Civil Engineering - Undergraduate Programs

Undergraduate Programs

The following sections apply to each student majoring in any undergraduate program housed in the Civil Engineering Department: Architectural Engineering, Civil Engineering, and Construction Management. In these sections, "program" refers to any of these programs and "student" refers to any student (UCOL, Intended, or Professional Program) majoring in any one of these programs.

Refer to the College of Engineering section of this catalog for additional information concerning the following topics: Admission to the College of Engineering, Advising, Admission into the Professional Program, College of Engineering Academic Regulations, Honors Degrees in Engineering, Professional Engineering Licensure, and Cooperative Education.

Admission Requirements

Admission as an Architectural Engineering major, a Civil Engineering major, or a Construction Management major is subject to the relevant requirements and policies of the University of Texas at Arlington and of the UTA College of Engineering. The Civil Engineering Department does not impose additional requirements.

Transfer Credit

When a student transfers, a loss of credit can occur that may require change in academic plans. A course, that appears to be similar, may be different in either content or level of difficulty and, as a result, cannot be used for degree credit. Another course may have no equivalent in a particular degree plan. More than one transferred course may satisfy a degree requirement when only one is required. The UTA Civil Engineering Department encourages students interested in our programs to make early contact with our advisors so that we can help avoid these problems.

A student must earn a grade of C or better for a course to be transferred. Any course that is offered under the Texas Common Course Numbering system is accepted as equivalent to the corresponding UTA course. It is the responsibility of the student to establish the equivalence of any other course or courses to a course required in a program. The student should be prepared to provide a syllabus or similar documents to establish equivalence. To be acceptable as equivalent, at a minimum, a transferred course must have no less credit value than the corresponding course and contain substantially equivalent course content. To be accepted in transfer, junior and senior level courses must be taken at a college or university with the same accreditation as UTA in the area offering the course. For example, a Civil Engineering course must come from an ABET accredited Civil Engineering program.

When a student's record or performance indicates weakness in certain areas of study, they may be required to retake courses or to take additional courses.

Before enrolling in a course at another institution to transfer for credit toward a program degree, a student should consult with a program advisor to verify that the course can be used in the student's degree plan and to obtain the necessary written permission.

Advising

Academic advisement is required for every undergraduate student before class enrollment each semester.

A new student with fewer than 24 hours of transferrable credit, including any student entering directly from high school, is advised in the University Advising Center of University College. After one or more semesters and sufficient progress in the degree program, this student is released by the University Advising Center to the program advisors.

Prior to enrollment, a new student with 24 or more hours of transferrable credit must make an appointment with the transfer advisor of their program. However, if all of the student's transfer credit was earned at a Texas community college, an appointment may be scheduled with any advisor for their program. The advising appointment should be scheduled as soon as possible after admission, but certainly prior to registration. A transfer student should not make an advising appointment with a transfer advisor after the initial evaluation of their transfer credit is complete.

During each long semester, a specified period is set aside for the academic advisement of continuing students. Each continuing student is responsible for meeting with their program advisor during this advising period. Continuing students will receive instructions prior to each advising period related to preparing for and making an advising appointment. Academic advising will be available at other times but a student who does not meet with their program advisor during the regular advising period may have fewer alternatives when selecting courses.

Academic Rules, Regulations, and Policies

In addition to the rules, regulations, and policies established below and in the individual program sections, each student is subject to the rules, regulations, and policies of the University of Texas at Arlington and of the UTA College of Engineering. Each student should become familiar with these. The rules, regulations, and policies of the University of Texas at Arlington and of the UTA College of Engineering are set forth in other sections of this catalog. It is the responsibility of each student to follow the applicable published rules. Failure to follow these rules may be grounds for dismissal from the program.

CE Department Course Requisites

- A student must have the written approval of their program advisor to register for any course that will satisfy a requirement of their degree program.
- A student must have specific written permission of their program advisor to register at a different institution for any course that will satisfy a requirement of their degree program.
- A student may not attempt a CE Department course without satisfying all current requisite requirements. A prerequisite course requirement is satisfied by earning a grade of C or better. A co-requisite course requirement is satisfied by earning a grade of C or better or by concurrent enrollment in the course at UTA.
- A student may not drop a course which is co-requisite to a CE Department course without also dropping the CE Department course.
- No professional program courses may be attempted until the student is admitted into the professional program or obtains the written permission of the Department Chair.

Repeating Courses

A student may not attempt any course more than three times and apply that course toward a program degree. Enrollment in a course for a period of time sufficient for assignment of a grade, including a grade of W, is considered an attempt.

Admission to the Professional Program

Requirements for admission to the professional program in each program are in accordance with those of the College of Engineering with the following added stipulations:

- Application to the professional program is to be made to the CE Department during the semester that the advancement requirements are being completed.
- Each student must complete all pre-professional courses stipulated under "Requirements for a Bachelor of Science Degree in" the program with a minimum grade of C in each course and a minimum GPA of 2.25 in: a) all courses, b) in all math, science, and engineering courses, and c) in all program specific courses.
- Upon receipt of the application, a student's record is individually reviewed including grades, academic and personal integrity, record of drops and course withdrawals, the order in which courses have been taken, the number of times a student has attempted a course for credit, and any other aspect of the student's record that may be deemed pertinent to admission.

The student must be admitted to the professional program and have an approved degree plan on file in order to graduate. The degree plan is generated upon entry to the professional program. Graduating seniors should apply to graduate during the next-to-last semester.

Grounds for Dismissal from the CE Program

A student whom the UTA Office of Student Conduct has found to have violated the UTA Code of Student Conduct a second time is subject to dismissal from the CE program.

Minor Field of Study

The Civil Engineering Department does not support the option of pursuing a minor in Architectural Engineering, in Civil Engineering, or in Construction Management by other engineering or non-engineering majors.

Educational and Professional Career Paths

Civil engineering is the oldest and broadest of the engineering disciplines. A civil engineer works with a wide spectrum of individuals in both the public and private sectors to meet today's challenges of pollution, infrastructure rehabilitation, traffic congestion, floods, earthquakes, and urban development. Civil engineers plan, design, construct, maintain, manage, and operate facilities essential to modern, civilized human life. Projects requiring civil engineering expertise vary widely in nature, size, and scope, such as: bridges, tunnels, transportation systems, airports, storm water drainage systems, dams, buildings, foundations, water treatment and distribution, wastewater collection and treatment, hazardous waste treatment, environmental remediation, environmental protection, and air pollution control.

Civil engineering graduates are prepared for advanced graduate degrees and a wide range of career paths in civil engineering including consulting, governmental agencies, and industry. In addition to the traditional careers in civil engineering, graduates may take advantage of their strong, broad-based engineering education to pursue careers in professions such as medicine, law, business, or teaching.

Fast Track Program for Master's Degrees in Civil Engineering

The Fast Track Program enables outstanding senior undergraduate Civil Engineering students to receive undergraduate and graduate credit for up to six hours of coursework. Technical electives which are dual-listed as graduate courses will satisfy both bachelor's and master's degree requirements. Students pursuing an MECE or MSCE degree may take up to two courses for dual credit.

Interested undergraduate Civil Engineering students should apply for admission to the Fast Track Program when they are within 30 hours of completing their bachelor's degree (and before graduation). For admission consideration, they must have completed at least 30 hours at UT Arlington and have an overall and College of Engineering GPA of at least 3.00 (in both) for the MECE option and the MSCE option. Additionally, they must have completed

a set of specified, basic undergraduate foundation courses with a grade of B or higher in each course and a GPA of at least 3.30 in these foundation courses. The specific foundation courses vary according to the student's desired specialty area for the master's degree.

In their final semester as an undergraduate, Fast Track students in good standing will be automatically admitted to graduate school with consent of the Graduate Advisor. No fees, transcripts, or test scores will be required. Students must start their master's program the long semester or summer semester immediately following their graduation or the next long semester. For further information about this program, contact an undergraduate advisor or the Graduate Advisor in Civil Engineering. Descriptions of CE Fast Track degree options and a list of approved, required departmental courses are also available in the CE Advising Office.

Civil Engineering BS Degree at UT Arlington

At the undergraduate level, the department offers a Bachelor of Science in Civil Engineering degree designed to provide a strong foundation in science, mathematics, and engineering science; technical competence in multiple areas of civil engineering practice; and an understanding of the importance of ethics, safety, professionalism, and socioeconomic concerns in resolving technical problems through synthesis, planning, and design. Elements of design are introduced at the freshman level. This is followed by an analysis and design component in professional program courses, culminating in a comprehensive design experience.

The UT Arlington Civil Engineering BS degree has been accredited since October 1967 by the Engineering Accreditation Commission of ABET, www.abet.org (http://www.abet.org/). ABET is recognized by the U.S. Department of Education as the sole agency responsible for accreditation of educational programs leading to degrees in engineering. Graduation from an ABET accredited program is an important factor in attaining registration as a Professional Engineer in the State of Texas and other states.

Educational Objectives of the Undergraduate Program

Most alumni of the CE program will attain the following Program Educational Objectives (PEOs) within a few years after graduation:

- Obtain professional position and practice civil engineering, or pursue graduate studies.
- Be involved in continuing education and professional development activities.
- Obtain PE licensure or other professional certification.

Student Outcomes of the Undergraduate Program

In order to produce graduates who will achieve the Program Educational Objectives a few years after graduation, it is expected that the undergraduate students will attain the following Student Outcomes by the time of graduation:

- an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
- an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
- an ability to communicate effectively with a range of audiences
- an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
- an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
- an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
- an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

Requirements for a Bachelor of Science Degree in Civil Engineering

Courses Fulfilling the University General Core Requirements (minimum 42 hours required)		**46**
Communication (minimum 6 hours required)		
ENGL 1301	RHETORIC AND COMPOSITION I	
COMS 2302	PROFESSIONAL AND TECHNICAL COMMUNICATION FOR SCIENCE AND ENGINEERING [2]	
Creative Arts (minimum 3 hours required)		
Any course which satisfies the University Core Curriculum requirement for Creative Arts is accepted.		
Government/Political Science (minimum 6 hours required)		
POLS 2311	GOVERNMENT OF THE UNITED STATES	
POLS 2312	STATE AND LOCAL GOVERNMENT	
Language, Philosophy & Culture (minimum 3 hours required)		
Any course which satisfies the University Core Curriculum requirement for Language, Philosophy & Culture is accepted.		
Mathematics (minimum 6 hours required)		
MATH 1426	CALCULUS I	

MATH 2425	CALCULUS II	
Life & Physical Sciences (minimum 6 hours required)		
PHYS 1443	GENERAL TECHNICAL PHYSICS I	
PHYS 1444	GENERAL TECHNICAL PHYSICS II	
Social & Behavioral Sciences (minimum 3 hours required)		
IE 2308	ECONOMICS FOR ENGINEERS	
US History (minimum 6 hours required)		
Any courses which satisfies the University Core Curriculum requirement for US History is accepted.		
Foundational Component Area Option (minimum 3 hours required)		
MATH 2326	CALCULUS III	
Pre-Professional Program Courses		**23**
Of the core courses, COMS 2302, ENGL 1301, IE 2308, MATH 1426, MATH 2425, MATH 2326, PHYS 1443, and PHYS 1444 are part of the CE Pre-Professional Program.		
CHEM 1465	CHEMISTRY FOR ENGINEERS	
CE 1105	INTRODUCTION TO CIVIL ENGINEERING [1]	
CE 1353	INTRODUCTION TO COMPUTER AIDED DESIGN TOOLS IN CIVIL ENGINEERING	
CE 2221	DYNAMICS	
CE 2311	STATICS	
CE 2313	MECHANICS OF MATERIALS I	
CE 2331	ENGINEERING MEASUREMENT AND COMPUTER MODELING	
MATH 3319	DIFFERENTIAL EQUATIONS & LINEAR ALGEBRA	
UNIV 1131	STUDENT SUCCESS	
or ENGR 1101	ENTRANCE TO ENGINEERING FOR TRANSFER STUDENTS	
CE Professional Program Courses		**61**
CE 3131	ENVIRONMENTAL ANALYSIS	
CE 3142	APPLIED FLUID MECHANICS LAB	
CE 3143	PROPERTIES AND BEHAVIOR OF SOILS	
CE 3210	CIVIL ENGINEERING COMMUNICATIONS	
CE 3253	APPLICATIONS OF COMPUTER-BASED DESIGN PROGRAMS IN CIVIL ENGINEERING	
CE 3301	STOCHASTIC MODELS FOR CIVIL ENGINEERING	
CE 3302	TRANSPORTATION ENGINEERING	
CE 3305	BASIC FLUID MECHANICS	
CE 3311	CONSTRUCTION ENGINEERING	
CE 3328	WATER SYSTEM DESIGN	
CE 3334	PRINCIPLES OF ENVIRONMENTAL ENGINEERING	
CE 3341	STRUCTURAL ANALYSIS	
CE 3342	WATER RESOURCES ENGINEERING	
CE 3343	SOIL MECHANICS	
CE 3347	REINFORCED CONCRETE DESIGN	
CE 3361	PROPERTIES & BEHAVIOR OF CIVIL ENGINEERING MATERIALS	
CE 4352	PROFESSIONAL PRACTICE	
CE 4383	SENIOR PROJECT	
GEOL 3340	GEOLOGY FOR ENGINEERS	
12 hours of senior technical electives		
Nine hours of CE technical electives to be selected from three of the following six areas: Construction, Environmental, Geotechnical, Structures, Transportation or Water Resources. One remaining three-hour course may be from any CE technical elective area, CE 4393 (Industrial Internship), or CE 4394 (Research Internship).		
Civil Engineering Technical Electives are all CE 4000-level courses, except CE 4352 (Professional Practice) and CE 4383 (Senior Project). The classification of each CE technical elective is provided on a form by the Civil Engineering Department.		
Total Hours		**130**

[1] Completion of CE 1105 INTRODUCTION TO CIVIL ENGINEERING and CE 1353 INTRODUCTION TO COMPUTER AIDED DESIGN TOOLS IN CIVIL ENGINEERING satisfies the University's computer proficiency requirement.

[2] Completion of COMS 2302 PROFESSIONAL AND TECHNICAL COMMUNICATION FOR SCIENCE AND ENGINEERING satisfies the University's communication requirement.

More hours may be required to strengthen student's program or demonstrate proficiency. See Prior Preparation and Course Requirements.

Total hours will depend upon prior preparation and academic qualifications. Also, students who do not have two units of high school foreign language will be required to take modern and classical languages courses in addition to the previously listed requirements.

Suggested Course Sequence

A suggested course sequence for the Pre-Professional and Professional Program courses is available on the CE Department's web site.

Prior Preparation and Course Requirements

The undergraduate baccalaureate degree in civil engineering is a four-year program and requirements for the degree are based upon prior high school preparation through either an honors or college track program. Students who have not had the appropriate prior preparation should contact the departmental advising office for a curriculum guide that will assist them in structuring a study plan that will include leveling courses. Students requiring leveling courses may require a period of time greater than four years to complete their undergraduate degree.

COURSES

CE 1000. FRESHMAN UNDERGRADUATE RESEARCH. 0 Hours.
Freshman level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

CE 1105. INTRODUCTION TO CIVIL ENGINEERING. 1 Hour.
Introduction to basic civil engineering practice. There are several writing assignments and an oral presentation. Use of spreadsheet and word processor software in solving civil engineering problems and presenting solutions. Professional engineering licensure and the various specializations within civil engineering are covered.

CE 1252. COMPUTER TOOLS - AUTOCAD. 2 Hours.
Introduction to computer aided design, using AutoCAD. Creation of precise two-and/or three- dimensional engineering drawings and solid models. Prerequisite: Grade of C or better in MATH 1421; or concurrent enrollment in:(1) MATH 1426 or 2) HONR-SC 1426.

CE 1353. INTRODUCTION TO COMPUTER AIDED DESIGN TOOLS IN CIVIL ENGINEERING. 3 Hours.
An introduction to computer aided design using AutoCAD interface built in Civil 3D. Students will be taught CAD commands, tools, 2D drawing objects, multi-view drawing, layer management, linetypes, object snap, polar tracking, and annotation. Civil 3D concepts and essential functions for creating, designing, and analyzing civil engineering drawings will be covered. Prerequisite: Grade of C or better in MATH 1421 (or concurrent enrollment) or MATH 1426 (or concurrent enrollment).

CE 2000. SOPHOMORE UNDERGRADUATE RESEARCH. 0 Hours.
Sophomore level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

CE 2152. COMPUTER TOOLS - MATHCAD. 1 Hour.
Introduction to computer aided mathematics, using Mathcad. Solution of engineering problems involving systems of simultaneous linear and nonlinear equations and elementary calculus, use of the tools for visualization. Prerequisite: Grade of C or better in PHYS 1443.

CE 2153. COMPUTER TOOLS - CIVIL 3D. 1 Hour.
Introduction to civil engineering construction documentation and building information modeling (BIM) using AutoCAD Civil 3D. Prerequisite: CE 1252.

CE 2191. PROBLEMS IN CIVIL ENGINEERING. 1 Hour.
Selected problems in civil engineering on an individual or group basis. Reference material is assigned and progress conferences are held frequently, by arrangement, with a faculty supervisor. Prerequisite: permission of the chair of the department and sophomore classification in civil engineering.

CE 2221. DYNAMICS. 2 Hours.
Planar and spatial kinematics and kinetics of particles and rigid bodies utilizing Newton's Laws of Motion, the principle of work and energy, and the principle of impulse and momentum; introduction to single degree of freedom vibration. Prerequisite: Grade of C or better in CE 2311; grade of C or better in MATH 2425.

CE 2291. PROBLEMS IN CIVIL ENGINEERING. 2 Hours.
Selected problems in civil engineering on an individual or group basis. Reference material is assigned and progress conferences are held frequently, by arrangement, with a faculty supervisor. Prerequisite: permission of the chair of the department and sophomore classification in civil engineering.

CE 2300. INTRODUCTION TO SUSTAINABLE ENGINEERING. 3 Hours.
Introduction to key sustainability concepts and challenges. The engineering design process and consideration of sustainability. Techniques for generating creative and innovative alternative solutions to sustainability problems. Use of life cycle assessment to quantify environmental, economic, and social impacts of various alternatives. Methods to incorporate life cycle assessment into alternatives evaluation. Case study project.

CE 2311. STATICS. 3 Hours.
Vector algebra; composition and resolution of forces; equivalence of force couple systems; equilibrium of force systems acting on particles, and force - couple systems acting on rigid bodies, and systems of rigid bodies; internal forces in rigid bodies; shear and moment diagrams; centroids and moments of inertia; frictional forces. Prerequisite: Grade of C or better in PHYS 1443.

CE 2312. STATICS AND DYNAMICS FOR NON-CE MAJORS. 3 Hours.
Principles of forces and force systems, resultants and components of force systems, forces due to friction, condition of equilibrium, forces acting on members of trusses and frame structures, centroids and moments of inertia, review of kinematics and kinetics of particle motion, and two-dimensional motion of rigid bodies. CE 2312 cannot be substituted for CE 2221 and CE 2311. Prerequisite: PHYS 1443 and MATH 2425 or concurrent enrollment.

CE 2313. MECHANICS OF MATERIALS I. 3 Hours.
Concepts of stress and strain; stress-strain relationships. Behavior of members subjected to tension, compression, shear, bending, torsion, and combined loading. Deflections and elastic curves, shear and bending moment diagrams for beams, and column theory. Prerequisite: Grade of C or better in CE 2311; Grade of C or better in MATH 2425.

CE 2331. ENGINEERING MEASUREMENT AND COMPUTER MODELING. 3 Hours.
Principles and theories of physical measurements of spatial quantities; the use of surveying instruments; introduction to engineering using computer modeling programs; and organization and programming for computer solutions. Prerequisite: Grade of C or better in CE 1353.

CE 2391. PROBLEMS IN CIVIL ENGINEERING. 3 Hours.
Selected problems in civil engineering on an individual or group basis. Reference material is assigned and progress conferences are held frequently, by arrangement, with a faculty supervisor. Prerequisite: Permission of the chair of the department.

CE 3000. JUNIOR UNDERGRADUATE RESEARCH. 0 Hours.
Junior level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

CE 3131. ENVIRONMENTAL ANALYSIS. 1 Hour.
Laboratory examinations of water, wastewater, and air. Water and air quality parameters and their significance. Sources and types of pollutants and their effects. Prerequisite: Concurrent enrollment in CE 3334 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3142. APPLIED FLUID MECHANICS LAB. 1 Hour.
Fluid flow measurements studied by means of performed laboratory experiments and/or digital computer programming of relevant equations. Prerequisite: Concurrent enrollment in CE 3342 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3143. PROPERTIES AND BEHAVIOR OF SOILS. 1 Hour.
An introduction to determination of civil engineering properties of soil and their behavior, identification, grain size analysis, Atterberg limits, compaction, permeability, consolidation, and shear strength. Also an introduction to sampling of soil materials. Prerequisite: Concurrent enrollment in CE 3343 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3161. CIVIL ENGINEERING MATERIALS LABORATORY. 1 Hour.
Various properties and behavior of civil engineering materials are investigated by laboratory experimentation. Prerequisite: Concurrent enrollment in CE 3261 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3210. CIVIL ENGINEERING COMMUNICATIONS. 2 Hours.
Technical writing, oral communication, professional presentations, and other related topics. Prerequisite: Grade of C or better in COMS 2302 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3253. APPLICATIONS OF COMPUTER-BASED DESIGN PROGRAMS IN CIVIL ENGINEERING. 2 Hours.
Applications of computer-based design programs including AutoCAD Civil 3D in civil engineering projects. Prerequisite: Grade of C or better in CE 1353 and CE 2331, and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3261. PROPERTIES AND BEHAVIOR OF CIVIL ENGINEERING MATERIALS. 2 Hours.
The nature and properties of materials used in civil engineering such as structural metals, concrete, timber, and bituminous materials. The engineering application and performance of materials are emphasized. Prerequisite: Grade of C or better in either CHEM 1465 or CHEM 1442; Grade of C or better in CE 2313; concurrent enrollment in CE 3161 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3301. STOCHASTIC MODELS FOR CIVIL ENGINEERING. 3 Hours.
Basic theory of probability and statistics with practical applications to civil and environmental engineering problems. Emphasis on sampling, distribution functions, tests of significance, and regression modeling. Prerequisite: Grade of C or better in MATH 2425; Permission of the CE Chair or Admission to the CE Professional Program.

CE 3302. TRANSPORTATION ENGINEERING. 3 Hours.
Planning, design, and operation of transportation facilities. Characteristics of vehicle movement; basic geometric design of highways; traffic flow relations in traffic streams; highway capacity; traffic engineering; and procedures for transportation planning. Prerequisite: Grade of C or better in CE 2331; and Grade of C or better in either CE 3301 or IE 3301 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3305. BASIC FLUID MECHANICS. 3 Hours.
Fundamentals of fluid statics, kinematics of fluid flow, fluid energy, fluid forces, similitude, and dimensional analysis. Related to steady flow of incompressible fluids in confined and free surface systems. Prerequisite: Grade of C or better in CE 2311; Grade of C or better in MATH 3319 or concurrent enrollment; Permission of the CE Chair or Admission to the CE Professional Program.

CE 3311. CONSTRUCTION ENGINEERING. 3 Hours.
Principles of construction engineering and the project management process, value engineering, specifications, different construction contracts and delivery methods, estimating and scheduling fundamentals and project control, and management of construction process. Prerequisite: Grade of C or better in IE 2308 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3328. WATER SYSTEM DESIGN. 3 Hours.
Hydraulic/hydrologic analysis and design of municipal water distribution, stormwater collection, and wastewater collection systems. Prerequisite: Grade of C or better in CE 3342 and Admission to the CE Professional Program.

CE 3334. PRINCIPLES OF ENVIRONMENTAL ENGINEERING. 3 Hours.
Physical, chemical, and biological unit operations and processes in an air, water, and land environment. Prerequisites: Grade of C or better in CHEM 1465 or CHEM 1442; Grade of C or better in CE 3305; concurrent enrollment in CE 3131 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3341. STRUCTURAL ANALYSIS. 3 Hours.
Structural analysis/design process, structural forms, and basic structural elements. Analysis of statically determinate structures including beams, trusses, frames, and composite structures, shear and moment diagrams, influence lines, and moving loads. Methods to compute deflections including double integration, moment area, and virtual work. Methods of analysis for statically indeterminate structures including consistent deformation, slope deflection and moment distribution. Use of structural analysis programs. Prerequisite: Grade of C or better in CE 2313 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3342. WATER RESOURCES ENGINEERING. 3 Hours.
Hydrologic cycle, precipitation, evapotranspiration, water budget, rainfall-runoff, hydrograph, reservoir and streamflow routing, groundwater flow, catchment hydrology, probability concepts in design, hydrologic modeling, open channel and pipe network hydraulics, pumps, urban stormwater drainage. Prerequisite: Grade of C or better in CE 3301; grade of C or better in CE 3305; concurrent enrollment in CE 3142 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3343. SOIL MECHANICS. 3 Hours.
An introduction to the significant geophysical and soil science properties and behavior of materials making up the earth's crust as they apply to civil engineering, sources of materials, classification, plasticity, permeability, stress distribution, consolidation, shear strength, and settlement. Also an introduction to basic foundation engineering concepts. Prerequisite: Grade of C or better in CE 2313; concurrent enrollment in CE 3143 and Permission of the CE Chair or Admission to the CE Professional Program.

CE 3347. REINFORCED CONCRETE DESIGN. 3 Hours.
An analysis, design and synthesis course for concrete structures, emphasizing strength design method. Topics include strength and serviceability requirements, design of one way slabs, rectangular beams, flanged sections and columns, for strength, shear, bond, bearing, and serviceability. Building codes, American Concrete Institute (ACI) specifications, material specifications, test methods, and recommended practice documents are involved. Prerequisite: Grade of C or better in CE 3341 and admission to the CE Professional Program.

CE 3361. PROPERTIES & BEHAVIOR OF CIVIL ENGINEERING MATERIALS. 3 Hours.
The nature and properties of materials used in civil engineering such as structural metals, concrete, timber, and bituminous materials. The engineering application and performance of materials are emphasized. Laboratory experimentation is also used to investigate properties and behavior of civil engineering materials. Prerequisite: Grade of C or better in CE 2313; Grade of C or better in either CHEM 1465 or CHEM 1442; Permission of the CE Chair or Admission to the CE Professional Program.

CE 4000. SENIOR UNDERGRADUATE RESEARCH. 0 Hours.
Senior level undergraduate research. Prerequisite: Departmental good standing and permission of instructor. May be taken a maximum of 3 times.

CE 4191. PROBLEMS IN CIVIL ENGINEERING. 1 Hour.
Selected problems in civil engineering on an individual or group basis. Reference material is assigned and progress conferences are held frequently, by arrangement, with a faculty supervisor. Prerequisite: permission of the chair of the department and sophomore standing in civil engineering.

CE 4291. PROBLEMS IN CIVIL ENGINEERING. 2 Hours.
Selected problems in civil engineering on an individual or group basis. Reference material is assigned and progress conferences are held frequently, by arrangement, with a faculty supervisor. Prerequisite: permission of the department chairperson and sophomore standing in civil engineering.

CE 4300. ADVANCED TOPICS IN CIVIL ENGINEERING. 3 Hours.
Advanced topics of current interest in any one of the various fields of civil engineering. The subject title to be listed in the class schedule. May be repeated for credit when topic changes. Prerequisite: changes with topic; consent of instructor required and Admission to the CE Professional Program.

CE 4301. ADVANCED TOPICS IN CIVIL ENGINEERING WITH LAB. 3 Hours.
Advanced topics of current interest in any one of the various fields of civil engineering. The subject title to be listed in the class schedule. May be repeated for credit when topic changes. Prerequisite: Changes with topic; Consent of instructor required and Admission to the CE Professional Program.

CE 4302. ADVANCED CONCRETE MATERIALS. 3 Hours.
Providing a practical understanding of design and characterization of advanced concrete materials, this course is intended for graduate and senior undergraduate students who want to advance their knowledge in new concepts of materials in construction. Topics include the study of properties at the nanoscale and how they affect the material's properties at the macro level. Lectures will focus on the advances in the design and technology of cement based materials, with particular emphasis on the evolution of nanotechnology in construction. Prerequisite: Grade of C or better in CE 3361 and admission to the CE Professional Program.

CE 4303. CONSTRUCTION PROJECT ADMINISTRATION. 3 Hours.
Topics in construction management and project administration, such as project delivery system, documentation and specification, electronic project administration, construction safety, risk allocation and liability sharing, changes and extra work, claims and disputes, and project closeout. Credit not granted for CE 4303 and CE 5342. Prerequisite: Grade of C or better in CE 3311 and admission to the CE Professional Program.

CE 4304. CONSTRUCTION CONTRACTS, SPECIFICATIONS, & ADMINISTRATION. 3 Hours.
Types of construction contracts, contractual relationship between general contractor and owner, contractual relationship between general contractor and subcontractors, legal issues in construction administration, insurance, and concepts in value engineering. Reading and evaluating specifications, CSI Master Format. Credit not granted for both CE 4304 and CE 5378. Prerequisite: Grade of C or better in CE 3311 and admission to the CE Professional Program.

CE 4305. TRENCHLESS TECHNOLOGY METHODS. 3 Hours.
Pipeline and utility design, construction and renewal. Topics include pipeline infrastructure structural considerations, planning and construction considerations, pipe materials, and trenchless technologies. Prerequisite: Grade of C or better in CE 3311 and admission to the CE Professional Program.

CE 4306. INFRASTRUCTURE ASSET MANAGEMENT. 3 Hours.
Infrastructure inventory, inspection, and life cycle costs. Topics include pipeline deterioration parameters, asset management technologies, risk assessment, government regulations and case studies. Prerequisite: Grade of C or better in CE 3311 and admission to the CE Professional Program.

CE 4307. CONSTRUCTION SUSTAINABILITY. 3 Hours.
Types of construction contracts, contractual relationship between general contractor and owner, contractual relationship between general contractor and subcontractors, legal issues in construction administration, insurance, and concepts in value engineering. Reading and evaluating specifications, CSI Master Format. Credit not granted for both CE 4307 and CE 5382. Prerequisite: Grade of C or better in CE 3311 and admission to the CE Professional Program.

CE 4308. TEMPORARY STRUCTURES. 3 Hours.
Analysis and design of temporary structures. Topics include loads on temporary structures, shoring, formwork, falsework, scaffolding, bracing, soldier beam and lagging, sheet piling, equipment bridges, and support of existing structures. Prerequisite: Grade of C or better in CE 3341 and CE 3343; Admission to the CE Professional Program.

CE 4310. SYSTEM EVALUATION IN CIVIL ENGINEERING. 3 Hours.
Techniques necessary to perform economic and multi-criteria evaluations of civil engineering projects. These will be used to assess the strengths and weaknesses of different decision-making strategies and analyze contemporary topics and case studies in making civil engineering decisions. Prerequisite: Grade of C or better in IE 2308; Grade of C or better in CE 3301.

CE 4311. URBAN TRANSPORTATION INFRASTRUCTURE PLANNING. 3 Hours.
Urban transportation system design, planning, transportation modeling, economic theory, travel demand and travel estimation techniques. Prerequisite: Grade of C or better in CE 3302 and Admission to the CE Professional Program.

CE 4312. STREET AND HIGHWAY DESIGN. 3 Hours.
The geometric design concepts for urban and rural roadways. Consideration of vehicle and road user characteristics in roadway design, including horizontal and vertical alignments, intersections, interchanges, and roadway cross-section and right-of-way considerations. Prerequisite: Grade of C or better in CE 3302 and Admission to the CE Professional Program.

CE 4313. TRAFFIC ENGINEERING. 3 Hours.
Design and control of fixed-time, actuated, and computer-controlled traffic signals; optimization of traffic flow at intersections; capacity analysis of intersections, legal requirements and traffic studies for installation of traffic control devices; characteristics of signs, signals, and markings; traffic laws. Prerequisite: Grade of C or better in CE 3302 and Admission to the CE Professional Program.

CE 4314. INTRODUCTION TO RAILROAD ENGINEERING. 3 Hours.
Overview of the railroad industry in the United States; structure of track, base, and foundation; drainage, railroad structures (bridges and retaining walls); geometric design; communications and signaling; maintenance. Credit not granted for both CE 4314 and CE 5334. Prerequisite: Grade of C or better in CE 3302 and Admission to the CE Professional Program.

CE 4320. EARTH STRUCTURES DESIGN. 3 Hours.
Study of the states of stress and analysis/design techniques associated with cuts, fills, and retaining structures. Includes slope stability, conventional and reinforced earth retaining walls, excavation bracing, and sheet pile wharf structures. Prerequisite: Grade of C or better in CE 3343 and Admission to the CE Professional Program.

CE 4321. FOUNDATION ENGINEERING. 3 Hours.
Aspects of design and construction considerations for all types of foundation systems in most soil/rock support conditions, interactions between soils and structures, bearing capacity theories, consolidation, shrink-swell, and settlement. Numerical analyses of design are applied to most of the situations. Prerequisite: Grade of C or better in both CE 3341 and CE 3343 and Admission to the CE Professional Program.

CE 4322. APPLICATIONS WITH GEOSYNTHETICS. 3 Hours.
Definitions and properties of geotextiles, geogrids, geonets, geocomposites and geomembranes; reinforcement design applications in rigid and flexible pavements, foundations, embankments, slopes and retaining walls; drainage and filtration application designs, AASHTO design criteria; construction methods. Prerequisite: Grade of C or better in CE 3343 and Admission to the CE Professional Program.

CE 4323. LANDFILL DESIGN. 3 Hours.
Introduction and types of landfills, landfill site selection, siting and configuration, compacted and geosynthetic clay liners, final cover design, landfill settlement and slope stability, post closure uses of landfills, leachate and gas generation, collection and removal system, bioreactor landfills and future trends. Prerequisite: Grade of C or better in CE 3343 and Admission to the CE Professional Program.

CE 4324. MECHANICS OF MATERIALS II. 3 Hours.
Theories of stress and deformation, stress-strain tensors, stress and strain relationships, stresses due to various loading conditions, theories of failure, energy methods, shear-center, unsymmetrical bending, curved beams, torsion in closed and open cell cross-sections and buckling analysis. Prerequisite: Grade of C or better in CE 2313 and Admission to the CE Professional Program.

CE 4325. FUNDAMENTALS OF FINITE ELEMENT METHOD. 3 Hours.
Stiffness method using basic equations and virtual work; element equations using shape functions for axial, beam, frame, two dimensional elements; stiffness methods for three dimensional structures. Flexibility method; finite elements modeling and optimization of idealized structures. Prerequisite: Grade of C or better in CE 3341 and Admission to the CE Professional Program.

CE 4326. GIS/HYDROLOGIC AND HYDRAULIC MODELING. 3 Hours.
Use of Geographic Information Systems (GIS) and design of GIS-developed hydrologic/hydraulic models commonly applied in the water resources field. The course will have three main areas of emphasis including: principles and operations of ArcGIS, design and implementation of standard hydrologic and hydraulic models, and the linkage of these models to engineering analysis of current water resources problems including flooding, water quality and water supply. Prerequisite: Grade of C or better in CE 3342 and Admission to the CE Professional Program.

CE 4327. SITE REMEDIATION ENGINEERING. 3 Hours.
This course provides practical understanding of the engineering principles and practices associated with the characterization and remediation of contaminated sites. Methods for site characterization and risk assessment will be highlighted while the emphasis will be on remedial action screening processes and technology principles and conceptual design. In-situ and ex-situ treatment processes will be covered, including unit operations, coupled processes, and complete systems within the context of community implementation. Case studies with focus on developing communities will be used and computerized tools for process selection and design will be presented. Prerequisite: Grade of C or better in CE 3334 and Admission to the CE Professional Program.

CE 4330. HYDRAULIC DESIGN. 3 Hours.
Design methods for appurtenances of water conveyance systems under open channel and pressure flow conditions. Prerequisite: Grade of C or better in CE 3342 and Admission to the CE Professional Program.

CE 4332. CONSTRUCTION EQUIPMENT, METHODS, & MANAGEMENT. 3 Hours.
Introduction to the construction industry and the methods, equipment, and management techniques used. Topics include equipment operating characteristics, underground construction, job site safety, and field management. Credit not granted for both CE 4332 and CE 5344. Prerequisite: Grade of C or better in CE 3311 and Admission to the CE Professional Program.

CE 4335. GEOTECHNICAL ASPECTS OF CONSTRUCTION. 3 Hours.
Review of engineering geology and soil mechanics; interpretation of geotechnical reports; site preparation; ground improvement; excavation including supports and dewatering; foundations including consideration of deep foundations and expansive soils; tunneling in soils and rock. Prerequisite: Grade of C or better in CE 3343 and admission to the CE Professional Program.

CE 4336. HOT MIX ASPHALT DESIGN & CONSTRUCTION. 3 Hours.
An in-depth study of the properties of constituent materials for asphalt concrete mixtures. Design methods for Hot-Mixes Asphalt (HMA) and Stone Matrix Asphalt (SMA). Theory and practice of asphalt concrete mix for pavements, including specifications and construction methods for hot-mix asphalt and surface treatments. Maintenance and rehabilitation of flexible pavements. Relationships of material engineering properties to pavement design and performance. Prerequisites: Grade of C or better in CE 3361 and Admission to the CE Professional Program.

CE 4337. PORTLAND CEMENT CONCRETE PAVEMENTS. 3 Hours.
Portland cement concrete mix design and production. Paving operations. Saw and seal operations. Subgrade preparation. Base selection. Drainage selection, design and construction. Bonded and unbonded concrete overlays. Whitetopping and Ultra-Thin Whitetopping. Concrete pavement restoration; Quality Assurance and Quality Control in Concrete Pavement Construction. Prerequisite: Grade of C or better in CE 3361 and Admission to the CE Professional Program.

CE 4348. STRUCTURAL DESIGN IN STEEL. 3 Hours.
A design synthesis course for structural steel structures using Allowable Strength Design and Load Resistance Factor Design. Topics include tension members, compression members, flexural members and simple connections. Building codes, American Institute of Steel Construction (AISC) specs, material specs, test methods, and recommended practice documents. Prerequisite: Grade of C or better in CE 3341 and Admission to the CE Professional Program.

CE 4350. INTRODUCTION TO AIR POLLUTION. 3 Hours.
An introduction to the air pollution field, including: pollutant types, sources, effects; atmosphere and basic calculations; emission estimates; Clean Air Act; dispersion modeling; air pollution reduction strategies. Prerequisite: Grade of C or better in CE 3334 and Admission to the CE Professional Program.

CE 4351. PHYSICAL UNIT PROCESSES. 3 Hours.
Principles of unit process modeling using reactor and kinetic theory, and theory and design of mixing, mass transfer, flocculation, sedimentation, filtration, and gas transfer. Prerequisite: Grade of C or better in both CE 3131 and CE 3334 and Admission to the CE Professional Program.

CE 4352. PROFESSIONAL PRACTICE. 3 Hours.
Professional practice issues in the private and public sector are addressed by visiting practitioners. Topics include project management, teamwork, obtaining work, regulatory requirements, specifications, issues in design/build, design alternatives, cost estimation, design and construction drawings, contract and construction law, legal issues, ethics and professionalism, design reports, licensure, lifelong learning, ethical and engineering practice organizations. Learning principles of engineering practice by working as a team is emphasized. Oral and written presentations are required. Prerequisites: Grade of C or better in CE 3210 and CE 3311 and Admission to the CE Professional Program.

CE 4353. WATER CHEMISTRY. 3 Hours.
Principles of water chemistry applied to the theory and design of unit processes including coagulation, precipitation, corrosion, oxidation-reduction, and membrane processes. Prerequisites: Grade of C or better in both CE 3334 and CE 3131 and Admission to the CE Professional Program.

CE 4354. INTRODUCTION TO SOLID WASTE ENGINEERING. 3 Hours.
This course provides an overview of the various aspects of integrated municipal solid waste management (with the exception of landfilling, covered in CE 4323). Topics covered include waste generation, characterization, and collection; source reduction; waste processing; design of facilities for materials recovery (recycling centers) and energy recovery (combustors and anaerobic digesters); life cycle analysis of solid waste management facilities; case study project. Prerequisite: Grade of C or better in CE 3334 and Admission to the CE Professional Program.

CE 4355. DESIGN OF WATER AND WASTEWATER TREATMENT FACILITIES. 3 Hours.
Design of facilities commonly used in water and wastewater treatment plants including pumps, pipelines, channels, flow measurement and control devices, screens, grit removal, mixing, sludge removal, aeration equipment, and chemical feed and storage. Materials of construction, process control interface, and operation and maintenance factors are also discussed. Prerequisite: Grade of C or better in both CE 3334 and CE 3142 and Admission to the CE Professional Program.

CE 4356. ADVANCED STEEL DESIGN. 3 Hours.
Covers torsional design of beams, beams with web holes, composite design of beams, lateral-torsional buckling of beams, plate buckling, column design and behavior, frame stability, bracing requirements for compression members. Prerequisite: CE 4348 and Admission to the CE Professional Program.

CE 4357. INTRODUCTION TO BIOLOGICAL WASTEWATER TREATMENT SYSTEMS. 3 Hours.
Basic understanding of biological processes used in water quality control and to show how theoretical concepts can be applied in a practical design. The course will include a discussion of the theory, design, and operation of biological systems used for water and wastewater treatment. Credit is not granted for both CE 4357 and CE 5325. Prerequisite: Grade of C or better in CE 3334 and CE 3131; Admission to the CE Professional Program.

CE 4358. OPEN CONDUIT SYSTEM. 3 Hours.
Non-pressure conduit and channel flow, surface profiles, steady and gradually varied flow, hydraulic jumps, and specific energy. Prerequisite: Grade of C or better in CE 3342 and Admission to the CE Professional Program.

CE 4360. DESIGN OF STRUCTURAL MASONRY. 3 Hours.
Covers masonry unit types and mortar types, reinforcing and connections. Design of beams, columns, pilasters, and walls. Structural behavior and construction practices. Includes plain and reinforced masonry. Building Codes, Masonry Standards Joint Committee (MSJC) specifications, material specifications, test methods, and recommended practice documents. Prerequisite: Grade of C or better in CE 3341 and Admission to the CE Professional Program.

CE 4361. ADVANCED REINFORCED CONCRETE DESIGN. 3 Hours.
Advanced topics on structural design of concrete structures. Topics include slender columns, shear walls, torsion, deep beams, brackets, retaining walls, strut and tie model for shear torsion, two-way slabs, and shear friction. Building codes, American Concrete Institute (ACI) specifications, material specifications, test methods, and recommended practice documents are involved. Prerequisite: Grade of C or better in CE 4347 and Admission to the CE Professional Program.

CE 4363. FUNDAMENTALS OF PRESTRESSED CONCRETE. 3 Hours.
Introduction to pre-tensioned and post-tensioned concrete structures, bonded and unbonded constructions, hardware, stress calculations, section proportioning, flexural design, shear design, prestress losses, deflections, allowable stress, load-balancing, and ultimate strength, design/analysis methods, including: partially prestressed systems shear design, analysis and design of composite beams, design of prestressed concrete bridges. Both American Concrete Institute (ACI-318) and American Association of State Highway and Transportation Officials (AASHTO-LRFD) provisions will be discussed. Prerequisite: Grade of C or better in CE 4347 and Admission to the CE Professional Program.

CE 4365. STRUCTURAL WOOD DESIGN. 3 Hours.
Covers material grade and properties of wood, design criteria using structural lumber, glue laminated lumber and structural panels. Design of bending and compression members, trusses and diaphragms. Building codes, National Design Specification for Wood Construction (NDS) specifications, material specifications, test methods, and recommended practice documents. Prerequisite: Grade of C or better in CE 3341 and Admission to the CE Professional Program.

CE 4366. FUNDAMENTALS OF FIBER REINFORCED COMPOSITES. 3 Hours.
Introduction to basic analysis, design and manufacture of composite materials for engineered structures. Fiber materials, tapes, cloths, resin system, elastic constants, matrix formulation, theory of failure. The course will also cover an introduction to design with composites, preliminary design, optimization, processing variables, product design. Prerequisite: Grade of C or better in CE 3341 and Admission to the CE Professional Program.

CE 4368. ADVANCED STRUCTURAL ANALYSIS. 3 Hours.
Advanced analysis of indeterminate beams, frames, trusses, arches, and cables. Credit will not be granted for both CE 5351 and CE 4368. Prerequisite: Grade of C or better in CE 3341 and Admission to the CE Professional Program.

CE 4369. LOADS ON STRUCTURES. 3 Hours.
Structural analysis of structures under gravity and lateral loads, emphasizing the logical reasoning process of analysis, synthesis and design. Use of recommended practice documents and commercial structural and mathematical software will assist in providing insight and understanding of load requirements, structural behavior and analysis tools. Prerequisite: Grade of C or better in CE 3341 and Admission to the CE Professional Program.

CE 4383. SENIOR PROJECT. 3 Hours.
Planning, analysis of alternatives, and designs of selected projects that cross various civil engineering disciplines, and include engineering standards and multiple realistic constraints. Application of computer-aided engineering in analysis and design. A final oral presentation and written report that presents pros and cons of alternative solutions, application of engineering standards and multiple realistic constraints are required. A team approach is emphasized. Prerequisite: Grade of C or better in CE 4352; Completion of all required 3000 level courses.

CE 4391. PROBLEMS IN CIVIL ENGINEERING. 3 Hours.
Selected problems in civil engineering on an individual or group basis. Reference material is assigned and progress conferences are held frequently, by arrangement, with a faculty supervisor. Prerequisite: Permission of the chair of the department.

CE 4393. INDUSTRIAL INTERNSHIP. 3 Hours.
Student to experience industrial internship under supervision of an industrial mentor and internship committee. May not be repeated for credit. Credit not granted for both CE 4393 and CE 4394. Prerequisite: Completion of all required 3000 level courses and admission to the CE Professional Program.

CE 4394. RESEARCH INTERNSHIP. 3 Hours.
Student to experience research internship under supervision of a CE faculty. May not be repeated for credit. Credit not granted for both CE 4393 and CE 4394. Prerequisite: Completion of all required 3000 level courses and admission to the CE Professional Program.

CE 5191. ADVANCED STUDIES IN CIVIL ENGINEERING. 1 Hour.
Individual studies of advanced topics under the supervision of a professor or professors. Prerequisite: consent of instructor.

CE 5300. TOPICS IN CIVIL ENGINEERING. 3 Hours.
Topics of current interest in the field of civil engineering. The subject title is listed in the class schedule and in the student's record. Topics vary. May be repeated for credit when topic changes. Prerequisite: consent of instructor.

CE 5301. TOPICS IN CIVIL ENGINEERING WITH LAB. 3 Hours.
Topics of current interest in the field of civil engineering. The subject title is listed in the class schedule and in the student's record. Topics vary. May be repeated for credit when topic changes. Prerequisite: Consent of instructor.

CE 5302. ADVANCED CONCRETE MATERIALS. 3 Hours.
Providing a practical understanding of design and characterization of advanced concrete materials, this course is intended for graduate and senior undergraduate students who want to advance their knowledge in new concepts of materials in construction. Topics include the study of properties at the nanoscale and how they affect the material's properties at the macro level. Lectures will focus on the advances in the design and technology of cement based materials, with particular emphasis on the evolution of nanotechnology in construction. Prerequisite: CE 3361.

CE 5303. INTRODUCTION TO FINITE ELEMENT. 3 Hours.
Stiffness method using basic equations and virtual work; element equations using shape functions for axial, beam, frame, two dimensional elements; stiffness method for three dimensional structures. Flexibility method; finite element modeling and optimization of idealized structures. Credit not granted for both CE 4325 and CE 5303. Prerequisite: CE 3341.

CE 5304. LIGHT GAGE STEEL DESIGN. 3 Hours.
Covers structural design issues for cold formed steel structures. Includes initial buckling and post buckling, stiffened and unstiffened plate behavior, braced and unbraced beams, columns, connectors and shear diaphragms. Building codes, American Iron and Steel Institute (AISI) specifications, material specifications, test methods, and recommended practice documents. Prerequisite: CE 4348 or CE 5306.

CE 5305. FIBER REINFORCED COMPOSITE DESIGN. 3 Hours.
Introduction to basic analysis, design and manufacture of composite materials for engineered structures. Fiber materials, tapes, cloths, resin systems, elastic constants, matrix formulation, theory of failure. The course will also cover an introduction to design with composites, preliminary design, optimization, processing variables, product design. Credit not granted for both CE 4366 and CE 5305. Prerequisite: CE 3341.

CE 5306. STRUCTURAL STEEL DESIGN. 3 Hours.
The basic design course for steel structures emphasizing Load Resistant Factor Design Method. Topics include tension members, compression members, flexural members, and simple connections. Building codes, American Institute of Steel Construction (AISC) specifications, material specifications, test methods, and recommended practice documents. Credit not granted for both CE 4348 and CE 5306. Prerequisite: CE 3341.

CE 5307. STRUCTURAL TIMBER DESIGN. 3 Hours.
Covers material grade, properties of wood, design criteria using structural lumber, glue laminated lumber and structural panels. Design of bending and compression members, trusses and shear diaphragms. Building codes, National Design Specifications (NDS) , material specifications, test methods, and recommended practice documents. Credit not granted for both CE 4365 and CE 5307. Prerequisite: CE 3341.

CE 5308. STRUCTURAL MASONRY DESIGN. 3 Hours.
Covers masonry unit type and grades of mortar types, reinforcing and connectors. Design of beams, columns, pilasters, and walls. Structural behavior and construction practices. Includes plain and reinforced masonry. Building codes, Masonry Standard Joint Committee (MSJC) specifications, material specifications, test methods, and recommended practice documents. Credit not granted for both CE 4360 and CE 5308. Prerequisite: CE 3341.

CE 5309. PRESTRESSED CONCRETE. 3 Hours.
Introduction to pre-tensioned and post-tensioned concrete structures, bonded and unbonded construction, hardware, stress calculations, section proportioning, flexural design, shear design, prestress losses, deflections, allowable stress, load-balancing, and ultimate strength design/analysis methods, including: partially prestressed systems shear design, analysis and design of composite beams, design of prestressed concrete bridges. Both American Concrete Institute (ACI 318-318) and American Association of State Highway and Transportation Officials Load and Resistance Factor Design (AASHTO LRFD) provisions will be discussed. Credit not granted for both CE 4363 and CE 5309. Prerequisite: CE 4347.

CE 5310. PLASTIC ANALYSIS AND DESIGN OF STRUCTURES. 3 Hours.
Behavior of structural members beyond elastic range; plastic analysis of steel and concrete members and framed structures; stepwise incremental load and mechanism methods; yield/failure mechanisms for various types of frames. Use of nonlinear structural analysis programs and design code provisions. Application to earthquake resistant design. Prerequisite: CE 4347 and CE 4348; or equivalent.

CE 5311. ADVANCED STEEL DESIGN I. 3 Hours.
Covers torsional design of beams, beams with web holes, composite design of beams, lateral-torsional buckling of beams, plate buckling, column design and behavior, frame stability, bracing requirements for compression members. Prerequisite: CE 4348 or CE 5306.

CE 5312. ADVANCED CONCRETE DESIGN I. 3 Hours.
Advanced topics on structural design of concrete structures. Topics include slender columns, shear walls, torsion, deep beams, brackets, retaining walls, strut and tie model for shear torsion, two-way slabs, and shear friction. Building codes, American Concrete Institute (ACI) specifications, material specifications, test methods, and recommended practice documents are involved. Credit not granted for both CE 4361 and CE 5312. Prerequisite: CE 4347.

CE 5313. GEOTECHNICAL ASPECTS OF CONSTRUCTION. 3 Hours.
Review of engineering geology and soil mechanics and teaching of the foundation and underground excavation construction solely to graduate students specializing in construction engineering & management. Topics include interpretation of geotechnical reports, embankment construction, foundations on expansive soils, excavation supports, excavation dewatering, deep foundation construction, tunneling in soft ground as well as in soft/hard rock, and trenchless technology piping. Credit not granted for both CE 4335 and CE 5313. Prerequisite: CE 5379 and CE 5386.

CE 5314. ADVANCED STEEL DESIGN II. 3 Hours.
Covers structural design of beam columns and building connections. Rigid frame and multi-story building design issues. Building codes, American Institute of Steel Construction (AISC) specifications, and recommended practice documents. Prerequisite: CE 4348 or CE 5306.

CE 5315. ADVANCED MECHANICS OF MATERIALS. 3 Hours.
Analysis of stresses and strains at a point, stress-strain relationships, stresses due to various leading conditions, theories of failure, energy methods, shear center, unsymmetrical bending, curved beams, torsion in closed and open cell cross-sections, principles of plastic analysis, and buckling analysis. Credit not granted for both CE 4324 and CE 5315. Prerequisite: CE 2313.

CE 5317. ENVIRONMENTAL ENGINEERING PROCESS AND ANALYSIS LAB. 3 Hours.
The course meets for 2 hours of lecture and 3 hours of lab each week. Lectures will cover advanced analytical procedures for the analyses of air, liquid, and other wastes, including optical, Chromatographic, electrical, and other instrumental methods of analysis. Lectures will also review the basics of physical/chemical processes. In the laboratory, students will demonstrate and analyze basic reactor types (CSTR, plug flow, and reactors in series) and treatment of contaminants, including gas transfer, adsorption, advanced oxidation processes, and membrane separation.

CE 5318. PHYSICAL-CHEMICAL PROCESSES I. 3 Hours.
Principles of unit process modeling using reactor and kinetic theory, theory and design of mixing, mass transfer, flocculation, sedimentation, filtration and gas transfer. Credit not granted for both CE 4351 and CE 5318. Prerequisite: CE 3131 and CE 3334; or consent of instructor.

CE 5319. PHYSICAL-CHEMICAL PROCESSES II. 3 Hours.
Principles of water chemistry applied to the theory and design of unit processes including coagulation, precipitation, corrosion, oxidation-reduction, and membrane processes. Credit not granted for both CE 4353 and CE 5319 Prerequisite: CE 3131 and CE 3334; or consent of instructor.

CE 5320. TEMPORARY STRUCTURES. 3 Hours.
Analysis and design of temporary structures. Topics include loads on temporary structures, shoring, formwork, falsework, scaffolding, bracing, soldier beam and lagging, sheet piling, equipment bridges, and support of existing structures. Prerequisite: CE 3341 and CE 3343.

CE 5321. ENGINEERING FOR ENVIRONMENTAL SCIENTISTS. 3 Hours.
Fundamental principles of engineering science applicable to the comprehension and design of engineered environmental systems. Includes water and air quality indices; kinetic and reactor theory; mass and energy balances; fluid system theory; and applications of physical, chemical and biological processes in the design of engineered environmental systems. May not be used to satisfy any of the requirements for a graduate degree in Civil Engineering. Prerequisite: PHYS 1441, CHEM 1442, and MATH 2425.

CE 5322. ADVANCED PHYSICAL-CHEMICAL PROCESSES. 3 Hours.
The course represents the fundamentals and applications of various advanced physical and chemical unit operations and processes for controlling drinking water quality. The course will cover 1) general overview on the standard, regulations, and goals of drinking water quality, 2) detailed discussion of the theory, design, and operation of advanced physical and chemical unit processes, including but not limited to, sorption, centrifugation, osmotic pressure, membrane separation, chemical oxidation and advanced oxidation, UV technology, and disinfection, and 3) post treatment issues. Prerequisites: CE 5318.

CE 5323. SUSTAINABLE ENGINEERING. 3 Hours.
Introduction to sustainability concepts and challenges through evaluation of case studies. The engineering design process and consideration of sustainability. Techniques for generating creative and innovative alternative solutions to sustainability problems. Training on Simapro software for life cycle assessment of environmental impacts. Evaluation of economic and social impacts of alternatives and decision-making.

CE 5324. INFRASTRUCTURE RELIABILITY & MONITORING. 3 Hours.
Durability and total cost of ownership for infrastructure; the physical, mechanical and chemical characteristics of deterioration and degradation for steel and other metals, Portland cement concrete, and organic materials; practical aspects of identification and remediation; a research literature review related to material durability.

CE 5325. BIOLOGICAL PROCESSES FOR WASTEWATER TREATMENT. 3 Hours.
Biological processes used in water quality control. Includes principles from microbiology and biochemistry applied to suspended and attached growth systems. Prerequisite: CE 5318.

CE 5326. WATER AND WASTEWATER TREATMENT FACILITIES DESIGN. 3 Hours.
Design of facilities commonly used in water and wastewater treatment plants including pumps, pipelines, channels, flow measurement and control devices, screens, grit removal, mixing, sludge removal, aeration equipment, and chemical feed and storage. Materials of construction, process control interface, and operation and maintenance factors are also discussed. Credit not granted for both CE 4355 and CE 5326. Prerequisite: CE 3131, CE 3142, and CE 3334.

CE 5327. ADVANCED PROJECT CONTROL. 3 Hours.
Fundamentals of construction estimating and scheduling, earned value, value engineering, risk allocations, jobsite management, safety and closeout.

CE 5328. FUNDAMENTALS OF AIR POLLUTION. 3 Hours.
An introduction to the air pollution field including: pollutant types, sources, effects; atmosphere and basic calculations; emission estimates; Clean Air Act; dispersion modeling; air pollution reduction strategies. Credit not granted for both CE 4350 and CE 5328. Prerequisite: concurrent enrollment in CE 3334 or CE 5321 or consent of instructor.

CE 5329. ENVIRONMENTAL RISK BASED CORRECTIVE ACTION. 3 Hours.
Process for the assessment and response to contamination; integrating risk and exposure practices to ensure protection of human health and environment. Includes characterization, EPA tier approach, general aspects of toxicology, dose exposure, pathways, receptors, migration and risk assessment. Prerequisite: consent of instructor.

CE 5330. CHARACTERISTICS OF TRAFFIC. 3 Hours.
The fundamental elements of traffic - the driver, the vehicle, and the roadway - are considered and then extended into studies of streams of traffic flow. Techniques of conducting traffic engineering studies, including methods of measuring speed, volume, and density, are covered along with methods for the determination of capacity on freeways and rural highways (uninterrupted flow facilities). Parking and accident studies are also included. Prerequisite: CE 3302; and CE 3301 or concurrent registration therein.

CE 5331. TRAFFIC ENGINEERING OPERATIONS. 3 Hours.
Methods of traffic regulation and control optimization. Traffic laws, motorist communication by means of traffic control devices, and the design and operation of both fixed time and actuated traffic signals at intersections. Analysis and design techniques for intersections using capacity and level of service concepts. Credit will not be granted for both CE 4313 and CE 5331. Prerequisite: CE 3302; and CE 3301 or concurrent registration therein.

CE 5332. HIGHWAY DESIGN. 3 Hours.
Geometric considerations necessary for the design of city streets, highways, and freeways such as the cross sections, vertical and horizontal alignment, sight distances and stopping distances. Includes the design of maneuver areas, channelization, ramps, intersections, and interchanges. Credit will not be granted for both CE 4312 and CE 5332. Prerequisite: CE 3302.

CE 5333. TRAFFIC CONTROL SYSTEMS. 3 Hours.
Control algorithms and optimization of splits, offsets, and cycle lengths for arterial progression and traffic signals in networks; computer simulation techniques; problem solving with computer simulation and optimization packages; freeway control using ramp meters and dynamic motorist communications. Prerequisite: CE 4313 or CE 5331 or Equivalent or Consent of Instructor.

CE 5334. INTRODUCTION TO RAILROAD ENGINEERING. 3 Hours.
Overview of railroad industry in the United States; structure of track, base, and foundation; drainage; railroad structures (bridges and retaining walls); geometric design; communications and signaling; maintenance. Credit not granted for CE 4314 and CE 5334. Prerequisite: CE 3302.

CE 5335. AIRPORT ENGINEERING. 3 Hours.
Airport master planning, for forecasting air travel demand, airside capacity, passenger terminal design, air traffic control, land access planning and design, landside operations, air cargo facility design. Prerequisite: CE 3302.

CE 5336. PAVEMENT DESIGN. 3 Hours.
Principles and theoretical concepts of rigid and flexible pavements for highways and airfields; effects of traffic loads, natural forces, and material quality; current design practices; and live cycle cost analysis. Prerequisite: CE 3302 and CE 3343.

CE 5337. URBAN TRANSPORTATION PLANNING. 3 Hours.
Theory and application of a comprehensive urban transportation planning methodology. Basic studies of population dynamics, urban growth, land use, forecasting trip generation and distribution, traffic assignment, mode split, evaluation, simulation models, characteristics of mass transit and other non-auto modes, and system design and evaluation. Credit will not be granted for both CE 4311 and CE 5337. Prerequisite: CE 3301 and CE 3302; or consent of instructor.

CE 5338. SYSTEM EVALUATION. 3 Hours.
Techniques necessary to perform economic and multi-criteria evaluations of civil engineering projects. These will be used to assess the strengths and weaknesses of different decision-making strategies and analyze contemporary topics and case studies in making civil engineering decisions. Prerequisite: IE 2308 and CE 3301 or IE 3301 or equivalents, or consent of instructor.

CE 5339. STATISTICS FOR CONSTRUCTION. 3 Hours.
Point estimation, interval estimation, sample size determination, tests of hypothesis, analysis of variance, linear regression, matrix methods for multiple linear regression, polynomial regression, transformations, non-linear regression. Prerequisite: CE 3301.

CE 5340. CONSTRUCTION PROJECT ACQUISITION. 3 Hours.
Fundamentals of acquiring the required goods and services necessary to fulfill the obligations of the construction contract. Service and subcontractor contracts, negotiating tactics and strategies, material pricing; and dispute resolution. The course includes negotiation practice based on typical construction acquisition situations to help prepare the student with experience of negotiating in the real world of construction and business. Prerequisite: consent of instructor.

CE 5341. PAVEMENT EVALUATION, REHABILITATION AND MANAGEMENT SYSTEMS. 3 Hours.
Pavement inventory; condition and structural evaluation techniques; serviceability concepts; deterioration modeling; maintenance vs. rehabilitation vs. reconstruction; economic considerations, selection of project alternatives and life cycle cost analysis. Prerequisite: CE 5336 or equivalent.

CE 5342. CONSTRUCTION PROJECT ADMINISTRATION. 3 Hours.
Topics in construction management and project administration, such as project delivery system, documentation and specification, electronic project administration, construction safety, risk allocation and liability sharing, changes and extra work, claims and disputes, and project closeout. Credit not granted for CE 4303 and CE 5342.

CE 5343. BUILDING INFORMATION MODELING. 3 Hours.
Introduction to current Building Information Modeling (BIM); Discussion of the role of BIM in the Construction Engineering and Management; Revit Architecture, Structure, and MEP; Creating sets, building elements, structural systems, and MEP systems; BIM and clash detection; BIM and Construction Cost Estimating and Scheduling.

CE 5344. CONSTRUCTION METHODS: FIELD OPERATIONS. 3 Hours.
Introduction to the methods, equipment, and management techniques used in the construction industry. Topics include equipment operating characteristics, job site safety, and field management. Credit not granted for CE 4332 and CE 5344.

CE 5345. INFRASTRUCTURE EVALUATION, MAINTENANCE, AND RENEWAL. 3 Hours.
This course is designed for engineers and managers involved in infrastructure development, sustainability, and replacement. Topics include asset management, inspection, evaluation, maintenance, and renewal alternatives for waste collection and water distribution systems, surface and subsurface drainage, pavements, bridges, culverts, buildings, and other structures. Prerequisite: Consent of instructor.

CE 5346. OPEN CHANNEL FLOW. 3 Hours.
Open channel hydraulic principles, flow classification, backwater curves, transitions, obstructions, bends, flood flow computations, and urban watershed applications. Credit not granted for both CE 4358 and CE 5346. Prerequisite: CE 3305 and CE 4328; or consent of instructor.

CE 5347. ADVANCED HYDROLOGY. 3 Hours.
Elements of hydrometeorology, infiltration, soil moisture, hydrographs, rainfall runoff relationships, and effects of these factors with regard to water resources, urban watersheds, flood control, and environmental issues. Prerequisite: CE 3342 and CE 4328 or equivalent.

CE 5348. GROUNDWATER HYDROLOGY. 3 Hours.
Hydrology and hydrogeology of groundwater to include aquifer and vadose properties and measurements, basic flow systems and solutions, well systems, elementary contaminate transport, water quality, recharge, subsidence, flow system analysis, flow nets, and leaky aquifers. Prerequisite: CE 3342 or consent of instructor.

CE 5349. ADVANCED GIS AND HYDROLOGIC AND HYDRAULIC MODELING. 3 Hours.
Use of Geographic Information Systems (GIS) and design of GIS developed hydrologic/hydraulic models commonly applied in the water resources field. The course will have three main areas of emphasis including: principles and operations of ArcGIS, design and implementation of standard hydrologic and hydraulic models, the linkage of these models to engineering analysis of current water resources problems including flooding, water quality and water supply.

CE 5350. RISK MANAGEMENT. 3 Hours.
The risk management process including risk identification, monitoring, and control; integrated quantitative cost and schedule risk analysis.

CE 5351. ADVANCED STRUCTURAL ANALYSIS I. 3 Hours.
Advanced analysis of indeterminate beams, frames, trusses, arches, and cables. Credit will not be given for both CE 5351 and CE 4368. Prerequisite: CE 3341.

CE 5352. REMOTE SENSING-HYDROMETEOROLOGY. 3 Hours.
Atmospheric composition, radiative fluxes, thermodynamics, water vapor, stability, circulation, precipitation processes, fronts, thunderstorms and tropical storms; basics of remote sensing; observing precipitation using weather radar and satellite-borne sensors; prediction of precipitation by numerical weather models. The class will be a combination of lectures and in-class computer-based laboratory exercises. Prerequisite: CE 3342 and CE 4328.

CE 5353. ADVANCED HYDRAULICS. 3 Hours.
Flow resistance, St. Venant equations, solution of St. Venant by finite difference methods, dam break problem, water hammer intro to finite elements to open channel flow. Credit will not be granted for both CE 4330 and CE 5353. Prerequisite: CE 5346 and CE 5347; or consent of instructor.

CE 5354. WATER RESOURCES PLANNING. 3 Hours.
Historical and current water development concepts. Administrative and allocation concerns. General principles and procedures of water resource planning includes regional, multipurpose, economic and systems considerations. Prerequisites: CE 3301, CE 3342, and IE 2308; or consent of instructor.

CE 5355. CONSTRUCTION MATERIALS. 3 Hours.
Principles of construction related to construction regulations and standards, loads, fire safety, acoustics, joints and sealants. Systems of construction involving concrete, steel, wood, masonry, sealants, and soil, and including excavations, below grade construction, formwork, cladding, joints, windows, doors, roofing, and ceilings.

CE 5356. SURFACE WATER QUALITY MODELING. 3 Hours.
Contaminant transport and fate in surface water. Engineering methods assessing surface water and transport for water and sediment quality. Modeling dissolved oxygen, chemicals and waterborne substances. Prerequisite: CE 5346.

CE 5357. HYDROLOGIC TECHNIQUES. 3 Hours.
A study of current hydrologic techniques and methods for the analysis of hydrologic variables necessary in the design of projects such as bridges, culverts, reservoirs. Techniques involve extreme value statistics, model hydrographs, deterministic and stochastic methods for data analysis. Prerequisite: CE 5347 or consent of instructor.

CE 5358. SOLID WASTE ENGINEERING. 3 Hours.
This course provides an overview of the various aspects of integrated municipal solid waste management (with the exception of landfilling, covered in CE 5375). Topics covered include waste generation, characterization, and collection; source reduction; waste processing; design of facilities for materials recovery (recycling centers) and energy recovery (combustors and anaerobic digesters); life cycle analysis of solid waste management facilities; case study project. Credit not granted for both CE 4354 and CE 5358. Prerequisite: CE 3334 or CE 5321 or consent of instructor.

CE 5359. GROUNDWATER CONTAMINANT MODELING. 3 Hours.
Study of sources and fates of contamination in groundwater. Mathematical modeling of reactive and nonreactive pollutant movement. Aquifer restoration strategies. Prerequisite: CE 5348.

CE 5360. PROBABILITY, STATISTICS AND DECISIONS FOR CIVIL ENGINEERS. 3 Hours.
Topics include elements of probability theory, random variables and distributions, derived distributions, moments and expectation, common distribution models, introduction to statistics, estimation of model parameters, model verification, elementary Bayesian analysis and decision theory. No previous experience with probability is assumed. Prerequisite: CE 3301.

CE 5361. DESIGN AND CONSTRUCTION OF ASPHALT CONCRETE. 3 Hours.
An in-depth study of the properties of constituent materials for asphalt concrete mixtures. Design methods for Hot-Mixes Asphalt (HMA) and Stone Matrix Asphalt (SMA). Theory and practice of asphalt concrete mix for pavements, including specifications and construction methods for hot-mix asphalt and surface treatments. Maintenance and rehabilitation of flexible pavements. Relationships of material engineering properties to pavement design and performance. Credit not granted for both CE 4336 and CE 5361. Prerequisite: CE 3361 or equivalent.

CE 5362. RIGID PAVEMENTS. 3 Hours.
Portland cement concrete mix design and production. Paving operations. Saw and seal operations. Subgrade preparation. Base selection. Drainage selection, design and construction. Bonded and unbonded concrete overlays. Whitetopping and ultra-thin whitetopping. Concrete pavement restoration; quality assurance and quality control in concrete pavement construction. Credit not granted for both CE 4337 and CE 5362. Prerequisite: CE 3361 or equivalent.

CE 5363. CONSTITUTIVE MODELING OF SOILS. 3 Hours.
Fundamental aspects of elasto-plastic behavior of soils along axisymmetric stress paths, shear strength of soils in light of critical state soil mechanics, and constitutive models to predict soil response under saturated conditions, including Cam Clay and modified Cam Clay models. Prerequisite: CE 3343 or consent of instructor.

CE 5364. FOUNDATION ANALYSIS AND DESIGN. 3 Hours.
The design, construction, and performance of footings, rafts, and piles founded on or in sands, clays, silts, stratified soils, and weak rock. Includes the influence of various geologic terrain on selecting foundation type and constructability, in-situ investigations to determine material design parameters, bearing capacity, and settlement of foundations. Credit not granted for both CE 4321 and CE 5364. Prerequisite: CE 3343.

CE 5365. THEORETICAL SOIL MECHANICS. 3 Hours.
Theory of consolidation, magnitude, time rate, pore pressure dissipation with variable construction rate and layered soils. Secondary compression, preconsolidation, and preloading. Shear strength of soil. Critical state soil mechanics, dilation and strain-softening in drained shear, pore pressure response in undrained shear, including static liquefaction. Prerequisite: CE 3343 or consent of instructor.

CE 5366. SOIL DYNAMICS. 3 Hours.
Fundamental aspects of mechanical behavior and characterization of soils and earth structures subjected to dynamic loads, including wave propagation in soils, dynamic soil properties, liquefaction of soils, dynamic bearing capacity of shallow foundations, seismic design of retaining walls, and seismic slope stability. Prerequisites: CE 2221 and CE 3343; or consent of instructor.

CE 5367. DESIGN OF EARTH STRUCTURES. 3 Hours.
Study of the states of stress and analysis techniques associated with cuts, fills, and retaining structures. Includes slope stability, embankment reinforcement, conventional and reinforced earth retaining walls, excavation bracing, and sheet pile wharf structures. Credit not granted for both CE 4320 and CE 5367. Prerequisite: CE 3343 or consent of instructor.

CE 5368. UNSATURATED SOIL MECHANICS. 3 Hours.
Fundamental aspects of the mechanical behavior of unsaturated soils, including stress and volumetric state variables, matrix suction measurements and soil-water characteristic curves, shear-strain-strength and volume change responses, suction-controlled laboratory testing techniques and constitutive modeling. Prerequisite: CE 3343; or consent of instructor.

CE 5369. COMPUTATIONAL GEOTECHNICS. 3 Hours.
Introduction to analytical, finite differences, and finite element modeling, analyses of embankments, earth dams, slopes, excavation support systems including soldier pile and diaphragm walls, shallow and deep foundation systems, and other geostructures using different geotechnical software. Prerequisite: CE 3343 or consent of instructor.

CE 5370. EXPERIMENTAL SOIL MECHANICS. 3 Hours.
Fundamentals of experimental studies of soil behavior, soil properties and their laboratory test methods which include consolidation, direct shear, static triaxial, cyclic triaxial, resonant column, bender elements and other advanced geotechnical laboratory tests, instrumentation and measurement techniques. Prerequisite: CE 3343 or consent of instructor.

CE 5371. SOIL BEHAVIOR. 3 Hours.
Fundamental aspects of soil behavior, bonding, crystal structure, surface characteristics, clay mineralogy, soil-water movement, fabric, effective stress concepts, conduction phenomena, consolidation, and shear strength. Prerequisite: CE 3343 or consent of instructor.

CE 5372. GEOSYNTHETICS. 3 Hours.
Geosynthetics properties and testing, design of geotextiles, geogrids, geonets, and geomembranes for applications in separation, pavement, embankment and retaining wall reinforcement, soil stabilization, filtration, drainage and liquid barrier, construction guidelines and case histories. Credit not granted for both CE 4322 and CE 5372. Prerequisite: CE 3343 or consent of instructor.

CE 5373. ENVIRONMENTAL GEOTECHNOLOGY. 3 Hours.
Physical and chemical principles of clays, clay mineralogy, coupled flow, hydraulic conductivity, in situ and laboratory tests, chemical transport, adsorption of chemicals, risk assessment and soil remediation technologies, bioremediation, phytoremediation, electrokinetics and soil washing, waste containment. Prerequisite: CE 5371 or consent of instructor.

CE 5374. GROUND IMPROVEMENT. 3 Hours.
Introduction and types of ground improvement for different problem soils including soft and expansive soils, shallow and deep soil densification, sand drains and wick drains, chemical modification, chemical binders and mechanisms of ground improvement, different types of grouting, deep mixing, stone columns, soil nailing, ground anchors, geosynthetics, MSE walls, reinforced slopes. Prerequisite: CE 3343 or consent of instructor.

CE 5375. GEOTECHNICAL ASPECTS OF LANDFILLS. 3 Hours.
Introduction and types of landfills, landfill site selection, siting and configuration, compacted and geosynthetic clay liners, final cover design, landfill settlement and slope stability, post closure uses of landfills, leachate and gas generation, collection and removal system, bioreactor landfills and future trends. Credit not granted for both CE 4323 and CE 5375. Prerequisite: CE 3343 or consent of instructor.

CE 5376. GIS IN GEOTECHNICS. 3 Hours.
Introduction to (GIS,Geographical Information Systems, ArcInfo/ArcView) based applications in geotechnical engineering, including bore-log database management and profiling, spatial analyses and assessment of liquefaction, ground motion amplification, landslide, and groundwater contamination hazard potentials. Prerequisite: CE 3343 or consent of instructor.

CE 5377. CONSTRUCTION FINANCE. 3 Hours.
Financial aspects and job costing of a construction project. Includes project management principles, budgets, cost codes, cost-to-complete, and financial reports specific to the management of a construction company and project control.

CE 5378. CONSTRUCTION CONTRACTS, SPECIFICATIONS, & ADMINISTRATION. 3 Hours.
Types of construction contracts, contractual relationship between general contractor and owner, contractual relationship between general contractor and subcontractors, legal issues in construction administration, insurance, and concepts in value engineering. Reading and evaluating specifications, CSI Master Format. Credit not granted for CE 4304 and CE 5378. Prerequisite: Consent of instructor.

CE 5380. MANAGEMENT OF INFRASTRUCTURE ASSETS. 3 Hours.
Overview of an infrastructure management system. Infrastructure asset development and management. Optimization of infrastructure asset procurement and preservation through good data input and the use of economic models, benefit cost studies, and good maintenance and rehabilitation practices to protect assets investments.

CE 5381. PUBLIC PRIVATE PARTNERSHIP FOR INFRASTRUCTURE PROJECTS. 3 Hours.
Public-private partnership (P3) arrangements as an innovative approach to deliver public infrastructure projects. Topics include P3 benefits, limitations, contracting and implementation strategies. Prerequisite: CE 3311 or IE 2308; or consent of instructor.

CE 5382. CONSTRUCTION SUSTAINABILITY. 3 Hours.
Introduction to International Code Council's 2012 International Building Code and USGBC's LEED® New Construction Guidelines v.3 for constructing sustainable/green buildings. Review of building occupancy categories, construction types, allowable height and area, life safety requirements, rated building assemblies, and egress. Site selection, energy and water efficiency, material reuse and indoor air quality. Credit not granted for CE 4307 and CE 5382.

CE 5383. EXPERIMENTAL STRESS ANALYSIS. 3 Hours.
Introduction to experimental stress-analysis techniques. Theory and application of mechanical strain gages, electrical strain gages, introduction to photoelastic and thermal techniques, and brittle coatings. Prerequisite: CE 2313.

CE 5384. CONCRETE BRIDGE DESIGN AND EVALUATION. 3 Hours.
Analysis, design and evaluation of concrete highway bridges using AASHTO specifications. Analysis and design topics include bridge type selection, preliminary design, AASHTO LRFD bridge design philosophy, design loads, deck design, shear design, barrier design and substructure design. Evaluation topics include bridge inspection, non-destructive evaluation (NDE), load testing and load rating, using the AASHTO procedures. Prerequisite: CE 4363 or CE 5309.

CE 5385. STRUCTURAL DYNAMICS. 3 Hours.
Equation of motion for single degree of freedom systems including: free vibration; harmonic and periodic excitations; arbitrary, step and pulse excitations. Dynamic response of multi degree of freedom systems including: free vibration; computation of vibration properties of structures; damping in structures; modal analysis; and response history analysis. Dynamic analysis of systems with distributed mass. Prerequisite: CE 5303 or concurrent registration.

CE 5387. CONSTRUCTION PRODUCTIVITY. 3 Hours.
Evaluation of construction project management's effectiveness. An investigation of the advanced techniques required for improvement of construction projects including time, cost, quality management, preplanning, field evaluation techniques, time-lapse photograph, safety, human factors, and communications. Prerequisite: CE 5327.

CE 5388. PIPELINE CONSTRUCTION AND TRENCHLESS TECHNOLOGY. 3 Hours.
Pipeline and utility design, construction and renewal. Topics include pipeline infrastructure structural considerations, planning and construction considerations, pipe materials, and trenchless technologies. Credit not granted for both CE 4305 and CE 5388. Prerequisite: graduate standing and consent of instructor.

CE 5389. PIPELINE SYSTEMS ASSET MANAGEMENT. 3 Hours.
Pipeline systems asset management, inventory, inspection, and life cycle costs. Topics include pipeline deterioration parameters, asset management technologies, risk assessment, government regulations, renewal technologies, and case studies. Credit not granted for both CE 4306 and CE 5389. Prerequisite: graduate standing and consent of instructor.

CE 5390. UNSATURATED SOIL MECHANICS II. 3 Hours.
Advanced principles of unsaturated soil behavior in light of critical state based soil mechanics. Topics: Cam-Clay model for saturated soils, Cam-Clay model for unsaturated soils, and calibration/programming of Barcelona Basic Model for unsaturated soils. Prerequisite: CE 5368 or consent of instructor.

CE 5391. ADVANCED STUDIES IN CIVIL ENGINEERING. 3 Hours.
Individual studies of advanced topics under the supervision of a professor or professors. Graded F, P, R. Prerequisite: consent of instructor.

CE 5392. SPECIAL TOPICS IN AIR POLLUTION. 3 Hours.
Sources, transport, fate, characteristics, and control of air contaminants. May be repeated for credit when topics vary. Topics include: Topic 1 - Air Quality Modeling. Mathematical models for predicting air pollutant transport and transformation in the atmosphere, to evaluate health impacts and potential control strategies. The course covers 4 types of air quality models: box models, photochemical grid models (for ozone and particulate matter), Gaussian dispersion models (major emphasis), and receptor models. Use of Gaussian dispersion modeling software. Topic 2 - Air Pollution Control System Design. Design of air pollution control systems for stationary sources, including particle control technologies (cyclones, electrostatic precipitators, fabric filters and wet scrubbers) and gaseous control technologies (incinerators, adsorption systems, absorption systems, biofilters, nitrogen oxide controls, mercury controls, and carbon dioxide controls). Topic 3 - Air Pollution Chemistry and Meteorology. Designed to give students an understanding of how pollutants react and travel in the atmosphere. Chemistry of ground-level ozone formation, ozone layer depletion, acid deposition, fine particle formation, and climate change; meteorological variables impacting pollutant transport in the atmosphere, such as atmospheric stability, turbulence and wind speed. Prerequisite: Graduate standing and consent of instructor.

CE 5393. ENVIRONMENTAL ORGANIC CHEMISTRY. 3 Hours.
Introduction to chemical structures, reactions, and transformations. Disposition of compounds of environmental significance utilizing sorption, bioaccumulation, acid-base reactions, hydrolysis reactions, biodegradation, and biotransformation. Prerequisite: CE 3334 or consent of instructor.

CE 5394. EARTHQUAKE DESIGN OF REINFORCED CONCRETE BUILDINGS. 3 Hours.
Design of earthquake resistant reinforced concrete (RC) building structures. ACI 318, ASCE 7, earthquake loads effects on buildings and related structural damage, properties of concrete and steel beyond the elastic range, development and anchorage, confined concrete, inelastic behavior of RC members under large load reversals, design of RC beams, columns, beam-column joints, special moment frames, coupling beams, special structural walls, and other structural systems. Prerequisite: CE 4347.

CE 5395. MASTER'S PROJECT. 3 Hours.
Non-thesis master's degree candidates with approval to include a project in their program. Graded F, P, R. Prerequisite: consent of instructor and approval of Civil Engineering Graduate Advisor.

CE 5396. SITE REMEDIATION ENGINEERING. 3 Hours.
This course provides practical understanding of the engineering principles and practices associated with the characterization and remediation of contaminated sites. Methods for site characterization and risk assessment will be highlighted while the emphasis will be on remedial action screening processes and technology principles and conceptual design. In-situ and ex-situ treatment processes will be covered, including unit operations, coupled processes, and complete systems within the context of community implementation. Case studies with focus on developing communities will be used and computerized tools for process selection and design will be presented. Prerequisite: CE 3334; or consent of instructor.

CE 5398. THESIS. 3 Hours.
Research and preparation pertaining to the master's thesis. Graded F, R.

CE 5695. MASTER'S PROJECT. 6 Hours.
Non-thesis master's degree candidates with approval to include a project in their program. Graded F, P, R. Prerequisite: consent of instructor and approval of Civil Engineering Graduate Advisor.

CE 5698. THESIS. 6 Hours.
Research and preparation pertaining to the master's thesis. Graded F, P, R.

CE 6197. RESEARCH IN CIVIL ENGINEERING. 1 Hour.
Individual supervised research projects. May be repeated for credit. Graded F, P, R. Prerequisite: consent of instructor and approval of Supervising Committee Chair.

CE 6297. RESEARCH IN CIVIL ENGINEERING. 2 Hours.
Individual supervised research projects. May be repeated for credit. Graded F, P, R. Prerequisite: consent of instructor and approval of Supervising Committee Chair.

CE 6300. ADVANCED TOPICS IN CIVIL ENGINEERING. 3 Hours.
Topics of current interest in the field of civil engineering. The subject title is listed in the class schedule and in the student's record. Topics vary. May be repeated for credit when topic changes. Prerequisite: consent of instructor.

CE 6306. PUBLIC TRANSIT PLANNING & OPERATIONS. 3 Hours.
Theory and application of technologies used for transit demand analysis, routing, scheduling, evaluation, crew assignment, maintenance strategies, and management. Land-use impact on public transit policy and operation is also introduced. Prerequisite: CE 4311 or CE 5337 or equivalent.

CE 6308. ANALYTICAL MODELS IN TRANSPORTATION. 3 Hours.
Development and analysis of mathematical models in transportation. Topics include travel demand, trip generation, distribution, mode choice, assignment, plan evaluation, spatial distribution, traffic control and flow models; principles of behavioral, econometric, deterministic, probabilistic, and chaotic simulation models, and their applications. Prerequisite: CE 4311 or CE 5337.

CE 6309. TRAFFIC FLOW THEORY. 3 Hours.
Speed, density relationships of vehicular traffic flow; statistical aspects of traffic events and queuing processes; deterministic models and simulation models of traffic flow behavior; applications of flow theory to traffic problem solutions. Prerequisite: CE 5330 or equivalent.

CE 6311. ADVANCED FOUNDATION DESIGN. 3 Hours.
Subsurface investigations; advanced design of mat foundations, retaining walls, reinforced retaining walls, anchor tiebacks, driven piles, and piers; destructive and nondestructive tests on deep foundations; group piles, laterally loaded piles, and design of foundations in expansive soils. Prerequisite: CE 4321 or CE 5364.

CE 6312. IN-SITU TESTING. 3 Hours.
Site characterization, in-situ testing procedures, and soil property interpretation methods for standard penetration tests, cone penetration tests utilizing friction cone, piezocone, and seismic cone, dilatometer, vane shear, pressure meter, and bore hole shear tests, non-destructive tests for pavement subgrade characterization. Prerequisite: CE 3143 or CE 5370 or consent of instructor.

CE 6313. DESIGN OF EARTH DAMS. 3 Hours.
Introduction to dams and levees, failure and damage analysis, erosion, seepage, filter, drainage design, foundation preparation for problematic subsoil conditions, seepage induced slope stability issues, desiccation crack and erosion control, numerical modeling and case studies, seismic issues. Prerequisite: CE 5367 or consent of instructor.

CE 6314. STORMWATER MODELING. 3 Hours.
Hydrologic modeling methods and issues, urban watershed modeling, methods of system analysis; analysis of hydrologic components as linear and nonlinear systems, watershed response, kinematic wave; and model parameters optimization. Prerequisite: CE 5346 and CE 5347; or consent of instructor.

CE 6315. ADVANCED GEOTECHNICAL MODELING. 3 Hours.
This course covers two numerical simulation methods: discrete element method (DEM) and finite element method (FEM). The four basic elements in DEM: initialization, search, contact models, velocity and displacement calculations will be introduced. This course will use FORTRAN as the coding language. A basic Fortran code will be provided. Students will learn how to make modifications to the basic code for their own applications. A term project will be required that consists of a numerical experiment. Fundamentals of FEM will be introduced including: basic elements, formulation methods, coordinate transformation, and boundary conditions. CAM clay model will be introduced and implemented in ABAQUS as a class exercise. Usage of ABAQUS will be introduced. Applications of FEM including pile soil interaction and simple beam simulation. Prerequisite: Grade of C or better in CE 5363; Grade of C or better in CE 5369; Programming language (FORTRAN, C, or MATLAB); and numerical analyses; or consent of instructor.

CE 6316. SEDIMENT TRANSPORT. 3 Hours.
Sourcing the sediment influx, the settling velocity, Shields critical shear stress, design with critical shear, bedload transport equations, suspended load transport, total transport equation, regime theory as index of stability. Prerequisite: CE 4358 or CE 5346; and CE 5347.

CE 6350. ADVANCED CONCRETE DESIGN II. 3 Hours.
Detailing of connections for ductility demands, modified compression field theory, strut and tie modeling of systems and areas, and design of shear walls and hybrid construction. Behavior of reinforced concrete structures, with emphasis on ductility and detailing. Prerequisite: CE 5312.

CE 6354. REPAIR AND REHABILITATION OF STRUCTURES. 3 Hours.
Causes of distress, evaluation methods for condition, strength, serviceability; repair materials, repair techniques, and quality control methods for repair of concrete. Criteria for rehabilitation; retrofit techniques for change in function, loading, and seismic forces. Prerequisite: CE 5311 and CE 5312.

CE 6355. EARTHQUAKE ENGINEERING. 3 Hours.
Earthquake characteristics; design of structures to resist earthquakes. Characterization of earthquakes for design. Development of design criteria for elastic and inelastic structural response. Seismic performance of various structural systems. Prediction of nonlinear seismic behavior. Basis for code design procedures. Preliminary design of steel and reinforced concrete structures. Evaluation of earthquake vulnerability of existing structures and rehabilitation of seismic deficiencies. Prerequisite: CE 5385.

CE 6356. ENERGY METHODS. 3 Hours.
Principles of mechanics; elastic beams and frames; variational method: curved cantilever beams; Rayleigh Ritz method; special form of Euler equation; differential equation for beam; variation of double integral; first variation of triple integral. Deformable bodies using indicial notation; buckling using energy method; Lagrange and Hamilton Principles; theory and analysis of plates; theory and buckling; and theory of vibration. Prerequisite: CE 5315.

CE 6357. STRUCTURAL STABILITY. 3 Hours.
Buckling of columns; approximate method of analysis for buckling problems; beam columns; structural system stability (buckling of frames); lateral torsional buckling; buckling of plates; and buckling of axially compressed cylindrical shells. Prerequisite: CE 5303 or concurrent registration therein.

CE 6358. ADVANCED ENGINEERING ANALYSIS. 3 Hours.
Introduction to matrices; vector spaces; tensors, Eigenvalue problems. Solution to discrete systems: steady state problems and propagation problems. Solution of continuous systems: differential formulation; variational method; and weighted residual methods. Solution of linear and nonlinear static equilibrium equations. Prerequisite: CE 5315 and MATH 3319.

CE 6360. THEORY OF ELASTICITY. 3 Hours.
Introductory mathematical concepts: vector calculus; tensor algebra. Theory of deformation; strain displacement relations in orthogonal curvilinear coordinate systems. Theory of stress; differential equation of equilibrium in curvilinear spatial coordinates; three dimensional equations of elasticity; nonlinear constitutive relationship; plane theory of elasticity; and plane elasticity in polar coordinates. Prerequisite: CE 5315.

CE 6391. ADVANCED PROJECTS IN CIVIL ENGINEERING. 3 Hours.
Projects related to advanced topics in graduate area. Graded F, P, R. Prerequisite: consent of instructor and approval of Civil Engineering Graduate Advisor.

CE 6397. RESEARCH IN CIVIL ENGINEERING. 3 Hours.
Individual supervised research projects. May be repeated for credit. Graded F, P, R. Prerequisite: consent of instructor and approval of Supervising Committee Chair.

CE 6399. DISSERTATION. 3 Hours.
Preparation of a doctoral dissertation in civil engineering. Graded F, R. Prerequisite: admission to candidacy for the Doctor of Philosophy degree.

CE 6697. RESEARCH IN CIVIL ENGINEERING. 6 Hours.
Individual supervised research projects. May be repeated for credit. Graded F, P, R. Prerequisite: consent of instructor and approval of Supervising Committee Chair.

CE 6699. DISSERTATION. 6 Hours.
Preparation of a doctoral dissertation in civil engineering. Graded F, R. Prerequisite: admission to candidacy for the Doctor of Philosophy degree.

CE 6997. RESEARCH IN CIVIL ENGINEERING. 9 Hours.
Individual supervised research projects. May be repeated for credit. Graded F, P, R. Prerequisite: consent of instructor and approval of Supervising Committee Chair.

CE 6999. DISSERTATION. 9 Hours.
Preparation of a doctoral dissertation in civil engineering. Graded F, P, R. Prerequisite: admission to candidacy for the Doctor of Philosophy degree.

CE 7399. DOCTORAL DEGREE COMPLETION. 3 Hours.

This course may be taken during the semester in which a student expects to complete all requirements for the doctoral degree and graduate. Enrolling in this course meets minimum enrollment requirements for graduation, for holding fellowships awarded by The Office of Graduate Studies and for full-time GTA or GRA positions. Students should verify that enrollment in this course meets other applicable enrollment requirements. To remain eligible in their final semester of study for grants, loans or other forms of financial aid administered by the Financial Aid Office must enroll in a minimum of 5 hours as required by the Office of Financial Aid. Other funding sources may also require more than 3-hours of enrollment. Additional hours may also be required to meet to requirements set by immigration law or by the policies of the student's degree program. Students should contact the Financial Aid Office, other sources of funding, Office of International Education and/or their graduate advisor to verify enrollment requirements before registering for this course. This course may only be taken once and may not be repeated. Students who do not complete all graduation requirements while enrolled in this course must enroll in a minimum of 6 dissertation hours (6699 or 6999) in their graduation term. Graded P/F/R.