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.

- Civil Engineering (p. 1)
- Environmental Engineering (p. 5)

**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**


**Transfer Students:** Preference will be given to junior-level applicants with the highest grades overall, and who have satisfactorily completed the following required courses: one year of approved calculus, one year of calculus-based physics with laboratories (mechanics, electricity and magnetism), completion of lower-division writing, one year of chemistry (with laboratory), and one additional approved course for the major.

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. Degree in Civil Engineering

All students must meet the University Requirements (http://catalogue.uci.edu/previouseditions/2014-15/informationforadmittedstudents/requirementsforabachelorsdegree).

All students must meet the School Requirements (http://catalogue.uci.edu/previouseditions/2014-15/thehenrysamuelischoolofengineering/#undergraduatestudytext).

Major Requirements

Mathematics and Basic Science Courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1A-1B</td>
<td>General Chemistry</td>
</tr>
<tr>
<td></td>
<td>and General Chemistry</td>
</tr>
<tr>
<td>CHEM 1LE</td>
<td>Accelerated General Chemistry Lab</td>
</tr>
<tr>
<td>or</td>
<td>General Chemistry</td>
</tr>
<tr>
<td>CHEM 1C-1LC</td>
<td>and General Chemistry Laboratory</td>
</tr>
<tr>
<td>MATH 2A-2B</td>
<td>Single-Variable Calculus</td>
</tr>
<tr>
<td></td>
<td>and Single-Variable Calculus</td>
</tr>
<tr>
<td>MATH 2D</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>MATH 3A</td>
<td>Introduction to Linear Algebra</td>
</tr>
<tr>
<td>MATH 3D</td>
<td>Elementary Differential Equations</td>
</tr>
<tr>
<td>MATH 2E</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>PHYSICS 7C</td>
<td>Classical Physics</td>
</tr>
<tr>
<td>PHYSICS 7C</td>
<td>Classical Physics Laboratory</td>
</tr>
<tr>
<td>PHYSICS 7D</td>
<td>Classical Physics</td>
</tr>
<tr>
<td>PHYSICS 7D</td>
<td>Classical Physics Laboratory</td>
</tr>
</tbody>
</table>

One Basic Science Elective from the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO SCI 55</td>
<td>Introduction to Ecology</td>
</tr>
<tr>
<td>BIO SCI 65</td>
<td>Biodiversity &amp; Conservation</td>
</tr>
<tr>
<td>BIO SCI 93</td>
<td>From DNA to Organisms</td>
</tr>
<tr>
<td>EARTHSS 1</td>
<td>Introduction to Earth System Science</td>
</tr>
<tr>
<td>EARTHSS 3</td>
<td>Oceanography</td>
</tr>
<tr>
<td>EARTHSS 5</td>
<td>The Atmosphere</td>
</tr>
<tr>
<td>EARTHSS 7</td>
<td>Physical Geology</td>
</tr>
<tr>
<td>EARTHSS 15</td>
<td>Introduction to Global Climate Change</td>
</tr>
<tr>
<td>EARTHSS 17</td>
<td>Hurricanes, Tsunamis, and other Catastrophes</td>
</tr>
<tr>
<td>EARTHSS 19</td>
<td>Introduction to Modeling the Earth System</td>
</tr>
</tbody>
</table>

Lower-Division Engineering Elective:

Select one 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>ENGR 54</td>
<td>Principles of Materials Science and Engineering</td>
</tr>
<tr>
<td>ENGR 7A-7B</td>
<td>Introduction to Engineering I</td>
</tr>
<tr>
<td></td>
<td>and Introduction to Engineering II</td>
</tr>
<tr>
<td>ENGRMAE 80</td>
<td>Dynamics</td>
</tr>
<tr>
<td>ENGRMAE 91</td>
<td>Introduction to Thermodynamics</td>
</tr>
</tbody>
</table>

Engineering Topics Courses:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 11</td>
<td>Methods II: Probability and Statistics</td>
</tr>
<tr>
<td>ENGRCEE 20</td>
<td>Introduction to Computational Engineering Problem Solving</td>
</tr>
<tr>
<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><em>course</em></td>
<td>course_name_</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</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>
<tr>
<td>ENGRCEE 171</td>
<td>Water Resources Engineering</td>
</tr>
<tr>
<td>ENGRCEE 181A-181B-181C</td>
<td>Senior Design Practicum and Senior Design Practicum and Senior Design Practicum</td>
</tr>
</tbody>
</table>

**Engineering Design Elective:**

Select one of the following:

- ENGRCEE 122: Transportation Systems II: Operations & Control
- ENGRCEE 123: Transportation Systems III: Planning & Forecasting
- ENGRCEE 155: Structural Steel Design (Students completing the specialization in Structural Engineering must take ENGRCEE 155.)
- ENGRCEE 172: Groundwater Hydrology

Engineering Design Elective cannot be counted toward the course requirement for a specialization.

**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

**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 & Forecasting

2. Select one:
   - ENGRCEE 152: Computer Methods in Structural Analysis and Design
   - ENGRCEE 153: Statically Indeterminate Structures
   - ENGRCEE 155: Structural Steel Design
   - ENGRCEE 156: Foundation Design

3. Select one:
   - ENGRCEE 162: Introduction to Environmental Chemistry
   - ENGRCEE 163: Biological Treatment Process Design
   - ENGRCEE 165: Physical-Chemical Treatment Processes
   - ENGRCEE 167: Ecology of Coastal Waters

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 162: Introduction to Environmental Chemistry
- ENGRCEE 163: Biological Treatment Process Design
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)
ENGRCEE 153  Statically Indeterminate Structures
Select three of the following:
  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 & Forecasting
Select two of the following:
  EECS 70A  Network Analysis I
  (EECS 70A may not be used in this Specialization if used for an Engineering Science Elective.)
  ENGRCEE 124  Transportation Systems IV: Freeway Operations and Control
  ENGRCEE 125  Transportation and the Environment
  ENGRMAE 140  Introduction to Engineering Analysis
  ENGRMAE 170  Introduction to Control Systems
  ENGRMAE 171  Digital Control Systems
or courses from an approved list

* ENGR 7A-7B is available only to first year students in Fall and Winter quarters. Both ENGR 7A-7B must be taken to be counted as either a Lower-Division Engineering Elective or as one of the Specialization Electives.

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 188 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

<table>
<thead>
<tr>
<th>Freshman</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH 2A</td>
<td>MATH 2B</td>
<td>MATH 2D</td>
</tr>
<tr>
<td>ENGRCEE 20</td>
<td>PHYSICS 7C</td>
<td>PHYSICS 7D</td>
</tr>
<tr>
<td>CHEM 1A</td>
<td>PHYSICS 7LC</td>
<td>PHYSICS 7LD</td>
</tr>
<tr>
<td>General Education</td>
<td>CHEM 1B</td>
<td>Basic Science Elective</td>
</tr>
<tr>
<td></td>
<td>CHEM 1LE</td>
<td>General Education</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sophomore</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MATH 3A</td>
<td>MATH 3D</td>
<td>MATH 2E</td>
</tr>
<tr>
<td>ENGRCEE 81A</td>
<td>ENGRCEE 81B</td>
<td>ENGRCEE 11</td>
</tr>
<tr>
<td>ENGRCEE 30</td>
<td>Lower-Div Engineering Elective</td>
<td>ENGRCEE 21</td>
</tr>
<tr>
<td>General Education</td>
<td>General Education</td>
<td>General Education</td>
</tr>
</tbody>
</table>
## Senior-Year Sample Programs of Study — Civil Engineering

### Senior: General Civil Engineering Specialization

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

### Senior: Environmental Hydrology and Water Resources Specialization

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

### Senior: Structural Engineering Specialization

<table>
<thead>
<tr>
<th>Senior</th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ENGRCEE 181A</td>
<td>ENGRCEE 181B</td>
<td>ENGRCEE 181C</td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 153</td>
<td>ENGRCEE 111</td>
<td>Spec. Elective</td>
</tr>
<tr>
<td></td>
<td>General Education</td>
<td>General Education</td>
<td>General Education</td>
</tr>
<tr>
<td></td>
<td>General Education</td>
<td>General Education</td>
<td>General Education</td>
</tr>
</tbody>
</table>

### Senior: Transportation Systems Engineering

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


Transfer Students: Preference will be given to junior-level applicants with the highest grades overall, and who have satisfactorily completed the following required courses: one year 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), and one additional approved course for the major.

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. Degree in Environmental Engineering


Major Requirements

Mathematics and Basic Science Courses:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHEM 1A-1B-1C</td>
<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>MATH 2A-2B</td>
<td>Single-Variable Calculus and Single-Variable Calculus</td>
</tr>
<tr>
<td>MATH 2D</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>MATH 2E</td>
<td>Multivariable Calculus</td>
</tr>
<tr>
<td>MATH 3A</td>
<td>Introduction to Linear Algebra</td>
</tr>
<tr>
<td>MATH 3D</td>
<td>Elementary Differential Equations</td>
</tr>
<tr>
<td>PHYSICS 7C</td>
<td>Classical Physics</td>
</tr>
<tr>
<td>PHYSICS 7LC</td>
<td>Classical Physics Laboratory</td>
</tr>
<tr>
<td>PHYSICS 7D</td>
<td>Classical Physics</td>
</tr>
<tr>
<td>PHYSICS 7LD</td>
<td>Classical Physics Laboratory</td>
</tr>
</tbody>
</table>

Two additional Basic Science Electives, one Earth System Science course and one Biological Sciences course from the following list:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>BIO SCI 42</td>
<td>Origin of Life</td>
</tr>
<tr>
<td>BIO SCI 93</td>
<td>From DNA to Organisms</td>
</tr>
<tr>
<td>EARTHSS 15</td>
<td>Introduction to Global Climate Change</td>
</tr>
<tr>
<td>EARTHSS 19</td>
<td>Introduction to Modeling the Earth System</td>
</tr>
</tbody>
</table>

Lower-Division Engineering Elective:

Students must take one course from the following:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</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>
</tbody>
</table>
Engineering Topics Courses:

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

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 11</td>
<td>Methods II: Probability and Statistics</td>
</tr>
<tr>
<td>ENGRCEE 20</td>
<td>Introduction to Computational Engineering Problem Solving</td>
</tr>
<tr>
<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>ENGRMAE 91</td>
<td>Introduction to Thermodynamics</td>
</tr>
<tr>
<td>ENGRCEE 110</td>
<td>Methods III: Modeling, Economics, and Management</td>
</tr>
<tr>
<td>ENGRCEE 130-130L</td>
<td>Soil Mechanics and Soil Mechanics Laboratory</td>
</tr>
<tr>
<td>ENGRCEE 150-150L</td>
<td>Mechanics of Materials and Mechanics of Materials Laboratory</td>
</tr>
<tr>
<td>ENGRCEE 160</td>
<td>Environmental Processes</td>
</tr>
<tr>
<td>ENGRCEE 162</td>
<td>Introduction to Environmental Chemistry</td>
</tr>
<tr>
<td>ENGRCEE 170</td>
<td>Introduction to Fluid Mechanics</td>
</tr>
<tr>
<td>ENGRCEE 181A-181B-181C</td>
<td>Senior Design Practicum and Senior Design Practicum</td>
</tr>
</tbody>
</table>

Engineering Elective Courses:

Students must take two courses each from two of the following three groups and one course from the remaining group.

<table>
<thead>
<tr>
<th>Water Supply and Resources:</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARTHSS 132</td>
</tr>
<tr>
<td>ENGRCEE 171</td>
</tr>
<tr>
<td>ENGRCEE 172</td>
</tr>
<tr>
<td>ENGRCEE 173</td>
</tr>
<tr>
<td>ENGRCEE 176</td>
</tr>
<tr>
<td>ENGRCEE 178</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Environmental Processes:</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 163</td>
</tr>
<tr>
<td>ENGRCEE 165</td>
</tr>
<tr>
<td>ENGRCEE 167</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Atmospheric Systems and Air Pollution Control:</th>
</tr>
</thead>
<tbody>
<tr>
<td>EARTHSS 112</td>
</tr>
<tr>
<td>ENGRMAE 110</td>
</tr>
<tr>
<td>ENGRMAE 115</td>
</tr>
<tr>
<td>ENGRMAE 164</td>
</tr>
</tbody>
</table>

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:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course 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>
<tr>
<td>or SOCECOL E8</td>
<td>Introduction to Environmental Analysis and Design</td>
</tr>
</tbody>
</table>

(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-7B is available only to first year students in Fall and Winter quarters. Both ENGR 7A-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

<table>
<thead>
<tr>
<th></th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freshman</td>
<td>MATH 2A</td>
<td>MATH 2B</td>
<td>MATH 2D</td>
</tr>
<tr>
<td></td>
<td>CHEM 1A</td>
<td>CHEM 1B</td>
<td>CHEM 1C</td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 20</td>
<td>PHYSICS 7C</td>
<td>PHYSICS 7D</td>
</tr>
<tr>
<td></td>
<td>General Education</td>
<td>PHYSICS 7LC</td>
<td>General Education</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MATH 2B</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MATH 2D</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CHEM 1C</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHYSICS 7D</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHYSICS 7LD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General Education</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sophomore

<table>
<thead>
<tr>
<th></th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MATH 3A</td>
<td>MATH 3D</td>
<td>MATH 2E</td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 81A</td>
<td>ENGRCEE 81B</td>
<td>ENGRCEE 11</td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 30</td>
<td>Lower-Division Engineering Elective</td>
<td>ENGRCEE 21</td>
</tr>
<tr>
<td></td>
<td>CHEM 51A</td>
<td>General Education</td>
<td>ENGRMAE 91</td>
</tr>
<tr>
<td></td>
<td>CHEM 1LD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MATH 3D</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MATH 2E</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 21</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENGRMAE 91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Junior

<table>
<thead>
<tr>
<th></th>
<th>Fall</th>
<th>Winter</th>
<th>Spring</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ENGRCEE 150</td>
<td>ENGRCEE 130</td>
<td>ENGRCEE 110</td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 150L</td>
<td>ENGRCEE 130L</td>
<td>ENGRCEE 160</td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 170</td>
<td>ENGRCEE 162</td>
<td>Basic Science Elective</td>
</tr>
<tr>
<td></td>
<td>Engineering Elective</td>
<td>General Education</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basic Science Elective</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 150</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 130</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 130L</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENGRCEE 162</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Engineering Elective</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Senior

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

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

- Civil Engineering (p. 8)
- Concentration in Environmental Engineering (p. 10)

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. degrees 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. degree 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. degree: a thesis option and a course work option. Opportunities are available for part-time study toward the M.S. degree. 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). 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
Doctor of Philosophy Degree

The Ph.D. degree 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

E4130 Engineering Gateway; (949) 824-5333
C. Sunny Jiang, Director and Graduate Advisor

Faculty

Amir AghaKouchak: Hydrology, hydroclimatology, data assimilation, remote sensing of critical global water resource issues

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

James S. Famiglietti: Modeling and remote sensing of global hydrology; global change and water availability; sea level rise

Stanley B. Grant: Environmental engineering, inland and coastal water quality, coagulation and filtration of colloidal contaminants, environmental microbiology

Engineering Admissions Requirements (http://www.eng.uci.edu/grad/programs/cee/admissions) and Planning, Policy and Design Admissions (http://ppd.socceco.uci.edu/pages/admissions) websites for more information about these requirements.
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: Surface hydrology and soil physics

Affiliated Faculty

Nancy A. Da Silva: Bioremediation, genetic engineering

Michael Kleinman (Adjunct): Uptake and distribution of inhaled toxic materials in the respiratory tract; effects of air pollutants on cardio-pulmonary function

Mikael Nilsson: Advanced nuclear fuel cycles, actinide chemistry, liquid-liquid extraction, process development, radiolysis, detection and detectors for online process control

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

Environmental Engineering is an interdisciplinary program engaging faculty from departments in both engineering and the sciences, and managed by the Department of Civil and Environmental Engineering. Environmental Engineering addresses the development of strategies to control anthropogenic emissions of pollutants to the atmosphere, waterways, and terrestrial environment; the remediation of polluted natural systems; the design of technologies to treat waste, energy efficiency and environmentally responsible power generation; and the evaluation of contaminant fate in the environment.

Environmental Engineering requires a curriculum that provides students with an understanding of fundamentals in air- and water-quality sciences, contaminant fate and transport, global climate change, water resources, energy, and design concepts for pollutant emission control and treatment.

Required Background

The program core curriculum builds on environmental engineering fundamentals such as fluid mechanics, environmental chemistry, air quality, microbial processes, thermodynamics, 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. degree 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 table below is a general checklist for the required background and a list of undergraduate courses that may be used to fulfill the background requirements.

<table>
<thead>
<tr>
<th>Required Background and Sample UCI Undergraduate Courses</th>
</tr>
</thead>
</table>

**Engineering Level Math:**

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

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

<table>
<thead>
<tr>
<th>BIO SCI M122</th>
<th>General Microbiology</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBEMS 112</td>
<td>Introduction to Biochemical Engineering</td>
</tr>
</tbody>
</table>
Areas of Emphasis

There are four primary areas of emphasis within Environmental Engineering: Water Quality and Treatment, Hydrology and Water Resources, Air Quality, and Energy. To achieve the interdisciplinary objectives of the program, students entering the program without an M.S. degree are required to take at least one course from each of the four primary areas of Environmental Engineering, in addition to an Advanced Mathematics course, to fulfill the core requirements. Students can take additional elective courses in one of the four areas or from more than one area. Courses outside of the School of Engineering (i.e., Earth System Science, Public Health, Biological Sciences) 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. degree must complete the following core requirements (22 units) before petitioning for an M.S. degree.

Advanced Mathematics area requirements: Select one of the three courses listed below

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBEMS 230</td>
<td>Applied Engineering Mathematics I</td>
</tr>
<tr>
<td>ENGRCEE 283</td>
<td>Mathematical Methods in Engineering Analysis</td>
</tr>
<tr>
<td>ENGRMAE 200A</td>
<td>Engineering Analysis I</td>
</tr>
</tbody>
</table>

Water Quality and Treatment area requirements: Select one of the two courses listed below

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 263</td>
<td>Advanced Biological Treatment Processes</td>
</tr>
<tr>
<td>ENGRCEE 265</td>
<td>Physical-Chemical Treatment Processes</td>
</tr>
</tbody>
</table>

Hydrology and Water Resources area requirements: Select one of the three courses listed below

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 272</td>
<td>Groundwater Hydrology</td>
</tr>
<tr>
<td>ENGRCEE 276</td>
<td>Hydrology</td>
</tr>
<tr>
<td>ENGRCEE 277</td>
<td>Hydrologic Transport Fundamentals</td>
</tr>
</tbody>
</table>

Air Quality area requirements: Select one of the two courses listed below

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRMAE 215</td>
<td>Advanced Combustion Technology</td>
</tr>
<tr>
<td>ENGRMAE 261</td>
<td>Air Quality Modeling</td>
</tr>
</tbody>
</table>

Energy area requirements: Select one of the two courses listed below

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 264</td>
<td>Carbon Footprint Analysis for Water and Wastewater Systems</td>
</tr>
<tr>
<td>ENGRMAE 218</td>
<td>Sustainable Energy Systems</td>
</tr>
</tbody>
</table>

Environmental Seminar area requirements: Two quarters of

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENGRCEE 295</td>
<td>Seminars in Engineering</td>
</tr>
</tbody>
</table>

Elective Courses

Additional course requirements can be fulfilled using elective courses in any of the areas. Courses within each area are listed below.

Water Quality and Treatment:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CBEMS 218</td>
<td>Bioengineering with Recombinant Microorganisms</td>
</tr>
<tr>
<td>CBEMS 220</td>
<td>Transport Phenomena</td>
</tr>
<tr>
<td>ENGRCEE 260</td>
<td>Desalination</td>
</tr>
</tbody>
</table>
Master of Science Degree

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

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 five 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 course work 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 five core courses. A maximum of eight 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.

NOTE: Students who entered prior to fall of 2012 should follow the course requirements outlined within the Catalogue of the year they entered. The change in number of units per course is not intended to change the course requirements for the degree nor to have any impact in the number of courses students are taking. As such, students will need to continue to meet the same high standards and plan of study requirements as previously required. Students will work with their advisor to create a plan of study encompassing the equivalent topical requirements, as well as the equivalent number of courses to the previous 36-unit requirement.

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 independent 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 retake 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 from 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

Amir Aghakouchak, Ph.D. University of Stuttgart, Assistant 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 (structural and earthquake engineering, risk and reliability engineering)

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)

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

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)

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)

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

Xiaogang Gao, Ph.D. University of Arizona, Adjunct Professor of Civil and Environmental Engineering (hydroclimatology, hydrology, fluid dynamics, engineering mathematics)

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 (water resources, groundwater, modeling uncertainty)

Kuo-Lin Hsu, Ph.D. University of Arizona, Associate 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, 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, Assistant 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)
Michael G. McNally, Ph.D. University of California, Irvine, Professor of Civil and Environmental Engineering; Planning, Policy, and Design (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 (structural analysis, experimental structural dynamics)

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 Urban Water Research Center 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)

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)

Brett F. Sanders, Ph.D. University of Michigan, Department Chair and Professor of Civil and Environmental Engineering (environmental hydrodynamics, computational fluid dynamics, coastal water quality)

Jean-Daniel M. Saphores, Ph.D. Cornell University, Professor of Civil and Environmental Engineering; Economics; Planning, Policy, and Design (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 (water reclamation, waste treatment processes, environmental engineering)

Robin Shepherd, Ph.D. University of Canterbury, Professor Emeritus of Civil and Environmental Engineering (structural dynamics, earthquake-resistant design)

Masanobu Shinozuka, Ph.D. Columbia University, Professor Emeritus of Civil and Environmental Engineering (continuum mechanics, structural dynamics, system reliability, risk assessment, remote sensing and GIS for disaster assessment)

Soroosh Sorooshian, Ph.D. University of California, Los Angeles, Director of the Center for Hydrometeorology and Remote Sensing 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 (structural dynamics and earthquake engineering)

Jasper A. Vrugt, Ph.D. University of Amsterdam, Assistant Professor of Civil and Environmental Engineering; Earth System Science (surface hydrology and soil physics)

Jann N. Yang, DSc Columbia University, Professor Emeritus of Civil and Environmental Engineering (system identification and damage detection, structural health monitoring, structural control, earthquake engineering, structural dynamics)

Farzin Zareian, Ph.D. Stanford University, Associate Professor of Civil and Environmental Engineering (structural engineering, performance-based earthquake engineering, structural reliability, structural control)
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 CSE 41 or I&C SCI 31) and MATH 3A.
Restriction: Civil Engineering and Environmental Engineering majors have first consideration for enrollment.

ENGRCEE 20. Introduction to Computational Engineering 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.

(Design units: 1)
Overlaps with ENGR 15.
Restriction: Civil Engineering and 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.

(Design units: 1)
Corequisite: MATH 3D.
Prerequisite: ENGRCEE 20 and MATH 3A.
Restriction: Civil Engineering and 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.

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

ENGRCEE 55. Land Measurements and Analysis. 4 Units.
Introduction to surveying and land measurements. Use of the level and transit equipment, legal descriptions, subdivisions, topographic surveys, mapping vertical and horizontal curves. Analysis of surveying field data using manual methods, computer programs, and the COGO software system. Laboratory sessions.

(Design units: 0)
Restriction: Civil Engineering majors 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.

(Design units: 0)

(III)
**ENGRCEE 80. Dynamics. 4 Units.**
Introduction to the kinetics 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. Course may be offered online.

(Design units: 0.5)

Prerequisite: MATH 2D and PHYSICS 7C.

Same as ENGR 80, ENGRMAE 80.

Restriction: School of 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 and 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. Materials fee.

(Design units: 1)

Restriction: Civil Engineering and 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 and 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 & 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, and 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.

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 125. Transportation and the Environment. 4 Units.
Analysis of the impacts of motor vehicle transportation on the environment. Introduction to life cycle analysis applied to transportation. Basic economic tools for transportation externalities. Transportation planning, urban form, health, and the environment. Transportation sustainability.

(Design units: 0)
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)
Prerequisite: ENGRCEE 150 and ENGRCEE 170.
Restriction: Civil Engineering and 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 and 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 80 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 and 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 and 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 153. Statically Indeterminate Structures. 4 Units.
Fundamentals of statically indeterminate structures; strain energy and virtual work; energy theorems; method of virtual work, Castigliano theorem; method of consistent deformations; slope-deflection method; approximate methods; stiffness method for trusses.

(Design units: 0)
Prerequisite: ENGRCEE 151A.
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 and 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).
Restriction: Chemical Engineering, Civil Engineering, Environmental Engineering, and Mechanical Engineering majors have first consideration for enrollment.

ENGRCEE 163. Biological 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 or CBEMS 45C.
Restriction: Chemical Engineering, Civil Engineering, and Environmental Engineering majors have first consideration for enrollment.
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 or CBEMS 45C.
Restriction: Civil Engineering and Environmental Engineering majors have first consideration for enrollment.
 Concurrent with ENGRCEE 265.

ENGRCEE 167. Ecology of Coastal Waters. 4 Units.
Examines the ecological processes of the coastal environment. Investigates the causes of coastal ecosystem degradation and strategies to restore the ecosystem balance or prevent further coastal ecosystem health degradation.
(Design units: 0)
Prerequisite: CHEM 1A and CHEM 1B and (SOCECOL E8 or ENGRCEE 60).
Restriction: Environmental Engineering majors have first consideration for enrollment.
 Concurrent with ENGRCEE 267.

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 and 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.
Prerequisite: PHYSICS 7C and ENGRCEE 20.
Overlaps with ENGRMAE 130A, CBEMS 125A.
Restriction: Civil Engineering and 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, Civil Engineering, and 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, Civil Engineering, and 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, Environmental Engineering, and 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 and 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 and Environmental Engineering majors have first consideration for enrollment.

Concurrent with ENGRCEE 278.

ENGRCEE 181A. Senior Design Practicum. 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)
Corequisite: ENGRCEE 121 or ENGRCEE 151C or ENGRCEE 162 or ENGRCEE 171.
Prerequisite: ENGRCEE 81A and ENGRCEE 81B and ENGRCEE 110 and ENGRCEE 130 and ENGRCEE 160. ENGRCEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.

Grading Option: In progress only.
Restriction: Civil Engineering and Environmental Engineering majors only.

ENGRCEE 181B. Senior Design Practicum. 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: ENGRCEE 181A. ENGRCEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.

Grading Option: In progress only.
Restriction: Civil Engineering and Environmental Engineering majors only.
ENGRCEE 181C. Senior Design Practicum. 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: ENGRCEE 181B. ENGRCEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.
Restriction: Civil Engineering and 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 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 225A. Transportation Planning Models I. 4 Units.
Analytical techniques for the study of interactions between transportation systems design and the spatial distribution of urban activities. Development of models of demographic and economic activity, land use, and facility location. Forecasting exogenous inputs to existing transportation models.

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.

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 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.

Prerequisite: ENGRCEE 156.
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.

(Design units: 0)
Restriction: Graduate students only.

ENGRCEE 242. Advanced Strength of Materials. 4 Units.

Prerequisite: ENGRCEE 150.
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 245. Experimental Modal Analysis. 4 Units.
A thorough coverage of modal analysis techniques including digital signal processing concepts, structural dynamics theory, modal parameter estimation techniques, and application of modal measurement methods suitable for practical vibration analysis problems.

Prerequisite: ENGRCEE 247.
Restriction: Graduate students only.
ENGRCEE 247. Structural Dynamics. 4 Units.
Vibration of discrete and continuous mass elastic systems. Isolation and transmissibility. Dynamic recording instruments. Introduction to nonlinear
integration techniques.

Prerequisite: ENGRCEE 80.
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.
Flexural strength of reinforced concrete elements. Flexural ductility of unconfined and confined members with axial loads. Shear and torsional behaviors.

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

Prerequisite: ENGRCEE 153.
Restriction: Graduate students only.

ENGRCEE 258. Earthquake Resistant Structural Design. 4 Units.
Objectives of seismic design. Cyclic load-distortion characteristics of typical structural elements. Desirable structural form. Ductility and methods of
achieving it. Use of energy dissipators. Project involving design of multistory, multibay rigid-jointed plane frame.

Restriction: Graduate students only.

ENGRCEE 259. Structural Stability. 4 Units.
Structural stability emphasizing the behavior of simple structural components that illustrate various modes of instability: Euler columns, beam columns,

Prerequisite: ENGRCEE 150 or ENGRMAE 150.
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. Laboratory on GC, GC-MS, and ion chromatography.
Prerequisite: ENGRCEE 162.
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.
Prerequisite: ENGRCEE 160.
Restriction: Graduate students only.

ENGRCEE 264. Carbon Footprint Analysis for Water and Wastewater Systems. 4 Units.
Mass- and energy-flux balance analysis applied to water and wastewater treatment systems. Case studies include analysis and design of aeration, membrane separations, disinfection, water supply, and water reclamation processes.
Prerequisite: ENGRCEE 160.

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.
Prerequisite: ENGRCEE 160.
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.
Prerequisite: CHEM 51A and ENGRCEE 160 and ENGRCEE 162.
Restriction: Graduate students only.

ENGRCEE 267. Ecology of Coastal Waters. 4 Units.
Examines the ecological processes of the coastal environment. Investigates the causes of coastal ecosystem degradation and strategies to restore the ecosystem balance or prevent further coastal ecosystem health degradation.
Prerequisite: CHEM 1A and CHEM 1B and (SOCECOI E8 or ENGRCEE 60).
Restriction: Graduate students only.
Concurrent with ENGRCEE 167.

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.
Prerequisite: ENGRCEE 172.
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.

Prerequisite: ENGRCEE 170.
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.

Prerequisite: ENGRCEE 170 and ENGRCEE 176.
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.

Prerequisite: ENGRCEE 11 and ENGRCEE 171.
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.

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

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

Prerequisite: ENGRCEE 11.

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.

Prerequisite: ENGRCEE 11.

Restriction: Graduate students only.

ENGRCEE 285. Reliability of Engineering Systems I. 4 Units.
Develops the basic concepts for the definition and assessment of safety and reliability of engineering systems. Includes probabilistic modeling of engineering problems, assessment of component reliability, systems reliability, and introduction to probability-based design.

Prerequisite: ENGRCEE 11.

Restriction: Graduate students only.

ENGRCEE 287. Random Vibrations. 4 Units.

Prerequisite: ENGRCEE 11 and (ENGRCEE 281 or ENGRCEE 284).

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 20 or ENGRMAE 10) and 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.
Repeatability: May be repeated for credit unlimited times.
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.
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.
Repeatability: May be repeated for credit unlimited times.

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.
Repeatability: May be repeated for credit unlimited times.
Restriction: Graduate students only.