Department of Civil and Environmental Engineering

The Department of Civil Engineering offers the Master of Civil Engineering degree and the Master of Science degree in Civil Engineering, as well as the Doctor of Philosophy degree in Environmental Science and Engineering.

Master of Science Degree in Civil Engineering

The Master of Science degree in Civil Engineering is designed to provide specialized knowledge in selected technical areas of Civil Engineering. The educational objective of this program is to produce graduates who are capable of research and professional practice in a specialized area of Civil Engineering, namely environmental engineering, geotechnical engineering, structural engineering, transportation engineering, and water resources engineering. This program involves both coursework and a thesis and it is designed to provide exposure to research that could possibly lead to subsequent doctoral study.

Admission Requirements

For unconditional admission, applicants must satisfy the following requirements, in addition to the University-wide graduate admission requirements (refer to Chapter 1, Admission):

- an undergraduate degree in Civil Engineering or a closely related field from an accredited institution of higher education, or proof of equivalent training at a foreign institution;
- a satisfactory score, as evaluated by the Civil Engineering Graduate Studies Committee, on the Graduate Record Examination (GRE);
- Test of English as a Foreign Language (TOEFL) minimum scores of 79 or 550 for Internet or paper versions, respectively;
- a statement of research/specialization interest; and
- a favorable recommendation by the Civil Engineering Graduate Studies Committee.

Degree Requirements

The minimum number of semester credit hours required for the degree is 30. At least 24 semester credit hours must be taken at UTSA. Elective courses may be chosen from the Department of Civil and Environmental Engineering (CEE) or outside the department, with approval from the CEE Graduate Studies Committee. Any grade lower than “B” in a graduate course cannot be counted toward the coursework requirement. Each candidate is required to pass a comprehensive examination during their thesis defense administered by his or her advisory committee.

Advisory Committee

Students must choose an Advisory Committee consisting of a chair and at least two additional graduate faculty members. Students must submit the names of their Advisory Committee to the CEE Graduate Studies Committee by the end of their first semester of study.

Program of Study

A. Degree Core Curriculum (6 semester credit hours):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 5043</td>
<td>Advanced Civil Engineering Statistics or STA 5103 Applied Statistics or ES 5023 Environmental Statistics</td>
</tr>
<tr>
<td>CE 5143</td>
<td>Numerical Methods in Civil Engineering</td>
</tr>
</tbody>
</table>

B. Electives (18 semester credit hours):

- Includes comprehensive examination/thesis defense/seminar presentation

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 5981</td>
<td>Master’s Thesis</td>
</tr>
<tr>
<td>CE 5982</td>
<td>Master’s Thesis</td>
</tr>
<tr>
<td>CE 5983</td>
<td>Master’s Thesis</td>
</tr>
</tbody>
</table>

Total Credit Hours 30

Master of Civil Engineering Degree

The Master of Civil Engineering degree is designed to provide specialized knowledge in selected technical areas of Civil Engineering. The educational objective of this program is to produce graduates who are capable of professional practice in a specialized area of Civil Engineering, namely environmental engineering, geotechnical engineering, structural engineering, transportation engineering, and water resources engineering. It involves courses only and a seminar. It does not normally lead to subsequent doctoral study.

Admission Requirements

For unconditional admission, applicants must satisfy the following requirements, in addition to the University-wide graduate admission requirements (refer to Chapter 1, Admission):

- an undergraduate degree in Civil Engineering or a closely related field from an accredited institution of higher education, or proof of equivalent training at a foreign institution;
- a satisfactory score, as evaluated by the Civil Engineering Graduate Studies Committee, on the Graduate Record Examination (GRE);
- Test of English as a Foreign Language (TOEFL) minimum scores of 79 or 550 for Internet or paper versions, respectively;
- a statement of specialization interest; and
- a favorable recommendation by the Civil Engineering Graduate Studies Committee.

Degree Requirements

The minimum number of semester credit hours required for the degree is 34. At least 24 semester credit hours must be taken at UTSA. Elective courses may be chosen from the Department of Civil and Environmental Engineering (CEE) or outside the department, with approval from the CEE Graduate Studies Committee. Any grade lower than “B” in a graduate course cannot be counted toward the coursework requirement.

Each student has to take a comprehensive examination during his or her seminar presentation at the end of his or her program. He/she is also expected to attend the seminars offered by other students. These seminars are administered by the Graduate Committee of the CEE Department.
Program of Study

A. Degree Core Curriculum (6 semester credit hours):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 5043</td>
<td>Advanced Civil Engineering Statistics</td>
</tr>
<tr>
<td>or STA 5103</td>
<td>Applied Statistics</td>
</tr>
<tr>
<td>or ES 5023</td>
<td>Environmental Statistics</td>
</tr>
<tr>
<td>CE 5143</td>
<td>Numerical Methods in Civil Engineering</td>
</tr>
</tbody>
</table>

B. Electives (27 semester credit hours): 27

1. Includes comprehensive examination
2. CE 5991 Graduate Seminar

C. Graduate Seminar (1 semester credit hour):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Credit Hours</td>
<td>34</td>
</tr>
</tbody>
</table>

**Doctor of Philosophy Degree in Environmental Science and Engineering**

The Civil and Environmental Engineering (CEE) Department offers the opportunity for advanced study and research leading to the Doctor of Philosophy degree in Environmental Science and Engineering. The educational objective of this program is to produce graduates who are capable of conducting original research in industry or academia as well as assuming a leadership role in their chosen employment field. This is a multidisciplinary program administered by the CEE Department. It encompasses faculty and facilities from the College of Sciences, the CEE Department, and Civil Engineering. The Ph.D. degree in Environmental Science and Engineering is awarded to candidates who display an in-depth understanding of the subject matter and demonstrate the ability to make an original contribution to knowledge in their field of specialty.

The regulations for this degree comply with the general University regulations (refer to Chapter 2, General Academic Regulations, and Chapter 5, Doctoral Degree Regulations).

**Admission Requirements**

Applicants must satisfy the following requirements, in addition to satisfying the University-wide graduate admission requirements (refer to Chapter 1, Admission):

- a Bachelor of Science degree and a Master of Science degree from an accredited university, and a minimum grade point average of 3.0 in upper-division and graduate courses. The degrees should be in biology, ecology, environmental science, chemistry, geology, geography, environmental engineering, civil engineering or other related scientific or engineering discipline. Exceptional applicants without a Master of Science degree may be considered for admission to the program on a case-by-case basis;
- three letters of recommendation from persons familiar with the applicant’s academic potential;
- official Graduate Record Examination (GRE) scores;
- a letter of research/specialization interest; and
- a résumé/curriculum vita.

Applications must be submitted to the UTSA Graduate School online at http://graduateschool.utsa.edu/. Incomplete applications will not be considered. Acceptance to the program is decided by the Doctoral Studies Committee (DSC), comprised of graduate faculty members selected from the CEE Department and the College of Sciences. Full-time students accepted for the program are eligible to apply for financial support in the form of competitive teaching assistantships, research assistantships, or research fellowships.

**Degree Requirements**

The Doctoral program in Environmental Science and Engineering requires that students complete a minimum of 60 semester credit hours beyond the Master’s degree. This coursework includes courses that have been designed to provide advanced instruction in areas considered to form the foundation for the disciplines of environmental science and engineering. Enrollment in the Graduate Seminar is required for a minimum of 2 semester credit hours. A minimum of 15 semester credit hours of Doctoral Research and 15 semester credit hours minimum of Doctoral Dissertation must be completed prior to graduation. Any grade lower than “B” in graduate or remedial coursework at the undergraduate level does not count toward the 60 semester credit hours. Students can apply, with the approval of the Chair of their Dissertation Committee, up to 12 semester credit hours of graduate coursework to elective courses (see below), if not applied toward their Master’s degree. Students with only a baccalaureate degree are required to have a minimum of 90 semester credit hours to graduate.

21 semester credit hours of required elective courses must be selected by each student according to his/her selected track of study, as defined below. These need to be approved by the Chair of the DSC and the student’s Dissertation Committee. These elective courses may be offered by departments in the College of Sciences, the College of Engineering or by other departments at UTSA.

**Students that have obtained a Master’s degree are required to complete the following courses:**

A. Degree Core Curriculum (10 semester credit hours):

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 5001</td>
<td>Process and Ethics in Thesis/Dissertation Research Development</td>
</tr>
<tr>
<td>CE 5043</td>
<td>Advanced Civil Engineering Statistics</td>
</tr>
<tr>
<td>or STA 5103</td>
<td>Applied Statistics</td>
</tr>
<tr>
<td>or ES 5023</td>
<td>Environmental Statistics</td>
</tr>
<tr>
<td>CE 5013</td>
<td>Civil Engineering Systems Analysis</td>
</tr>
<tr>
<td>or ES 5233</td>
<td>Experimental Design and Analysis</td>
</tr>
<tr>
<td>or EGR 5213</td>
<td>Topics in Systems Modeling</td>
</tr>
</tbody>
</table>

Select one of the following:

- CE 6113 Global Change
- ES 5043 Global Change
- GEO 5043 Global Change

B. Track Electives (12 semester credit hours):

These can be selected from 5000–7000 level courses offered in Civil and Environmental Engineering or other departments, with the approval of the Environmental Science and Engineering Doctoral Studies Committee.

1. Environmental Science Track Electives
The objective of this track is to train students in conducting research in the various aspects of environmental science with a focus on the application of physical and biological sciences in solving environmental problems. These elective courses can be selected from the graduate courses offered by the College of Sciences, the CEE Department or other UTSA departments. The overall program of study for this track may differ by no more than 12 semester credit hours from the program of study for the Ph.D. degree in Environmental Science and Engineering and must be approved by the student’s Dissertation Advisor and the Doctoral Studies Committee.

**C. Other Electives (6 semester credit hours):**

These can be selected from 5000–7000 level courses offered in Civil and Environmental Engineering or other departments, with the approval of the Environmental Science and Engineering Doctoral Studies Committee.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 6221</td>
<td>Graduate Seminar in Environmental Science and Engineering</td>
</tr>
<tr>
<td>or ES 5981</td>
<td>Graduate Seminar in Environmental Science and Engineering</td>
</tr>
</tbody>
</table>

**D. Seminars (2 semester credit hours):**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 6221</td>
<td>Graduate Seminar in Environmental Science and Engineering</td>
</tr>
<tr>
<td>or ES 5981</td>
<td>Graduate Seminar in Environmental Science and Engineering</td>
</tr>
</tbody>
</table>

**E. Doctoral Research and Dissertation (30 semester credit hours):**

Select one of the following options (15 semester credit hours required of Doctoral Research and 15 semester credit hours required of Doctoral Dissertation):

**Option I:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>CE 7213</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>or CE 7212</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>or CE 7211</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>CE 7313</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or CE 7312</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or CE 7311</td>
<td>Doctoral Dissertation</td>
</tr>
</tbody>
</table>

**Option II:**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 7213</td>
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</tr>
<tr>
<td>or CE 7212</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>or CE 7211</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>CE 7313</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or CE 7312</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or CE 7311</td>
<td>Doctoral Dissertation</td>
</tr>
</tbody>
</table>

**Total Credit Hours**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES 7213</td>
<td>Doctoral Research</td>
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<tr>
<td>or ES 7212</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>or ES 7211</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>ES 7313</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or ES 7312</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or ES 7311</td>
<td>Doctoral Dissertation</td>
</tr>
</tbody>
</table>

**Total Credit Hours**

**Students that have obtained a Bachelor’s degree are required to complete the following courses:**

**A. Degree Core Curriculum (semester credit hours):**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>CE 5001</td>
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<td>or ES 5023</td>
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<td>Civil Engineering Systems Analysis</td>
</tr>
<tr>
<td>or ES 5233</td>
<td>Experimental Design and Analysis</td>
</tr>
</tbody>
</table>

Select one of the following:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 6113</td>
<td>Global Change</td>
</tr>
<tr>
<td>ES 5043</td>
<td>Global Change</td>
</tr>
<tr>
<td>GEO 5043</td>
<td>Global Change</td>
</tr>
</tbody>
</table>

**B. Track Electives (21 semester credit hours):**

These can be selected from 5000–7000 level courses offered in Civil and Environmental Engineering or other departments, with the approval of the Environmental Science and Engineering Doctoral Studies Committee.

1. **Environmental Science Track Electives**

The objective of this track is to train students in conducting research in the various aspects of environmental science with a focus on the application of physical and biological sciences in solving environmental problems. These elective courses can be selected from the graduate courses offered by the College of Sciences, the CEE Department or other departments. The overall program of study for this track may differ by no more than 12 semester credit hours from the program of study for the Ph.D. degree in Environmental Science and Engineering and must be approved by the student’s Dissertation Advisor and the Doctoral Studies Committee.

2. **Environmental Engineering Track Electives**

The objective of this track is to train students in conducting research in the various aspects of civil engineering with an emphasis on the application of civil engineering principles in the design, construction, and maintenance of the physical and naturally built environment. Elective courses can be selected from the graduate courses offered by the College of Sciences, the CEE Department or other College of Engineering departments. The overall program of study for this track may differ by no more than 12 semester credit hours from the program of study for the Ph.D. degree in Environmental Science and Engineering and must be approved by the student’s Dissertation Advisor and the Doctoral Studies Committee.

3. **Civil Engineering Track Electives**

The objective of this track is to train students in conducting research in the various aspects of civil engineering with an emphasis on the application of civil engineering principles in sustaining the natural environment (i.e., air, water and land). Elective courses can be selected from the graduate courses offered by the College of Sciences, the CEE Department or other departments. The overall program of study for this track may differ by no more than 12 semester credit hours from the program of study for the Ph.D. degree in Environmental Science and Engineering and must be approved by the student’s Dissertation Advisor and the Doctoral Studies Committee.
The objective of this track is to train students in conducting research in the various aspects of civil engineering with an emphasis on the application of civil engineering principles in the design, construction, and maintenance of the physical and naturally built environment. Elective courses can be selected from the graduate courses offered by the CEE Department or other College of Engineering departments. The overall program of study for this track may differ by no more than 12 semester credit hours from the program of study for the Ph.D. degree in Environmental Science and Engineering and must be approved by the student’s Dissertation Advisor and the Doctoral Studies Committee.

C. Other Electives (12 semester credit hours):

These can be selected from 5000–7000 level courses offered in Civil and Environmental Engineering or other departments, with the approval of the Environmental Science and Engineering Doctoral Studies Committee.

D. Seminars (2 semester credit hours):

CE 6221 Graduate Seminar in Environmental Science and Engineering
or ES 5981 Graduate Seminar in Environmental Science and Engineering

E. Doctoral Research and Dissertation (45 semester credit hours):

Select one of the following options:

**Option I:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE 7213</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>or CE 7212</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>or CE 7211</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>CE 7313</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or CE 7312</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or CE 7311</td>
<td>Doctoral Dissertation</td>
</tr>
</tbody>
</table>

**Option II:**

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES 7213</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>or ES 7212</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>or ES 7211</td>
<td>Doctoral Research</td>
</tr>
<tr>
<td>ES 7313</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or ES 7312</td>
<td>Doctoral Dissertation</td>
</tr>
<tr>
<td>or ES 7311</td>
<td>Doctoral Dissertation</td>
</tr>
</tbody>
</table>

Total Credit Hours 90

**Dissertation Committee**

Students must choose a Dissertation Committee consisting of a chair and at least four additional graduate faculty members. This committee must include a minimum of one faculty member from the CEE Department and one from the College of Sciences. Students must submit the names of their Dissertation Committee to the DSC Chair by the end of their second semester of study.

**Advancement to Candidacy**

Ph.D. students advance to candidacy after completing their written and oral qualifying examinations. First, students must complete the core curriculum courses and then take the written qualifying examination. Full-time students must take the written qualifying examination by the end of their second semester of study. Part-time students need to take the written qualifying examination at a time dictated by the DSC. The written qualifying examination may include questions on six core areas, including statistics, hydrogeology, biology, chemistry, environmental engineering and civil engineering. Students are expected to show in-depth knowledge of the topics pertaining to their track of study. This examination is administered by the DSC with input from the faculty participating in the program. The written qualifying examination tests the student’s undergraduate background, their degree of understanding of the material presented in graduate courses, as well as their critical thinking and written communication skills. No more than two attempts to pass the written qualifying examination are permitted. Students who fail the written qualifying examination twice are terminated from the program.

Upon successful completion of the written qualifying examination, students are allowed to take Doctoral Research credit hours. Students must take their oral qualifying examination within two semesters after passing their written qualifying examination. The oral qualifying examination is a dissertation proposal defense. The dissertation proposal should describe the topic, the literature review, the proposed methodology and experimental approach, as well as highlight the novelty and potential contribution of the topic to the scientific field. The student’s Dissertation Committee must approve the student’s research proposal before scheduling the oral examination. Upon successful completion of the oral qualifying examination, students advance to Ph.D. candidacy and are allowed to take Doctoral Dissertation credit hours. No more than two attempts to pass the oral qualifying examination are permitted. Students who fail the oral qualifying examination twice are terminated from the program.

Results of the written and oral examinations must be reported to the DSC and the Dean of the Graduate School. Admission into the Doctoral program does not guarantee advancement to candidacy. After advancement to candidacy, the student’s Dissertation Committee can be changed at the student’s request and with the approval of the chair of the DSC.

**Dissertation**

Candidates must demonstrate their ability to conduct independent research by completing an original dissertation. The Dissertation Committee guides, critiques and finally approves the candidate’s dissertation. The format of the dissertation must follow the doctoral degree regulations of the Graduate School as documented under Chapter 5 of this catalog.

**Final Oral Dissertation Defense**

The student must notify the Graduate School in writing two weeks prior to the final scheduled oral defense. The final oral defense consists of a public presentation of the dissertation, followed by a closed oral defense. Results of the oral defense must be reported to the Dean of the Graduate School. Awarding of the degree is based on the approval of the Dissertation Committee and the Dean of the Graduate School. The Dean of the Graduate School certifies the completion of all University-wide requirements.

**Civil Engineering (CE) Courses**

CE 5001. Process and Ethics in Thesis/Dissertation Research Development. (1-0) 1 Credit Hour.

Course discusses the process and the ethical issues involved in conducting research and developing a thesis or dissertation. It covers research organizational skills, literature searches, technical writing, honesty in writing and plagiarism issues.
CE 5013. Civil Engineering Systems Analysis. (3-0) 3 Credit Hours.
Systems approach to optimization and problem solving; operations research applications in civil engineering; mathematical modeling and analysis techniques including linear programming, dynamic programming, decision analysis and use of software to solve linear and nonlinear programming problems.

CE 5023. Finite Element Methods. (3-0) 3 Credit Hours.
Derivation and computer implementation of the finite element method for the solution of civil engineering boundary value problems. (Same as ME 5483. Credit cannot be earned for both CE 5023 and ME 5483).

CE 5043. Advanced Civil Engineering Statistics. (3-0) 3 Credit Hours.
Statistical analysis methods include descriptive statistics, interval estimation and hypothesis testing, analysis of variance, design of experiments, regression analysis, and time series analysis. Additional topics covered include probabilistic methods, decision analysis and reliability analysis applied to civil engineering systems.

CE 5103. Advanced Steel Design. (3-0) 3 Credit Hours.
Connection design, welded and bolted, moment-resistant connections, plate girders, column stability, bracing design, and seismic design of frames. (Formerly CE 5343 Topic 4: Advanced Steel Design. Credit cannot be earned for both CE 5103 and CE 5343 Advanced Steel Design).

CE 5123. Bridge Engineering. (3-0) 3 Credit Hours.
Design loads, load distribution, design of superstructures and substructures, and evaluation and load rating capacity of bridges. (Formerly CE 5343 Topic 8: Bridge Engineering. Credit cannot be earned for both CE 5123 and CE 5343 Bridge Engineering).

CE 5133. Advanced Reinforced Concrete. (3-0) 3 Credit Hours.
Curved beams, torsion design, retaining walls and shear walls, stairs, two-way slabs, yield-line theory, biaxial load on columns, slenderness effects, joint design, strut-and-tie methods, and concrete elasticity and failure criteria. (Formerly CE 5343 Topic 2: Advanced Reinforced Concrete Structures. Credit cannot be earned for both CE 5133 and CE 5343 Advanced Reinforced Concrete Structures).

CE 5143. Numerical Methods in Civil Engineering. (3-0) 3 Credit Hours.
Mathematical equation root finding and optimization methods, matrix equations, solution methods, eigenvector and eigenvalue solution methods, finite difference methods, curve-fitting methods, numerical integration and differentiation techniques, and introduction to finite element formulations.

CE 5153. Prestressed Concrete. (3-0) 3 Credit Hours.
Overview of prestressed concrete development; design properties of materials; analysis and design of pre-tensioned and post-tensioned concrete members; full and partial prestressing; serviceability and strength requirements, code criteria for prestressed continuous beams, statically indeterminate frames and other structures. (Formerly CE 5343 Topic 3: Prestressed Concrete. Credit cannot be earned for both CE 5153 and CE 5343 Prestressed Concrete).

CE 5203. Environmental Microbiology. (3-0) 3 Credit Hours.
To provide a basic understanding of environmental microbiology primarily from two aspects: microbial interactions with chemical pollutants in the environment and the fate of microbial pathogens in the environment. Topics covered include microbial environments, detection of bacteria and their activities in the environment, microbial biogeochemistry, bioremediation and water quality. (Same as ES 5063. Credit cannot be earned for both CE 5203 and ES 5063).

CE 5213. Biological Phenomena in Environmental Engineering. (3-0) 3 Credit Hours.
The major biological phenomena and processes used in environmental engineering control. Fundamentals of microbiology and biochemistry as applied to wastewater treatment, drinking water treatment, and hazardous waste remediation. (Formerly titled "Industrial Waste Treatment").

CE 5293. Geographic Information Systems (GIS). (3-0) 3 Credit Hours.
Introduces vector, raster and tabular concepts, emphasizing the vector approach. Topics include spatial relationships, map features, attributes, relational database, layers of data, data ingesting, digitizing from maps, projections, output, applications, and availability of public data sets. Focus will be placed on spatial/temporal data analyses using digitized maps and database information in an area of CE specialization.

CE 5303. Hydrometeorology. (3-0) 3 Credit Hours.
The main objective of this course is to familiarize the student with the local and global distribution of freshwater. Conceptualizations of the water balance/budget are developed using principles of physical hydrology and meteorology. Emphasis will be on recent research and modern methods for data analysis and modeling. Real life events and phenomena will be discussed. In addition to the text, material will be presented from other sources. Guest instructors will give presentations on some case studies.

CE 5343. Advanced Characterization of Highway Materials. (3-0) 3 Credit Hours.
Basic and advanced level of the fundamentals of material response to static and repeated loading; emphasis on the deformation and fatigue behavior of asphalt mixtures, constitutive modeling for mixtures, microstructure characterization for mixtures, nondestructive testing of pavements, asphalt binder characterization, unbound materials (base and sub-base materials) evaluation and characterization.

CE 5403. Advanced Characterization of Highway Materials. (3-0) 3 Credit Hours.

CE 5423. Advanced Pavement Analysis and Design. (3-0) 3 Credit Hours.

CE 5433. Advanced Geometric Design. (3-0) 3 Credit Hours.
Course deals with the geometric design of highways and streets. Topics include highway functions, design controls and criteria, elements of design, local roads and streets, freeways, and intersections. (Formerly CE 5513 Topic 6: Advanced Geometric Design. Credit cannot be earned for both CE 5433 and CE 5513 Advanced Geometric Design).

CE 5443. Pavement Management. (3-0) 3 Credit Hours.
Pavement evaluation and performance, evaluation of pavement distress condition surveys, evaluation of pavement roughness ride quality, skid resistance of pavements, evaluation of pavement structural capacity, maintenance and rehabilitation, prioritization and optimization of pavement maintenance, and rehabilitation needs. (Formerly CE 5513 Topic 4: Pavement Management Systems. Credit cannot be earned for both CE 5443 and CE 5513 Pavement Management Systems).

CE 5403. Advanced Characterization of Highway Materials. (3-0) 3 Credit Hours.

CE 5423. Advanced Pavement Analysis and Design. (3-0) 3 Credit Hours.

CE 5433. Advanced Geometric Design. (3-0) 3 Credit Hours.
Course deals with the geometric design of highways and streets. Topics include highway functions, design controls and criteria, elements of design, local roads and streets, freeways, and intersections. (Formerly CE 5513 Topic 6: Advanced Geometric Design. Credit cannot be earned for both CE 5433 and CE 5513 Advanced Geometric Design).

CE 5443. Pavement Management. (3-0) 3 Credit Hours.
Pavement evaluation and performance, evaluation of pavement distress condition surveys, evaluation of pavement roughness ride quality, skid resistance of pavements, evaluation of pavement structural capacity, maintenance and rehabilitation, prioritization and optimization of pavement maintenance, and rehabilitation needs. (Formerly CE 5513 Topic 4: Pavement Management Systems. Credit cannot be earned for both CE 5443 and CE 5513 Pavement Management Systems).
CE 5453. Transportation Engineering. (3-0) 3 Credit Hours.
Study of the Highway Capacity Manual, traffic stream parameters and relationships, analytical techniques in traffic engineering such as capacity analysis, queuing theory, and traffic simulation. Design and operation of advanced traffic management systems including signalization, real-time motorist information, urban incident management, and ITS concepts. (Formerly CE 5513 Topic 8: Principles of Traffic Engineering. Credit cannot be earned for both CE 5453 and CE 5513 Principles of Traffic Engineering).

CE 5463. Foundation Engineering. (3-0) 3 Credit Hours.
Shallow and deep foundations, including footings, slabs on-grade, cofferdams, sheet-pile walls, drilled shafts, piles and retaining walls. (Formerly CE 5353 Topic 2: Advanced Foundation Engineering. Credit cannot be earned for both CE 5463 and CE 5353 Advanced Foundation Engineering).

CE 5513. Environmental Chemistry. (3-0) 3 Credit Hours.
This course explores the chemistry of the environment, the chemistry underlying environmental problems and solutions to environmental problems. Emphasis is placed on thermodynamics and kinetics of reaction cycles; sources, sinks and transport of chemical species; and quantitation of chemical species. Examples are selected from the chemistry of natural and contaminated air, water, and soil.

CE 5623. Advanced Treatment Processes for Water Quality Control. (3-0) 3 Credit Hours.
Principles, modeling and design aspects of physical chemical treatment processes in drinking water, wastewater and groundwater remediation applications. (Formerly CE 5233 Topic 1: Physical and Chemical Treatment Operations. Credit cannot be earned for both CE 5623 and CE 5233 Physical and Chemical Treatment Operations).

CE 5643. Sustainable Energy Systems. (3-0) 3 Credit Hours.
Course explores various facets of sustainable energy systems and their role in securing America's energy future. It covers national and global energy trends, social, political, regulatory, technical/economic constraints and policy considerations. The course uses a systems approach in examining the technology and economics behind each alternative energy source and the major qualitative and quantitative factors affecting their large-scale deployment. (Same as ME 5273. Credit cannot be earned for both CE 5643 and ME 5273).

CE 5653. River Science. (3-0) 3 Credit Hours.
An in-depth examination of river sediment transport principles. Topics include water and sediment supply, sediment dynamics, river morphology, and channel instability. Field trip required. (Same as GEO 5413. Credit cannot be earned for both CE 5653 and GEO 5413).

CE 5663. River Mechanics and Engineering Applications. (3-0) 3 Credit Hours.
Prerequisite: CE 5653 or equivalent. This course focuses on the application of sediment transport principles to practical river mechanics and environmental problems. Applications include laboratory experiments, and numerical simulations related to the solution of practical river engineering problems.

CE 5703. Special Topics in Hydraulics and Hydrology. (3-0) 3 Credit Hours.
Course deals with special aspects of hydraulics and hydrology. May be repeated for credit as topics vary.

CE 5713. Special Topics in Structures. (3-0) 3 Credit Hours.
Course deals with special aspects of structural engineering. May be repeated for credit as topics vary.

CE 5733. Special Topics in Environmental Engineering. (3-0) 3 Credit Hours.
Course deals with special aspects of environmental engineering. May be repeated for credit as topics vary.

CE 5743. Special Topics in Geotechnical Engineering. (3-0) 3 Credit Hours.
Course deals with special aspects of geotechnical engineering. May be repeated for credit as topics vary.

CE 5973. Special Project. (0-0) 3 Credit Hours.
Work carried out by nonthesis Master’s students under the direction of their Advisory Committee to fulfill the project requirement of their degree. It may involve applied or theoretical work and a report documenting the findings.

CE 5981. Master’s Thesis. (0-0) 1 Credit Hour.
Prerequisite: Approval of the student’s Advisory Committee. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master’s degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. (Formerly CE 6983).

CE 5982. Master’s Thesis. (0-0) 2 Credit Hours.
Prerequisite: Approval of the student’s Advisory Committee. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master’s degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. (Formerly CE 6983).

CE 5983. Master’s Thesis. (0-0) 3 Credit Hours.
Prerequisite: Approval of the student’s Advisory Committee. Thesis research and preparation. May be repeated for credit, but not more than 6 hours will apply to the Master’s degree. Credit will be awarded upon completion of the thesis. Enrollment is required each term in which the thesis is in progress. (Formerly CE 6983).

CE 5991. Graduate Seminar. (1-0) 1 Credit Hour.
Graduate seminar may be repeated for credit up to 3 semester credit hours.

CE 6013. Hydrologic Modeling and Analysis. (3-0) 3 Credit Hours.
This course will address hydrological modeling (both theory and practical applications with focus on the latter) and related issues. Multimedia and advanced visualization will be used in lectures and class work. Most of the course is dedicated to hands-on, problem-oriented applications using a variety of practical techniques. It will provide students with the knowledge and tools necessary to use data derived from geographical information systems (GIS) to develop hydrologic estimates needed for different applications.

CE 6103. Fate and Transport of Contaminants in the Environment. (3-0) 3 Credit Hours.
The course deals with the hydrodynamics of mixing and transport, as well as the interaction of mixing and various reaction rate processes. Applications in the course will include water and wastewater treatment, groundwater pollution, and transport and mixing in rivers, lakes and reservoirs. (Formerly CE 6053 Topic 1: Fate and Transport of Contaminants in Environmental System. Credit cannot be earned for both CE 6103 and CE 6053 Fate and Transport of Contaminants in Environmental System).
CE 6113. Global Change. (3-0) 3 Credit Hours.
Changes in the global distribution of plants and animals and the causes of the changes will be examined. Factors that are apparently coupled to changes in the atmosphere and environmental temperature will be examined. (Same as ES 5043 and GEO 5043. Credit can be earned for only one of the following: CE 6113, ES 5043, or GEO 5043).

CE 6221. Graduate Seminar in Environmental Science and Engineering. (1-0) 1 Credit Hour.
Will include presentations of current research by faculty and invited guests who are experts in various aspects of research in the environmental sciences and engineering, and advanced graduate students who are about to complete their dissertation research. May be repeated for credit.

CE 6523. Advanced Surface Water Hydrology. (3-0) 3 Credit Hours.
Use of state-of-the-art computer models to study the rainfall-runoff process. Extreme events are the focus of the course (droughts and floods). Approaches to developing design precipitation events will also be presented. (Formerly CE 5313 Topic 3: Advanced Surface Water Hydrology. Credit cannot be earned for both CE 6523 and CE 5313 Advanced Surface Water Hydrology).

CE 6951. Independent Study. (0-0) 1 Credit Hour.
Prerequisites: Written permission of the instructor and the student’s Advisory Committee. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master’s degree.

CE 6952. Independent Study. (0-0) 2 Credit Hours.
Prerequisites: Written permission of the instructor and the student’s Advisory Committee. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master’s degree.

CE 6953. Independent Study. (0-0) 3 Credit Hours.
Prerequisites: Written permission of the instructor and the student’s Advisory Committee. Independent reading, research, discussion, and/or writing under the direction of a faculty member. For students needing specialized work not normally available as part of the regular course offerings. May be repeated for credit, but not more than 6 hours, regardless of discipline, will apply to the Master’s degree.

CE 6961. Comprehensive Examination. (0-0) 1 Credit Hour.
Prerequisite: Written permission of the student’s Advisory Committee. The comprehensive examination course is intended as a 1 semester credit hour substitute for the Master of Science degree in Civil Engineering thesis or the Master of Civil Engineering graduate seminar. Students may register for this course in a semester in which the examination is to be taken, if they are not enrolled in other courses. The grade report for the course is either “CR” (satisfactory performance on the Comprehensive Examination) or “NC” (unsatisfactory performance on the Comprehensive Examination).

CE 7211. Doctoral Research. (0-0) 1 Credit Hour.
Prerequisites: Admission to Doctoral candidacy, consent of the student’s Dissertation Committee and consent of the DSC. Research work carried out by the student under the supervision of their Dissertation Committee. May be repeated as necessary, but no more than 15 hours may be applied to the Doctoral degree.

CE 7212. Doctoral Research. (0-0) 2 Credit Hours.
Prerequisites: Admission to Doctoral candidacy, consent of the student’s Dissertation Committee and consent of the DSC. Research work carried out by the student under the supervision of their Dissertation Committee. May be repeated as necessary, but no more than 15 hours may be applied to the Doctoral degree.

CE 7213. Doctoral Research. (0-0) 3 Credit Hours.
Prerequisites: Admission to Doctoral candidacy, consent of the student’s Dissertation Committee and consent of the DSC. Research work carried out by the student under the supervision of their Dissertation Committee. May be repeated as necessary, but no more than 15 hours may be applied to the Doctoral degree.

CE 7311. Doctoral Dissertation. (0-0) 1 Credit Hour.
Prerequisites: Successful defense of the oral defense, consent of the student’s Dissertation Committee and consent of the DSC. Dissertation work carried out by the student under the supervision of their Dissertation Committee. May be repeated as necessary, but not more than 15 hours may be applied to the Doctoral degree.

CE 7312. Doctoral Dissertation. (0-0) 2 Credit Hours.
Prerequisites: Successful defense of the oral defense, consent of the student’s Dissertation Committee and consent of the DSC. Dissertation work carried out by the student under the supervision of their Dissertation Committee. May be repeated as necessary, but not more than 15 hours may be applied to the Doctoral degree.

CE 7313. Doctoral Dissertation. (0-0) 3 Credit Hours.
Prerequisites: Successful defense of the oral defense, consent of the student’s Dissertation Committee and consent of the DSC. Dissertation work carried out by the student under the supervision of their Dissertation Committee. May be repeated as necessary, but not more than 15 hours may be applied to the Doctoral degree.