Environmental Engineering, Ph.D.

COLLEGE OF ENGINEERING

Learn more about the Doctor of Philosophy in Environmental Engineering.

About the Program

The Ph.D. in Environmental Engineering is designed to produce graduates who have:

- built a solid core knowledge base in science, technology, environmental engineering, and mathematics;
- gained the ability to adapt to interdisciplinary research projects and employ emerging technology;
- learned how to plan, develop, and conduct a research project on their own as future principal investigators; and
- mastered professional oral and written communication skills.

Time Limit for Degree Completion: 7 years

Campus Location: Main

Full-Time/Part-Time Status: Students are able to complete the didactic portion of the Ph.D. degree program through classes offered after 4:30 p.m.

Interdisciplinary Study: Research in Environmental Engineering is interdisciplinary and requires collaboration of members of the faculty and students within all departments of the College of Engineering, in the Mathematics Department and departments engaged in the study of the sciences, and at the Lewis Katz School of Medicine at Temple University.

Areas of Specialization: Faculty in the Department of Civil and Environmental Engineering are actively engaged in research in the following areas of Environmental Engineering:

- Advanced Treatments for Drinking Water and Wastewater
- Emerging Contaminants in the Environment
- Environmental Biotechnology
- Fate and Transformation of Environmental Contaminants
- Surface and Subsurface Hydrology

In the first term, the student and the Civil and Environmental Engineering (CEE) Graduate Program Director jointly initiate a Plan of Study. This form lists all required courses and the program requirement sequence for the student to follow. The Plan of Study is used to track the student's progress, with an annual annotation and update as the student completes various benchmarks in the Ph.D. program.

Job Prospects: The program is primarily intended for individuals who wish to pursue careers in industry, government, and academia in a highly creative environment. The program is dedicated to producing engineers who will contribute to advancements in environmental engineering.

Non-Matriculated Student Policy: Up to 9 credits of graduate Engineering coursework may be taken at Temple University on a non-matriculated basis and subsequently applied to the Ph.D. degree upon admission. If the applicant's undergraduate GPA was less than 3.0, a GPA of 3.25 or better is required on this non-matriculated graduate coursework to receive an admissions exception. Consequently, the CEE Graduate Program Director may encourage those with an undergraduate GPA less than 3.0 to take their first three graduate courses prior to making formal application to the Ph.D. program. (See the relevant Graduate School policies on special admission procedures for non-matriculated students: 02.23.11.03 and 02.24.19.)

Financing Opportunities: Applicants for full-time study in the Environmental Engineering Ph.D. program are automatically considered for financial aid. Three forms of financial aid are awarded to Ph.D. students on a competitive basis:

1. Teaching Assistantship (TA): TA awards are made solely by the Department and require the awardee to work 20 hours per week in support of the Department's undergraduate programs. The TA is compensated with a 9-month stipend, a basic health-insurance plan, and 9 credits per term of tuition remission.
2. Research Assistantship (RA): Individual faculty confer RA awards, using their research funds, upon students who appear well-qualified to carry out the research. Typically, this faculty member becomes the RA's doctoral advisor. The RA normally works up to 20 hours per week and is compensated with a stipend, basic health insurance, and tuition remission.
3. Fellowships: Fellowships are awarded by the University in a competitive process that is open to all Ph.D. applicants. The CEE Graduate Program Director nominates exceptional Ph.D. applicants for a University Fellowship. Fellows receive 9 to 12 months of stipend, depending on the award; basic health insurance; and 12 credits of tuition remission each Fall and Spring term. Fellows of the University have no work obligations with respect to either the Department, the College, or the University.

Because financial aid is awarded on a competitive basis, applicants are urged to complete the application as early as possible.

Admission Requirements and Deadlines

Application Deadline:

Fall: March 1
Spring: November 1; August 1 international

Applications are processed on a continual basis. Ordinarily, the applicant is informed of an admissions decision within 4 to 6 weeks of receipt of all supporting application documents.

Both admissions and financial aid award decisions originate in the Department of Civil and Environmental Engineering within the College of Engineering. Applicants who plan to matriculate full-time are automatically considered for financial aid awards so no separate application for financial aid is required. **To ensure financial aid consideration for the intended term of study, however, applicants should submit a complete application by January 15 (Fall) and August 1 (Spring).**

APPLY ONLINE to this graduate program.

Letters of Reference:
Number Required: 3

From Whom: Letters of recommendation should be obtained from college or research faculty who are familiar with the applicant's competency. If the applicant has an established career in engineering, one of the letters should be provided by the applicant's immediate supervisor. If the applicant has been out of school long enough that relevant academic reference letters appear impractical, s/he should contact the CEE Graduate Program Director to obtain a waiver of this admission requirement.

Coursework Required for Admission Consideration: Students not adequately prepared for advanced courses may be required to take a number of prerequisites. The Department of Civil and Environmental Engineering identifies the needed coursework on a case-by-case basis.

Master's Degree in Discipline/Related Discipline: A master's degree is not required, but preferred.

Bachelor's Degree in Discipline/Related Discipline: A bachelor's degree is required.

University regulations stipulate that the applicant must have earned a 3.0 grade-point average on a 4.0 scale in her/his undergraduate studies, but admission exceptions are made for a variety of circumstances. (See Graduate School Policy 02.23.11.03.) The CEE Graduate Program Director helps the applicant navigate the admission possibilities and assists in the assessment of her/his overall educational qualifications with respect to the departmental requirements for the Ph.D. program.

Statement of Goals: Describe your relevant technical experiences, career goals, and specific research interests in one to two pages, ensuring that you have clearly identified your area of interest within the field of civil and environmental engineering.

Standardized Test Scores:
GRE: Required. Scores must be no more than 5 years in advance of the application date. (See Graduate School Policy 02.23.12.) Applicants who require a waiver of the GRE should consult the CEE Graduate Program Director concerning the mechanics and consequences of obtaining an exception.

Applicants who earned their baccalaureate degree from an institution where the language of instruction was other than English, with the exception of those who subsequently earned a master’s degree at a U.S. institution, must report scores for a standardized test of English that meet these minimums:

- TOEFL iBT: 79
- IELTS Academic: 6.5
- PTE Academic: 53

Resume: Current resume required.

Advanced Standing: Both transfer credit for courses taken at another institution while matriculated at Temple and/or advanced standing credit for courses taken within the 5-year period prior to matriculating at Temple may be applied toward the Ph.D.-level didactic coursework requirement. Written approval is required from the student’s doctoral advisor, the College’s Associate Dean for Graduate Study, and the Graduate School. (See Graduate School Policy 02.24.21.) Up to six credits of advanced standing for courses taken within the 5-year period prior to matriculating at Temple may be used to satisfy the master’s-level didactic coursework requirement. Approval of the CEE Graduate Program Director is required. The courses must be equivalent to courses offered at Temple in the student's area of study and research, and the grades must be "B" or better.

Program Requirements

General Program Requirements:

Number of Credits Required Beyond the Bachelor's: 60, including 45 credits of graduate-level didactic coursework and 15 research credits, including preliminary Ph.D. examination and dissertation research

Number of Credits Required Beyond the Master's: 30, including 15 credits of graduate-level didactic coursework and 15 research credits, including preliminary Ph.D. examination and dissertation research

Required Courses:

Post-Baccalaureate (for students WITHOUT a master's degree in Environmental Engineering)

Code	Title	Credit Hours
Core Courses [1]		**45**
Research Courses [2]		**15**
CEE 9991	Directed Research (8 credits)	
CEE 9994	Preliminary Examination Preparation (1 credit)	
CEE 9998	Pre-Dissertation Research (3 credits)	
CEE 9999	Dissertation Research (3 credits)	
Total Credit Hours		60

1 Coursework is typically selected by the student's Doctoral Advisory Committee. It may include up to, but no more than, 3 credits of CEE 9182 Independent Study I, 3 credits of CEE 9282 Independent Study II, or 3 credits of CEE 9991 Directed Research. Furthermore, students who wish to take graduate coursework outside the College of Engineering in one of Temple University's other schools/colleges need to obtain the appropriate written approvals on their Plan of Study form.

2 Expected distribution of the 15 credits associated with Ph.D. examinations and dissertation research is shown, although the actual distribution of credits can vary across courses depending on the student's particular circumstances.

Post-Master's (for students WITH a master's degree in Environmental Engineering)

Code	Title	Credit Hours
Core Courses [1]		**15**
Research Courses [2]		**15**
CEE 9991	Directed Research (8 credits)	
CEE 9994	Preliminary Examination Preparation (1 credit)	
CEE 9998	Pre-Dissertation Research (3 credits)	
CEE 9999	Dissertation Research (3 credits)	
Total Credit Hours		30

1 Coursework is typically selected by the student's Doctoral Advisory Committee. It may include up to, but no more than, 3 credits of CEE 9182 Independent Study I, 3 credits of CEE 9282 Independent Study II, or 3 credits of CEE 9991 Directed Research. Furthermore, students who wish to take graduate coursework outside the College of Engineering in one of Temple University's other schools/colleges need to obtain the appropriate written approvals on their Plan of Study form.

2 Expected distribution of the 15 credits associated with Ph.D. examinations and dissertation research is shown, although the actual distribution of credits can vary across courses depending on the student's particular circumstances.

Culminating Events:

Formation of the Doctoral Advisory Committee:

Selection of a research advisor and formation of a Doctoral Advisory Committee constitute the first steps toward achieving a Ph.D. Selection of a doctoral advisor depends on the student's level of preparation upon entering the Ph.D. program. The Doctoral Advisory Committee selects the required coursework and guides the progress of the student's dissertation research:

- Students entering the Ph.D. program with a master's degree, i.e., those who must complete 30 credits to earn the degree, form their Doctoral Advisory Committee before the end of their second regular term of study.
- Students entering the program with a bachelor's degree, i.e., those who must complete 60 credits to earn the Ph.D. degree, generally complete most of their coursework before forming their Doctoral Advisory Committee by the end of their fourth regular term in the program.

See Graduate School Policy 02.28.11 for clarification on the composition of the Doctoral Advisory Committee.

Preliminary Examination:

All students generally complete their didactic coursework prior to taking the preliminary examination. (See Graduate School Policy 02.27.11.) Students in the 30-credit cohort ordinarily take the exam in their third or fourth term. Students in the 60-credit cohort typically take the exam no later than the eighth regular term. Students should register for one credit of CEE 9994 Preliminary Examination Preparation in the term when the exam will be taken.

The preliminary exam tests both the student's core knowledge in Environmental Engineering and her/his capacity to synthesize and interpret research communications. The student coordinates the scheduling of the preliminary exam with the CEE Graduate Program Director. The CEE Graduate Program Director supervises the specific form, content, and frequency of the Environmental Engineering preliminary exam. A maximum of two opportunities to pass the preliminary exam are available to the student. In each term when the exam is attempted, the student registers for one credit of CEE 9994. Students are dismissed upon the second failure.

Dissertation Proposal:
Within a year of passing the preliminary exam, the student must develop a written research proposal and present it in an open College seminar. Ten business days prior to the presentation seminar, the student must schedule the proposal and post an announcement. Immediately following the seminar, the Doctoral Advisory Committee questions the student about the details and strategy of her/his proposed research.

Approval is granted for the proposed dissertation research when the "Dissertation Proposal Transmittal for Elevation to Candidacy" form (found in TUportal under the Tools tab within "University Forms") has been signed off by the entire Doctoral Advisory Committee. After the dissertation proposal has been accepted by the Doctoral Advisory Committee and the Graduate School has received the form, the student is considered to be a doctoral candidate. (See Graduate School Policy 02.28.12 for more information.)

Research Credits:
Students carry out research throughout their studies and register for the corresponding research credits while in the Ph.D. program. However, the type of research credits that a student registers for depends on the student's progress in the program:

- Prior to passing the preliminary exam, credit hours associated with the student's research should be registered under CEE 9991 Directed Research.
- After the preliminary exam is passed, but before elevation to candidacy, credit hours associated with the student's research should be registered under CEE 9998 Pre-Dissertation Research.
- After elevation to candidacy, the student's research credits should be registered under CEE 9999 Dissertation Research. Students are required to register for at least three credits of CEE 9999 following their elevation to candidacy. (See Graduate School Policy 02.28.15.)

Publications:
Paper writing and presentation at a conference are considered integral to the student's training. Also, peer review, in part, offers an indication of the quality and novelty of the student's research. All doctoral students must publish at least two technical papers in refereed journals or refereed conferences. The papers must be based on the student's dissertation research with the student as the first author.

Dissertation:
The dissertation defense is an open University seminar in which the student presents the concepts and results of her/his research.

The student must coordinate the formation of the Dissertation Examining Committee in the term that s/he intends to defend her/his dissertation. This committee consists of the original Doctoral Advisory Committee plus one additional "external" member who is not faculty in the College of Engineering. If the external examiner is not a member of Temple University's Graduate Faculty, the person must be approved by the Graduate School at least four weeks prior to the dissertation defense.

The dissertation defense is to take place during a regular academic term (i.e., not scheduled during study days, final exams, or the breaks between terms). If the student is to graduate in the same term as the dissertation defense is held, then the defense should take place at least 30 days prior to the end of the term to allow for document revisions.

Three weeks prior to the defense, the members of the committee elect a Chair of the Dissertation Examining Committee. The Chair cannot be the student's doctoral advisor. The Associate Dean of Research and Graduate Studies must approve the selection. The Chair is identified to the Graduate School in the student's official request for permission to schedule the defense. (See Graduate School Policy 02.28.15.) The Chair's role includes coordination of the proceedings of the defense and completion of all relevant College and Graduate School forms concerning the defense.

The dissertation document should be prepared in a format compliant with University standards. (See Graduate School Policy 02.28.18.) A copy of the completed dissertation must be provided to the committee at least three weeks before the date of the dissertation defense. Note that any Graduate Faculty may request a copy of the dissertation in advance of the defense and may participate in the defense.

A minimum of two weeks prior to the defense, a public announcement of the defense must be posted. Prior to posting, this announcement must be approved in writing by the Graduate School. (See Graduate School Policy 02.28.16.)

Immediately following the presentation, the Dissertation Examining Committee closely examines the student's performance and her/his research. External attendees may participate in this closed portion of the defense with the permission of the Dissertation Examining Committee Chair. However, only members of the Dissertation Examining Committee may actually vote on the decision to accept the dissertation as prepared, accept the dissertation with revisions, or not accept the dissertation. If the dissertation is accepted with revisions, a revised copy of the dissertation must be submitted and approved by the Committee within 30 days of the original defense date.

Contacts

Program Web Address:

https://www.temple.edu/academics/degree-programs/environmental-engineering-phd-en-enve-phd

Department Information:

College of Engineering
ATTN: CEE Programs
1947 N. 12th Street
Philadelphia, PA 19122-6077
gradengr@temple.edu
215-204-7800

Submission Address for Application Materials:

https://apply.temple.edu/Engineering/

Department Contacts:

Admissions:
Colleen P. Baillie, Ed.D.
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215-204-7800

Graduate Program Director, CEE:
Joseph Coe, Ph.D.
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215-204-6100

Chairperson, CEE:
Rominder Suri, Ph.D.
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Courses

CEE 5048. Probability and Statistics in Engineering. 3 Credit Hours.
This course is designed to build a conceptual background in probability, statistics, and stochastic analysis. It prepares the graduate student for research in uncertainty analysis and stochastic models in engineering. It begins by building a solid integrated background on the subjects that conform uncertainty analysis in engineering: probability, statistics, and stochastic modeling. The theory is complemented with numerous exercises of application in engineering uncertainty analysis, and with computer simulations using modern computer algebra software, such as MAPLE. Students are gradually taken to more advanced subjects and eventually to the analysis of differential equations subject to random initial conditions, random forcing terms, and random parameters. Partial differential equations and nonlinear stochastic equations are treated.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5058. Probability Statistics in Engineering. 3 Credit Hours.
Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5110. Special Topics. 3 Credit Hours.
Special topics courses are developed to cover emerging issues or specialized content and they do not repeat material presented by regular semester courses.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

CEE 5201. Transportation Systems Management. 3 Credit Hours.
This course covers cost-effective techniques for the rebuilding of deteriorated transportation systems; pavement management and traffic systems management; extensive use of advanced computer software packages.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5202. Transportation Engineering. 3 Credit Hours.
This course focuses on the principal modes of transportation, including highway, rail, and air; analysis of elements of transport technology; and transportation system development, planning, design, construction, and maintenance.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5203. Structural Design of Pavements. 3 Credit Hours.
This course covers basic characteristics of different pavement structures; various modes of failure and design of pavement structures; identification and analysis of stresses; strains and deflections in flexible and rigid pavements; computation of traffic loading and volume for the structural design of pavements; engineering properties of pavement materials; pavement performance and distress; and empirical and mechanistic-empirical approaches.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5211. Bridge Design. 3 Credit Hours.
The course covers bridge design in structural steel and reinforced concrete; application of AASHTO bridge design specifications; and analysis techniques for complex structures. Preliminary designs include investigating alternative structural systems and materials. Final designs include preparation of design calculations and sketches.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5212. Transportation Engineering Materials. 3 Credit Hours.
Topics include physical properties of asphalt, aggregates, portland cement, portland cement concrete, and their combinations; advanced techniques in material characterization in the lab and the field; material variability, sampling, and statistical techniques; and the impact of these properties on their characterization of the design, construction, rehabilitation, and management of transportation facilities, including portland cement concrete pavements with steel reinforcement; construction methodologies, recycling, and energy consideration; and application of the state-of-the-art computer software packages.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5221. Intelligent Transportation Systems. 3 Credit Hours.
Coverage embraces the multidimensional upgrades needed for highway and vehicles for developing intelligent transportation systems. Contributions from important related fields such as telecommunications, safety, management, urban and regional planning, and economics where they interface with transport are included. Several case studies constitute an integral part of the course.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5231. Airport Engineering. 3 Credit Hours.
This course deals with the various aspects of airport engineering, planning, design and development of 21st century airports. The course covers airport master and system planning, airside layout, landside access design, passenger and cargo facilities, terminal design, drainage and pavement design.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5241. Pavement Management and Traffic Systems Management. 3 Credit Hours.
The course covers development of management methods for analysis, planning, design, construction, maintenance, and rehabilitation of pavements and traffic systems. The objective functions include creation of more efficient use of existing facilities through improved management and operation of vehicles and roadway.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5244. Introduction to Geosynthetics. 3 Credit Hours.
This course will enhance your critical understanding of Geosynthetic Materials used in civil engineering applications and develop the knowledge and skills required for designing and applying geosynthetic materials in civil engineering and environmental applications. Geosynthetics properties, testing of properties, design of geotextile, geogrids, geonets, and geomembranes for applications in separation, pavement design, embankment and retaining wall reinforcement, soil stabilization, filtration, drainage and liquid barrier, construction guidelines and case histories. The module will also develop critical understanding of the processes and materials used for the manufacture of geosynthetic materials.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5251. Pavement Rehabilitation and Maintenance. 3 Credit Hours.
The course covers fundamental behavior of materials used in building pavements. These materials include aggregate mixtures, asphalt binders and mixtures, and Portland cement concrete. The course covers methods of field construction and quality control of materials and their impact on long term performance. The course helps students understand the role of material properties in design of pavements including cost analysis. Students will learn testing methods, selection criteria, and standard specifications. Finally, the students will use accumulated knowledge through the course to understand strategies of pavement rehabilitation and maintenance. Principles of asset management will be introduced in the course to optimize maintenance and rehabilitation interventions for improving longevity.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5301. Construction Administration. 3 Credit Hours.
The course focuses on the engineering and construction industry; the basis of construction contracting; organizational structure and its functions; management structure and its functions; office administration, employment practices, and labor relations; organizational financing and accounting; and safety practices, risk management, and industrial insurance.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5302. Engineering Project Management. 3 Credit Hours.
This course provides an overview of the basic principles underlying all methods of project management, including project estimating, planning and scheduling, budgeting, cost accounting and cost control, project documentation, tracking and resource leveling. It also focuses on utilization of project management software packages for selected civil engineering projects; different types of projects; organizing the project management functions; setting up the project team; starting up and managing engineering projects; and ensuring the effective completion of the project on time, within budget, and meeting specifications.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5303. Construction Financial Management. 3 Credit Hours.
Coverage includes project development in construction, project budgeting and job costing approaches, cost management and financing alternatives, evaluation of financial and accounting objectives required with each project, forecasting cash needs and profit, and financial reporting procedures.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5312. Construction Equipment Management. 3 Credit Hours.
This course focuses on the concepts and theories of construction equipment operation, ownership costs, and their relationship to production systems; analysis of depreciation and fixed costs for equipment pricing on construction projects; selection and use of construction equipment; and equipment economics and financing.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5321. Geotechnical Engineering. 3 Credit Hours.
This course deals with soil testing, site investigation, design of shallow and deep foundations, earth retaining structures, and advanced topics in soil behavior and stability.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5411. Structural CADD Systems. 3 Credit Hours.
Topics include behavior and analysis of simple and complex structures subjected to dynamic loads; using exact and approximate analytical techniques; determination of free response and force response using modal superposition and numerical integration; review of the characteristics of earthquakes with consideration of site and structural parameters on the response of buildings; and application of analysis and design procedures required to achieve earthquake-resistant structures in accordance with building code specifications.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5421. Structural Dynamics. 3 Credit Hours.
This design course addresses developments in theory and practice of earthquake engineering. It familiarizes students with new techniques of analysis and seismic design. Students learn advanced concepts in applied mathematics, especially structural dynamics and application of seismic building and bridge codes. Familiarity with differential equations, matrix methods of analysis, non-linear equations, eigenvalue solutions, and finite elements modeling are required. Students are instructed to learn and apply new software for dynamic analysis. Laboratory work includes the study of experimental models such as for bridge piers (frames, walls, and hammerhead columns) using an MTS machine for applying dynamic loads.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5431. Behavior and Design of Steel Structures. 3 Credit Hours.
The course's design objective is to develop within the student an awareness of the fundamentals required to produce safe, functional, and economical steel structures, which are in conformance with national building codes and industry specifications and standards. This is an advanced course in structural engineering intended to develop professional-level competence in the design of steel-framed buildings, utilizing the most up-to-date design code.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5432. Structural Mechanics. 3 Credit Hours.
Topics include principles of mechanics and stress and strain at a point; analysis of statically determinate and indeterminate structures with static and moving loads using energy methods and force and deformation methods; beam theory, shear center, unsymmetrical bending, introduction to numerical methods, and computer techniques; and introduction to the use of the GT-STRUDAL and ANSYS computer programs.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5433. Behavior and Design of Masonry Structures. 3 Credit Hours.
Coverage includes the fundamental principles of masonry behavior and design. In this course, up-to-date information about material testing, research methodology in the area of masonry structures, and codes are presented. The first part of the course presents the fundamental behavior and characteristics of masonry materials and masonry assemblages, the deformational characteristics of brick and block masonry, performance of load-bearing wall systems and shear wall system, the design of unreinforced and reinforced masonry elements, and the construction details of masonry structures. The second part of the course concentrates on the seismic resistance of masonry structures, prestressed masonry, and applied design of low and high-rise buildings.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5434. Behavior and Design of Reinforced Concrete Structures. 3 Credit Hours.
Behavior, analysis, and design of advanced reinforced concrete structures and components including columns subjected to flexure in one or two direction, slender columns, floor systems including two-way slabs, and analysis, design application using modern software.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5445. Earthquake Engineering and Seismic Design. 3 Credit Hours.
Basic knowledge of and introduction to earthquake engineering, seismic design and analysis methods, and seismic design based on International Building Code (IBS), ASCE 7 - Minimum Design Loads for buildings and other structures, introduction of material specific design requirement.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5446. Advanced Concrete Technology. 3 Credit Hours.
This course focuses on theoretical and practical aspects of concrete technology. It covers the principles of cement and concrete production, concrete mixture design, strength and durability requirements (i.e., performance engineered mixture design), and environmental effect. It introduces concepts of construction with green cementitious materials (e.g., supplementary and alternative cementitious materials). Specific concepts include understanding the mechanisms, test methods, and evaluation procedures of main durability and sustainability issues in concrete infrastructure. Concrete related guidelines and specifications will be introduced.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5531. Life Cycle Assessment and Carbon Footprinting. 3 Credit Hours.
Life Cycle Assessment (LCA) examines the environmental impacts of products, processes and policies beyond their direct production. Cradle to grave analysis in this manner provides the full picture that is needed to understand the true impact. This course provides an overview of Life Cycle Assessment principles and practice in relation to environmental and energy concerns. Regulatory and economic decision support tools and software analysis packages will be included. The course is structured such that students will start an LCA from the beginning of the course and progress on it as topics are covered.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
College Restrictions: Must be enrolled in one of the following Colleges: Engineering.

Repeatability: This course may not be repeated for additional credits.

CEE 5621. Engineering Hydrology. 3 Credit Hours.
Quantifying water flow in watersheds is a crucial step in the design of environmental facilities, such as drinking water treatment plants, and in delineating floodplains. This course deals with the water cycle over watersheds by addressing the motion of water masses in the atmosphere and in surface and subsurface systems. Students who successfully pass this class are able to deal with most hydrology problems treated in the industry sector.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5622. Fate of Pollutants in Subsurface Environments. 3 Credit Hours.
This course focuses on integrated chemical, physical, and microbiological principles of contaminant fate and transport processes necessary in the use of engineered approaches toward selecting and implementing subsurface cleanup options. It also covers abiotic processes, biotic processes, empirical models, and vulnerability mapping.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5623. Contaminant Dynamics in Urban Streams. 3 Credit Hours.
This course will focus on environmental systems near the air:water and water:sediment interfaces. These systems are by definition boundary or edge systems and are therefore exceptionally important to aquatic ecosystem functioning. After briefly discussing the air:water interface in rivers and lakes, the course will focus on the water:sediment interface. It is here that steep gradients in chemical concentration can be found and significant nutrient cycling occurs. In addition, studies have shown that significant ecosystem productivity and respiration occurs within the bed sediments of flowing water. The course will discuss the concept of transient storage and hyporheic exchange; issues surrounding modeling of transient storage and hyporheic exchange; phosphorus and nitrogen biogeochemistry within the hyporheic zone; and biotic/abiotic nutrient cycling.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5631. Environmental Hydrology. 3 Credit Hours.
Topics include the physics of surface and subsurface circulation and storage of water and the transport of contaminants in watersheds, soils, aquifers, rivers, the ocean, and the atmosphere, as well as the laws and equations that govern the recharge, flow, storage, and discharge of water in natural environments. Emphasis is given to qualitative analysis and quantitative evaluation methods of the different hydrologic processes with potential applications in surface and groundwater resources engineering, and environmental analysis. Analytical and numerical procedures to solve the arising equations are presented, along with the most commonly used models to solve water resources problems. Also studied are engineering methods for the sustainable use of water resources; engineering methods for the containment and treatment of surface and groundwater pollution; and the restoration of aquifers.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5641. Urban Streams and Stormwater Management. 3 Credit Hours.
Stormwater management has become a significant issue in recent years. In the past, the typical thinking was "get it out of my town," which resulted in downstream communities suffering the brunt of poor or inadequate management. In fact, only the rate of runoff was addressed, not the volume nor the quality of that runoff. In urban areas, the volume of runoff increases significantly due to additional impervious cover (e.g., pavement and rooftops), and urban stormwater runoff causes water quality degradation due to excess amounts of nutrients, metals, bacteria, and sediment. This course addresses the impact of improperly controlled runoff on urban streams and how the rate, volume, and quality of urban stormwater runoff can be properly controlled through appropriate Best Management Practice (BMP) implementation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5701. Physical Principals of Environmental Systems. 3 Credit Hours.
Basic principles of process engineering as they relate to pollution control are studied, including heat and mass transfer; mixing, chemical, and biological reactions; and reaction and kinetics.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5702. Chemical Principles of Environmental Systems. 3 Credit Hours.
This course focuses on the essential chemical principles necessary to understand the nature of commonly occurring pollution problems and engineering approaches to their solutions; thermodynamics, chemical equilibria, acid-base chemistry, carbonate system, Redox chemistry, and adsorption/desorption phenomena.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5703. Mathematical Modeling. 3 Credit Hours.
This introductory graduate course focuses on numerical modeling of engineering systems. It covers standard mathematical techniques, such as interpolation, numerical integration, numerical solutions of ordinary and partial differential equations, parameter estimation, and optimization. Students will have to use an algorithmic programming language, such as Matlab, Fortran, or C++.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5711. Air Pollution Control. 3 Credit Hours.
Topics include theory and principles of the design and operation of the major categories of air pollution control equipment, and an introduction to dispersion modeling. An extensive design problem is a major course component.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5721. Weather Monitoring and Forecasting. 3 Credit Hours.
This online course will offer a basic understanding of measurements of the atmosphere used for weather analysis and forecasting. Data from instruments such as weather balloons, radar, lightning mapping arrays, and satellites will be included. Special emphasis will be on interpreting satellite imagery and use in weather forecasting and warnings. Students will have the opportunity to learn to interpret real-time data online, and to make their own weather forecasts. The course will be taught primarily online, though one or two on-campus meetings may be required during the semester.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5731. Solid Wastes Engineering. 3 Credit Hours.
Coverage includes engineering principles of solid waste generation, characterization, collection and transport, separation, source reduction and recycling, and physical chemical and biological treatment strategies.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5751. Water and Wastewater Treatment. 3 Credit Hours.
This course covers the design and analysis of common unit operations at water and wastewater treatment plants such as type I-IV sedimentation, coagulation and flocculation; filtration; disinfection, and biological processes.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5761. Environmental Chemistry. 3 Credit Hours.
This is an advanced course focusing on examination of processes that affect the behavior and fate of anthropogenic organic contaminants in aquatic environments. The lectures will begin with intermolecular interactions and thermodynamic principles governing the kinetics of some of the important chemical and physicochemical transformation reactions of organic contaminants. From this class, students will learn to predict chemical properties and to apply the knowledge of chemical properties and transformation reactions to assess the environmental fate of organic contaminants.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5762. Environmental Organic Chemistry. 3 Credit Hours.
This is an advanced course focusing on examination of processes that affect the behavior and date of anthropogenic organic contaminants in aquatic environments. The lectures will focus on intermolecular interactions and thermodynamic principles governing the kinetics of some of the important chemical and physiochemical transformation reactions of organic contaminants.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5771. Chemistry for Environmentally Sustainable Engineering. 3 Credit Hours.
This course is a survey of environmental chemistry as it relates to the development of environmentally sustainable engineered systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5772. Sustainable Development and Industrial Ecology. 3 Credit Hours.
As an introduction to the concepts of industrial ecology and sustainability, the course focuses on an interdisciplinary framework for the design and operation of industrial systems as living systems interdependent with natural systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5773. Sustainability Aspects of Water Supply and Wastewater Treatment. 3 Credit Hours.
Major environmental, economic and social trends are influencing the application of sustainability principles within the engineering profession. This course will examine the sustainability principles that will transform future engineering practice regarding drinking water supply and the treatment of wastewater. The term, wastewater, will be replaced by one more representative of the fact that 'wastewater' is in fact a largely untapped source of raw materials. It is in the areas of energy recovery, small molecule harvesting, and the water energy nexus where the next generation of environmental engineers will have a major impact on meeting societal needs regarding the provision of adequate drinking water as well as industrial requirements for this increasingly scarce resource. The course will introduce the underlying principles of sustainability directly relevant to meeting this need. Case studies will evaluate the above mentioned principles and the applicable areas of energy, chemical intermediates, and reclamation of previously used water, with a focus on dealing with emerging microconstituents in the water environment.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5774. Membrane Separation in Wastewater Treatment. 3 Credit Hours.
The course describes in detail membrane separation technology for a wide range of applications including water treatment and desalination. The course covers: global water shortages and need for membrane technology, microfiltration, ultrafiltration, nanofiltration and reverse osmosis membrane processes and current applications in water treatment, operational and energy issues, limitations, fouling and membranes processes coupled with biological treatment. The course is valuable as a prerequisite to more advanced research in environmental engineering, as a technical education to stimulate graduate students' interest in environmental sustainability, and as an introduction to environmental constraints that are increasingly important to other engineering disciplines.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5792. Biological Principles of Environmental Systems. 3 Credit Hours.
Applications of biological processes in environmental engineering are historic and eminently modern, from traditional ones like activated sludge and anaerobic digestion to emerging applications like detoxification of hazardous chemical and biofiltration of drinking water. This course is designed to identify the biological principles essential for the understanding and designing of biological processes used for environmental protection and improvement. While many biological processes are being employed and developed by environmental engineers, there is no place in the standard civil engineering curriculum for detailed discussion on the underlining principles and their applications. This course emphasizes the comprehension of theoretical concepts and their application in a variety of situations. It covers the fundamental biological principles by their practical applications in engineered and natural environments.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5793. Environmental Biotechnology. 3 Credit Hours.
Biotechnology plays a central role in environmental science and engineering, including wastewater treatment, pathogen control, and biodegradation. The objective of the course is to provide environmental engineers and scientists with advanced concepts and quantitative tools that are necessary for understanding environmental processes and designing environmental protection systems.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5794. Advanced Biological Wastewater Treatment. 3 Credit Hours.
Biological processes play a central role in wastewater treatment and are used in every wastewater treatment plant to remove organic compounds, nutrients, and other compounds from the water before discharging it back to the environment. The objective of the course is to provide environmental engineers and scientists with advanced concepts and quantitative tools necessary for understanding environmental processes and designing environmental treatment systems related to wastewater including advanced aerobic and anaerobic processes. The course integrates the use of microbiological principles into engineering wastewater treatment process. The course will provide a better understanding of interesting and complex environmental topics related to sustainable environmental remediation and protection. The course is valuable as a prerequisite to more advanced research in environmental engineering, as a technical education to stimulate graduate students' interest in environmental sustainability, and as an introduction to environmental constraints that are increasingly important to other engineering disciplines.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5795. Aquatic Toxicology in Environmental Engineering. 3 Credit Hours.
This course provides an introduction to the basic concepts of toxicology necessary to understand the effects of contaminants in the water environment. Specific topics include sources and classes on aquatic contaminants, environmental chemistry that influences behavior in the aquatic environment, the disposition and metabolism of these substances that affect their toxicity, and the physiological response of exposure in aquatic species and humans. The course will provide an overview of aquatic toxicity testing methods and application of toxicity data in the risk assessment of aquatic exposures to emerging contaminants, such as pesticides, pharmaceuticals, and natural products. Case studies will cover historical and contemporary examples of contaminant-driven effects.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5799. Environmental Engineering. 3 Credit Hours.
This course focuses on the generation, transport, effects, and control of environmental pollution within and across media, as well as problem analysis and control design. Theoretical development is augmented with applications of state-of-the-art software packages. Students complete a term project.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5811. Advanced Soil Mechanics. 3 Credit Hours.
Advanced concepts related to behavior of soil as an engineering material. Topics include consolidation magnitude and time rate, evaluation of secondary compression, mitigation of consolidation of settlements, shear strength of soils and other geologic materials, principles of critical state soil mechanics, and normalization of undrained shear strength.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5821. Foundation Engineering. 3 Credit Hours.
Principles of foundation engineering and design. Topics include soil stress distributions, bearing capacity of shallow (footings, mats) and deep foundations (driven piles, drilled shafts), tolerable settlements, construction techniques, and field quality control.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5822. Earth Retaining Systems. 3 Credit Hours.
Principles related to design of earth retaining systems and stability of earth slopes. Topics include lateral earth pressure theory, temporary and permanent retaining structures, in-situ reinforcement, and braced evacuations. Shear strength of cohesive and granular soils and slope stability analysis using limited equilibrium, design charts and numerical methods.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 5823. Geotechnical Earthquake Engineering. 3 Credit Hours.
An introduction to seismology and earthquake hazards in geotechnical engineering. Topics include plate tectonics and earthquake faulting, strong ground motions, dynamic soil properties, and characterization of design ground motions based on deterministic and probabilistic seismic hazard analysis. Analysis of earthquake-induced ground failures, seismic design of earth retaining systems and slopes, and effects of soil-structure interaction.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 8302. Advanced Project Management. 3 Credit Hours.
This course covers analysis of project control, job budgeting and costing, safety and risk management, bidding strategies and management, construction information management, and case studies of construction projects and company profiles.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 8701. Advanced Physical/Chemical Treatment Processes. 3 Credit Hours.
There are numerous sites in the environment where surface water, ground water or soil is contaminated with toxic chemicals. In addition, many industrial wastewater and air emissions contain toxic chemicals which required treatment. Due to the chemical toxicity, we rely on physical and chemical processes for the decontamination of the fluid stream. Some of the commonly used treatment technologies are carbon absorption, air stripping and scrubbing. Of late, advanced oxidations processes have been examined and implemented as well. These processes are also used to produce high quality drinking water. The course deals with the analysis and design of some commonly used advanced physical/chemical processes for treatment of contaminated water and air. This course complements, and builds upon the fundamental science discussed in other courses in the curriculum on physical and chemical principles. In this course, emphasis will be placed on understanding the basic science, and the engineering design principles. Treatment of water, wastewater and air using processes such as air stripping, scrubbing, carbon absorption and advanced oxidation processes will be discussed, and design of the treatment systems will be conducted.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 8702. Advanced Chemical Principles of Environmental Systems. 3 Credit Hours.
This is an advanced course focusing on examination of processes that affect the behavior and fate of anthropogenic organic contaminants in aquatic environments. The lectures will focus on intermolecular interactions and thermodynamic principles governing the kinetics of some of the important chemical and physiochemical transformation reactions of organic contaminants.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 8703. Computer Modeling of Environmental Transport. 3 Credit Hours.
Topics include theory and computer modeling of transport and diffusion within and across media; and application of models to problems of air, water, and soil pollution with case studies.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may not be repeated for additional credits.

CEE 9182. Independent Study I. 3 Credit Hours.
Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by MS/MSE students and once by Ph.D. students.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

CEE 9282. Independent Study II. 3 Credit Hours.
Special study in a particular aspect of engineering under the direct supervision of a graduate faculty member. May be taken once by Ph.D. students.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

CEE 9991. Directed Research. 1 to 6 Credit Hour.
Under the guidance of a faculty member, the student conducts independent research on a selected topic in engineering.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

CEE 9994. Preliminary Examination Preparation. 1 to 6 Credit Hour.
This course is intended for Ph.D. students who have completed their coursework but who have not yet passed both the Ph.D. Preliminary Examination.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

CEE 9995. Project. 1 to 3 Credit Hour.
A project is assigned with the approval of the Civil and Environmental Engineering Graduate Committee and conducted under the supervision of a graduate faculty advisor. An oral presentation in an open seminar and a written report are required to complete the independent project. Projects related to industrial applications are encouraged. For non-thesis students only.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

CEE 9996. Thesis. 1 to 3 Credit Hour.
Master's thesis. May be taken twice.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

CEE 9998. Pre-Dissertation Research. 1 to 6 Credit Hour.
This course is intended for Ph.D. students who have passed both the Preliminary and Qualifying Examinations but who have not been elevated to candidacy.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.

Repeatability: This course may be repeated for additional credit.

CEE 9999. Dissertation Research. 1 to 6 Credit Hour.
This course is intended only for those students who have achieved Ph.D. Candidacy status. A minimum of 6 semester hours is required for graduation.

Level Registration Restrictions: Must be enrolled in one of the following Levels: Graduate.
Student Attribute Restrictions: Must be enrolled in one of the following Student Attributes: Dissertation Writing Student.

Repeatability: This course may be repeated for additional credit.