<tr>
<td>ENGRCEE 60 or SOCECOL E8</td>
<td>Contemporary and Emerging Environmental Challenges or Introduction to Environmental Analysis and Design</td>
</tr>
</tbody>
</table>

**Specialization Electives:**

Students must select one of the areas of specialization and complete the associated requirements, as shown below. Students select, with the approval of a faculty advisor, any additional engineering topics courses needed to satisfy school and departmental requirements.

**Specialization in General Civil Engineering:**

Requires four courses, at least one course each from three of the following four options:

1. Select one:
   - ENGRCEE 122  Transportation Systems II: Operations & Control
   - ENGRCEE 123  Transportation Systems III: Planning and Forecasting
2. Select one:
   - ENGRCEE 149  Introduction to Earthquake Engineering
   - ENGRCEE 151B  Structural Timber Design
   - ENGRCEE 152  Computer Methods in Structural Analysis and Design
   - ENGRCEE 155  Structural Steel Design
   - ENGRCEE 156  Foundation Design
3. Select one:
   - ENGRCEE 163  Wastewater Treatment Process Design
   - ENGRCEE 164  Carbon and Energy Footprint Analysis
   - ENGRCEE 165  Physical-Chemical Treatment Processes
   - ENGRCEE 169  Environmental Microbiology for Engineers
4. Select one:
   - ENGRCEE 172  Groundwater Hydrology
   - ENGRCEE 173  Watershed Modeling
   - ENGRCEE 176  Hydrology
   - ENGRCEE 178  Fluid Mechanics of Open Channels

**Specialization in Environmental Hydrology and Water Resources:**

Select four of the following:

- ENGRCEE 163  Wastewater Treatment Process Design
- ENGRCEE 164  Carbon and Energy Footprint Analysis
- ENGRCEE 165  Physical-Chemical Treatment Processes
- ENGRCEE 169  Environmental Microbiology for Engineers
- ENGRCEE 172  Groundwater Hydrology
- ENGRCEE 173  Watershed Modeling
- ENGRCEE 176  Hydrology
- ENGRCEE 178  Fluid Mechanics of Open Channels

**or courses from an approved list**

**Specialization in Structural Engineering:**

ENGRCEE 155  Structural Steel Design (required for Engineering Design Elective)

Select three of the following:

- ENGRCEE 149  Introduction to Earthquake Engineering
- ENGRCEE 151B  Structural Timber Design
- ENGRCEE 152  Computer Methods in Structural Analysis and Design
- ENGRCEE 156  Foundation Design
- ENGRMAE 155  Composite Materials and Structures
ENGRMAE 157 | Lightweight Structures

or courses from an approved list

Specialization in Transportation Systems Engineering:

ENGRCEE 122 | Transportation Systems II: Operations & Control
ENGRCEE 123 | Transportation Systems III: Planning and Forecasting

Select two of the following:

EECS 70A | Network Analysis I

(EECS 70A may not be used in this Specialization if used for a Lower-Division Technical Elective.)

ENGRCEE 124 | Transportation Systems IV: Freeway Operations and Control
ENGRMAE 170 | Introduction to Control Systems

ENGRMAE 171 | Digital Control Systems

or courses from an approved list

* ENGR 7A-ENGR 7B is available only to lower-division students in Fall and Winter quarters. Both ENGR 7A-ENGR 7B must be taken to be counted as one Lower-Division Technical Elective.

In addition, students must aggregate a minimum of 22 design units. Design unit values are indicated at the end of each course description. The faculty advisors and the Student Affairs Office can provide necessary guidance for satisfying the design requirements.

(The nominal Civil Engineering program will require 185 units of courses depending on specialization to satisfy all university and major requirements. Because each student comes to UCI with a different level of preparation, the actual number of units will vary.)

At most an aggregate total of 6 units of 199 or H199 courses may be used to satisfy degree requirements.

Program of Study

The sample program of study chart shown is typical for the accredited major in Civil Engineering. Students should keep in mind that this program is based upon a rigid set of prerequisites, beginning with adequate preparation in high school mathematics, physics, and chemistry. Therefore, the course sequence should not be changed except for the most compelling reasons. Students must have their programs approved by their faculty advisor. Civil Engineering majors are encouraged to consult with academic counselors as needed, and students who are academically at risk are mandated to see a counselor as frequently as deemed necessary by the advising staff.

Sample Program of Study — Civil Engineering

Freshman

<table>
<thead>
<tr>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>MATH 2A</td>
<td>MATH 2B</td>
<td>MATH 2D</td>
</tr>
<tr>
<td>CHEM 1A or ENGR 1A</td>
<td>PHYSICS 7C</td>
<td>PHYSICS 7D</td>
</tr>
<tr>
<td>Lower-Division Technical Elective</td>
<td>PHYSICS 7LC</td>
<td>PHYSICS 7LD</td>
</tr>
<tr>
<td>General Education</td>
<td>CHEM 1B</td>
<td>ENGRCEE 81A</td>
</tr>
<tr>
<td>General Education</td>
<td>General Education</td>
<td>Basic Science Elective</td>
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</tbody>
</table>

Sophomore

<table>
<thead>
<tr>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>MATH 3A</td>
<td>MATH 3D</td>
<td>MATH 2E</td>
</tr>
<tr>
<td>ENGRCEE 20</td>
<td>ENGRCEE 11</td>
<td>ENGRCEE 21</td>
</tr>
<tr>
<td>ENGRCEE 30</td>
<td>ENGRCEE 81B</td>
<td>Lower-Division Technical Elective</td>
</tr>
<tr>
<td>General Education</td>
<td>General Education</td>
<td>General Education</td>
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</table>

Junior

<table>
<thead>
<tr>
<th>Fall</th>
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<tbody>
<tr>
<td>ENGRCEE 121</td>
<td>ENGRCEE 130</td>
<td>ENGRCEE 110</td>
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<tr>
<td>ENGRCEE 150</td>
<td>ENGRCEE 130L</td>
<td>ENGRCEE 151C</td>
</tr>
<tr>
<td>ENGRCEE 150L</td>
<td>ENGRCEE 151A</td>
<td>ENGRCEE 160</td>
</tr>
<tr>
<td>ENGRCEE 170</td>
<td>ENGRCEE 171</td>
<td>General Education</td>
</tr>
<tr>
<td>ENGR 190W</td>
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</tr>
</tbody>
</table>

* Note: ENGR 7A-ENGR 7B is available only to lower-division students in Fall and Winter quarters. Both ENGR 7A-ENGR 7B must be taken to be counted as one Lower-Division Technical Elective.

The following sample plans of study are provided for the senior year only; the first three years are common to all specializations.
Senior-Year Sample Programs of Study — Civil Engineering

Senior: General Civil Engineering Specialization

<table>
<thead>
<tr>
<th>Senior</th>
<th>Winter</th>
<th>Spring</th>
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</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGRCEE 181A</td>
<td>ENGRCEE 181B</td>
<td>ENGRCEE 181C</td>
</tr>
<tr>
<td>Spec. Elective</td>
<td>ENGRCEE 111</td>
<td>Spec. Elective</td>
</tr>
<tr>
<td>General Education</td>
<td>Spec. Elective</td>
<td>Spec. Elective</td>
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<tr>
<td>General Education</td>
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<td>General Education</td>
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</table>

Senior: Environmental Hydrology and Water Resources Specialization

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<thead>
<tr>
<th>Senior</th>
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<th>Spring</th>
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<tbody>
<tr>
<td>Fall</td>
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</tr>
<tr>
<td>ENGRCEE 181A</td>
<td>ENGRCEE 181B</td>
<td>ENGRCEE 181C</td>
</tr>
<tr>
<td>Spec. Elective</td>
<td>ENGRCEE 111</td>
<td>Spec. Elective</td>
</tr>
<tr>
<td>General Education</td>
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Senior: Structural Engineering Specialization

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<tr>
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<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENGRCEE 181A</td>
<td>ENGRCEE 181B</td>
<td>ENGRCEE 181C</td>
</tr>
<tr>
<td>ENGRCEE 155</td>
<td>ENGRCEE 111</td>
<td>Spec. Elective</td>
</tr>
<tr>
<td>Spec. Elective</td>
<td>Spec. Elective</td>
<td>General Education</td>
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Senior: Transportation Systems Engineering

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Fall</td>
<td></td>
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</tr>
<tr>
<td>ENGRCEE 181A</td>
<td>ENGRCEE 181B</td>
<td>ENGRCEE 181C</td>
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<tr>
<td>Spec. Elective</td>
<td>ENGRCEE 111</td>
<td>ENGRCEE 123</td>
</tr>
<tr>
<td>General Education</td>
<td>ENGRCEE 122</td>
<td>Spec. Elective</td>
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Undergraduate Major in Environmental Engineering

**Program Educational Objectives:** Graduates of the Environmental Engineering program will (1) establish an Environmental Engineering career in industry, government, or academia and achieve professional licensure as appropriate; (2) demonstrate excellence and innovation in engineering problem solving and design in a global and societal context; (3) commit to lifelong learning and professional development to stay current in technology and contemporary issues; and (4) take on increasing levels of responsibility and leadership in technical and/or managerial roles. (Program educational objectives are those aspects of engineering that help shape the curriculum; achievement of these objectives is a shared responsibility between the student and UCI.)

The curriculum includes a core of mathematics, physics, chemistry, and biology, as well as engineering mechanics and methods courses. Students may select from a variety of environmental engineering courses to fulfill the remaining portion of the program and to focus their environmental engineering training in one or more of the following areas: water supply and resources, waste water management, or atmospheric systems and air pollution control. Design experiences are integrated into environmental engineering courses, and seniors enroll in a capstone design course.

Admissions

**High School Students:** See School Admissions information.

**Transfer Students:** Preference will be given to junior-level applicants with the highest grades overall, and who have satisfactorily completed the following required courses: two years of approved calculus, one year of calculus-based physics with laboratories (mechanics, electricity and magnetism), completion of lower-division writing, one year of general chemistry (with laboratory), one course in introductory programming, statics, and engineering graphics. For course equivalency specific to each college, visit assist.org.

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**Requirements for the B.S. in Environmental Engineering**

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All students must meet the School Requirements.

**Major Requirements**

**Mathematics and Basic Science Courses:**

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<td>General Chemistry and General Chemistry</td>
</tr>
<tr>
<td>CHEM 1LC- 1LD</td>
<td>General Chemistry Laboratory and General Chemistry Laboratory</td>
</tr>
<tr>
<td>CHEM 51A</td>
<td>Organic Chemistry</td>
</tr>
<tr>
<td>ENGRCEE 11</td>
<td>Methods II: Probability and Statistics</td>
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<tr>
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</tbody>
</table>

Two additional basic science electives, one Earth System Science course approved for General Education II and one Biological Sciences course approved for General Education II.

**Lower-Division Engineering Elective:**

Students must take one course from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBE 40A</td>
<td>Chemical Processes and Material Balances</td>
</tr>
<tr>
<td>EECS 70A</td>
<td>Network Analysis I</td>
</tr>
<tr>
<td>ENGR 7A- 7B</td>
<td>Introduction to Engineering I</td>
</tr>
<tr>
<td>ENGR 54</td>
<td>Principles of Materials Science and Engineering</td>
</tr>
<tr>
<td>ENGRCEE 80</td>
<td>Dynamics</td>
</tr>
<tr>
<td>or ENGRMAE 80</td>
<td>Dynamics</td>
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</table>

**Engineering Topics Courses:**

Students must complete a minimum of 19 units of engineering design.

**Core Courses:**

<table>
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<td>ENGRCEE 20</td>
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<tr>
<td>ENGRCEE 150- 150L</td>
<td>Mechanics of Materials and Mechanics of Materials Laboratory</td>
</tr>
<tr>
<td>ENGRCEE 160</td>
<td>Environmental Processes</td>
</tr>
<tr>
<td>ENGRCEE 162</td>
<td>Introduction to Environmental Chemistry</td>
</tr>
<tr>
<td>ENGRCEE 170</td>
<td>Introduction to Fluid Mechanics</td>
</tr>
</tbody>
</table>
Engineering Elective Courses:
Students must take two courses each from two of the following three groups and one course from the remaining group.

Water Supply and Resources:
- EARTHSS 132: Terrestrial Hydrology
- ENGRCEE 171: Water Resources Engineering
- ENGRCEE 172: Groundwater Hydrology
- ENGRCEE 173: Watershed Modeling
- ENGRCEE 176: Hydrology
- ENGRCEE 178: Fluid Mechanics of Open Channels

Environmental Processes:
- ENGRCEE 163: Wastewater Treatment Process Design
- ENGRCEE 164: Carbon and Energy Footprint Analysis
- ENGRCEE 165: Physical-Chemical Treatment Processes

Atmospheric Systems and Air Pollution Control:
- EARTHSS 112: Global Climate Change and Impacts
- ENGRMAE 110: Combustion and Fuel Cell Systems
- ENGRMAE 115: Applied Engineering Thermodynamics
- ENGRMAE 164: Air Pollution and Control

All additional engineering topics courses needed to satisfy school and major requirements must be approved by the faculty advisor. Environmental Engineering is an inherently interdisciplinary program. Students interested in pursuing a second degree along with Environmental Engineering may be able to substitute appropriate course work for required courses stated above. Please consult with an Engineering academic or faculty advisor.

Engineering Professional Topics Courses:
- ECON 20A- 20B: Basic Economics I and Basic Economics II
- ENGR 190W: Communications in the Professional World
- ENGRCEE 60: Contemporary and Emerging Environmental Challenges
  or SOCECOL E8: Introduction to Environmental Analysis and Design

(The nominal Environmental Engineering program requires 191 units of courses to satisfy all university and major requirements. Because each student comes to UCI with a different level of preparation, the actual number of units will vary.)

At most an aggregate total of 6 units of 199 or H199 courses may be used to satisfy degree requirements.

* ENGR 7A-ENGR 7B is available only to lower-division students in Fall and Winter quarters. Both ENGR 7A-ENGR 7B must be taken to be counted as one Lower-Division Engineering Elective course.

Program of Study
The sample program of study chart shown is typical for the major in Environmental Engineering. Students should keep in mind that this program is based upon a sequence of prerequisites, beginning with adequate preparation in high school mathematics, physics, and chemistry. Students who are not adequately prepared, or who wish to make changes in the sequence for other reasons, must have their programs approved by their faculty advisor. Environmental Engineering majors are encouraged to consult with academic counselors as needed, and students who are academically at risk are mandated to see a counselor as frequently as deemed necessary by the advising staff.

Sample Program of Study — Environmental Engineering

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Graduate Study in Civil and Environmental Engineering

Civil and Environmental Engineering provides innovative solutions at the interface of the natural and the built environment for the benefit of society. As such, education and research addresses the efficient design, maintenance, and sustainability of infrastructure while preserving and sustaining natural, social, and economic resources. The Department of Civil and Environmental Engineering focuses its graduate study and research program on four areas: Structures, Geotechnics, and Materials, including civil infrastructure materials, engineering mechanics, advanced composites, structural dynamics, performance-based earthquake engineering, geotechnical engineering, and reliability and risk assessment; Transportation Systems, including traffic operations and management, advanced information technology applications, travel behavior, and transportation systems analysis; Hydrology and Water Resources Systems, including dynamics of the hydrologic cycle and climate induced variability, flood and drought prediction and mitigation, and remote sensing of hydrologic systems; and Environmental and Energy Systems, including environmental pollution mitigation, water and air quality, water treatment technologies, water and energy nexus, and renewable energy.

The Department offers the M.S. and Ph.D. in Civil and Environmental Engineering.

At the point of application a student is required to choose one of four focus areas: Structures, Geotechnics and Materials; Transportation Systems; Hydrology and Water Resources Systems; or Environmental and Energy Systems. Once admitted, each student will be assigned to an advisor from among active faculty in their focus area. Financial support through research or teaching assistantships and a variety of fellowships and scholarships is available to qualified students and highly competitive. Interdisciplinary study in one or more areas outside of the student’s primary focus area is strongly encouraged.

Structures, Geotechnics, and Materials
This area emphasizes the application of analytical, numerical, experimental, and practical approaches to the investigation of built infrastructure systems that withstand natural and man-made loads and hazards. Specific interests include sensors and structural health monitoring, composites for infrastructure applications, reliability and risk assessment of civil engineering systems, structural control, system identification and damage detection, performance-based earthquake engineering, soil-structure interaction, smart materials and structures, multi-scale modeling, and sustainable green materials and infrastructural systems.

Transportation Systems
Among leading centers for transportation research, the department offers a graduate research area that is distinguished by its interdisciplinary approach to the study of current and emerging urban transportation issues and through its partnership with the UC Irvine Institute of Transportation Studies. This area focuses on the planning, design, operation, and management of complex transportation systems. Emphasis is on the development of fundamental knowledge in engineering, systems analysis, modeling, and planning, combined with advanced computational techniques and information technologies, to address transportation problems affecting urban travel and goods movement.

Hydrology and Water Resources Systems
Developing sustainable water supplies while preserving natural resources and the environment is a grand challenge in the 21st century requiring interdisciplinary thinking and engineering solutions. This area focuses on fundamentals and the use of mathematical, computational, and experimental approaches to understanding the dynamics of the hydrologic cycle, transport within aquatic systems, and the impact of human activity, particularly in
urban areas. Specific areas include water resources planning, remote sensing of the environment, water-related hazards such as floods and droughts, and transport in land, oceans, and the atmosphere.

Environmental and Energy Systems
Treatment, distribution, and collection of water and wastewater are energy intensive operations, and energy generation and distribution have direct and indirect impacts on environmental systems. This area addresses these interrelated challenges by focusing on the treatment and supply of water for municipal, agricultural, energy, and environmental uses, sustainable practices for managing urban stormwater, and chemical and microbiological processes for water treatment. Additionally, novel approaches for energy generation and distribution are covered in this area. Understanding and minimizing emissions of greenhouse gases associated with water and wastewater treatment and energy generation and distribution are common themes in this area.

Master of Science Degree
The M.S. reflects achievement of an advanced level of competence for the professional practice of civil and environmental engineering. Two plans are available to those working toward the M.S.: Thesis option and Course Work option. Opportunities are available for part-time study toward the M.S. The Plan of Study for both options must be developed in consultation with a Faculty Advisor and approved by the Program Graduate Advisor.

Plan I: Thesis Option
The thesis option requires completion of 48 units of study of which a maximum of ten units can be taken for study in conjunction with the thesis research topic. Upon approval of the Program Graduate Advisor, the maximum of 10 units of thesis research can be extended to 16 units. Thesis research includes the completion of an original research project; the writing of the thesis describing it; and review by a thesis committee. Of the 48 units, a minimum of 28 units must be in non-research, graduate-level approved engineering or related courses (numbered 200–291). The remaining units may be earned as graduate-level course work, individual research, or upper-division undergraduate units (maximum ten units).

Plan II: Course Work Option
Course Work option requires the completion of 48 units of study, at least 40 of which must be in non-research graduate-level approved engineering or related courses (numbered 200–291). The remaining eight units may be earned as graduate-level course work, individual research, or upper-division undergraduate units.

Concurrent Master’s Degree Program with Planning, Policy, and Design
The Department of Civil and Environmental Engineering (CEE) and the Department of Urban Planning and Public Policy (UPPP) in the School of Social Ecology offer a concurrent degree program that allows students to earn both a master’s in Civil and Environmental Engineering (M.S.) and a master’s in Urban and Regional Planning (M.U.R.P.) in less than the three years required if degrees were pursued sequentially.

Requirements
The concurrent degree program involves a course plan that fulfills requirements in both programs. The engineering focus of the concurrent degree program requires 48 units and is organized around two tracks: (1) Transportation Systems, and (2) Hydrology and Water Resources Systems. The course load for both CEE and M.U.R.P. is the same for both tracks. For the CEE track, two plans are available: Thesis option and Course Work option. The plan of study for both options must be developed in consultation with a Faculty Advisor and approved by the Program Graduate Advisor. There may be no redundancy of courses between the CEE and M.U.R.P. tracks.

Plan I: Thesis Option
Thesis option requires the completion of 48 units of study of which a maximum of 10 units can be taken for study in conjunction with the thesis research topic. Upon approval of the Program Graduate Advisor, the maximum of 10 units of thesis research can be extended to 16 units. Thesis research includes the completion of an original research project; the writing of the thesis describing it; and review by a thesis committee. Of the 48 units, a minimum of 28 units must be in non-research, graduate-level approved engineering or related courses (numbered 200-291) with at least 16 of 28 units from the CEE Department. The remaining units may be earned as graduate-level course work, individual research, or upper-division undergraduate units (maximum 10 units).

Plan II: Course Work Option
Course Work option requires the completion of 48 units of study, at least 40 of which must be in non-research graduate-level approved engineering or related courses (numbered 200-291) with at least 28 of 40 units from the CEE Department. The remaining eight units may be earned as graduate-level course work, individual research, or upper-division undergraduate units. Undergraduates seeking admission to the concurrent master’s degree program should have a strong record of course work in disciplines related to civil and environmental engineering and urban planning, and they must meet the requirements for admission in both departments. For more information about these requirements, visit the CEE Graduate Admissions (http://engineering.uci.edu/dept/cee/graduate/admission-requirements) and MURP Graduate Admissions (https://uppp.soceco.uci.edu/murp/admissions) websites.

Doctor of Philosophy Degree
The Ph.D. indicates attainment of an original and significant research contribution to the state-of-the-art in the candidate’s field, and an ability to communicate advanced engineering concepts. The doctoral program is tailored to the individual needs and background of the student. The detailed
program of study for each Ph.D. student is formulated in consultation with a faculty advisor who takes into consideration the objectives and preparation of the candidate. The program of study must be approved by the faculty advisor and the Graduate Advisor of the Department.

There are no specific course requirements. Within this flexible framework, the School maintains specific guidelines that outline the milestones of a typical doctoral program. All doctoral students should consult the Civil and Environmental Engineering program's guidelines for details, but there are several milestones to be passed: admission to the Ph.D. program by the faculty; early assessment of the student's research potential (this includes a preliminary examination); research preparation, formal advancement to candidacy by passing the qualifying examination in the third year (second year for students who entered with a master's degree), completion of a significant research investigation, and the submission and oral defense of an acceptable dissertation. There is no foreign language requirement. Ph.D. students have to meet departmental research requirements as a research assistant or equivalent, with or without salary. The degree is granted upon the recommendation of the Doctoral Committee and the Dean of Graduate Studies. The normative time for completion of the Ph.D. is five years (four years for students who entered with a master's degree). The maximum time permitted is seven years.

**Faculty**

Mohammad Javad Abdolhosseini Qomi, Ph.D. Massachusetts Institute of Technology, *Assistant Professor of Civil and Environmental Engineering* (mechanics and physics of multi-scale porous materials, nano- and meso-chemo-mechanics, engineering advanced materials for sustainable infrastructures)

Adeyemi Adeleye, Ph.D. University of California, Santa Barbara, *Assistant Professor of Civil and Environmental Engineering* (water chemistry; environmental applications of nanotechnology; fate and effects of emerging contaminants (engineered engineering nanomaterials, pharmaceuticals, and microplastics); nanotoxicity; water and wastewater treatment)

Amir AghaKouchak, Ph.D. University of Stuttgart, *Associate Professor of Civil and Environmental Engineering* (hydrology, climatology, remote sensing of environment, climate extremes, water-energy nexus, climate change, stochastic modeling, water resources management)

Alfredo H.-S. Ang, Ph.D. University of Illinois at Urbana-Champaign, *Professor Emeritus of Civil and Environmental Engineering* (structural and earthquake engineering, risk and reliability engineering)

Tirtha Banerjee, Ph.D. Duke University, *Assistant Professor of Civil and Environmental Engineering* (atmospheric boundary layer dynamics, turbulent fluid dynamics, land/water/vegetation - atmosphere interaction, wildfires, vegetation dynamics, carbon and water cycles, hydrology, wetlands and terrestrial aquatic interfaces)

William J. Cooper, Ph.D. University of Miami, *Professor Emeritus of Civil and Environmental Engineering; Urban Planning and Public Policy* (environmental chemistry, advanced oxidation processes for water treatment, aquatic photochemistry of carbon cycling)

Kristen A. Davis, Ph.D. Stanford University, *Assistant Professor of Civil and Environmental Engineering; Earth System Science* (coastal oceanography, fluid mechanics, turbulent flows)

Russell L. Detwiler, Ph.D. University of Colorado Boulder, *Associate Professor of Civil and Environmental Engineering* (groundwater hydrology, contaminant fate and transport, subsurface process modeling, groundwater/surface-water interaction)

Efi Foufoula-Georgiou, Ph.D. University of Florida, *Distinguished Professor of Civil and Environmental Engineering* (hydrology and geomorphology with emphasis on modeling the interactions between the atmosphere, land, and the terrestrial environment at plot to large-watershed scale)

Stanley B. Grant, Ph.D. California Institute of Technology, *Professor Emeritus of Civil and Environmental Engineering* (environmental engineering, inland and coastal water quality, coagulation and filtration of colloidal contaminants, environmental microbiology)

Gary L. Guymon, Ph.D. University of California, Davis, *Professor Emeritus of Civil and Environmental Engineering* (water resources, groundwater, modeling uncertainty)

Kuo-Lin Hsu, Ph.D. University of Arizona, *Professor of Civil and Environmental Engineering* (remote sensing of precipitation, hydrologic systems modeling, stochastic hydrology, water resources systems planning)

Michael Hyland, Ph.D. Northwestern University, *Assistant Professor of Civil and Environmental Engineering* (modeling, design, control, and analysis of smart city transportation systems with emphases on shared-use autonomous mobility services and urban transit networks)

R. (Jay) Jayakrishnan, Ph.D. University of Texas at Austin, *Professor of Civil and Environmental Engineering* (transportation systems analysis)

C. Sunny Jiang, Ph.D. University of South Florida, *Department Chair and Professor of Civil and Environmental Engineering; Ecology and Evolutionary Biology; Environmental Health Sciences* (water pollution microbiology, environmental biotechnology, aquatic microbial ecology)

Wenlong Jin, Ph.D. University of California, Davis, *Associate Professor of Civil and Environmental Engineering* (intelligent transportation systems, traffic flow theory, transportation network analysis)
Joel Lanning, Ph.D. University of California, San Diego, Assistant Professor of Teaching of Civil and Environmental Engineering (seismic design of civil structures, large-scale testing, alternative building materials, teaching methods in engineering education)

Anne Lemnitzer, Ph.D. University of California, Los Angeles, Associate Professor of Civil and Environmental Engineering (geotechnical and earthquake engineering, soil structure interaction, RC design, seismic monitoring)

Mo Li, Ph.D. University of Michigan, Assistant Professor of Civil and Environmental Engineering; Chemical and Biomolecular Engineering; Materials Science and Engineering (responsive materials, multifunctional materials and structures, fracture mechanics, cement chemistry, industrial ecology, materials-structure-environment interaction)

Michael G. McNally, Ph.D. University of California, Irvine, Professor of Civil and Environmental Engineering; Urban Planning and Public Policy (travel behavior, transportation systems analysis)

Ayman S. Mosallam, Ph.D. Catholic University of America, Professor of Civil and Environmental Engineering (advanced composites and hybrid systems, seismic repair and rehabilitation of structures, diagnostic/prognostic structural health monitoring techniques, 3D printing in Construction and sustainable and green building technology)

Farzad Naeim, Ph.D. University of Southern California, Adjunct Professor of Civil and Environmental Engineering (performance-based earthquake engineering; structural health monitoring; seismic instrumentation; structural design of tall buildings; nonlinear response of structures; seismic isolation; energy dissipation systems and devices; design characteristics of earthquake ground motions; seismic analysis and design of complex structures)

Phu Dinh Nguyen, Ph.D. University of California, Irvine, Assistant Adjunct Professor of Civil and Environmental Engineering (hydrology, GIS, satellite precipitation estimation algorithms, databases and visualization tools for remotely-sensed data and information, crowdsourcing, water resources systems)

Betty H. Olson, Ph.D. University of California, Berkeley, Professor Emeritus of Civil and Environmental Engineering (molecular applications for optimizing biological processes in wastewater treatment, environmental health, drinking water microbiology)

Gerard C. Pardoen, Ph.D. Stanford University, Professor Emeritus of Civil and Environmental Engineering (structural analysis, experimental structural dynamics)

Wilfred W. Recker, Ph.D. Carnegie Mellon University, Distinguished Professor of Civil and Environmental Engineering (transportation systems modeling, traffic control, and urban systems analysis)

Stephen G. Ritchie, Ph.D. Cornell University, Director of the Institute of Transportation Studies and Professor of Civil and Environmental Engineering (transportation engineering, advanced traffic management and control systems, development and application of emerging technologies in transportation)

Diego Rosso, Ph.D. University of California, Los Angeles, Director of the UCI Water-Energy Nexus Center (WEX) and Professor of Civil and Environmental Engineering (environmental process engineering, mass transfer, wastewater treatment, carbon- and energy-footprint analysis)

Brett F. Sanders, Ph.D. University of Michigan, Professor of Civil and Environmental Engineering; Urban Planning and Public Policy (urban flooding, coastal flooding, dam-break flooding, flood hazard modeling, flood risk management, sediment management, shallow-water hydrodynamics and morphodynamics, computational methods, remote-sensing with drones, translational research for flood modeling targeting community resilience, population health and poverty alleviation)

Jean-Daniel M. Saphores, Ph.D. Cornell University, Professor of Civil and Environmental Engineering; Economics; Urban Planning and Public Policy (transportation and environmental systems (with a focus on air pollution and energy use), travel behavior analysis, alternative fuel vehicles, automated vehicles, transit use, sustainable infrastructure management, and decision making under uncertainty using real options)

Jan W. Scherflig, Ph.D. University of California, Berkeley, Professor Emeritus of Civil and Environmental Engineering (water reclamation, waste treatment processes, environmental engineering)

Soroosh Sorooshian, Ph.D. University of California, Los Angeles, Director of the Center for Hydrometeorology and Remote Sensing (CHRS) and UCI Distinguished Professor of Civil and Environmental Engineering; Earth System Science (hydrology, hydrometeorology and hydroclimate modeling, remote sensing, water sources management)

Lizhi Sun, Ph.D. University of California, Los Angeles, Professor of Civil and Environmental Engineering (micro- and nano-mechanics, composites and nanocomposites, smart materials and structures, multiscale modeling, elastography)

Roberto Villaverde, Ph.D. University of Illinois at Urbana-Champaign, Professor Emeritus of Civil and Environmental Engineering (structural dynamics and earthquake engineering)

Jasper A. Vrugt, Ph.D. University of Amsterdam, Associate Professor of Civil and Environmental Engineering; Earth System Science (examining how (eco)systems work, why theories deviate from data, how scientists diagnose change, as applied to biogeosciences, ecology, geomorphology, geophysics, hydrology, soils)
Jann N. Yang, DSc Columbia University, Professor Emeritus of Civil and Environmental Engineering (system identification and damage detection, structural health monitoring, structural control, earthquake engineering, structural dynamics)

Farzin Zareian, Ph.D. Stanford University, Associate Professor of Civil and Environmental Engineering (structural engineering, performance-based earthquake engineering, structural reliability, structural control)

Affiliate Faculty

Jacob Brouwer, Ph.D. Massachusetts Institute of Technology, Professor of Mechanical and Aerospace Engineering; Civil and Environmental Engineering (fuel cells, energy systems dynamics, electrochemical systems design and analysis, chemical kinetics, reacting flows)

Donald Dabdub, Ph.D. California Institute of Technology, Associate Dean, Undergraduate Education and Professor of Mechanical and Aerospace Engineering; Civil and Environmental Engineering (mathematical modeling of urban and global air pollution, dynamics of atmospheric aerosols, secondary organic aerosols, impact of energy generation on air quality, chemical reactions at gas-liquid interfaces)

Steven J. Davis, Ph.D. Stanford University, Department Vice Chair and Associate Professor of Earth System Science; Civil and Environmental Engineering

Derek Dunn-Rankin, Ph.D. University of California, Berkeley, Department Chair and Professor of Mechanical and Aerospace Engineering; Civil and Environmental Engineering; Environmental Health Sciences (combustion, optical particle sizing, particle aerodynamics, laser diagnostics and spectroscopy)

Amelia C. Regan, Ph.D. University of Texas at Austin, Professor of Computer Science; Civil and Environmental Engineering (algorithm development and complexity, networks and distributed systems, network optimization)

G. Scott Samuelsen, Ph.D. University of California, Berkeley, Director of Advanced Power and Energy Program, Research Professor and Professor Emeritus of Mechanical and Aerospace Engineering; Civil and Environmental Engineering (energy systems, fuel cells, combustion, sprays, laser diagnostics, air quality, turbulent transport, alternative fuels, modeling reacting flows, practical systems, energy and environmental conflict)

Courses

ENGRCEE 11. Methods II: Probability and Statistics. 4 Units.
Modeling and analysis of engineering problems under uncertainty. Engineering applications of probability and statistical concepts and methods.

(Design units: 0)

Prerequisite: (ENGRCEE 20 or EECS 10 or EECS 12 or ENGRMAE 10 or I&C SCI 31) and MATH 3A
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 20. Introduction to Computational Problem Solving. 4 Units.
Introduction to computer programming within a numerical computing environment (MATLAB or similar) including types of data representation, graphical display of data, and development of modular programs with application to engineering analysis and problem solving. Course may be offered online.

(Design units: 1)

Corequisite: MATH 3A
Overlap with BME 60B.
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 21. Computational Problem Solving. 4 Units.
Engineering analysis and problem solving using MATLAB (or similar), including matrix algebra, solving systems of linear and nonlinear equations, numerical integration of ordinary differential equations (ODEs) and coupled ODEs, and analysis of numerical errors. Course may be offered online.

(Design units: 1)

Corequisite: MATH 3D
Prerequisite: ENGRCEE 20 and MATH 3A
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRCEE 30. Statics. 4 Units.
Addition and resolution of forces, distributed forces, equivalent system of forces centroids, first moments, moments and products on inertia, equilibrium of rigid bodies, trusses, beams, cables. Course may be offered online.

(Design units: 0)
Corequisite: MATH 2D
Prerequisite: MATH 2D and PHYSICS 7C
Same as ENGR 30, ENGRMAE 30.
Restriction: School of Engineering students have first consideration for enrollment.

ENGRCEE 60. Contemporary and Emerging Environmental Challenges. 4 Units.
Introduces contemporary and emerging environmental challenges, illustrates links between human behavior, environmental policy, and engineering practices, examines policy options in the context of current institutions, and introduces tools and frameworks to reach sound economic, social, and environmental solutions. Course may be offered online.

(Design units: 0)

(III)

ENGRCEE 80. Dynamics. 4 Units.
Introduction to the kinematics and dynamics of particles and rigid bodies. The Newton-Euler, Work/Energy, and Impulse/Momentum methods are explored for ascertaining the dynamics of particles and rigid bodies. An engineering design problem using these fundamental principles is also undertaken.

(Design units: 0.5)
Prerequisite: MATH 2D and PHYSICS 7C
Same as ENGR 80, ENGRMAE 80.
Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 81A. Civil Engineering Practicum I. 3 Units.
Introduction to civil engineering through presentations on structural, environmental, water, and transportation systems. Introduction to graphics. Graphical visualization and communication using hand and computer sketching. Fundamentals of Computer Aided Design (CAD) using AutoCad. Laboratory sessions. Materials fee.

(Design units: 2)
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 81B. Civil Engineering Practicum II. 3 Units.
Principles of surveying; fundamentals of Geographic Information Systems (GIS); introduction to the state-of-the-art and future areas of the profession, including applications of advanced technology and computers; Introduction to visualization and communication of design concepts; laboratory sessions. Course may be offered online. Materials fee.

(Design units: 1)
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 110. Methods III: Modeling, Economics, and Management. 4 Units.
Analysis, modeling, and management of civil engineering systems. Statistics and system performance studies, probabilistic models and simulation, basic economics and capital investments, project elements and organization, managerial concepts and network technique, project scheduling. Emphasis on real-world examples. Laboratory sessions.

(Design units: 1)
Prerequisite: ENGRCEE 11
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRCEE 111. Methods IV: Systems Analysis and Decision-Making. 4 Units.
Analysis and optimization for decision-making in civil and infrastructural systems. Topics include linear programming formulations and solution algorithms, network models, and logistical models. Emphasis is on project-level and managerial decision-making and selection from alternative designs.

(Design units: 1)
Prerequisite: MATH 3A and MATH 3D
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 121. Transportation Systems I: Analysis and Design. 4 Units.
Introduction to analysis and design of fundamental transportation system components, basic elements of geometric and pavement design, vehicle flow and elementary traffic, basic foundations of transportation planning and forecasting. Laboratory sessions.

(Design units: 2)
Prerequisite: ENGRCEE 11 and ENGRCEE 81A
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 122. Transportation Systems II: Operations & Control. 4 Units.
Introduction to fundamentals of urban traffic engineering, including data collection, analysis, and design. Traffic engineering studies, traffic flow theory, traffic control devices, traffic signals, capacity and level of service analysis of freeways and urban streets. Laboratory sessions.

(Design units: 2)
Prerequisite: ENGRCEE 11 and ENGRCEE 121
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 123. Transportation Systems III: Planning and Forecasting. 4 Units.
Theoretical foundations of transportation planning, design, and analysis methods. Theory and application of aggregate and disaggregate models for land use development, trip generation, destination, mode, and route choice. Transportation network analysis. Planning, design, and evaluation of system alternatives.

(Design units: 2)
Corequisite: ENGRCEE 110
Prerequisite: ENGRCEE 121
Restriction: Civil Engineering Majors have first consideration for enrollment.
Concurrent with ENGRCEE 223.

ENGRCEE 124. Transportation Systems IV: Freeway Operations and Control. 4 Units.
Fundamentals of traffic on urban freeways, including data collection analysis, and design. Traffic engineering studies, traffic flow theory, freeway traffic control devices, capacity, and level of service analysis of freeways and highways. Laboratory sessions.

(Design units: 2)
Prerequisite: ENGRCEE 121
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 130. Soil Mechanics. 4 Units.
Mechanics of soils, composition and classification of soils, compaction, compressibility and consolidation, shear strength, seepage, bearing capacity, lateral earth pressure, retaining walls, piles.

(Design units: 0)
Corequisite: ENGRCEE 130L
Prerequisite: ENGRCEE 150 and ENGRCEE 170
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRCEE 130L. Soil Mechanics Laboratory. 1 Unit.
Laboratory procedures of soil testing for engineering problems. Materials fee.

(Design units: 0)
Corequisite: ENGRCEE 130
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 149. Introduction to Earthquake Engineering. 4 Units.
Plate tectonics. Structural dynamics. Earthquake magnitude, intensity, and frequency. Seismic damage to structures. Earthquake load prediction including response spectra, normal mode, and direct integration techniques. The basis of building code earthquake load requirements for buildings.

(Design units: 2)
Prerequisite: ENGRCEE 11 and ENGRCEE 20 and ENGRCEE 151A
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 150. Mechanics of Materials. 4 Units.
Stresses and strains, strain-stress diagrams, axial deformations, torsion, bending and shear stresses in beams, shear force and bending moment diagrams, combined stresses, principal stresses, Mohr's circle, deflection of beams, columns.

(Design units: 1)
Corequisite: ENGRCEE 150L
Prerequisite: ENGRCEE 30 or ENGRMAE 30 or ENGR 30
Overlaps with ENGR 150, ENGRMAE 150.
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 150L. Mechanics of Materials Laboratory. 1 Unit.
Experimental methods and fundamentals for mechanics of materials analysis. Materials fee.

(Design units: 0)
Corequisite: ENGRCEE 150
Prerequisite: ENGRCEE 30 or ENGRMAE 30 or ENGR 30
Overlaps with ENGRMAE 150L.
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 151A. Structural Analysis. 4 Units.

(Design units: 0)
Prerequisite: ENGRCEE 150 or ENGRMAE 150
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 151B. Structural Timber Design. 4 Units.
Design of timber structures. Beams, columns, beam-columns, roof, and connections.

(Design units: 3)
Prerequisite: ENGRCEE 151A
Restriction: Civil Engineering Majors have first consideration for enrollment.
ENGRCEE 151C. Reinforced Concrete Design. 4 Units.

(Design units: 3)
Prerequisite: ENGRCEE 151A
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 152. Computer Methods in Structural Analysis and Design. 4 Units.
Matrix techniques for indeterminate framed structures. Computer implementation using the stiffness method. Software packages for design of reinforced concrete, steel, and/or timber structures.

(Design units: 2)
Prerequisite: ENGRCEE 151C
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 155. Structural Steel Design. 4 Units.
Design in steel of tension members, beams, columns, welded and bolted connections; eccentrically loaded and moment resistant joints; plate girders. Plastic design; load and resistance factor design. Composite construction; introduction to computer-aided design.

(Design units: 4)
Prerequisite: ENGRCEE 151A
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 156. Foundation Design. 4 Units.
Applications of soil mechanics principles to the analysis and design of shallow foundations, retaining walls, pile foundations, and braced cuts. Design criteria: bearing capacity, working loads and tolerable settlements, structural integrity of the foundation element. Damage from construction operations.

(Design units: 3)
Prerequisite: ENGRCEE 130 and ENGRCEE 151C
Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 160. Environmental Processes. 4 Units.

(Design units: 1)
Prerequisite: CHEM 1B and ENGRCEE 170
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 162. Introduction to Environmental Chemistry. 4 Units.
Basic concepts from general, physical, and analytical chemistry as they relate to environmental engineering. Particular emphasis on the fundamentals of equilibrium and kinetics as they apply to acid-base chemistry, gas solubility, and redox reactions. Laboratory sessions. Materials fee.

(Design units: 0)
Prerequisite: (ENGR 1A or CHEM 1A) and CHEM 1B and (CHEM 1LC or CHEM 1LE) and CHEM 51A
Restriction: Chemical Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.
ENGRCEE 163. Wastewater Treatment Process Design. 4 Units.
Design of biological treatment processes. Topics include attached and suspended growth, aeration, anaerobic systems, process control, and economics. Design projects included. Materials fee.

(Design units: 4)
Prerequisite: ENGRCEE 160
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 164. Carbon and Energy Footprint Analysis. 4 Units.
Process design for wastewater treatment. Mass- and energy-balance analysis applied to water and wastewater treatment systems. Case studies include analysis of water supply, treatment, reclamation, and reuse.

(Design units: 2)
Prerequisite: ENGRCEE 160
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
Concurrent with ENGRCEE 264.

ENGRCEE 165. Physical-Chemical Treatment Processes. 4 Units.
Theory and dynamics of physical and chemical separation processes in water and wastewater treatment. Topics include coagulation, sedimentation, filtration, gas-transfer, membrane separations, and adsorption.

(Design units: 2)
Prerequisite: ENGRCEE 160 and (ENGRMAE 91 or CBEMS 45C)
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
Concurrent with ENGRCEE 265.

ENGRCEE 169. Environmental Microbiology for Engineers. 4 Units.
Fundamental and applied principles of microbiology. Structures and functions of microorganisms, the microbiology of water, wastewater and soil used in environmental engineering, and the impact of microorganisms on human and environmental health.

(Design units: 0)
Prerequisite: ENGRCEE 160
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 170. Introduction to Fluid Mechanics. 4 Units.
Thermodynamic and mechanical fluid properties; fluid statics; control volume and differential approaches for mass, momentum, and energy; dimensional analysis and similarity.

(Design units: 1)
Corequisite: MATH 2E and ENGRCEE 20
Prerequisite: PHYSICS 7C
Overlaps with ENGRMAE 130A, CBEMS 125A.
Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 171. Water Resources Engineering. 4 Units.
Principles governing the analysis and design of water resource systems including pressurized pipelines, pipe networks, channels, and ground water. Coverage of fluid mass, momentum and energy conservation, flow resistance, and related laboratory measurements in different systems. Materials fee.

(Design units: 2)
Prerequisite: ENGRCEE 170
Restriction: Chemical Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.
ENGRCEE 172. Groundwater Hydrology. 4 Units.
Topics include conservation of fluid mass, storage properties of porous media, matrix compressibility, boundary conditions, flow nets, well hydraulics, groundwater chemistry, and solute transport. Design projects and computer applications included.

(Design units: 2)

Prerequisite: ENGRCEE 170 or ENGRMAE 130A or CBE 120A

Restriction: Civil Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 272.

ENGRCEE 173. Watershed Modeling. 4 Units.
Basic principles of hydrologic modeling are practiced. Concepts of watershed delineation, land use change impact, design studies, and GIS tools are discussed. Focus on the USACE (HEC) software tools (HEC-HMS, and HEC-RAS) along with their associated GIS interfaces.

(Design units: 1)

Prerequisite: ENGRCEE 170 and ENGRCEE 176

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment. Mechanical Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 273.

ENGRCEE 176. Hydrology. 4 Units.
Elements of the hydrologic cycle including precipitation, infiltration, evapotranspiration, ground water, and runoff. Unit Hydrograph theory and routing methods. Introduction to precipitation/runoff relationship and watershed modeling. Statistical methods and flood frequency analysis.

(Design units: 2)

Prerequisite: ENGRCEE 170 or ENGRMAE 130A

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 276.

ENGRCEE 178. Fluid Mechanics of Open Channels. 4 Units.
Fundamentals of fluid motion in open channels. Navier-Stokes equations and one-dimensional momentum and energy principles. Topics include rapidly varied flow, flow resistance and turbulence, gradually varied flow, unsteady flow, and computational methods for channel flow modeling.

(Design units: 1)

Prerequisite: (ENGRCEE 20 or ENGRMAE 10) and (ENGRCEE 170 or ENGRMAE 130A)

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 278.

ENGRCEE 181A. Senior Design Practicum I. 2 Units.
Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 1)

Prerequisite: ENGRCEE 81A and ENGRCEE 81B and ENGRCEE 110 and (ENGRCEE 121 or ENGRCEE 151C or ENGRCEE 162 or ENGRCEE 171). ENGRCEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.

Restriction: Civil Engineering Majors only. Environmental Engineering Majors only.
ENGRCEE 181B. Senior Design Practicum II. 2 Units.
Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 2)
Corequisite: ENGRCEE 130
Prerequisite: ENGRENGRCEE 181A. CEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.
Grading Option: In Progress (Letter Grade with P/NP).
Restriction: Civil Engineering Majors only. Environmental Engineering Majors only.

ENGRCEE 181C. Senior Design Practicum III. 2 Units.
Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 2)
Prerequisite: ENGRENGRCEE 181B. ENGRCEE 181A and CEE 181B and ENGRCEE 181C must be taken in the same academic year.
Restriction: Civil Engineering Majors only. Environmental Engineering Majors only.

ENGRCEE 195. Special Topics in Civil and Environmental Engineering. 1-4 Units.
Studies in selected areas of Civil and Environmental Engineering. Topics addressed vary each quarter.

(Design units: 1-4)
Prerequisite: Prerequisites vary.
Repeatability: Unlimited as topics vary.

ENGRCEE 198. Group Study. 1-4 Units.
Group study of selected topics in Civil and Environmental Engineering.

(Design units: 1-4)
Repeatability: May be repeated for credit unlimited times.
Restriction: Upper-division students only.

ENGRCEE 199. Individual Study. 1-4 Units.
For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)
Repeatability: May be taken for credit for 8 units.

ENGRCEE 199P. Individual Study. 1-4 Units.
Supervised independent reading, research, or design for undergraduate Engineering majors. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)
Grading Option: Pass/no pass only.
Repeatability: May be repeated for credit unlimited times.

ENGRCEE 214. GIS for Civil and Environmental Engineering. 4 Units.
GIS for CEE provides an introduction to Geographic Information Systems (GIS) and their various applications in civil and environmental engineering. Topics include GIS data formats, data queries, spatial and attribute data, spatial data analysis, coordinate systems, raster data analysis.
Concurrent with ENGRCEE 114.
ENGRCEE 220A. Travel Demand Analysis I. 4 Units.

Restriction: Graduate students only.

ENGRCEE 220B. Travel Demand Analysis II. 4 Units.
Methods of discrete choice analysis and their applications in the modeling of transportation systems. Emphasis on the development of a sound understanding of theoretical aspects of discrete choice modeling that are useful in many applications in travel demand analysis.

Prerequisite: ENGRCEE 220A

Restriction: Graduate students only.

ENGRCEE 220C. Travel Demand Analysis III: Activity-based Approaches. 4 Units.
The methodological underpinnings of activity-based travel demand modeling. Presents methodologies within the context of a generalization of discrete choice modeling approaches, emphasizing the distinctions that separate these two approaches and presenting appropriate mathematical and statistical tools to address these distinctions.

Prerequisite: ENGRCEE 220A

Restriction: Graduate students only.

ENGRCEE 221A. Transportation Systems Analysis I. 4 Units.
Introduction to mathematical methods and models to address logistics and urban transportation problems. Techniques include stochastic models, queueing theory, linear programming, and introductory non-linear optimization.

Restriction: Graduate students only.

ENGRCEE 221B. Transportation Systems Analysis II. 4 Units.
Advanced mathematical methods and models to address logistics and urban transportation problems. Topics include network flows, advanced optimization techniques, network models, and heuristic algorithms.

Prerequisite: ENGRCEE 221A

Restriction: Graduate students only.

ENGRCEE 222. Transit Systems Planning. 4 Units.
Planning methods for public transportation in urban areas. Technological and operating characteristics of vehicles, facilities, and systems. Short-range planning techniques: data collection and analysis, demand analysis, mode choice, operational strategies, financial analysis. Design of systems to improve performance.

Restriction: Graduate students only.

ENGRCEE 223. Transportation Systems III: Planning and Forecasting. 4 Units.
Theoretical foundations of transportation planning, design, and analysis methods. Theory and application of aggregate and disaggregate models for land use development, trip generation, destination, mode, and route choice. Transportation network analysis. Planning, design, and evaluation of system alternatives.

Restriction: Graduate students only.

Concurrent with ENGRCEE 123.

ENGRCEE 224A. Transportation Data Analysis I. 4 Units.
Statistical analysis of transportation data sources. Analysis of categorical and ordinal data. Regression and advanced multivariate analysis methods such as discriminant analysis, canonical correlation, and factor analysis. Sampling techniques, sample error and bias, survey instrument design.

Restriction: Graduate students only.

ENGRCEE 225B. Transportation Planning Models II. 4 Units.
Design and application of comprehensive transportation models. Network development, demand modeling, and equilibrium assignment. Model calibration, validation, prediction, and evaluation. Regional modeling, site impact analysis, and circulation studies. Design of transportation alternatives.

Prerequisite: ENGRCEE 223

Restriction: Graduate students only.
ENGRCEE 226A. Traffic Flow Theory I. 4 Units.

Restriction: Graduate students only.

ENGRCEE 226B. Traffic Flow Theory II. 4 Units.

Prerequisite: ENGRCEE 226A

Restriction: Graduate students only.

ENGRCEE 228A. Urban Transportation Networks I. 4 Units.
Analytical approaches and algorithms to the formulation and solution of the equilibrium assignment problem for transportation networks. Emphasis on user equilibrium (UE) comparison with system optimal, mathematical programming formulation, supply functions, estimation. Estimating origin-destination matrices, network design problems.

Prerequisite: ENGRCEE 220A

Restriction: Graduate students only.

ENGRCEE 228B. Urban Transportation Networks II. 4 Units.
Advanced analysis, optimization, and modeling of transportation networks. Topics include advanced static and dynamic traffic assignment algorithms, linear and nonlinear multi-commodity network flow optimization, network simplex, and network control problems.

Prerequisite: ENGRCEE 221A and ENGRCEE 228A

Restriction: Graduate students only.

ENGRCEE 229A. Traffic Systems Operations and Control I. 4 Units.
Introduction to operation, control and analysis of arterial and freeway traffic systems. Control concepts, traffic stream principles, detectors, local controllers, system masters, traffic signal and ramp metering timing principles, traffic measurement technologies, traffic delay principles.

Restriction: Graduate students only.

ENGRCEE 229B. Traffic Systems Operations and Control II. 4 Units.
Advanced topics related to operation, control, and analysis of arterial and freeway traffic systems. Control concepts, traffic stream principles, detectors, local controllers, system masters, traffic signal and ramp metering timing principles.

Prerequisite: ENGRCEE 229A

Restriction: Graduate students only.

ENGRCEE 231. Foundation Engineering. 4 Units.
Essentials for design and analysis of structural members that transmit superstructure loads to the ground. Topics include subsurface investigations, excavation, dewatering, bracing, footing, mat foundations, piles and pile foundations, caissons and cofferdams, other special foundations.

Restriction: Graduate students only.

ENGRCEE 232. Geotech Earthquake Engineering. 4 Units.
In-situ and laboratory determination of dynamic soil properties, liquefaction of soil, cyclic softening of clays, seismic compression and settlement analyses, ground improvement methods, seismic slope stability, introduction to soil structure interaction.

Restriction: Graduate students only.

ENGRCEE 242. Advanced Strength of Materials. 4 Units.

Restriction: Graduate students only.
ENGRCEE 243. Mechanics of Composite Materials. 4 Units.
Stress-strain relationship for orthotropic materials; invariant properties of an orthotropic lamina; biaxial strength theory for an orthotropic lamina; mechanics of materials approach to stiffness; elasticity approach to stiffness; classical lamination theory; strength of laminates; statistical theory of fatigue damage.
Restriction: Graduate students only.

ENGRCEE 247. Structural Dynamics. 4 Units.
Restriction: Graduate students only.

ENGRCEE 249. Earthquake Engineering. 4 Units.
Earthquake magnitude, intensity, and frequency. Seismic damage to structures. Earthquake load prediction including response spectra, normal mode, and direct integration techniques. The basis of building code earthquake load requirements for buildings. Seismic response of special structures. Lifeline engineering.
Restriction: Graduate students only.

ENGRCEE 250. Finite Element Method in Structural Engineering. 4 Units.
Finite element concepts in structural engineering including variational formulations, shape functions, elements assembly, convergence and computer programming. Stiffness of truss, beam, and frame members, two- and three-dimensional solids, plate and shell elements. Static, vibration, stability, and inelastic analysis.
Restriction: Graduate students only.

ENGRCEE 254. Advanced Reinforced Concrete Behavior and Design. 4 Units.
Restriction: Graduate students only.

ENGRCEE 255. Advanced Behavior and Design of Steel Structures. 4 Units.
Advanced principles of structural steel design. Analysis and design of beam-column members, braced and unbraced frames for buildings, and plate girders. Review of seismic design provisions. Design of connections.
Restriction: Graduate students only.

ENGRCEE 258. Earthquake Resistant Structural Design. 4 Units.
Restriction: Graduate students only.

ENGRCEE 260. Desalination. 4 Units.
Introduction of state of technology, costs and benefits, environmental issues, and implementation issues related to desalination. Emphasis on membrane processes and biofouling prevention.
Restriction: Graduate students only.

ENGRCEE 261. Applied Environmental Microbiology. 4 Units.
Microbes in the environment and their impact on human interactions. Microbiological application in solving environmental engineering problems.
Restriction: Graduate students only.

ENGRCEE 262. Environmental Chemistry II. 4 Units.
Advanced concepts from physical and organic chemistry as they relate to environmental engineering. Emphasis on equilibrium and kinetics as they apply to redox reactions, coordination, absorption, gas phase reactions, and ion exchange.
Restriction: Graduate students only.
ENGRCEE 263. Advanced Biological Treatment Processes. 4 Units.
Analysis of biological processes in natural and engineered systems. Biological treatment processes, both aerobic and anaerobic, with emphasis on suspended growth systems including design consideration. Containment degradation or control covered. Includes laboratory on molecular tools used in wastewater treatment.
Restriction: Graduate students only.

ENGRCEE 264. Carbon and Energy Footprint Analysis. 4 Units.
Process design for wastewater treatment. Mass- and energy- balance analysis applied to water and wastewater treatment systems. Case studies include analysis of water supply, treatment, reclamation, and reuse.
Restriction: Graduate students only.
Concurrent with ENGRCEE 164.

ENGRCEE 265. Physical-Chemical Treatment Processes. 4 Units.
Theory and dynamics of physical and chemical separation processes in water and wastewater treatment. Topics include coagulation, sedimentation, filtration, gas transfer, membrane separations, and absorption.
Restriction: Graduate students only.
Concurrent with ENGRCEE 165.

ENGRCEE 266. Drinking Water and Wastewater Biotechnology. 4 Units.
Water and wastewater microbiology. Engineering principles, molecular aspects, and overview of microorganisms of importance to public health. Topics include aerobic and anaerobic wastewater treatment and disinfection of pathogens in water, wastewaters, and biosolids.
Restriction: Graduate students only.

ENGRCEE 267. Energy, Climate Change, and Urban Air Quality. 4 Units.
An introduction to the connection between energy, climate change, and urban air quality. It will focus on air quality and climate implications of energy choices, bringing light to the most important and time-relevant issues.
Restriction: Graduate students only.

ENGRCEE 270. Flood Risk and Modeling. 4 Units.
Global and national trends in flooding and related impacts including disasters; flood risk management; theory and numerical methods for flood inundation modeling; flood risk communication strategies including flood hazard visualizations.

ENGRCEE 271. Flow in Unsaturated Porous Media. 4 Units.
Fluid flow in the unsaturated zone (zone of aeration) of the subsurface. Soil-water physics, flow in regional groundwater systems, miscible displacement, mathematical modeling techniques.
Restriction: Graduate students only.
Concurrent with ENGRCEE 172.

ENGRCEE 272. Groundwater Hydrology. 4 Units.
Topics include conservation of fluid mass, storage properties or porous media, matrix compressibility, boundary conditions, flow nets, well hydraulics, groundwater chemistry, and solute transport. Includes introduction to advanced topics in porous media. Design projects and computer applications included.
Restriction: Graduate students only.
Concurrent with ENGRCEE 172.

ENGRCEE 273. Watershed Modeling. 4 Units.
Basic principles of hydrologic modeling are practiced. Concepts of watershed delineation, land use change impact, design studies, and GIS tools are discussed. Focus on the USACE (HEC) software tools (HEC-HMS and HEC-RAS) along with their associated GIS interfaces.
Restriction: Graduate students only.
Concurrent with ENGRCEE 173.

ENGRCEE 274. Climate Data Analysis. 4 Units.
Trend analysis; statistical indices for diagnosing and detecting changes in extremes; nonstationary processes; extreme value analysis; multivariate extreme value methods; tail dependence estimation; uncertainties in observed and projected changes in climate extremes.
ENGRCEE 275. Topics in Coastal Engineering. 4 Units.
Linear wave theory. Wave properties: particle kinematics, energy propagation, shoaling, refraction, reflection, diffraction, and breaking. Wave statistics and spectra. Selected topics from: design of coastal structures; harbor engineering; littoral transport and shoreline morphology; and hydrodynamics of estuaries.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.

ENGRCEE 276. Hydrology. 4 Units.
Elements of the hydrologic cycle including precipitation, infiltration, evapotranspiration, ground water, and runoff. Unit Hydrograph theory and routing methods. Introduction to precipitation/runoff relationship and watershed modeling. Statistical methods and flood frequency analysis. Discussion section covers advanced topics.
Restriction: Graduate students only.

Concurrent with ENGRCEE 176.

ENGRCEE 277. Hydrologic Transport Fundamentals. 4 Units.
Process description, mathematical and numerical modeling of transport processes in surface and ground water. Topics include advection, molecular diffusion, Taylor dispersion, mechanical dispersion in porous media, shear flow dispersion in channels, and turbulent jets and plumes.
Prerequisite: ENGRMAE 278
Restriction: Graduate students only.

ENGRCEE 278. Fluid Mechanics of Open Channels. 4 Units.
Fundamentals of fluid motion in open channels. Navier-Stokes equations and one-dimensional momentum and energy principles. Topics include rapidly varied flow, flow resistance and turbulence, gradually varied flow, unsteady flow, and computational methods for channel flow modeling.
Restriction: Graduate students only.

Concurrent with ENGRCEE 178.

ENGRCEE 279. Hydrologic Computational Modeling. 4 Units.
Computational modeling of multi-dimensional flow and scalar transport problems in surface and ground water. Topics include mathematical model formulation, numerical method selection, serial and parallel implementation, model verification and validation.
Prerequisite: ENGRCEE 272 and ENGRCEE 277 and ENGRCEE 278
Restriction: Graduate students only.

ENGRCEE 281. Structural Reliability. 4 Units.
Restriction: Graduate students only.

ENGRCEE 283. Mathematical Methods in Engineering Analysis. 4 Units.
Matrices; vector calculus; eigenvalue problems; Fourier analysis; partial differential equations; special functions; numerical analysis; finite difference method.

ENGRCEE 284. Engineering Decision and Risk Analysis. 4 Units.
Develops applications of statistical decision theory in engineering. Presents the fundamental tools used in engineering decision making and analysis of risk under conditions of uncertainty. All concepts are presented and illustrated thoroughly with engineering problems.
Restriction: Graduate students only.

ENGRCEE 289. Analysis of Hydrologic Systems. 4 Units.
ENGRCEE 290. Merging Models and Data. 4 Units.

Restriction: Graduate students only.

ENGRCEE 291. Hydrologic Remote Sensing. 4 Units.
Introduction to principles of remote sensing and application in hydrology. Review of sensor systems, thermal and multispectral image processing, and image classification. Examples from remote sensing of hydrologic processes such as precipitation, soil moisture, and vegetation are covered.

Prerequisite: ENGRCEE 276

Restriction: Graduate students only.

ENGRCEE 292. Wavelets in Hydrology, Engineering, and Geoscience. 4 Units.
Multiscale analysis of hydrologic, engineering, and earth system processes; energy decomposition in the time-frequency domain via wavelets; applications to fluid flows, climate and mechanical signals for feature extraction, trend analysis, coherent structures, and upscaling/downscaling.

Restriction: Graduate students only.

ENGRCEE 295. Seminars in Engineering. 1-4 Units.
Seminars scheduled each year by individual faculty in major field of interest.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

ENGRCEE 296. Master of Science Thesis Research. 1-16 Units.
Individual research or investigation conducted in preparation of the thesis required for the M.S. degree in Engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

ENGRCEE 297. Doctor of Philosophy Dissertation Research. 1-16 Units.
Individual research or investigation conducted in preparation for the dissertation required for the Ph.D. degree in Engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

ENGRCEE 298. Special Topics in Civil Engineering. 1-4 Units.
Presentation of advanced topics and special research areas in civil engineering.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

ENGRCEE 299. Individual Research. 1-16 Units.
Individual research or investigation under the direction of an individual faculty member.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.