CIVIL ENGINEERING (CE)

Explanation of Course Numbers

- Courses in the 1000s are primarily introductory undergraduate courses
- Those in the 2000–4000s are upper-division undergraduate courses that can also be taken for graduate credit with permission and additional work
- Those in the 6000s and 8000s are for master's, doctoral, and professional-level students
- The 6000s are open to advanced undergraduate students with approval of the instructor and the dean or advising office

CE 1010. Introduction to Civil and Environmental Engineering. 1 Credit.
An introduction to the profession of civil and environmental engineering. Field visits and laboratory exercises complement classroom instruction.   (Fall).

CE 1020. Introduction to a Sustainable World. 1 Credit.
The science underlying the basic processes that gave rise to the world we live in and that maintain its viability for human life. Ecosystem-functioning environmental issues, such as greenhouse gas emission and ozone, with current efforts to resolve them. Technological innovations in the context of sustainability.

CE 1098. Variable Topics. 1-36 Credits.

CE 2210. Engineering Computations. 3 Credits.
Numerical methods for engineering applications. Methods for solving systems of linear equations, root finding, curve fitting, and data approximation. Numerical differentiation and integration and numerical solution of differential equations. Computer applications. Prerequisites: CSCI 1121, APSC 2113.   (Spring).

CE 2220. Introduction to the Mechanics of Solids. 3 Credits.
Stress and strain, axial load problems, torsion, shear force and bending moment, pure bending of beams, shearing stresses in beams, compound stresses, analysis of plane stress and plane strain, combined stresses, deflection of beams, statically indeterminate problems, columns, energy methods. Prerequisite: APSC 2057, APSC 2113.

CE 2510. Environmental Sustainability. 3 Credits.
An introduction to environmental sustainability with focus on the nexus of water, energy, and climate; energy demands of water systems, water footprints of energy generation, and how the two valuable resources are limiting each other; technologies and research frontiers toward a sustainable water and energy supply.

CE 2710. Introduction to Transportation Engineering. 3 Credits.
Transportation system components; roadway traffic capacity and network performance measures; signalized and un-signalized intersections; monitoring techniques, instruments and data processing. Sustainability issues and environmental impact of transportation systems with focus on urban design, planning and regulation. Prerequisites: Math 2233.   (Spring).

CE 3110W. Civil Engineering Materials. 2 Credits.
Mechanical properties and behavior of civil engineering materials such as metals, concrete, and fiber-reinforced polymer composites. Properties range from plastic deformations of metallic materials to crushing of confined and unconfined concrete. Basis of the strength of materials. Concepts of creep, fatigue, fracture, and crack propagation. Prerequisite: CE 2220. (Fall).

CE 3111W. Civil Engineering Materials Lab. 1 Credit.
Measurement of stress–strain characteristics and study of failure modes in ductile steel, brittle concrete, and anisotropic composite materials. Experiments include data collection, data analysis, and interpretation and presentation of results regarding tension, compression, bending, impact, and shear properties. Prerequisite or corequisite: CE 3110W. Prerequisites: CE 3110W.   (Fall).

CE 3140. Sustainability in Engineering Materials. 2 Credits.
Sustainable engineering: overall materials energy needs/properties and impacts; load resistance and aging, thermodynamics, water conservation, heat transfer, use of energy-efficient materials in construction, life-cycle assessment.   (Fall and spring, Every Year).

CE 3230. Structural Theory I. 3 Credits.
Theory of statically determinate structures; stability and determinacy; influence lines and moving loads. Analysis of beams, frames, trusses, and arches. Calculation of deflections. Prerequisites: CE 2210, CE 2220.   (Fall).

CE 3240. Structural Theory 2. 3 Credits.
Theory of statically indeterminate structures using matrix methods and classical approaches such as moment distribution and slope-deflection; influence lines; energy methods. Prerequisite: CE 3230.

CE 3310. Reinforced Concrete Structures. 3 Credits.
Properties of concrete and reinforcement; design of flexural reinforcement, shear reinforcement; development of reinforcement; design of columns, floor slabs; ethics and professionalism in design. A design project, including the use of computer software and a detailed report, is required. Prerequisite or corequisite: CE 3240.

CE 3520. Environmental Engineering I: Water Resources and Water Quality. 3 Credits.
Physical and chemical analyses of water quality and characteristics. Microbiology of water and pathogens. Introduction to water treatment processes involving coagulation, flocculation, filtration, and disinfection. Prerequisite or corequisite: CE 3610.

CE 3521. Environmental Engineering Laboratory. 1 Credit.
Laboratory experiments for physical and chemical analyses of water and wastewater. Measurement of turbidity, alkalinity, dissolved oxygen, BOD, COD, suspended solids, and optimum coagulant dose using jar tests. Corequisite: CE 3520.

CE 3610. Hydraulics. 3 Credits.
Fluid statics: pressure forces, buoyancy, and flotation. Application of kinematic principles; flow fields, stream tubes, and flow nets. Fluid dynamics: applications to pipe flow, hydraulic models, measurement of pressure, and velocity. Open channel flow: applications to water resources engineering. Prerequisite: MAE 3126.

CE 3611. Hydraulics Laboratory. 1 Credit.
Laboratory experiments and demonstrations of hydraulics in pipe and open-channel flow. Topics include center of pressure, floating bodies, Bernoulli's theorem, discharge coefficients, velocity profile, and head losses. Prerequisite or corequisite: CE 3610.

CE 3720. Highway Engineering and Design. 3 Credits.
Road vehicle performance. Principles of highway design: horizontal and vertical alignments, roadside design; drainage and drainage structures, earthwork, intersections, interchanges, parking facilities; basic traffic models; highway materials. Application of safety standards. Prerequisite: MATH 2233; prerequisite or corequisite: APSC 3115 and CE 2220.

CE 3730. Sustainable Urban Planning Dynamics. 3 Credits.
Human and physical processes shaping urban environments; human–environment interactions in the context of an urban region; urban design, materials, transport, planning, and regulation. Prerequisite: CE 2710.

CE 4320. Metal Structures. 3 Credits.
Principles of the design of metal structures, structural elements, connections, specific problems of analysis including the use of computer software, methods of construction, professionalism in design. Prerequisite: CE 3240.

CE 4330W. Contracts and Specifications. 3 Credits.
Law of contracts, construction contracts, specifications, bidding, insurance and bonds, professional liability, arbitration of disputes, litigation. Restricted to juniors and seniors. (Spring, Every Year).

CE 4341. Senior Design Project I. 1 Credit.
First in a two-course sequence for the senior design project in civil and environmental engineering. Outcomes include team formation, project selection, task formulation and assignments, preliminary design validation and/or prototyping. Restricted to students in the civil engineering program with senior standing.   (Fall, Every Year).

CE 4342. Senior Design Project II. 3 Credits.
Second in a two-course sequence for the senior design project in civil and environmental engineering. Application of civil and environmental engineering concepts in the design of a project that integrates the concepts and technical knowledge learned in two or more of the following disciplines: engineering mechanics, materials, environmental engineering, geotechnical engineering, structural engineering, transportation engineering, and water resources engineering. Restricted to students in the civil engineering program with senior standing. Prerequisite: CE4341. Recommended background: Knowledge of structural analysis of indeterminate structures, reinforced concrete and structural steel design, and soil mechanics.   (Spring, Every Year).

CE 4410. Introduction to Geotechnical Engineering. 3 Credits.
Soils and rock formation, soil composition, permeability, seepage and flow netanalysis, stresses in soil medium, consolidation and settlement, shear strength of soil, analysis of lateral earth pressures, soil compaction. Prerequisite: CE 2220, MAE 3126.

CE 4411. Geotechnical Engineering Laboratory. 1 Credit.
Laboratory experiments to evaluate liquid and plastic limits, grain-size distribution, shear strength, compressibility, permeability, and moisture–density relationship of soils. Prerequisite or corequisite: CE 4410.

CE 4450. Introduction to Geo-environmental Engineering. 3 Credits.
Characterization of soils and wastes, engineering properties of soils and geo-synthetics, fundamental concepts of fate and transport of contaminants, common practice in design and construction of waste containment systems, current methods for remediation of contaminated groundwater and soils. Prerequisites: CE 3520, CE 4410. (Spring, Every Year).

CE 4530. Environmental Engineering II: Water Supply and Pollution Control. 3 Credits.
Introduction to wastewater treatment systems including clarification, suspended and attached growth processes. Use of dissolved oxygen models. Water supply and wastewater collection systems, applied hydraulics of pipelines and pumps. Planning to meet quality needs and regulatory requirements. Prerequisite: CE 3520.

CE 4620. Hydrology and Hydraulic Design. 3 Credits.
Descriptive hydrology: hydrologic cycle, precipitation, stream flow, evaporation, and transpiration. Quantitative hydrology: hydrograph analysis, hydrographs of basin outflow, storage routing. Probability concepts in hydrology: flood frequency, rainfall frequency, stochastic hydrology. Culverts and stilling basins. Prerequisite or corequisite: APSC 3115, CE 3610.

CE 4810. Research. 1-3 Credits.
Applied research and experimentation projects, as arranged. Prerequisite: junior or senior status.

CE 4820. Special Topics. 1-6 Credits.
Topic announced in the Schedule of Classes. May be repeated for credit provided the topic differs.

CE 6101. Numerical Methods in Engineering. 3 Credits.
Eigenvalue problems. Numerical solution of systems of equations and ordinary differential equations. Solution techniques for elliptic, parabolic, and hyperbolic partial differential equations. Numerical methods for solving finite element equations. Introduction to solution of fluid-flow problems. Prerequisite: CE 2210.

CE 6102. Application of Probability Methods in Civil Engineering. 3 Credits.
Uncertainty in real-world information; basic probability concepts and models; random variables; useful probability distributions, statistical estimation of distribution parameters from observed data; empirical determination of distribution models; testing hypothesis; regression and correlation analyses; decision theory. Prerequisite: APSC 3115.

CE 6201. Advanced Strength of Materials. 3 Credits.
Deflection of beams using singular functions, unsymmetrical bending of beams, beams on elastic foundation. Beam-column problems, shear center for thin-walled beam cross sections, curved beams. Applications of energy methods, torsion, basic equations for theory of elasticity, thin- and thick-walled cylinders, stress concentration, and failure criteria. Prerequisites: CE 2220, CE 3240.   (Spring).

CE 6202. Methods of Structural Analysis. 3 Credits.
Modern methods of analysis of statically indeterminate structures, matrix analysis based on flexibility, stiffness, energy and variational methods, substructuring techniques; consideration of plastic collapse of structures; introduction to the finite element method. Prerequisites: CE 2220, CE 3240.   (Fall).

CE 6203. Reliability Analysis of Engineering Structures. 3 Credits.
Probability theory, theory of structural reliability, probabilistic analysis of strength and loads, risk and reliability function, empirical distribution, probability plot. The design service life, method of perturbation, Monte Carlo simulation. Fatigue and fracture, proof testing, inspection and repair–replacement maintenance. Prerequisite: APSC 3115.

CE 6204. Analysis of Plates & Shells. 3 Credits.
Bending and stretching of thin elastic plates under loading with various boundary conditions, continuous plates and plates on elastic foundations, theory of folded-plate structures. Theory of curved surfaces; general linear bending theory and its simplification to membrane theory; bending stresses in shells of revolution, shallow-shell theory.   Prerequisites: CE 2220, CE 3240.   (Spring, odd years).

CE 6205. Theory of Structural Stability. 3 Credits.
General criteria for stability, buckling of elastic and inelastic columns and frames, torsional and lateral buckling, variational methods. Buckling of plates and shells under static loads, stability of stiffened structures, effect of imperfections and boundary conditions. Prerequisites: CE 2220, CE 3240.   (Fall).

CE 6206. Continuum Mechanics. 3 Credits.
Introduction to the mechanics of continuous media. Tensor calculus; kinematics; stress and stress rate, conservation of mass, conservation of linear and angular momentum, energy balance, second law of thermodynamics; constitutive theory; linear and nonlinear elasticity, newtonian fluids, micropolar elasticity.   Prerequisites: CE 2220.   (Fall, spring, and summer, even years).

CE 6207. Theory of Elasticity I. 3 Credits.
Introduction to Cartesian tensors; deformation, stress, constitutive relations for linear elasticity; formulation of boundary value problems, variational principles, torsion and bending of prismatial rods, plane problems. Prerequisites: CE 2220. (Same as MAE 6207)   (Spring).

CE 6208. Plasticity. 3 Credits.
Introduction to the continuum theory of plastic deformation. Physical basis of rate-independent plasticity. Concepts of yield, strain hardening and softening, reverse yield, and cyclic plasticity. Constitutive equations describing plastic deformation. Prerequisite: CE 6201 or CE 6206.

CE 6209. Mechanics of Composite Materials. 3 Credits.
Stress–strain relationship for orthotropic materials, invariant properties of an orthotropic lamina, biaxial strength theory for an orthotropic lamina. Mechanics of materials approach to stiffness, elasticity approach to stiffness. Classical lamination theory, strength of laminates. Statistical theory of fatigue damage. Same as MAE 6233. Prerequisite: CE 3240.

CE 6210. Introduction to Finite Element Analysis. 3 Credits.
Calculus of variations. Variational formulation of the finite element method. Weighted residual techniques. Computer implementation of the finite element method. Application to problems in heat transfer, stress analysis, fluid flow, and structural analysis. Prerequisites: proficiency in one computer language, CE 2220, CE 3240.   (Fall).

CE 6301. Design of Reinforced Concrete Structures. 3 Credits.
Structural behavior of reinforced concrete structures, ultimate strength and deformation characteristics; design of structural components including beams, columns, floor slabs, deep beams, corbels, and composite slab/beam systems. Prerequisite: CE 3310.

CE 6302. Prestressed Concrete Structures. 3 Credits.
Structural behavior and failure modes of prestressed concrete structures; design in prestressed concrete, including long-span structures, bridges, and precast systems. Prerequisite: CE 3310.

CE 6310. Advanced Reinforced Concrete Structures. 3 Credits.
Conception, analysis, and design of low-rise and high-rise buildings by ultimate-strength methods, precast systems, progressive collapse, earthquake considerations, domes, folded plates, shell-type structures, and special topics. Prerequisite: CE 6301.

CE 6311. Bridge Design. 3 Credits.
Application of basic design procedures for reinforced and prestressed concrete bridges, according to AASHTO bridge specifications. Various types of concrete bridges, design superstructure bridge elements (deck slab, girders, bearing pads), and development of superstructure/substructure details. Prerequisite: CE 6302.

CE 6320. Design of Metal Structures. 3 Credits.
Structural behavior of metal structures and composite girders. Conception, analysis, and design of low-rise and high-rise buildings by elastic and inelastic methods. Earthquake considerations and special topics. Prerequisite: CE 4320.

CE 6321. Advanced Metal Structures. 3 Credits.
Conception and design of advanced structural components and systems, hysteretic behavior, plastic design principles, box-type girders, cable systems, and unique structural systems. Prerequisite: CE 6320.   (As arranged).

CE 6340. Structural Dynamics. 3 Credits.
Vibration of continuous systems: membranes, beam plates, and shells; approximate methods of vibration analysis; methods of integral transform; analysis of nonlinear systems; wave propagation. Prerequisites: APSC 2058, CE 3240. (Fall, odd years).

CE 6341. Random Vibration of Structures. 3 Credits.
Introduction to random processes, responses of linear structures to stationary and nonstationary random inputs. Structural responses to earthquakes, waves, boundary-layer turbulences, wind loads, etc. Failure analysis of structures under random loads. Prerequisites: APSC 3115, CE 6340. (Spring, even years).

CE 6342. Structural Design to Resist Natural Hazards. 3 Credits.
Prediction of forces due to earthquakes and strong winds; generalized codes; pseudostatic methods for preliminary design; codes based on spectra, energy absorption and ductility; influence of foundations; ground failures; static and aeroelastic effects of strong winds. Design project. Prerequisites: CE 3240, CE 4340, either CE 6340 or CE 6701. (Spring).

CE 6350. Intro to Biomechanics. 3 Credits.
Fundamentals of continuum mechanics as they apply to biological materials: concepts of stress, strain, and equilibrium; elastic and viscoelastic properties of solids; physiological fluid mechanics and bioheat and mass transfer. Fundamentals of solid mechanics of soft tissues and bone structures. Development of computer models and applications. Prerequisite: CE 2220.

CE 6401. Fundamentals of Soil Behavior. 3 Credits.
Soil mineralogy, clay–water–electrolyte systems, soil composition, fabric, structure, volume change behavior, permeability, coupled phenomena, in-situ evaluation of soil behavior. Prerequisite: CE 4410.

CE 6402. Theoretical Soil Mechanics. 3 Credits.
Porous media, stress–strain behavior of soil skeleton, elastic and elastoplastic models for soil behavior, critical state concept, cam clay, strength of soils, stress–dilatancy, stress paths.   (Fall, odd years).

CE 6403. Geotechnical Engineering. 3 Credits.
Principles of soil mechanics applied to the analysis and design of mat foundations, pile foundations, retaining structures including sheeting and bracing systems, and waterfront structures. Foundations on difficult soils and reinforced earth structures. Prerequisite: CE 4410.

CE 6404. Geotechnical Earthquake Engineering. 3 Credits.
Ground motion, wave propagation, foundation isolation, site response analysis, seismic stability of retaining structures, soil structure interaction. Prerequisite: graduate standing.

CE 6405. Rock Engineering. 3 Credits.
Classification and properties of rock; nature of rock masses and rock discontinuities; field exploration; methods of excavation; design and applications to foundation slopes, tunnels, and chambers in rock. Prerequisite: CE 4410.

CE 6501. Environmental Chemistry. 3 Credits.
Principles of chemistry of natural waters, water supplies, wastewaters, hazardous wastes. Stoichiometry, equilibrium, solubility, kinetics, organic chemistry, biochemistry, analytical techniques. Examples from water/wastewater practice to illustrate applications. Prerequisites: CHEM 1111, CHEM 1112. (Fall).

CE 6502. Advanced Sanitary Engineering Design. 3 Credits.
Elements of design including basic parameters and hydraulic requirements. Layout and design of water supply and wastewater systems, pumping stations, and treatment plants. Plant expansions and modifications. Prerequisite: CE 4530.

CE 6503. Principles of Environmental Engineering. 3 Credits.
Basic concepts of water, air, and terrestrial environments and interrelationships among them. Principles of environmental chemistry and microbiology. Assessment of environmental quality and impacts. Environment and health. Water and wastewater systems. Legal and regulatory controls.   Prerequisites: CE 3520. (Fall).

CE 6504. Water and Wastewater Treatment Processes. 3 Credits.
Theory and application of commonly used processes. Sedimentation, coagulation, filtration, disinfection, gas transfer, activated sludge, trickling filters, oxidation ponds, sorption, and sludge stabilization and disposal. Process combinations to produce treatment systems. Prerequisite: CE 6503.

CE 6505. Environmental Impact Assessment. 3 Credits.
Public policy and legislation on environmental quality. Methods for assessing impacts of engineering projects. Technology for assessing impacts on air, water, and land environments, applied to transportation facilities, water and wastewater facilities, industrial and community development.   Prerequisites: CE 3520.   (Fall).

CE 6506. Microbiology for Environmental Engineers. 3 Credits.
Principles and applications of advanced treatment systems for water, wastewater, and hazardous wastes, including: biological nutrient removal, oxidation-reduction processes, stripping, sorption, membrane processes, chemical precipitation, others. Prerequisites: CE 3520.   (Spring, even years).

CE 6507. Advanced Treatment Processes. 3 Credits.
Principles and applications of advanced treatment systems for water, waste-water, and hazardous wastes, including: biological nutrient removal, oxidation-reduction processes, stripping, sorption, membrane processes, chemical precipitation, others. Prerequisite: CE 6504.

CE 6508. Industrial Waste Treatment. 3 Credits.
Types of industries, waste sources. Characteristics, measurements, and evaluation. Minimization and reuse. Treatment process selection, development, and design. Regulations, permits, standards, monitoring, and pretreatment.   (Fall).

CE 6509. Introduction to Hazardous Wastes. 3 Credits.
Regulations, including RCRA and Superfund. Transport and fate of hazardous substances. Elements of environmental toxicology, risk assessment, and hazard ranking. Monitoring, data collection, and evaluation. Waste minimization. Case histories.   Prerequisites: CE 3520.   (Spring).

CE 6601. Open Channel Flow. 3 Credits.
Types and regimes of flow; energy and momentum principles, uniform flow, gradually varied flow, spatially and rapidly varied flow. Flow in nonprismatic channels. Unsteady flow; dam break problem, flood routing. Prerequisite: CE 3610 .

CE 6602. Hydraulic Engineering. 3 Credits.
Hydraulic design of conveyance, regulating, and measurement structures. Design for spillways, energy dissipators, inlet and outlet works related to dams. Forces on hydraulic structure and stability analysis. Hydraulic turbines and pumps. Design considerations for flow through pipes. Transients and cavitation. Prerequisite: CE 3610.

CE 6603. Design of Dams. 3 Credits.
Project planning and investigations. Types of dams; design of earth–rock fill dams; stability analysis, foundation treatment, wind–wave protection. Construction methods for dams. Reservoir sedimentation. Safety inspection of dams. Prerequisite: CE 3610.

CE 6604. Advanced Hydrology. 3 Credits.
Precipitation, evaporation, and transpiration. Soil physics; stream flow, drainage basins, hydrograph analysis, and stream-flow routing. Design criteria, flood frequency statistics and analysis, flood forecasting and control, water supply forecasting. Prerequisite: CE 4620.

CE 6605. Ground Water and Seepage. 3 Credits.
Permeability theory of groundwater flow, flow nets, analogs, computer solutions; applications to engineering problems such as excavation dewatering, flow through dams, stabilization of earth slopes. Prerequisites: CE 4410.   (Spring).

CE 6606. Mechanics of Water Waves. 3 Credits.
Irrotational theory for deep- and shallow-water waves, reflexion, refraction, diffraction, attenuation. Water waves of finite amplitude: shallow-water theory, tides, bores, long-waves theory, conoidal and solitary waves. Wave generation by wind. Wave breaking and reflexion. Prerequisite: APSC 6213 and permission of instructor.

CE 6607. Water Resources Planning and Control. 3 Credits.
The parameters of water resources planning and control, economics of water resources and related natural resources, economics of water-quality control, physical parameters of water resource development, water resources law. Prerequisite: approval of department.

CE 6608. Hydraulic Modeling. 3 Credits.
Dimensional analysis and similitude. Types of models–physical, mathematical. Distortions in physical models. Erodible bed models. Prerequisite: CE 3610.

CE 6609. Numerical Methods in Environmental and Water Resources. 3 Credits.
Use of microcomputers in water resources. Elements of finite difference schemes, basic operations, convergence, stability, and consistency. Nonuniform flow and error analysis; unsteady laminar flow; diffusion problems; unsteady flow in open channels; water hammer, seepage flow, and diffusion–dispersion problems. Prerequisites: CE 2210, MAE 3126.   (Spring).

CE 6610. Pollution Transport Systems. 3 Credits.
Distribution of pollutants in natural waters and atmosphere, diffusive and advective transport, mathematics for stream pollutant deoxygenation rates, groundwater pollution transport, sediment transport, thermal transport, numerical simulation of pollutant transports in streams and estuaries. Prerequisite: CE 3610, MAE 2131.

CE 6701. Analytical Mechanics. 3 Credits.
Fundamental principles, particle and rigid-body dynamics, generalized coordinates, variational principles and Lagrange's equations, nonholonomic systems, Hamilton's equations, theory of small oscillations.   Prerequisites: APSC 2058, APSC 2113.   (Fall).

CE 6702. Vehicle Dynamics. 3 Credits.
Engineering principles and analytical methods explaining the performance of an automotive vehicle. Basic mechanics governing vehicle dynamic performance in longitudinal, ride, and handling modes. Engineering analysis techniques applied to basic systems and subsystems to derive the governing equations. Prerequisite or corequisite: CE 6701. Prerequisites: CE 6701 (either prerequisite or corequisite).   (Spring, even years).

CE 6705. Nonlinear Finite Element Modeling and Simulation. 3 Credits.
Rigid and flexible body methods for modeling crashes. Application of dynamic nonlinear finite element methods with contact algorithms for modeling crash phenomena. Modeling and simulation of vehicles, airbags, safety restraining systems, and highway barriers.   (Spring).

CE 6706. Pavement & Runway Design. 3 Credits.
Pavement types, wheel-load characteristics; stresses in pavements and subgrades; empirical methods of design of flexible and rigid highway and airfield pavements; general principles of runway design.   (Spring, odd years).

CE 6707. Systems Dynamics Modeling and Control. 3 Credits.
Introduction of concepts in control theory and applications to solve problems in civil and transportation engineering dealing with single-input/single-output and multi-input/multi-output systems. Review of classical control theory in the frequency and time domain, state–space analysis, system optimization, and non-linear control.   (Fall).

CE 6721. Traffic Engineering and Highway Safety. 3 Credits.
Roadway traffic capacity and network performance measures; steady and unsteady traffic flow phenomena; traffic control signalization theory and practical implementation; monitoring techniques, instruments, and data processing for highway safety. Traffic related highway safety design concepts.   (Fall).

CE 6722. Intelligent Transportation Systems. 3 Credits.
Commands, controls, and communications in modern multimodal transportation; infrastructure/highway and vehicle automation, advanced traffic management, vehicle control and safety systems; information, data, and sensory requirements; practical applications and projects. Prerequisite: CE 2710 or CE 3720. Recommended background: basic knowledge of transportation engineering. (Spring, Every Year).

CE 6730. Sustainable Urban Planning. 3 Credits.
Human and physical processes shaping urban ecologies and environments; human-environment interactions in the context of an urban region; urban land use, transport and planning. Restricted to students with departmental approval. Prerequisite: CE 2710.   (Spring, Every Year).

CE 6800. Special Topics. 1-6 Credits.
Topic to be announced in the Schedule of Classes.

CE 6801. Civil and Environmental Engineering Graduate Internship. 1 Credit.
For graduate students in the department. May be repeated once for credit. Prerequisite: required courses in the area of focus and department approval. Additional prerequisites may be required for a specific internship as determined by the research supervisor.

CE 6808. Research. 1-12 Credits.
Basic research projects, as arranged. May be repeated for credit.

CE 6998. Thesis Research. 3 Credits.

CE 6999. Thesis Research. 3 Credits.

CE 8320. Theory of Elasticity II. 3 Credits.
Application of integral transform and analytic function theory to solution of plane problems; elastic wave propagation. Three-dimensional elasto-statics. Prerequisite: APSC 6211; CE 6207.

CE 8321. Nonlinear Mechanics of Continua. 3 Credits.
Polar decomposition, invariance, isotropy, representation theorems for invariants and isotropic tensor functions. Deformation, kinematics, stress, balance principles. Principles for constitutive relations. Applications to nonlinear elasticity and non-Newtonian fluids. Prerequisite: CE 6206.

CE 8330. Advanced Finite Element Analysis. 3 Credits.
Review of variational formulation of the finite element method. Formulation of various continuum and structural elements. Application to static and dynamic problems in elasticity, plasticity, large deflection, and instability in plates and shells. Recent developments in finite element methods. Same as MAE 6288. Prerequisite: CE 6206, 6210; or MAE 6210, MAE 6286.

CE 8350. Sedimentation Engineering. 3 Credits.
Problems of erosion and sedimentation. Properties of sediment. Initiation of motion. Suspension of sediment and sediment discharge theories. Sedimentation measurements. Economic and legal aspects. Prerequisite: CE 6601 or approval of department.

CE 8351. Mechanics of Alluvial Channels. 3 Credits.
Physical processes in drainage basins and channels. Channel forms and bed forms. Hydraulics and sediment transport in alluvial channels. Design of stable channels. Qualitative and quantitative response of rivers. Channel stabilization, navigation channels. Case studies including environmental impacts. Prerequisite: CE 6601 or approval of department.

CE 8352. Advanced Hydraulics. 3 Credits.
Theory of unsteady flow. Diffusion and dispersion through pipes and open channels. Numerical solutions using finite element and finite difference methods. Prerequisite: CE 6601 or approval of department.

CE 8370. Intelligent Systems Theory and Applications. 3 Credits.

Overview of artificial intelligence, neural networks, genetic algorithms, fuzzy systems, and hybrid intelligent systems and their integration with other information processing methods. Intelligent systems applications; examples are drawn from ITS and traffic engineering, vehicle safety, remote sensing, and structural design optimization. Prerequisite: CE 6707.

CE 8380. Advanced Biomechanics. 3 Credits.

Historical overview of biomechanics and biomaterials. Fundamental concepts in mechanics as applied to the treatment of biological systems. Approaches to the mechanical analysis of the human structure under physiological and non-physiological loading conditions. Constitutive laws for biological materials. Finite element applications. Prerequisite: CE 6206 or 6350.   (As arranged).

CE 8998. Advanced Reading and Research. 1-12 Credits.

Limited to students preparing for the Doctor of Philosophy qualifying examination. May be repeated for credit.

CE 8999. Dissertation Research. 1-12 Credits.

Limited to Doctor of Philosophy candidates. May be repeated for credit.