Department of Civil and Environmental Engineering

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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 Code</th>
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</thead>
<tbody>
<tr>
<td>CHEM 1A</td>
<td>General Chemistry</td>
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<tr>
<td>or</td>
<td></td>
</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>
</tr>
<tr>
<td>MATH 2A-2B</td>
<td>Single-Variable Calculus</td>
</tr>
<tr>
<td></td>
<td>and Single-Variable Calculus</td>
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<tr>
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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:
- ENGR 7A-7B Introduction to Engineering I and Introduction to Engineering II

Section B:
- CHEM 1LE Accelerated General Chemistry Lab
- CHEM 1C-1LC General Chemistry and General Chemistry Laboratory

Section C:
- EECS 70A Network Analysis I
- ENGR 54 Principles of Materials Science and Engineering
- ENGRMAE 80 Dynamics
- ENGRMAE 91 Introduction to Thermodynamics

Engineering Topics Courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 20</td>
<td>Introduction to Computational Problem Solving</td>
</tr>
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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>Title</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</td>
<td>Contemporary and Emerging Environmental Challenges</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 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 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 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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>EECS 70A</td>
<td>Network Analysis I</td>
</tr>
<tr>
<td>(EECS 70A may not be used in this Specialization if used for a Lower-Division Technical Elective.)</td>
<td></td>
</tr>
<tr>
<td>ENGRCEE 124</td>
<td>Transportation Systems IV: Freeway Operations and Control</td>
</tr>
<tr>
<td>ENGRMAE 170</td>
<td>Introduction to Control Systems</td>
</tr>
<tr>
<td>ENGRMAE 171</td>
<td>Digital Control Systems</td>
</tr>
<tr>
<td>or courses from an approved list</td>
<td></td>
</tr>
</tbody>
</table>

* ENGR 7A-ENGR 7B is available only to first year 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**

**Sample Program of Study — Civil Engineering**

**Freshman**

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

**Sophomore**

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

**Junior**

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

* Note: ENGR 7A-ENGR 7B is available only to first year 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></th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 181A</td>
<td>ENGRCEE 181B</td>
<td></td>
<td>ENGRCEE 181C</td>
</tr>
<tr>
<td>Spec. Elective</td>
<td>ENGRCEE 111</td>
<td></td>
<td>Spec. Elective</td>
</tr>
<tr>
<td>General Education</td>
<td>Spec. Elective</td>
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<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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</tbody>
</table>
## Senior: Environmental Hydrology and Water Resources Specialization

<table>
<thead>
<tr>
<th>Senior</th>
<th>Winter</th>
<th>Spring</th>
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<tbody>
<tr>
<td>Fall</td>
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<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>
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<tr>
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## Senior: Structural Engineering Specialization

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<thead>
<tr>
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<th>Spring</th>
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<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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<tr>
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</tbody>
</table>

## Senior: Transportation Systems Engineering

<table>
<thead>
<tr>
<th>Senior</th>
<th>Winter</th>
<th>Spring</th>
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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>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>
</tr>
<tr>
<td>General Education</td>
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<td>General Education</td>
</tr>
</tbody>
</table>

Students must obtain approval for their program of study and must see their faculty advisor at least once each year.

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 who select the Environmental Engineering specialization within the Civil Engineering major should follow the Civil Engineering sample program.) Students must have their programs approved by their faculty advisor. Civil Engineering majors must consult at least once every year with the academic counselors in the Student Affairs Office and with their faculty advisors.

### 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

All students must meet the University Requirements.  
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>
</tr>
<tr>
<td>MATH 2A- 2B</td>
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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</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBEMS 45A</td>
<td>Chemical Processing and Materials 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 and Introduction to Engineering II</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>
</tr>
</tbody>
</table>

### Engineering Topics Courses:

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

<table>
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<td>Soil Mechanics and Soil Mechanics Laboratory</td>
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<tr>
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<td>ENGRCEE 160</td>
<td>Environmental Processes</td>
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</tr>
<tr>
<td>ENGRCEE 170</td>
<td>Introduction to Fluid Mechanics</td>
</tr>
</tbody>
</table>
ENGRCEE 181A-181B-181C
Senior Design Practicum I
and Senior Design Practicum II
and Senior Design Practicum III

**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 189 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 first year 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 must consult at least once every year with the academic counselors in the Student Affairs Office and with their faculty advisors.

**Sample Program of Study — Environmental Engineering**

### Freshman

<table>
<thead>
<tr>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</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>CHEM 1B</td>
<td>CHEM 1C</td>
</tr>
<tr>
<td>Lower-Division Engineering Elective</td>
<td>PHYSICS 7C</td>
<td>PHYSICS 7D</td>
</tr>
<tr>
<td>General Education</td>
<td>PHYSICS 7LC</td>
<td>PHYSICS 7LD</td>
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<tr>
<td></td>
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<td>ENGRCEE 81A</td>
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</tbody>
</table>

### Sophomore

<table>
<thead>
<tr>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 3A</td>
<td>MATH 3D</td>
<td>MATH 2E</td>
</tr>
</tbody>
</table>


Students must obtain approval for their program of study and must see their faculty advisor at least once each year.

On This Page:

- Civil Engineering
- Concentration in Environmental Engineering

Graduate Study in Civil Engineering

Civil Engineering addresses the technology of constructed environments and, as such, embraces a wide range of intellectual endeavors. The Department of Civil and Environmental Engineering focuses its graduate study and research program on three areas: Structural Engineering, including engineering mechanics, advanced composites, structural dynamics, earthquake engineering, and reliability and risk assessment; Transportation Systems Engineering, including traffic operations and management, advanced information technology applications, travel behavior, and transportation systems analysis; Hydrology and Water Resources Engineering, including hydrology, water resources, and remote sensing.

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

At the point of application a student is required to identify a thrust area. Specifically, the three thrust areas that have been identified for the Civil Engineering Graduate program are: Structural Engineering, Transportation Systems Engineering, and Hydrology and Water Resources Engineering. Once admitted, an advisor will be assigned according to the thrust area a student has chosen. Financial support through research or teaching assistantships and a variety of fellowships and scholarships is available to qualified students.

Structural Engineering

The Structural Engineering area emphasizes the application of analytical, numerical, and experimental approaches to the investigation of constructed facilities and systems that support or resist various loads. The objective of the program is to prepare graduates for leadership positions in industry and academic institutions by providing an opportunity to learn state-of-the-art methodologies applied to significant structural engineering problems. 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 mechanistic analysis, and sustainable green materials and infrastructural systems.

Transportation Systems Engineering

Among leading centers for transportation research, the Department of Civil and Environmental Engineering offers a graduate research area that is distinguished by its interdisciplinary approach to the study of current and emerging urban transportation issues and by its unique relationship with the UC Irvine Institute of Transportation Studies. The research 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 Engineering

This area focuses on the distribution and transport of water among and between land, atmosphere, and oceans, the supply of water for municipal, agricultural, and environmental uses, and water-related hazards such as flooding and drought. Mathematical and computational modeling is germane to research activity in this area as well as professional practice, so course work is designed to develop theory-based mathematical modeling skill, on the one hand, as well as computational modeling skill on the other. Course work emphasizes important fundamentals such as mass, energy and momentum conservation principles, applied to hydrologic systems, and also increasingly important remote sensing and information technologies. Interdisciplinary
study is an important dimension to hydrology and water resources, particularly in the areas of water quality, ecology, infrastructure systems, technology, and policy. Consequently, students are encouraged to take courses in these areas.

**Master of Science Degree**

The M.S. reflects achievement of an advanced level of competence for the professional practice of civil engineering. Two plans are available to those working toward the M.S.: a thesis option and a 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 (a maximum of ten of which can be taken for study in conjunction with the thesis research topic; 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 nonresearch, graduate-level approved engineering or related courses (numbered 200–289) 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 ten units).

**Plan II: Course Work Option**

The course work option requires the completion of 48 units of study, at least 40 of which must be in nonresearch graduate-level approved engineering or related courses (numbered 200–289) 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.

**Concurrent Master’s Degree Program with Planning, Policy, and Design**

The Department of Civil and Environmental Engineering (CEE) and the Department of Planning, Policy, and Design (PPD) in the School of Social Ecology offer a concurrent degree program that allows students to earn both a master’s in Civil Engineering (M.S.) and a master’s in Urban and Regional Planning (M.U.R.P.) in two years (instead of more than three years if these degrees were pursued sequentially).

**Requirements**

The concurrent degree program requires 84 units of study and is organized around two tracks: (1) transportation systems, and (2) environmental hydrology and water resources. The program core comprises 15 graduate courses for the transportation systems track, and 13 graduate and two undergraduate courses for the environmental hydrology and water resources track.

Students choose between a thesis option and a comprehensive examination option. The thesis option requires completion of 84 units of study (a maximum of ten of which may be taken in conjunction with the thesis research); completion of an original research project and the writing of a thesis to describe it; completion of required core courses; and completion of enough units of approved electives to meet the total requirement of 84 units. The comprehensive examination option also requires completion of 84 units of study as well as a professional report, which represents a substantial piece of planning practice, as the capstone event. These units of study include core courses and enough units of approved electives to meet the total requirement of 84 units, with no redundancy of core courses in either CEE or PPD. Electives may include as many as ten units of independent study or approved undergraduate courses.

Undergraduates seeking admission to the concurrent master’s degree program should have a strong record of course work in disciplines related to civil engineering and urban planning, and they must meet the requirements for admission in both departments. Visit the Civil and Environmental Engineering Admissions Requirements (http://www.eng.uci.edu/dept/cee) and Planning, Policy and Design Admissions website (http://ppd.soceco.uci.edu/pages/admissions) for more information about these requirements.

**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 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.

The Institute of Transportation Studies

The Institute of Transportation Studies at Irvine (ITS) is part of a multicampus research unit of the University of California. ITS Irvine consists of faculty, staff, and graduate and undergraduate students engaged at the forefront of knowledge in interdisciplinary transportation research and education. Currently, the Institute involves faculty and students from The Henry Samueli School of Engineering, the School of Social Sciences, the School of Social Ecology, The Paul Merage School of Business, and the Donald Bren School of Information and Computer Sciences. Collaborations with colleagues from outside the University are common. The mission of the Institute is to create and disseminate significant new knowledge to help solve society’s pressing transportation problems, both in California and globally. It achieves this through cutting-edge activities in research, education, and professional outreach. A characteristic of ITS Irvine transportation research is a systems approach, focusing on the areas of planning, policy, economics (including pricing and finance), operations (including traffic, transit, logistics and freight, and safety), energy and the environment, and information technologies. The Institute has close ties to the University’s Transportation Science interdisciplinary graduate degree program. Students choosing to focus their studies in transportation will find strong interdisciplinary opportunities between the Department and ITS. See the Office of Research section of the Catalogue for additional information.

The Urban Water Research Center

The Urban Water Research Center focuses on five integrating water issues in urban areas: (1) supply, demand, and distribution; (2) water quality; (3) urban ecology; (4) water reuse; and (5) institutions and public policy. In each of these areas the Center enables the issues to be addressed in an integrated way from the points of view of biology, earth systems, economics, engineering public policy, and public health. The Center is the collaborative effort of the Department of Civil and Environmental Engineering, the Department of Earth System Science, and the School of Social Ecology.

Graduate Concentration in Environmental Engineering

Russel Detwiler, Director and Graduate Advisor
844C Engineering Tower
949-824-7152

Students may pursue either the M.S. or Ph.D. in Engineering with a concentration in Environmental Engineering.

Environmental Engineering is an interdisciplinary program engaging faculty from departments in both Civil & Environmental Engineering and Mechanical & Aerospace Engineering. Environmental Engineering addresses the development of strategies to control anthropogenic emissions of pollutants to the environment; the generation of sustainable water and energy in response to climate change and population growth; and the enhancement of science and engineering understanding, which can be translated into management strategies to face the challenge of water, energy shortage, and global climate variability.

Environmental Engineering requires a curriculum that provides students with an understanding of fundamentals in Water, Energy, Air Quality, and Climate.

Faculty

Amir AghaKouchak: Hydrology, climatology, remote sensing of environment, climate extremes, water-energy nexus, climate change, stochastic modeling, water resources management

Jacob Brouwer: High-temperature electrochemical dynamics, fuel cells, renewable and sustainable energy

William J. Cooper: Environmental chemistry, advanced oxidation processes for water treatment, aquatic photochemistry of carbon cycling

Donald Dabdub: 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

Kristen Davis: Coastal oceanography, fluid mechanics, and turbulent flows

Russell L. Detwiler: Groundwater hydrology, contaminant fate and transport, subsurface process modeling, groundwater/surface-water interaction

Derek Dunn-Rankin: Combustion, optical particle sizing, particle aero-dynamics, laser diagnostics and spectroscopy

Efi Foufoula-Georgiou: 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: Environmental engineering, inland and coastal water quality, coagulation and filtration of colloidal contaminants, environmental microbiology
Kuolin Hsu: Remote sensing of precipitation, hydrologic systems modeling, stochastic hydrology, water resources systems planning

C. Sunny Jiang: Water pollution microbiology, environmental biotechnology, aquatic microbial ecology

Betty H. Olson: Molecular applications for optimizing biological processes in wastewater treatment, environmental health, drinking water microbiology

Diego Rosso: Environmental process engineering, mass transfer, wastewater treatment, carbon- and energy-footprint analysis

G. Scott Samuelsen: Energy, fuel cells, hydrogen economy, propulsion, combustion and environmental conflict; turbulent transport in complex flows, spray physics, NOx and soot formation, laser diagnostics and experimental methods; application of engineering science to practical propulsion and stationary systems; environmental ethics

Brett F. Sanders: Environmental and computational fluid dynamics, water resources engineering

Jean-Daniel M. Saphores: Transportation economics, planning and policy, environmental and natural resource economics and policy, quantitative methods

Soroosh Sorooshian: Hydrology, hydrometeorology and hydroclimate modeling, remote sensing, water sources management

Jasper A. Vrugt: Artificial intelligence, computational science, hydrology, surface, unsaturated zone, groundwater, geophysics, ecology, statistics, systems theory, numerical modeling stochastic analysis, earth systems, agriculture, soils, geomorphology, hydrogeophysics

**Required Background**

The program core curriculum builds on environmental engineering fundamentals such as fluid mechanics, environmental chemistry, microbial processes, thermodynamics, hydrological and climate science, and reactor theory and design. The interdisciplinary nature of the program allows students with a variety of science and engineering backgrounds to undertake studies in this field. Students admitted to the program lacking one or more fundamental courses can earn credit toward the M.S. by completing these courses at UC Irvine. Students entering the program are expected to have had exposure to engineering-level math that includes linear algebra, differential equations and statistics.

The degree to which each student meets the program’s background requirement is determined by a faculty committee at the time of admission. Students with an insufficient background who are offered admission will be required to take a set of appropriate prerequisite undergraduate courses before entering the program or at the beginning of the program.

The list below is a general checklist for the required background and a list of undergraduate courses that may be used to fulfill the background requirements.

### Required Background and Sample UCI Undergraduate Courses

**Engineering Level Math:**

<table>
<thead>
<tr>
<th>Courses</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 2D</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>MATH 3D</td>
<td>Elementary Differential Equations</td>
</tr>
</tbody>
</table>

**Environmental Chemistry/Microbiology (two of the following):**

<table>
<thead>
<tr>
<th>Courses</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO SCI M122</td>
<td>General Microbiology</td>
</tr>
<tr>
<td>CBEMS 112</td>
<td>Introduction to Biochemical Engineering</td>
</tr>
<tr>
<td>CHEM 51A</td>
<td>Organic Chemistry</td>
</tr>
<tr>
<td>EARTHSS 142</td>
<td>Atmospheric Chemistry</td>
</tr>
<tr>
<td>ENGRCEE 162</td>
<td>Introduction to Environmental Chemistry</td>
</tr>
</tbody>
</table>

**Fluid Mechanics/Momentum Transport (two of the following):**

<table>
<thead>
<tr>
<th>Courses</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBEMS 45C</td>
<td>Chemical Engineering Thermodynamics</td>
</tr>
<tr>
<td>ENGRCEE 170</td>
<td>Introduction to Fluid Mechanics</td>
</tr>
<tr>
<td>ENGRMAE 91</td>
<td>Introduction to Thermodynamics</td>
</tr>
<tr>
<td>ENGRMAE 115</td>
<td>Applied Engineering Thermodynamics</td>
</tr>
<tr>
<td>ENGRMAE 130A</td>
<td>Introduction to Fluid Mechanics</td>
</tr>
</tbody>
</table>

**Reactor Theory/Intro. Environmental Engineering (one of the following):**

<table>
<thead>
<tr>
<th>Courses</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBEMS 45A</td>
<td>Chemical Processing and Materials Balances</td>
</tr>
<tr>
<td>CBEMS 110</td>
<td>Reaction Kinetics and Reactor Design</td>
</tr>
<tr>
<td>CBEMS 125C</td>
<td>Mass Transfer</td>
</tr>
</tbody>
</table>
Areas of Emphasis
Water, Energy, Air Quality and Climate are areas of emphasis in the Environmental Engineering Concentration. To achieve the interdisciplinary objectives of the Concentration, students entering the program without an M.S. degree are required to complete three core courses and three quarters of the Environmental Engineering seminar. Students can take additional elective courses in all areas or only one area. A limited number of courses (less than 4) outside of The Henry Samueli School of Engineering (i.e., Schools of Physical Sciences, Biological Sciences, Social Ecology, and the Program in Public Health) can be used toward elective credits with the approval of the faculty advisor and the graduate director.

Core Requirement
Students entering the program without an M.S. must complete the following core requirements before petitioning for an M.S.

**Advanced Mathematics: Select one of the courses listed below:**
- ENGRCEE 283: Mathematical Methods in Engineering Analysis
- ENGRMAE 200A: Engineering Analysis I
- ENGRMAE 200B: Engineering Analysis II
- PHYSICS 229A: Computational Methods

**Water: Select one of the courses listed below:**
- ENGRCEE 260: Desalination
- ENGRCEE 261: Applied Environmental Microbiology
- ENGRCEE 262: Environmental Chemistry II
- ENGRCEE 263: Advanced Biological Treatment Processes
- ENGRCEE 265: Physical-Chemical Treatment Processes
- ENGRCEE 266: Drinking Water and Wastewater Biotechnology
- ENGRCEE 271: Flow in Unsaturated Porous Media
- ENGRCEE 272: Groundwater Hydrology
- ENGRCEE 273: Watershed Modeling
- ENGRCEE 276: Hydrology
- ENGRCEE 277: Hydrologic Transport Fundamentals
- ENGRCEE 278: Fluid Mechanics of Open Channels
- ENGRCEE 279: Hydrologic Computational Modeling
- ENGRCEE 290: Merging Models and Data
- ENGRCEE 291: Hydrologic Remote Sensing

**Energy, Air Quality & Climate: Select one of the courses listed below:**
- ENGRCEE 264: Carbon and Energy Footprint Analysis
- ENGRCEE 274: Climate Data Analysis
- ENGRCEE 267: Energy, Climate Change, and Urban Air Quality
- ENGRCEE 291: Hydrologic Remote Sensing
- EARTHSS 240: Atmospheric Chemistry and Physics
- ENGRMAE 210: Advanced Fundamentals of Combustion
- ENGRMAE 214A: Fuel Cell Fundamentals and Technology
- ENGRMAE 215: Advanced Combustion Technology
- ENGRMAE 218: Sustainable Energy Systems
- ENGRMAE 238: Experimental Fluid Dynamics
- ENGRMAE 260: Current Issues Related to Tropospheric and Stratospheric Processes
- ENGRMAE 284: Fundamentals of Experimental Design

**Seminars in Environmental Engineering: Three courses of:**
- ENGRCEE 295: Seminars in Engineering

**Elective Courses**
Additional course requirements can be fulfilled using any of the courses listed above in the areas of emphasis. Other courses can be included with the approval of the faculty advisor and graduate director.
Master of Science Degree

Two options are available for M.S. students: a thesis option and a comprehensive examination option. Both options require the completion of at least 48 units of study.

Plan I. Thesis Option

A thesis option is available to students who prefer to conduct a focused research project. Students selecting this option must complete an original research investigation and a thesis, and obtain approval of the thesis by a thesis committee. Of the 48 required units, at least 28 units must be nonresearch, graduate-level courses including six core courses. A maximum of 16 M.S. research units and up to ten units of upper-division undergraduate elective courses may be applied to the degree with the prior approval of the Graduate Advisor.

Plan II. Comprehensive Examination Option

Alternatively, students may select a coursework option in which they must successfully complete 48 units of study and pass a comprehensive examination. At least 36 units must be nonresearch, graduate-level courses, including six core courses. A maximum of eight research units and up to ten units of upper-division undergraduate elective courses may be applied to the degree with the prior approval of the Graduate Advisor.

Doctor of Philosophy Degree

The Ph.D. concentration in Environmental Engineering requires the achievement of original and significant research that advances the discipline. Doctoral students are selected on the basis of an outstanding record of scholarship and potential for research excellence.

Each student will match with a faculty advisor, and an individual program of study is designed by the student and their faculty advisor. Students entering with a master’s degree are not required to fulfill the core requirements. However, in preparation for a successful preliminary examination, additional courses may be required in consultation with the graduate advisor and the program director. Students without a master’s degree may be admitted into the Ph.D. program. However, these students will be required to complete the course work option requirements for the master’s degree before registering for the preliminary exam. Within this flexible framework, the School maintains specific guidelines that outline the milestones of a typical doctoral program. There are several milestones to be passed: admission to the Ph.D. program by the faculty, passage within the first two years of a preliminary examination, formal advancement to candidacy by passing a qualifying examination in the third year (or 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. During their research project, students are expected to enroll in at least 12 units of Individual Research or Dissertation Research per quarter.

The preliminary examination committee is comprised of three core examiners from different areas of Environmental Engineering. Students who fail the preliminary examination in the first year may reattempt the examination the following year. Students who fail the second attempt will not be allowed to continue in the program. Committees for Ph.D. qualifying examinations must have five members. Three members of this committee must be core faculty in the Environmental Engineering program. One member must be a UC faculty member outside the Environmental Engineering Program. The student’s faculty advisor serves as the technical chair of the committee. The qualifying examination follows campus and The Henry Samueli School of Engineering guidelines and consists of an oral and written presentation of original work completed thus far, and a coherent plan for completing a body of original research. The student’s dissertation topic must be approved by the student’s doctoral committee. The degree is granted upon the recommendation of the doctoral committee and the Dean of Graduate Division. 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 materials at nano- and meso-scales)

Amir AghaKouchak, Ph.D. University of Stuttgart, Associate Professor of Civil and Environmental Engineering (hydrology, hydroclimatology, data assimilation, remote sensing of critical global water resource issues)

Alfredo H.-S. Ang, Ph.D. University of Illinois at Urbana-Champaign, Professor Emeritus of Civil and Environmental Engineering

William J. Cooper, Ph.D. University of Miami, Professor 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, Associate Dean for Research and Innovation and 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 of Civil and Environmental Engineering; Chemical Engineering and Materials Science (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

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

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; 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)

Anne Lemnitzer, Ph.D. University of California, Los Angeles, Assistant 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 Engineering and Materials Science (responsive materials, multifunctional materials and structures, fracture mechanics, infrastructure sustainability)

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, blast mitigation and diagnostic/prognostic techniques for infrastructure security)

Betty H. Olson, Ph.D. University of California, Berkeley, Professor 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

Wilfred W. Recker, Ph.D. Carnegie Mellon University, 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 Associate Professor of Civil and Environmental Engineering; Chemical Engineering and Materials Science (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 (environmental hydrodynamics, computational fluid dynamics, coastal water quality)

Jean-Daniel M. Saphores, Ph.D. Cornell University, Professor of Civil and Environmental Engineering; Economics; Urban Planning and Public Policy (transportation economics, planning and policy, environmental and natural resource economics and policy, quantitative methods)

Jan W. Scherfig, Ph.D. University of California, Berkeley, Professor Emeritus of Civil and Environmental Engineering

Robin Shepherd, Ph.D. University of Canterbury, Professor Emeritus of Civil and Environmental Engineering

Masanobu Shinozuka, Ph.D. Columbia University, Professor Emeritus of Civil and 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; Chemical Engineering and Materials Science (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

Jasper A. Vrugt, Ph.D. University of Amsterdam, Associate Professor of Civil and Environmental Engineering; Earth System Science (complex systems, modeling, statistics, hydrology, geophysics, ecology, data, optimization, hydropower, data assimilation)

Jann N. Yang, DSc Columbia University, Professor Emeritus of Civil and Environmental Engineering
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, Associate Professor of Mechanical and Aerospace Engineering; Civil and Environmental Engineering (high-temperature electrochemical dynamics, fuel cells, renewable and sustainable energy)

Donald Dabdub, Ph.D. California Institute of Technology, 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)

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 aero-dynamics, laser diagnostics and spectroscopy)

Farzad Naeim, Ph.D. University of Southern California, Civil and Environmental Engineering (theory and practice of structural engineering, earthquake engineering and earthquake resistant design, applied performance-based analysis and design of structures, design of seismic protective systems)

Phu Dinh Nguyen, Ph.D. University of California, Irvine, Civil and Environmental Engineering (hydrology, water resources, satellite precipitation estimation, flood modeling, and forecasting)

Amelia C. Regan, Ph.D. University of Texas at Austin, Professor of Computer Science; Civil and Environmental Engineering

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, fuel cells, hydrogen economy, propulsion, combustion and environmental conflict, turbulent transport in complex flows, spray physics, NOx and soot formation, laser diagnostics and experimental methods, application of engineering science to practical propulsion and stationary systems, environmental ethics)

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
Overlaps 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)
Prerequisite: ENGRCEE 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
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
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
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.
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 only.
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 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 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.

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 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.