Civil and Environmental Engineering / Graduate Program Course Descriptions

Please note: 300-level courses are offered to Undergraduates and Graduates; 400-level courses are graduate only.

CIV_ENG 302-0 Engineering Law

The American legal system from an engineer's perspective. Socratic-method analysis of statutory and case law. Contract, patent, corporation, antitrust, property, and environmental law. Prerequisite: Junior standing.

CIV_ENG 304-0 Civil and Environmental Engineering Systems Analysis

Explores problems that arise in planning and managing engineering projects/systems. Integrates methodological tools, often used in the management sciences, with applications in civil and environmental engineering—engineering economics, decision making under uncertainty (decision analysis and dynamic programming), and optimization (constrained optimization and linear programming).

CIV_ENG 306-0 Uncertainty Analysis in Civil Engineering

Probability, statistics, and decision theory. Discrete and continuous random variables, marginal and conditional distributions, moments, statistical model selection and significance tests, hypothesis testing, and elementary Bayesian decision theory. Application to problems in soil mechanics, water resources, transportation, and structures.

CIV_ENG 307-0 Microstructure of Cement-Based Materials

Chemistry of the principal silicate and aluminate cements used in building and civil and environmental engineering. Emphasis on underlying science rather than on practical application. Experimental and theoretical aspects of cement chemistry; relationships between processing, microstructure, and properties.

CIV_ENG 318-0 Mechanics of Fracture

Stress concentration: analysis of the stress field near a crack tip; fracture modes; brittle and ductile fracture; fracture toughness; fracture criteria; fracture mechanics design; fatigue; dynamic effects. Prerequisites: CIV_ENG 216 and MATH 217.

CIV_ENG 319-0 Theory of Structures II

Shear center, nonprismatic members, nonlinear materials, influence lines, Mueller-Breslau Principle, approximate methods of analysis, energy methods, stiffness matrix, and computer methods of analysis. Prerequisite: CIV_ENG 221.

CIV_ENG 320-0 Structural Analysis

Single and multiple degree of freedom systems subjected to period, seismic, and general loadings. Time history analysis of linear and nonlinear systems. Design methods for earthquakes.

CIV_ENG 321-0 Properties of Concrete

Concrete as a composite material; relationship between constitutive laws and microstructure; failure theories, fracture; fatigue; strain rate effects; destructive and nondestructive testing; creep and shrinkage; chemistry of cement hydration; admixtures; aggregates; proportioning; new materials.

CIV_ENG 322-0 Structural Design

Design criteria; planning and design aspects of structural systems for gravity and lateral loads; an integral part of the class is a total design project involving the analysis and design of a structure. Prerequisite: CIV_ENG 222 or equivalent.

CIV_ENG 325-0 Reinforced Concrete

Fundamentals of reinforced concrete theory and design. Analysis and design of beams, slabs, and columns. Concurrent familiarization with current building codes, specifications, and practices. Prerequisite: CIV_ENG 221.

CIV_ENG 327-0 Finite Element Methods in Mechanics

Development of finite elements from variational principles and application to static stress analysis. Introduction to techniques for transient and generalized field problems. Computer implementation.

CIV_ENG 330-0 Construction Management

Techniques for coordinating decisions and actions of various parties in the design and construction of civil and environmental engineering projects. Delivery systems; preconstruction services; project planning; cost control and value engineering; bidding. Prerequisite: Graduate standing or permission of instructor.

CIV_ENG 332-0 Construction Estimating

Estimation of cost at different stages of design; conceptual estimating, quantity take-off of various elements, such as materials, labor, equipment. Prerequisite: CIV_ENG 330 or permission of instructor.

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CIV_ENG 336-0 Project Scheduling

Project planning, scheduling, and control using CPM arrow and precedence networks; resource allocation and leveling; earned-value analysis, linear scheduling; PERT; hands-on experience in using computer tools. Prerequisite: CIV_ENG 330 or permission of instructor.

CIV_ENG 338-0 Public Infrastructure Management

Explores the complexity of managing public infrastructure facilities by means of a five-part interactive model of infrastructure management. Aims to impart a realistic appreciation of contemporary public infrastructure management policies and practices. Prerequisite: Senior standing.

CIV_ENG 340-0 Fluid Mechanics II

Civil engineering applications of fluid mechanics. Turbulent flow in pipes, pipe networks, and open channels. Water waves and coastal engineering. Prerequisite: MECH_ENG 241 or CHEM_ENG321 or permission of instructor.

CIV_ENG 352-0 Foundation Engineering

Application of soil mechanics to analysis and design of foundations and embankments. Settlement of structures, bearing capacities of shallow and deep foundations, earth pressures on retaining structures and slope stability. Prerequisite: CIV_ENG 250.

CIV_ENG 355-0 Engineering Aspects of Groundwater Flow

Applied aspects of groundwater flow and seepage, including Darcy's law, parameter determination, aquifer test analysis, flow-net construction and application, modeling techniques, slope-stability analysis, drainage, and filter design. Prerequisite: MECH_ENG 241, CIV_ENG 340, and Pre-senior or senior standing.

CIV_ENG 356-0 Transport Processes in Porous Media

Transport processes in porous media, including unsaturated flow, flow in deformable porous media, convective transport of solutes with hydrodynamic dispersion effects and coupled flow phenomena with particular emphasis on electrokinetics. Prerequisite: CIV_ENG 355.

CIV_ENG 358-0 Airphoto Interpretation

Principles and practice of using aerial photographs to obtain information about natural features of the earth's surface, with emphasis on earth materials. Landforms, geological processes, rocks, and soils. Stereoscopic photographs, elements of photogrammetry. Prerequisite: Junior standing or permission of instructor.

CIV_ENG 361-0 Environmental Microbiology and Public Health

Basic principles of microbiology; etiology of infectious and noninfectious diseases; control of environmentally-based health hazards.

CIV_ENG 362-0 Ethics, Engineering, and Environment

A broad introduction to ethics for scientists and engineers required to make both personal and professional ethical decisions that include complexity and issues of environment.

CIV_ENG 363-0 Environmental Engineering Applications I: Air & Land

Nature and control of community air pollution. Sources, physical and chemical properties, and effects of major air pollutants; analytical measurements and monitoring of air pollutants; engineering and legislative control. Prerequisite: Junior standing.

CIV_ENG 364-0 Environmental Engineering Applications II: Water

Engineering elements of water supply and water pollution abatement. Water quality standards, water and wastewater treatment processes, and the management of receiving waters to control pollution. Prerequisite: MECH_ENG 241 and CIV_ENG 340.

CIV_ENG 365-0 Environmental Laboratory

Chemical and microbiological aspects of environmental engineering and science are explored through an integrated laboratory course.

CIV_ENG 367-0 Aquatic Chemistry

Chemical equilibria in natural waters. Development of the theoretical basis for the investigation of chemical behavior of aquatic systems emphasizing a problem-solving approach. Prerequisite: CHEM 103, or permission of instructor.

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CIV_ENG 370-0 Environmental Engineering Design

Decision-making in selection and implementation of environmental control measures. Water supply and wastewater management: quantities to be handled, transportation systems, treatment processes, solid wastes management. Prerequisite: CIV_ENG 364.

CIV_ENG 371-0 Introduction to Transportation Planning and Analysis

Analysis and design of solutions to transportation problems; introduction to selected operations research and statistical analysis techniques; extensive use of case studies in urban transportation, intercity passenger transport, and freight movements. Prerequisite: Junior standing or permission of instructor.

CIV_ENG 376-0 Transportation System Operations

Traffic flow theory; vehicle and human factors, capacity analysis; intersection performance and control; management and control of arterial streets and networks; neighborhood traffic restraint, urban transit operations. Operations concepts and theories applied to actual problems through laboratory practice.

CIV_ENG 382-0 Infrastructure of Facilities and Systems

Theory, function, planning, design, ownership, finance and operation of contemporary infrastructure systems presented in lecture-discussion format, along with weekly field trips to example systems.

CIV_ENG 395-0 Special Topics in Civil Engineering

Topics suggested by students or faculty and approved by the department.

CIV_ENG 398-1,2 Community-based Design

Year-long participation in two- or three-person team projects involving research, analysis, and/or design in the solution of environmental problems affecting primarily low-income communities. Grade assigned only on completion of both units. Prerequisite: Junior or senior standing in civil or environmental engineering and permission of instructor.

CIV_ENG 399-0 Projects

Special studies under faculty direction. Credit to be arranged. Each instructor has own section—student must obtain permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENG 411-0 Micromechanics

Mechanics of microstructures of materials, such as continuum theory of dislocations, inclusions, inhomogeneities, cracks, and composite materials. Unified eigenstrain method employed.

CIV_ENG 414-1,2 Mechanics of Composite Materials I, II

Introduction to basic concepts: fabrication of composite materials, micromechanics, macromechanics of uni-directional lamina, failure theories, mechanics of multi-directional laminate, lamination theory, hydrothermal effects, interlaminar stresses, stress concentrations, structural design and optimization, and nondestructive evaluation.

CIV_ENG 415-0 Theory of Elasticity

Notions of stress and strain. Basic equations of the linear theory of elastic media. Stress function and displacement potentials. Applications to specific classes of problems such as plane strain, contact stresses, and axisymmetric problems. Stress concentration. Singular states of stress. Dislocations and residual stresses.

CIV_ENG 417-1 Mechanics of Continua I

Introduction to the mechanics of continuous media. Cartesian tensors; kinematics of deformable media; stress; balance laws; constitutive relations for selected solids and fluids. Prerequisites: CIV_ENG 212 and MATH 217 or MATH 219 or equivalent.

CIV_ENG 417-2 Mechanics of Continua II

Kinematics of deformable media, thermodynamics and balance laws of continua, general theory of constitutive equations. Emphasis on large deformation theories; objective stress and deformation measures with applications in finite strain elasticity. Introduction to nonlinear and inelastic material behavior including applications in plasticity and viscoelasticity. Prerequisite: CIV_ENG 417-1 or equivalent.

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CIV_ENG 420 Advanced Structural Analysis

Solution of nonlinear equations for structures, shear center and center of twist of open and multicell cross sections, shear stresses in multicell closed cross sections, restrained warping torsion stresses.

CIV_ENG 422 Inelastic Analysis of Structures

Inelastic analysis of frames, plates, and shells. Plastic behavior and limit analysis theorems. Static and kinematic methods for calculating collapse loads. Yield surfaces for plates and shells, plastic potential flow law, and load capacity. Viscoelastic behavior and rheologic models. Creep of concrete and its effects in structures.

CIV_ENG 423-0 Matrix Analysis of Structures

Use of matrix methods for analysis of articulated structural systems, geometric matrices, stability, analysis of geometrically nonlinear systems, introduction to the finite element method. Prerequisite: CIV_ENG 221.

CIV_ENG 424 Stability of Structures

Buckling of perfect and imperfect columns, mathematical treatment of various types of stability problems and stability criteria, dynamic and static instability, and energy methods. Buckling of frames, trusses, and beams. Snap-through, elastic-plastic columns, creep buckling, and basic approach to buckling of two- and three-dimensional bodies.

CIV_ENG 426-1,2 Advanced Finite Element Methods I, II

Methods for treating material and geometric nonlinearities by finite elements; transient analysis: explicit and implicit time integration, partitioned methods, and stability; hybrid and mixed elements; finite elements for plates and shells; convergence, efficiency, and computer implementation.

CIV_ENG 430 Cohesive Fracture and Scaling

Essentials of linear fracture mechanics. Nonlinear cohesive fracture of concrete, rock, composites, ice, and ceramics. Crack band model, and smeared cracking. Cohesive softening materials models. Nonlocal theories. Micromechanics and random particle systems. Scaling laws, size effect and brittleness. Weibull's statistical theory. Effects of environment, loading rate, and cycles. Stability of crack systems, crack spacings, and width. Effect of reinforcement and bond slip. Ductility of beams and frames. Localization of softening damage. Relevance to structural design.

CIV_ENG 435 Cost Engineering and Control

Application of cost engineering for construction companies and projects; time and cost integration; estimating process and bid preparation; labor estimates; accounting for equipment; cost-control concepts; changes and extras; claims. Prerequisites: IEMS 423 and IEMS 425 or permission of instructor.

CIV_ENG 436 Construction Contracts and Dispute Resolutions

Contracts as part of the project delivery system. Components of a construction contract. Intended and unintended contract changes. Payment Process. Trade union influences. Negotiations. Alternative dispute resolution. Mechanics liens. Risk management through insurance. Prerequisite: CIV_ENG 330-0 or permission of instructor.

CIV_ENG 440-0 Environmental Transport Processes (formerly Physical Principles in Environmental Engineering)

Processes controlling transport and fate of dissolved and suspended substances in natural and engineered environmental systems. Mass balances, hydrodynamic transport, phase and mass transfers; the fate of reactive species in complex environmental systems. Prerequisites: PHYS 135-1,2 and CHEM_ENG 321, MECH_ENG 241, or equivalent.

CIV_ENG 441-0 Methods in Microbial Complexity

Principles of microbial physiology and biochemistry applied to microorganisms of environmental interest. Prerequisite: CIV_ENG 367.

CIV_ENG 442 Processes in Environmental Biotechnology

Theory and practice of microbiological processes used in pollution control: kinetics of suspended growth and fixed-film processes, activated sludge, biofilm processes, nitrogen and phosphorus removal, methanogenesis. Prerequisites: CIV_ENG 440, CIV_ENG 441, and CIV_ENG 467.

CIV_ENG 444 Physical/Chemical Processes in Environmental Control

Theory and practice of separations and conversions in water quality and residuals management. Water quality, coagulation, adsorption, ion exchange, membranes, oxidation, sedimentation, flocculation, filtration. Prerequisite: CIV_ENG 367, 440 or equivalent.

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CIV_ENG 445 Environmental Systems Laboratory

Mechanistic aspects of the performance of selected unit processes typically used in drinking water treatment: coagulation, filtration, reactor hydraulics, disinfection, chemical reaction and other physicochemical phenomena to elucidate parameters and conditions critical for controlling treatment effectiveness and efficiency.

CIV_ENG 446-0 Environmental Analytical Chemistry

Theory and the applications of analytical chemistry as applied to complex, multi-phase environmental systems. Prerequisite: CIV_ENG 367 .

CIV_ENG 448-0 Biophysicochemical Processes in Environmental Systems

Microbiological and engineering fundamentals of bioremediation, with emphasis on current and emerging technologies for major classes of environmental contaminants and contaminated sites.

CIV_ENG 449-1,2,3 Environmental Laboratory Experience

A combined year-long laboratory experience that is coupled to classroom learning. Three laboratory exercises will be conducted each quarter and these are designed to reinforce the fundamentals of environmental transport, chemistry and microbiology that are taught in the core curriculum. Students will learn how to make selected measurements, collect and analyze data, design experiments. and draw conclusions based on their observations. The labs will parallel materials presented in coursework and provide students with hand-on learning opportunity. In the fall, the labs will be focused on environmental chemistry and transport, in the winter, environmental microbiology and advanced environmental chemistry, and in the spring the labs will stress integration of these basic principles to look at the behavior of environmental systems. Prerequisite: Permission of Instructor

CIV_ENG 450-1,2,3 Soil Mechanics I, II, III

450-1: Shear strength of soils. Theory of consolidation. Problems of rate-independent and rate-dependent settlement. 450-2: Foundation engineering. Bearing capacity of shallow and deep foundations. Deformation of foundations. Effects of construction on performance. Case studies. 450-3: Earth and earth-supported structures. Earth pressures on walls. Design of retaining structures and supported excavations. Effects of construction on performance. Stability of slopes. Design of earth dams and embankments. Case studies.

CIV_ENG 451-0 Engineering Properties of Soils

Determination and interpretation of engineering properties of soils. Laboratory testing procedures and methods of evaluation and control. Report writing. Prerequisite: CIV_ENG 250.

CIV_ENG 453 Rock Mechanics

Engineering properties and behavior of rock masses. Shear strength of rock, in situ and laboratory tests of strength, rock fracture, three-dimensional geometry of joint systems, stability of rock masses, in situ stress determination, and deformability of rock masses.

CIV_ENG 454 Constitutive Models for Soils

Numerical models of effective and total stress-strain response of soils; non-linear pseudo-elastic, elasto-plastic and bounding surface models; parameter identification and applications. Prerequisite: CIV_ENG 450-1 or permission of instructor.

CIV_ENG 457-0 Environmental Geotechnics

Site characterization and geotechnical aspects of waste containment and remediation. Geological setting and the heterogeneous nature of soils. Design, testing, and quality control of geosynthetics.

CIV_ENG 458 Soil Dynamics

Dynamics of soils and soil-foundation systems; nuclear weapons effects, earthquake response, vibrations of machine foundations, reactions due to impact equipment, industrial noise and blast effects, fatigue concepts, wave propagation and attenuation, blast-resistant construction, and linear and nonlinear systems.

CIV_ENG 461 Soil Science for Environmental Engineering

Fundamental properties and behavior of soil systems, with emphasis on soil physics, soil chemistry, and soil microbiological and biochemical reactions applied to contaminant transport and fate. Includes laboratory experience with soil.

CIV_ENG 467 Advanced Environmental Chemistry

Principles and applications needed to develop advanced problem-solving techniques in environmental chemistry.

Major topics include applied thermodynamics, environmental organic chemistry, and problem solving for acid/base, complexation, precipitation/dissolution, and redox.

CIV_ENG 468 Chemical Speciation in Aquatic Systems
Advanced theories, computerized methods, and chemical tools for investigating the chemical speciation of natural waters.

CIV_ENG 471-1,2 Transportation Systems Analysis I, II
Applications of optimization methods to the analysis, design, and operation of transportation logistics networks. Network equilibrium. Flow prediction in congested multi-commodity networks. Vehicle routing and fleet management. Dynamic and stochastic transportation network modeling. Prerequisite: IEMS 310 or equivalent background.

CIV_ENG 479 Transportation Systems Planning and Management
Functional and structural description of transportation systems; characteristics of major U.S. transportation modes; transportation analysis, planning, problem-solving, and decision-making methods illustrated through urban, freight, and intercity case studies.

CIV_ENG 480-1,2 Travel Demand Analysis and Forecasting I, II
Introduction and application of statistical, econometric, and marketing research techniques to study and forecast travel behavior. First Quarter: introduction to theory, analysis, and model development. Second Quarter: advanced theory, disaggregate choice models, and prediction methods.

CIV_ENG 482 Evaluation and Decision-Making for Infrastructure Systems
Theories and methods of evaluation and choice from alternatives for transportation and other infrastructure projects and systems. Economic, quantitative, and judgmental methods for both a priori and before-and-after evaluation. Measurement, modeling, analysis, and presentation problems. Prerequisite: CIV_ENG 306.

CIV_ENG 483 Infrastructure Systems Analysis
Quantitative techniques to develop prescriptive models that can be used to support efficient planning and management of civil infrastructure systems.

CIV_ENG 495 Selected Topics in Civil Engineering
Special topics in Civil and Environmental Engineering.

CIV_ENG 497 Selected Topics in Civil Engineering
Half-unit special topics in Civil and Environmental Engineering.

CIV_ENG 499 Projects
Special projects under faculty direction (1, 2, or 3 units). Each instructor has own section—student must obtain permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu)

CIV_ENG 512 Structural Engineering and Mechanics
Selected topics in structural engineering and mechanics.

CIV_ENG 515-1,2 Geotechnics Seminar
Discussion of classical and current literature in the field.

CIV_ENG 516-1,2,3 Seminar in Environmental Engineering and Science
Topics vary. Examples: environmental microbiology, innovation technologies for recycle , recovery, treatment of chemical residuals, environmental policy, public health, water and waste treatment processes, contaminant fate and impact in nature.

CIV_ENG 517 Seminar in Transportation Engineering
Selected topics in transportation engineering.

CIV_ENG 533-1,2,3 Project Management Seminar
Selected topics in project management and engineering.

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CIV_ENG 590 Research

Independent investigation of selected problems pertaining to thesis or dissertation (1, 2, or 3 units). Each instructor has own section—student must obtain permission from instructor and Permission Number from the Academic Coordinator in Tech A236.