Course Catalog - Spring 2009

Civil and Environmental Engineering

195 ***About Civil Engineering*** credit: 0 hours.
Civil engineering orientation course including historical developments, education requirements, relation to science, professional practice, and specialties within the profession. Approved for S/U grading only.

199 ***Undergraduate Open Seminar*** credit: 1 to 5 hours.
May be repeated.

201 ***Systems Engrg & Economics*** credit: 3 hours.
Introduction to the formulation and solution of civil engineering problems. Major topics are: engineering economy, mathematical modeling, and optimization. Techniques, including classical optimization, linear and nonlinear programming, network theory, critical path methods, simulation, decision theory, and dynamic programming are applied to a variety of civil engineering problems. Credit is not given for both CEE 201 and either GE 330 or IE 310. Prerequisite: MATH 231; credit or concurrent registration in MATH 225.

202 ***Engineering Risk & Uncertainty*** credit: 3 hours.
Identification and modeling of non-deterministic problems in civil engineering design and decision making. Development of stochastic concepts and simulation models, and their relevance to real design and decision problems in various areas of civil engineering. Credit is not given for both CEE 202 and either GE 331 or IE 300. Prerequisite: Recommended: credit or concurrent registration in MATH 241.

300 ***Behavior of Materials*** credit: 4 hours.
Macroscopic mechanical behavior in terms of phenomena at the nanometer and micrometer levels for the three types of engineering materials (metals, ceramics, and polymers) with emphasis on specific materials used in civil engineering -- steel, rocks, clay, portland cement concrete, asphaltic concrete, and wood. Lecture-lab format. Same as TAM 324. Credit is not given for both CEE 300 and either ME 330 or MSE 280. Prerequisite: Completion of Composition I general education requirement; CHEM 104; TAM 251.
This course satisfies the General Education Criteria for a Advanced Composition course.

310 ***Transportation Engineering*** credit: 3 hours.
Introduction to the design, planning, operation, management, and maintenance of transportation systems; integrated multi-modal transportation systems (highways, air, rail, etc.); layout of highways, airports, and railroads with traffic flow models, capacity analysis, and safety. Design of facilities and systems with life cycle costing procedures and criteria for optimization. Prerequisite: TAM 251; credit or concurrent registration in CEE 202.

320 ***Construction Engineering*** credit: 3 hours.
Introduction to the construction processes: contracting and bonding, planning and scheduling, estimating and project control, productivity models, and construction econometrics. Prerequisite: CEE 201; credit or concurrent registration in CS 101 and CEE 202.

330 ***Environmental Engineering*** credit: 3 hours.

Sources, characteristics, transport, and effects of air and water contaminants; biological, chemical, and physical processes in water; atmospheric structure and composition; unit operations for air and water quality control; solid waste management; environmental quality standards. Prerequisite: CHEM 104.

350 ***Water Resources Engineering*** credit: 3 hours.
Quantitative aspects of water in the earth's environment and its engineering implications, including design and analysis of systems directly concerned with use and control of water; quantitative introduction to hydrology, hydraulic engineering, and water resources planning. Prerequisite: CEE 202; credit or concurrent registration in TAM 335 and CEE 201.

360 ***Structural Engineering*** credit: 3 hours.
Analysis, behavior, and design of trusses and framed structures under static loads; analysis topics include member forces in trusses, shear and moment diagrams, deflections, simple applications of the force method and slope-deflection; introduction to computer applications. Prerequisite: TAM 251.

380 ***Geotechnical Engineering*** credit: 3 hours.
Introduction to geotechnical engineering. Classification of soils, compaction in the laboratory and in the field, soil exploration, boring and sampling, permeability of soils, one-dimensional settlement analyses, strength of soil, introduction to foundations. Prerequisite: TAM 251.

400 ***Welding and Joining Processes*** credit: 0 to 4 hours.
Physical principles of fusion welding; heat flow; thermal cycles; physical metallurgy and mechanical properties of welded joints; applications of welding to large structures; testing of welds; nondestructive testing; design, economics, and weld specifications; laboratory experiments in welding. Same as MSE 444. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 300 or MSE 206.

401 ***Concrete Materials*** credit: 4 hours.
Examines the influence of constituent materials (cements, water, aggregates and admixtures) on the properties of fresh and hardened concrete, concrete mix design, handling and placement of concrete, and the behavior of concrete under various types of loading and environment. Laboratory exercises, which utilize standard concrete test methods, are an integral part of the course. A few field trips are held during scheduled laboratory sessions. Prerequisite: CEE 300.

405 ***Asphalt Materials I*** credit: 3 or 4 hours.
Properties and control testing of bituminous materials, aggregates for bituminous mixtures, and analysis and design of asphalt concrete and liquid asphalt cold mixtures; structural properties of bituminous mixes; surface treatment design; recycling of mixtures. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

406 ***Pavement Design I*** credit: 3 or 4 hours.
Analysis, behavior, performance, and structural design of pavements for highways and airfields; topics include climate factors, rehabilitation, life cycle design economics, and traffic loadings. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

407 ***Airport Design*** credit: 3 or 4 hours.
Basic principles of airport facilities design to include aircraft operational characteristics, noise, site selection, land use compatibility, operational area, ground access and egress, terminals, ground service areas, airport capacity, and special types of airports. 3 undergraduate hours. 3 or 4 graduate hours.

408 ***Railroad Transportation Engrg*** credit: 3 or 4 hours.
Principles and analysis of railroad transportation efficiency, economics, energy, and engineering; effect on production and markets. Introduction to railroad infrastructure; locomotive and rolling stock design, function, and operation. Computation of train speed, power, and acceleration requirements; introduction to railway traffic control and signaling. Quantitative analytical tools for rail-transportation decision-making and optimization. Field trip to observe railroad infrastructure, equipment and operations. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

409 ***Railroad Track Engineering*** credit: 3 or 4 hours.
In-depth examination of railroad track engineering concepts including track component and system design, construction, evaluation, maintenance, load distribution, and wheel-rail interaction. Design and analysis tools for railroad track engineering and maintenance. Field trip to observe railroad track system and components. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

410 ***Railroad Signaling & Control*** credit: 3 or 4 hours.
Railway traffic control and signaling systems; train performance and scheduling tools; analysis of temporal and spatial separation of trains for safety and efficiency; train movement authority and operating rules, track circuit and wireless train position monitoring technology; interlocking design; railroad capacity modeling tools; economic analysis of traffic control system design, optimization, and selection. Field trip to observe signal system infrastructure and railway traffic operations control center. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 408.

415 ***Geometric Design of Roads*** credit: 4 hours.
Analysis of factors in developing a highway transportation facility; traffic estimates and assignment; problems of highway geometrics and design standards; planning and location principles; intersection design factors; street systems and terminal facilities; programming improvements; drainage design; structural design of surface; concepts of highway management and finance; highway maintenance planning. Prerequisite: CEE 310.

416 ***Traffic Capacity Analysis*** credit: 3 or 4 hours.
Fundamentals of traffic engineering; analysis of traffic stream characteristics; capacity of urban and rural highways; design and analysis of traffic signals and intersections; traffic control; traffic impact studies; traffic accidents. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 310.

417 ***Urban Transportation Planning*** credit: 4 hours.
Same as UP 430. See UP 430.

420 ***Construction Productivity*** credit: 3 or 4 hours.
Introduction to the application of scientific principles to the measurement and forecasting of productivity in construction engineering. Conceptual and mathematical formulation of labor, equipment, and material factors affecting productivity. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 320.

421 ***Construction Planning*** credit: 3 or 4 hours.
Project definition; scheduling and control models; material, labor, and equipment allocation; optimal schedules; project organization; documentation and reporting systems; management and control. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 320.

422 ***Construction Cost Analysis*** credit: 3 or 4 hours.
Introduction to the application of scientific principles to costs and estimates of costs in construction engineering; concepts and statistical measurements of the factors involved in direct costs, general overhead costs, cost markups, and profits; the fundamentals of cost recording for construction cost accounts and cost controls. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 320.

430 ***Ecological Quality Engineering*** credit: 2 hours.
Characteristics of rivers and lakes which affect the management of domestic and industrial wastewaters; includes assessment of chemical hazards, an introduction to surveillance and biomonitoring, and a review of regulations governing effluents. Prerequisite: CEE 330.

431 ***Biomonitoring*** credit: 3 hours.
The theory and application of biomonitoring as a component of environmental management; reviews a range of techniques to analyze effluents and assess condition and trend in the environment, using biological and ecological systems; emphasizes biomonitoring program design, selection and analysis of data, and interpretation of biomonitoring results. Prerequisite: CEE 430.

432 ***Stream Ecology*** credit: 3 hours.
Description of physical, chemical, and biological characteristics in streams and rivers including an integrated study of the environmental factors affecting the composition and distribution of biota; emphasizes the application of ecological principles in aquatic ecosystem protection and management. Same as IB 450. Prerequisite: CEE 430.

434 ***Environmental Systems I*** credit: 3 hours.
Introduction to the concepts and applications of environmental systems analysis. Application of mathematical programming and modeling to the design, planning, and management of engineered environmental systems, regional environmental systems, and environmental policy. Economic analysis, including benefit-cost analysis and management strategies. Concepts of tradeoff, non-inferior sets, single- and multi-objective optimization. Practical application to case studies to convey an understanding of the complexity and data collection challenges of actual design practice. Prerequisite: CEE 201 or GE 330; CEE 330.

437 ***Water Quality Engineering*** credit: 3 hours.
Fundamental theory underlying the unit processes utilized in the treatment of water for domestic and industrial usage, and in the treatment of domestic and industrial wastewaters. Prerequisite: CEE 330; credit or concurrent registration in TAM 335.

440 ***Solid and Hazardous Waste*** credit: 3 hours.
Investigation of the regulatory and technical issues affecting solid and hazardous waste management, with an emphasis on the principles governing the transport, fate, and remediation of solid and hazardous waste in the

subsurface, including advection, dispersion, sorption, interphase mass transfer, and transformation reactions. Prerequisite: CEE 330.

442 ***Env Eng Principles, Physical*** credit: 3 hours.
Analysis of the physical principles which form the basis of many water and air quality-control operations; sedimentation, filtration, inertial separations, flocculation, mixing, and principles of reactor design. Prerequisite: CEE 437.

443 ***Env Eng Principles, Chemical*** credit: 4 hours.
Application of principles of chemical equilibrium and chemical kinetics to air and water quality. Chemistry topics are thermodynamics, kinetics, acid/base chemistry, complexation, precipitation, dissolution, and oxidation/reduction. Many applications are also presented. Prerequisite: CEE 437.

444 ***Env Eng Principles, Biological*** credit: 3 hours.
Application of principles of biochemistry and microbiology to air and water quality, wastes, and their engineering management; biological mediated changes in water and in domestic and industrial wastewater. Prerequisite: CEE 443.

445 ***Air Quality Modeling*** credit: 3 hours.
Overview of practical and advanced approaches to air pollution modeling, including aspects of pollutant transport, transformation, and loss. Models considered include: Gaussian plume, chemical mass balance, chemical reaction, grid and trajectory. Evaluation of models and the development of efficient control strategies are also discussed. Same as ATMS 425. Prerequisite: CEE 330 and credit or concurrent registration in TAM 335; or ATMS 302.

446 ***Air Quality Engineering*** credit: 3 hours.
Description and application of chemical and physical principles related to air pollutants, aerosol mechanics, attenuation of light in the atmosphere, air quality regulation, generation of air pollutants, methods to remove gaseous and particulate pollutants from gas streams, and atmospheric dispersion. Prerequisite: CEE 330; credit or concurrent registration in TAM 335.

447 ***Atmospheric Chemistry*** credit: 3 hours.
Current knowledge of the biochemical cycles of atmospheric trace gases, their interactions on global and regional scales, and their significance for the chemistry in the atmosphere. The important fundamental concepts that are central to understanding air pollutants, e.g., the formation of aerosols and the transformation and removal of species in the atmosphere, will be introduced. Same as ATMS 420 and ENVS 450. Prerequisite: CHEM 102; ATMS 201 or CEE 330.

448 ***Indoor Air Quality Engineering*** credit: 4 hours.
Same as ABE 476. See ABE 476.

449 ***Environmental Engineering Lab*** credit: 3 hours.

Exposure to the use of traditional analysis tools and techniques in analysis, control, and design of natural and engineered environmental systems including air, water, wastewater, solid and hazardous waste, and ecological systems. Lecture-lab format. Prerequisite: CEE 437 or CEE 446.

450 ***Surface Hydrology*** credit: 3 hours.
Descriptive and quantitative hydrology dealing with the distribution, circulation, and storage of water on the earth's surface; principles of hydrologic processes and presents methods of analysis and their applications to engineering and environmental problems. Prerequisite: CEE 350.

451 ***Environmental Fluid Mechanics*** credit: 3 hours.
Incompressible fluid mechanics with particular emphasis on topics in analysis and applications in civil engineering areas; primary topics include principles of continuity, momentum and energy, kinematics of flow and stream functions, potential flow, laminar motion, turbulence, and boundary-layer theory. Prerequisite: TAM 335.

452 ***Hydraulic Analysis and Design*** credit: 3 hours.
Hydraulic analysis and design of engineering systems: closed conduits and pipe networks; hydraulic structures, including spillways, stilling basins, and embankment seepage; selection and installation of hydraulic machinery. Prerequisite: TAM 335.

453 ***Urban Hydrology and Hydraulics*** credit: 4 hours.
Hydraulic analysis and design of urban, highway, airport, and small rural watershed drainage problems; discussion of overland and drainage channel flows; hydraulics of storm-drain systems and culverts; determination of design flow; runoff for highways, airports, and urban areas; design of drainage gutters, channels, sewer networks, and culverts. Prerequisite: CEE 350.

455 ***Erosion and Sediment Control*** credit: 2 hours.
Same as ABE 455 and TSM 455. See ABE 455.

457 ***Groundwater*** credit: 3 hours.
Physical properties of groundwater and aquifers, principles and fundamental equations of porous media flow and mass transport, well hydraulics and pumping test analysis, role of groundwater in the hydrologic cycle, groundwater quality and contamination. Prerequisite: CEE 350 and TAM 335.

460 ***Steel Structures I*** credit: 3 hours.
Introduction to the design of metal structures; behavior of members and their connections; theoretical, experimental, and practical bases for proportioning members and their connections. 3 undergraduate hours. No graduate credit. Prerequisite: CEE 360.

461 ***Reinforced Concrete I*** credit: 3 hours.
Study of the strength, behavior, and design of reinforced concrete members subjected to moments, shear, and axial forces; extensive discussion of the influence of the material properties on behavior. 3 undergraduate hours. No graduate credit. Prerequisite: CEE 360.

462 ***Steel Structures II*** credit: 3 or 4 hours.
Metal members under combined loads; connections, welded and bolted; moment-resistant connections; plate girders, conventional behavior, and tension field action. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 460.

463 ***Reinforced Concrete II*** credit: 3 or 4 hours.
Study of the strength, behavior, and design of indeterminate reinforced concrete structures, with primary emphasis on slab systems; emphasis on the strength of slabs and on the available methods of design of slabs spanning in two directions, with or without supporting beams. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 461.

465 ***Design of Structural Systems*** credit: 3 or 4 hours.
The whole structural design process including definition of functional requirements, selection of structural scheme, formulation of design criteria, preliminary and computer-aided proportioning, and analysis of response, cost, and value. 3 undergraduate hours. 4 graduate hours. Prerequisite: Credit in either CEE 460 or CEE 461 with concurrent registration in the other.

467 ***Masonry Structures*** credit: 3 or 4 hours.
Introduction to analysis, design, and construction of masonry structures. Mechanical properties of clay and concrete masonry units, mortar, and grout. Compressive, tensile, flexural, and shear behavior of masonry structural components. Strength and behavior of unreinforced bearing walls. Detailed design of reinforced masonry beams, columns, structural walls with and without openings, and complete lateral-force resisting building systems. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 461.

468 ***Prestressed Concrete*** credit: 3 or 4 hours.
Study of strength, behavior, and design of prestressed reinforced concrete members and structures, with primary emphasis on pretensioned, precast construction; emphasis on the necessary coordination between design and construction techniques in prestressing. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 461.

469 ***Wood Structures*** credit: 3 or 4 hours.
Mechanical properties of wood, stress grades, and working stresses; effects of strength-reducing characteristics, moisture content, and duration of loading and causes of wood deterioration; glued-laminated timber and plywood; behavior and design of connections, beams, and beam-columns; design of buildings and bridges; other structural applications: trusses, rigid frames, arches, and pole-type buildings; prismatic plates and hyperbolic paraboloids. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 460 or CEE 461.

470 ***Structural Analysis*** credit: 4 hours.
Direct stiffness method of structural analysis; fundamentals and algorithms; numerical analysis of plane trusses, grids and frames; virtual work and energy principles; introduction to the finite element method for plane stress and plane strain. Credit is not given for both CEE 470 and ME 471. Prerequisite: CEE 360.

471 ***Structural Mechanics*** credit: 3 or 4 hours.
Beams under lateral load and thrust; beams on elastic foundations; virtual work and energy principles; principles of solid mechanics, stress and strain in three dimensions; static stability theory; torsion; computational methods. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: MATH 285 and TAM 251.

472 ***Structural Dynamics I*** credit: 3 or 4 hours.
Analysis of the dynamic response of structures and structural components to transient loads and foundation excitation; single-degree-of-freedom and multi-degree-of-freedom systems; response spectrum concepts; simple inelastic structural systems; introduction to systems with distributed mass and flexibility. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 360, MATH 285, and TAM 212.

480 ***Foundation Engineering*** credit: 3 hours.
Analysis and design of foundations, bearing capacity and settlement of foundations; stability of excavations and slopes; ground movements due to construction; analysis and design of excavations, retaining walls, slopes, and underground structures in soil and rock. 3 undergraduate hours. No graduate credit. Prerequisite: CEE 380.

483 ***Soil Mechanics and Behavior*** credit: 4 hours.
Composition and structure of soil; water flow and hydraulic properties; stress in soil; compressibility behavior and properties of soils; consolidation and settlement analysis; shear strength of soils; compaction and unsaturated soils; experimental measurements. Prerequisite: CEE 380.

484 ***Applied Soil Mechanics*** credit: 4 hours.
Application of soil mechanics to earth pressures and retaining walls, stability of slopes, foundations for structures, excavations; construction considerations; instrumentation. Prerequisite: CEE 483.

490 ***Computer Methods*** credit: 3 or 4 hours.
Review of programming concepts; formulation and programming of numerical, data processing, and logical problems with applications from various branches of civil engineering; organization of programs and data; development and use of problem-oriented programming languages in civil engineering. Same as CSE 491. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CS 101.

491 ***Decision and Risk Analysis*** credit: 3 or 4 hours.
Development of modern statistical decision theory and risk analysis, and application of these concepts in civil engineering design and decision making; Bayesian statistical decision theory, decision tree, utility concepts, and multi-objective decision problems; modeling and analysis of uncertainties, practical risk evaluation, and formulation of risk-based design criteria, risk benefit trade-offs, and optimal decisions. 3 undergraduate hours. 3 or 4 graduate hours. Prerequisite: CEE 202.

495 ***Professional Practice*** credit: 0 hours.
Series of lectures by outstanding authorities on the practice of civil engineering and its relations to economics, sociology, and other fields of human endeavor. Approved for S/U grading only.

497 ***Independent Study*** credit: 1 to 16 hours.
Individual investigations or studies of any phase of civil engineering selected by the student and approved by the department. 1 to 4 undergraduate hours. 1 to 16 graduate hours. May be repeated. Prerequisite: Consent of instructor.

498 ***Special Topics*** credit: 1 to 4 hours.
Subject offerings of new and developing areas of knowledge in civil and environmental engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

501 ***Constr Matls Characterization*** credit: 4 hours.
Laboratory methods, such as mercury intrusion porosimetry, gas absorption, thermal analysis, scanning electron microscopy, and X-ray diffraction, used to characterize civil engineering materials. General topics covered for each methods are theoretical background, calculation methods, models, and underlying assumptions, as well as operation of the instrument. Prerequisite: CEE 401.

502 ***Advanced Cement Chemistry*** credit: 4 hours.
Advanced topics in chemistry of portland cement, chemistry and microstructure of cements, chemical reactions that lead to hardening, chemistry and microstructure of hydrated cements, effects of chemical and mineral admixtures, and chemical issues involved in the engineering behavior of the cements. Prerequisite: CEE 401.

506 ***Pavement Design II*** credit: 4 hours.
Development of models for and analysis of pavement systems; use of transfer functions relating pavement response to pavement performance; evaluation and application of current pavement design practices and procedures; analysis of the effects of maintenance activities on pavement performance; economic evaluation of highway and airport pavements. Prerequisite: CEE 406.

508 ***Pavement Evaluation and Rehab*** credit: 4 hours.
Concepts and procedures for condition survey rating; evaluation by nondestructive testing (roughness, skid resistance, structural capacity): destructive testing, maintenance strategies, rehabilitation of pavement systems for highways and airfields. Prerequisite: CEE 406.

509 ***Transportation Soils*** credit: 4 hours.
Occurrence and properties of surficial soils, soil classification systems, soil variability; subgrade evaluation procedures, repeated loading behavior of soils; soil compaction and field control; soil moisture, soil temperature, and frost action; soil trafficability and subgrade stability for transportation facility engineering. Prerequisite: CEE 483.

512 ***Logistics Systems Analysis*** credit: 4 hours.
Planning, design and operations of complex logistics systems: logistics costs; production, transportation and distribution systems; lot-sizing; traveling salesman problem (TSP) and vehicle routing problem (VRP); transshipments; facility location problem; supply chain management and inventory control; order instability; analytical methods and practical solution techniques. Prerequisite: CEE 310 and IE 310.

515 ***Traffic Flow Theory*** credit: 4 hours.
Fundamentals of traffic flow, traffic flow characteristics, statistical distributions of traffic flow parameter, traffic stream models, car following models, continuum follow models, shock wave analysis, queuing analysis, traffic flow models for intersections, network flow models and control, traffic simulation. Prerequisite: CEE 416 and knowledge of probability and statistics.

516 ***Network Analysis of Systems*** credit: 4 hours.
Same as IE 512. See IE 512.

524 ***Construction Law*** credit: 4 hours.
Introduction to the legal aspects of the construction process and the potential liability that engineers can incur through the design, and post-construction processes. Organization and operation of the American court system, contact formation, defenses, remedies, and typical areas of dispute, and design services contracts, torts, product liability, agency, business organizations, intellectual property, and risk managements. Includes a mock trial of a recent construction-related case with the class serving as plaintiffs and defendants. Prerequisite: CEE 420, CEE 421, and CEE 422.

525 ***Construction Case Studies*** credit: 4 hours.
Case studies of bridges, tunnels, buildings, transportation systems, heavy industrial construction, waterways, and marine structures in the context of construction engineering and management. Research, a team-oriented term project, presentations, and discussions in studio-style format. Prerequisite: Two of CEE 420, CEE 421, and CEE 422.

527 ***Constr Conflict Resolution*** credit: 4 hours.
Basic theories and applications of dispute avoidance and resolution techniques in the construction industry. Mechanisms to promote collaborative environments and resolve disputes in construction projects; the different steps in the Dispute Resolution Ladder and the main features of a conflict management plan; case studies of practical applications of disputes avoidance and resolution techniques in the construction industry throughout the world. Prerequisite: One of CEE 420, CEE 421, CEE 422.

528 ***Construction Data Modeling*** credit: 4 hours.
Introduces state-of-the-art research and literature in the construction data modeling domain. Fundamental techniques of construction data modeling; existing construction data representation approaches and specifications for the architecture, engineering, and construction domain; building information models; capabilities and limitation of data process models and representation approaches and techniques. Prerequisite: Two of CEE 420, CEE 421, CEE 422.

534 ***Surface Water Quality Modeling*** credit: 4 hours.
Mathematical modeling of the movement and fate of pollutants and other substances in streams, lakes, and other natural water bodies. Development of one-, two-, and three-dimensional differential conservation equations, one-, two-, and three-dimensional steady-state and transient solutions. Finite difference, finite element, and finite particle methods. Lagrangian and Eulerian formulations, diffusion and dispersion tensors, numerical dispersion, and solution stability. Kinetic relationships describing important physical, chemical, and biochemical water constituent transformation phenomena. Field or laboratory experiment in model calibration and verification. Same as CSE 564. Prerequisite: MATH 285, CEE 442, and CEE 451.

535 ***Environmental Systems II*** credit: 4 hours.
Fundamental concepts of uncertainty, risk, and reliability applied to environmental and water resources decision making. Chance constraints, Markov and Monte Carlo modeling, geostatistics, unconditional and conditional simulation, genetic algorithms, neural networks, simulated annealing, and a review of relevant portions of basic probability and statistical theory. Many techniques are applied to a real-world environmental decision making problem initially developed in CEE 434. Prerequisite: CEE 202 and CEE 434.

536 ***Multiattribute Decision Making*** credit: 4 hours.
Same as GE 530. See GE 530.

537 ***Water Quality Control Proc I*** credit: 4 hours.
Theory and basic design of processes used in water and wastewater treatment, including adsorption, ion exchange, chemical oxidation and reduction, disinfection, sedimentation, filtration, coagulation, flocculation, and chemical precipitation. Prerequisite: Credit or concurrent registration in CEE 442 and CEE 443.

538 ***Water Quality Control Proc II*** credit: 4 hours.
Theory and its application for design and operation of processes used in water and wastewater treatment; emphasis is on biological treatment processes and related processes for gas transfer, sludge dewatering, sludge disposal, and solids separations. Prerequisite: CEE 442 and CEE 443; credit or concurrent registration in CEE 444.

540 ***Remediation Design*** credit: 4 hours.
Evaluation and design of alternative treatment processes for hazardous waste sites contaminated with organic and/or metal wastes. Group design project due at the end of the term. Prerequisite: CEE 440.

545 ***Aerosol Sampling and Analysis*** credit: 4 hours.
Principles of sampling for particles and gases in the field of air pollution; examines instrumental techniques relevant to the design of sampling systems used in process control, ambient air monitoring, and laboratory experiments; methods of sample analysis and their limitations. Same as ATMS 535, ENVS 545, and ME 516. Prerequisite: CEE 446 and MATH 285.

546 ***Air Quality Control*** credit: 4 hours.
Application of principles describing the generation, separation, and removal of air contaminants from gas streams generated by stationary sources. Local field trips typically occur each term to see the application of the air quality control devices in the field. Same as ME 515. Prerequisite: CEE 442 and CEE 446.

550 ***Hydroclimatology*** credit: 4 hours.
Application of deterministic and probabilistic concepts to simulate and analyze hydrologic systems; discussion of the theory and application of linear and nonlinear, lumped, and distributed systems techniques in modeling the various phases of the hydrologic cycle. Prerequisite: CEE 450.

551 ***Open-Channel Hydraulics*** credit: 4 hours.
Advanced hydraulics of free surface flow in rivers and open channels; discussion of theory, analytical and numerical solution techniques, and their applications to gradually and rapidly varied nonuniform flows, unsteady flow, and flow in open-channel networks. Prerequisite: CEE 451.

552 ***River Basin Management*** credit: 4 hours.
Introduction to the multidisciplinary knowledge (hydrology, economics, systems engineering, etc.) and methodological skills (optimization, simulation, etc.) for river basic management. River basin characterization-natural and social features; water availability assessment based on hydrology, infrastructure, and policy;

environmental flow requirements; water demand management and microeconomics theory; integrated river basic management modeling. Prerequisite: CEE 350 and CEE 434.

555 ***Mixing in Environmental Flows*** credit: 4 hours.
Physical processes involved in transport of pollutants by water; turbulent diffusion and longitudinal dispersion in rivers, pipes, lakes, and the ocean; diffusion in turbulent jets, buoyant jets, and plumes. Prerequisite: MATH 241 or MATH 380; MATH 285; TAM 335.

557 ***Groundwater Modeling*** credit: 4 hours.
Theory and application of numerical methods, finite differences and finite element, for solving the equations of groundwater flow and solute transport; transport of chemically reacting solutes; model calibration and verification. Same as CSE 565. Prerequisite: CEE 457 and MATH 285.

559 ***Sediment Transport*** credit: 4 hours.
Physical processes of transportation and deposition of sediment particles in liquid bodies with particular emphasis on fluvial sediment problems; sediment in desilting basins; reservoirs and delta formation; erosion; stable channel design; river morphology. Prerequisite: CEE 551.

560 ***Steel Structures III*** credit: 4 hours.
Theories of ultimate behavior of metal structural members with emphasis on buckling and stability of members and frames; theory of torsion applied to beam torsion, lateral-torsional buckling, curved beams with emphasis on design criteria; post-buckling strength of plates and post-buckling versus column behavior. Prerequisite: CEE 462.

561 ***Reinforced Concrete III*** credit: 4 hours.
In-depth study of the behavior of reinforced concrete members, including the relationships between behavior and building code requirements. Prerequisite: CEE 463.

563 ***Reinforced Concrete IV*** credit: 4 hours.
Strength and behavior of assemblages of reinforced concrete members, including a study of the applicability of traditional elastic design procedures to structures which exhibit inelastic behavior under the influence of both short and long term loadings. Prerequisite: CEE 561.

570 ***Finite Element Methods*** credit: 4 hours.
Theory and application of the finite element method; stiffness matrices for triangular, quadrilateral, and isoparametric elements; two- and three-dimensional elements; algorithms necessary for the assembly and solution; direct stress and plate bending problems for static, nonlinear buckling and dynamic load conditions; displacement, hybrid, and mixed models together with their origin in variational methods. Same as CSE 551. Prerequisite: CEE 471 or TAM 551.

571 ***Plates and Shells*** credit: 4 hours.
Classical plate bending theory; emphasis on methods of solution including series expansions, variational procedures, and finite element techniques applicable to plate-type structures commonly encountered in practice; consideration of inplane loads, large deflections, buckling, and anisotropy. Prerequisite: CEE 471.

572 ***Earthquake Engineering*** credit: 4 hours.
Source mechanisms, stress waves, and site response of earthquake shaking; effect on the built environment; nature of earthquake actions on structures; fundamental structural response characteristics of stiffness, strength, and ductility; representation of the earthquake input in static and dynamic structural analysis; modeling of steel and concrete structures under earthquake effects; outputs for safety assessment; comprehensive source-to-design actions project. Prerequisite: CEE 472.

573 ***Structural Dynamics II*** credit: 4 hours.
Advanced concepts in structural dynamics and fundamentals of experimental structural dynamics. Modern system theory; data acquisition and analysis; digital signal processing; experimental model analysis theory and implementation; random vibration concepts; system identification; structural health monitoring and damage detection; pseudo-dynamic testing and model-based simulation; smart structures technology (e.g., smart sensors; passive, active, and semi-active control). Prerequisite: CEE 472.

574 ***Probabilistic Loads and Design*** credit: 4 hours.
Application of probabilistic methods in describing and defining loads on structures with emphasis on the random fluctuation in time and space. Introduction to random vibration methods and applications to dynamic response of structures under wind and earthquake loads. Computer simulation of structural loads and responses. Probability-based safety criteria and review of current methods of selection of design loads and load combinations. Prerequisite: CEE 202 and CEE 472.

575 ***Fracture and Fatigue*** credit: 4 hours.
Fatigue and fracture behavior of steel structures and connections; fatigue and fracture mechanics theory and experimental data; assessment of behavior and current design specification practice. Prerequisite: CEE 462.

576 ***Nonlinear Finite Elements*** credit: 4 hours.
Nonlinear formulations in solid mechanics and nonlinear equation solving strategies; finite deformation (hyperelasticity) elastostatics and elastodynamics, semi-discrete weighted residual formulations, implicit and explicit time-stepping algorithms and stability analysis; theory of mixed finite element methods, strain-projection methods, and stabilized methods; mixed methods for nonlinear coupled-field problems. Prerequisite: CEE 471 or TAM 445; CEE 470 or ME 471.

580 ***Excavation and Support Systems*** credit: 4 hours.
Classical and modern earth pressure theories and their experimental justification; pressures and bases for design of retaining walls, bracing of open cuts, anchored bulkheads, cofferdams, tunnels, and culverts. Prerequisite: Credit or concurrent registration in CEE 484.

581 ***Earth Dams*** credit: 4 hours.
Fundamentals of problems of slope stability; seepage in composite sections and anisotropic materials; methods of stability analysis; mechanism of failure of natural and artificial slopes; compaction; field observations. Prerequisite: Credit or concurrent registration in CEE 484.

582 ***Consolidation of Clays*** credit: 4 hours.
Elastic solutions relevant to soil mechanics; permeability; general application of Terzaghi's theory of one-dimensional consolidation; advances in consolidation theories; mechanism of volume change; delayed and

secondary compressibility and creep; theory of three-dimensional consolidation and solutions; radial flow and design of sand drains; analysis and control of settlement. Prerequisite: CEE 483.

583 ***Shear Strength of Soils*** credit: 4 hours.
Physico-chemical properties of soils; fabric and structure of soil; mechanism of shearing resistance; residual shear strength of overconsolidated clays and clay shales; long-term shear strength of overconsolidated clays; Hvorslev shear strength parameters; undrained shear strength of clays. Prerequisite: CEE 483.

584 ***Geotechnical Case Histories*** credit: 4 hours.
Critical study of case histories of projects in geotechnical engineering; current practice in the design and construction of foundations, embankments, and waterfront structures. Prerequisite: CEE 484.

585 ***Deep Foundations*** credit: 4 hours.
Ultimate capacities and load-deflection of piles and drilled shafts subjected to compressive loads, tensile loads, and lateral loads; effects of duration of load, soil-structure interaction; two- and three-dimensional analysis of pile groups with closely-spaced piles; effects of installation; inspection of deep foundations and full-scale field tests. Prerequisite: CEE 484.

586 ***Rock Mechanics and Behavior*** credit: 4 hours.
Physical properties and classification of intact rock, theories of rock failure, state of stress in the earth's crust, stresses and deformations around underground openings assuming elastic, plastic, and time-dependent behavior; effect of geologic discontinuities on rock strength; introduction to stability analyses in rock. Prerequisite: CEE 483, GEOL 550, and TAM 451.

587 ***Applied Rock Mechanics*** credit: 4 hours.
Application of rock mechanics to engineering problems; shear strength of rock masses; dynamic and static stability of rock slopes; deformability of rock masses; design of pressure tunnel linings and dam foundations; controlled blasting and blasting vibrations; tunnel support; machine tunneling; design and construction of large underground openings; field instrumentation. Prerequisite: CEE 586.

588 ***Geotechnical Earthquake Engrg*** credit: 4 hours.
Seismic hazard analysis, cyclic response of soils and rock; wave propagation through soil and local site effects; liquefaction and post liquefaction behavior, seismic soil-structure of foundations and underground structures, seismic design of retaining walls, underground structures and tunnels. Construction and machine vibrations. Blasting. Prerequisite: CEE 472 and CEE 483.

589 ***Computational Geomechanics*** credit: 4 hours.
Numerical modeling, multi-phase domain equations, constitutive modeling of soils and rock, continuum and discrete element modeling. Upper and lower bound limit analysis methods. Simulation of soil-structure interaction problems and construction activities. Prerequisite: CEE 483. Recommended: one of AE 420, CEE 470, CSE 451, or ME 471.

595 ***Seminar*** credit: 0 to 1 hours.

Discussion of current topics in civil and environmental engineering and related fields by staff, students, and visiting lecturers. Approved for S/U grading only. May be repeated.

597 ***Independent Study*** credit: 1 to 16 hours.
Individual investigations or studies of any phase of civil engineering selected by the student and approved by the adviser and the staff member who will supervise the investigation. May be repeated. Prerequisite: Consent of instructor.

598 ***Special Topics*** credit: 1 to 4 hours.
Subject offerings of new and developing areas of knowledge in civil and environmental engineering intended to augment the existing curriculum. See Class Schedule or departmental course information for topics and prerequisites. May be repeated in the same or separate terms if topics vary.

599 ***Thesis Research*** credit: 0 to 16 hours.
Approved for S/U grading only. May be repeated.