McCormick

Northwestern Engineering

Civil and Environmental Engineering Graduate Student Course Descriptions

300s = Undergraduates (meeting Prerequisites) and Graduates; 400s = Graduates and Undergraduates (with permission of instructor and permission number from the CEE Academic Coordinator, j-soule@northwestern.edu)

CIV_ENV 302-0 Engineering Law

Exploring 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: Senior standing.

CIV_ENV 303-0 Environmental Law and Policy

An introduction to many important and interesting aspects of environmental law and policy. A wide range of environmental topics are covered focusing on national environmental policy as implemented through major federal environmental statutes. Prerequisite: Junior or Senior standing.

CIV_ENV 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). Prerequisite: Junior or Senior standing; MATH 224 or equivalent (calculus and probability).

CIV_ENV 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. Prerequisite Math 230-0

CIV_ENV 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. Prerequisite Permission of instructor.

CIV_ENV 314-0 Mechanics of Crustal Processes

Application of elementary mechanics to geological processes of crustal deformation, including faulting, earthquake generation and deformation, and folding and coupling of fluid flow with deformation. Prerequisite Permission of instructor.

CIV_ENV 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_ENV 221.

CIV_ENV 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. Prerequisite: CIV_ENV 221

CIV_ENV 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. Prerequisite: CIV_ENV 216.

CIV_ENV 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_ENV 221.

CIV_ENV 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. Prerequisite: MECH_ENG 262, MATH 215, or CIV_ENV 216, and permission of instructor.

CIV_ENV 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: Senior standing in engineering, or permission of instructor.

CIV_ENV 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_ENV 330 **and** permission of instructor.

CIV_ENV 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_ENV 330 or permission of instructor.

CIV_ENV 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_ENV 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_ENV 250.

CIV_ENV 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_ENV 340, and Pre-senior or senior standing.

CIV_ENV 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_ENV 361-0 Environmental Microbiology and Public Health
Basic principles of microbiology; etiology of infectious and noninfectious diseases; control of environmentally-based health hazards. Prerequisite: Junior standing.

CIV_ENV 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. Prerequisite: Junior standing.

CIV_ENV 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_ENV 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_ENV 340.

CIV_ENV 365-0 Environmental Laboratory
Chemical and microbiological aspects of environmental engineering and science are explored through an integrated laboratory course. Junior standing.

CIV_ENV 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.

CIV_ENV 368 Sustainability: Issues and Actions, Near and Far
The purpose of this course is to explore the issues that motivate the design and engineering of sustainable resource use and development. Case studies and examples from both developed and developing economies are discussed/compared.

CIV_ENV 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 in engineering or permission of instructor.

CIV_ENV 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. Prerequisite: Junior standing, and basic knowledge of calculus and statistics. Knowledge of MATLAB is desirable, but not required.

CIV_ENV 395-0 Special Topics in Civil Engineering
Undergraduate level experimental courses.

CIV_ENV 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 BSCE or BSEE and permission of instructor.

CIV_ENV 399-0 Projects
Special projects 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_ENV 411-0 Micromechanics
Mechanics of microstructures of materials, such as continuum theory of dislocations, inclusions, inhomogeneities, cracks, and composite materials. Unified eigenstrain method employed. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 413-0 Experimental Stress Analysis
Experimental techniques in measuring stress and strain. Strain gauge, photoelastic, brittle coating, and Moire techniques studies and applied with selected laboratory experiments. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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: GEN_ENG 205-2,3 or CIV_ENV 212 and MATH 240. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 417-1 or equivalent. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 421 Prestressed Concrete
Principles of prestressed concrete. Prestressing systems, end anchorage, and loss of prestress. Analysis and design of sections for flexure, shear, bond, bearing, and deflection. Continuous beams, slab, tension, and compression members. Circular prestressing. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 221. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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 Prerequisite: Permission of instructor.

CIV_ENV 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_ENV 330-0 or permission of instructor.

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 250. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 450-1 or Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 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_ENV 306. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 483 Infrastructure Systems Analysis
Quantitative techniques to develop prescriptive models that can be used to support efficient planning and management of civil infrastructure systems. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 495 Selected Topics in Civil Engineering
Graduate-level experimental courses. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 497 Selected Topics in Civil Engineering
Half-unit special courses under faculty direction. Prerequisite: Permission from instructor and Permission Number from the Academic Coordinator in Tech A236 (j-soule@northwestern.edu).

CIV_ENV 499-0 Projects
Special projects 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).