4300:500 Introduction to Nuclear Power Generation and Simulation (3 Credits)
Prerequisites: Admission to the Graduate Nuclear Engineering Certificate Program and permission of advisor. Nuclear power history, fundamental reactions, thermodynamic heat cycles, 1-fluid homogeneous simulator thermodynamics, steam, numerical simulation of commercial nuclear power plants, controls.

4300:501 Nuclear Reactor Engineering and Balance of Plant Systems (3 Credits)

4300:502 Nuclear Process and Radioactive Waste Management, Safeguards (3 Credits)
Prerequisite: Admission to Nuclear Engineering Certificate program and permission of advisor. Nuclear industry chemistry, processing and waste disposal. Nuclear material safeguards, security and response systems. Radiation process and shielding, reactor licensing and safety, and the environment.

4300:503 Nuclear Thermodynamics, Simulation, and Advanced Reactor (3 Credits)
Prerequisite: Admission to Nuclear Engineering Certificate program and permission of advisor. Reactor power distribution, thermal and exposure limits, critical heat flux and pressure design, neutronic/thermal hydraulic relationships. Full-plant simulation with advanced BOP components.

4300:514 Design of Earth Structures (3 Credits)
Prerequisite: 4300:314 or permission. Design of earth structures; dams, highway fills, cut and fill, etc. Embankment construction techniques, quality control, embankment analysis, instrumentation, foundation soil stabilization, seepage analysis and control. Design problem. Graduate students will perform more advanced analysis and design.

4300:518 Soil & Rock Exploration (3 Credits)
Prerequisite: 4300:314 or permission. Soil exploration criteria and planning. Conventional boring, sampling and in situ testing methods. Theory and application of geophysics and geophysical methods including seismic, electrical resistivity, gravity, magnetic and radioactive measurements. Air photo interpretation.

4300:523 Chemistry for Environmental Engineers (3 Credits)
Prerequisite: One year of college chemistry. General, physical, organic, biochemistry, equilibrium, and colloidal chemistry concepts applied to environmental engineering. Concepts are used in water and wastewater laboratory.

4300:526 Environmental Engineering Design (3 Credits)
Prerequisite: 4300:323. An introduction to the physical, chemical and biological processes utilized in the treatment of water and wastewater, with design parameters emphasized.

4300:527 Water Quality Modeling & Management (3 Credits)
Prerequisite: 4300:323. Analysis and simulation of the physical, chemical and biochemical processes affecting stream quality. Development of management strategies based upon the application of water quality modeling techniques to environmental systems.

4300:528 Hazardous & Solid Wastes (3 Credits)
Prerequisite: senior standing or permission of instructor. Hazardous and solid waste quantities, properties and sources are presented. Handling, processing, storage and disposal methods are discussed with non-technical constraints outlined.

4300:543 Advanced Mechanics of Materials (3 Credits)

4300:551 Computer Methods of Structural Analysis (3 Credits)
Prerequisite: 4300:341. Review of design principles; urban hydraulics, steam channel mechanics, sedimentation, coastal engineering.

4300:553 Optimum Structural Design (3 Credits)
Prerequisite: 306. Basic concepts in structural optimization. Mathematical programming methods including unconstrained minimization, multidimensional minimization and constrained minimization.

4300:554 Advanced Mechanics of Materials (3 Credits)

4300:563 Transportation Planning (3 Credits)
Prerequisite: 4300:361. Theory and techniques for development, analysis and evaluation of transportation systems. Emphasis on understanding and using tools and professional methods available to solve transportation planning problems, especially in urban areas.

4300:564 Highway Design (3 Credits)
Prerequisite: 4300:361. Study of modern design of geometrical and pavement features of highways. Design problem and computer use. Graduate students will produce a more complete design.

4300:565 Pavement Engineering (3 Credits)
Prerequisite: 4300:361. Theories of elasticity, of viscoelasticity and of layered systems as applied to pavements. Pavement materials characterization; pavement design, pavement restoration for rigid and flexible pavements.

4300:566 Traffic Engineering (3 Credits)
Prerequisite: 4300:361. Vehicle and urban travel characteristics, traffic flow theory, traffic studies, accidents and safety, traffic signs and marking, traffic signal planning, traffic control and transportation administration.

4300:567 Advanced Highway Design (3 Credits)
Prerequisite: 4300:564, Autocad or permission. Computer-aided geometric design of highways including survey data input, digital terrain modeling, cross-section templates, horizontal and vertical roadway design, earthwork computations, and advanced topics.

4300:568 Highway Materials (3 Credits)
Prerequisites: 4300:361, 4300:380 or permission. Properties of aggregates, manufacture and properties of portland cement concrete, properties of asphaltic materials, design and testing of hot mix asphalt pavement mixes and of surface treatments. Laboratory preparation of specimens and determination of properties. Graduate student requirement: Graduate students will be required to perform an additional eight-hour asphalt laboratory (Abson recovery of asphalt from solution) and to prepare a paper on a highway materials topic.
4300:574 Underground Construction (2 Credits)
Prerequisite: 4300:314. Description of practices and techniques of underground construction. Selection of proper method for individual job. Design of underground openings, support systems and linings.

4300:604 Dynamics of Structures (3 Credits)

4300:605 Structural Stability (3 Credits)

4300:606 Energy Methods & Elasticity (3 Credits)

4300:607 Prestressed Concrete (3 Credits)
Prerequisite: 4300:404. Basic concepts. Design of double-tee roof girder; shear; development length; column; piles; design of highway bridge girder; pretensioned, post-tensioned; continuous girders; corbels; volume-change forces; connections.

4300:608 Multistory Building Design (3 Credits)
Prerequisite: 4300:401. Floor systems; staggered truss system; braced frame design; unbraced frame design; drift indices; monocoque (tube and partial tube) systems; earthquake design; fire protection. Analysis by STRUDL.

4300:609 Finite Element Analysis I (3 Credits)
Prerequisite: 4300:554 or equivalent. Introductory development of finite element method as applied to various topics from continuum mechanics. Such areas as plane, axisymmetric and 3-D stress analysis; conduction, fluid mechanics; transient problems and geometric and material nonlinearity.

4300:610 Composite Materials in Civil Infrastructure (3 Credits)
Prerequisite: 4300:554 or equivalent. Constituent materials; manufacturing processes; panel properties by micro/macromechanics; simplified analysis of composite beams, columns, and applications to highway bridges; composites in concrete and wood structures.

4300:611 Fundamentals of Soil Behavior (2 Credits)
Prerequisite: 4300:314. In-depth examination of structure and fundamental physico-chemical and mechanical properties of engineering soils viewed as particulate matter.

4300:612 Advanced Soil Mechanics (3 Credits)
Prerequisite: 4300:314. Study of mechanics of behavior of soil as continuum. Principles of stress, strain, deformation, shear strength and pore water pressure as applied to mechanical behavior of soil masses.

4300:613 Advanced Geotechnical Testing (3 Credits)
Prerequisites: 4300:518 and 4300:612. Theory and practice of static and dynamic in situ and laboratory soil testing. Testing procedures, applicability, limitations. General evaluation of geotechnical parameters for routine and special site conditions. One lecture, two laboratories per week.

4300:614 Foundation Engineering I (3 Credits)
Prerequisite: 4300:313 or permission. Foundation bearing capacity and settlement analysis. Design of shallow and deep foundation systems. Pile driving and load test procedures and analysis. Theory and design of earth-retaining structures including retaining walls, tiebacks and bulkheads.

4300:615 Foundation Engineering II (3 Credits)
Prerequisite: 4300:614 or permission. Soil-structure interaction theory and applications to underground structures including conduits, tunnels and shafts. Advanced foundation construction methods and problems including dewatering, soil stabilization, underpinning and cofferdams. Slope stability analysis.

4300:616 Soil Improvement (3 Credits)
Prerequisites: 4300:313 and 4300:314. Admixture stabilization, precompression with vertical drains, blasting, vibrocompaction, injection and grouting, thermal methods, electro-osmosis, soil reinforcement, case studies.

4300:617 Numerical Methods in Geotechnical Engineering (3 Credits)

4300:618 Rock Mechanics (3 Credits)
Prerequisite: 4300:554 or permission. Mechanical nature of rocks; linear elasticity and application to rock problems; inelastic behavior of rocks, time dependence and effects of pore pressure, experimental characterization of rock properties; failure theory and crack propagation.

4300:620 Sanitary Engineering Problems (2 Credits)
Prerequisite: 4300:323. Application of both laboratory methods and theory to solution of sanitary engineering problems involving water pollution, stream regeneration, special industrial wastes, detergents and others.

4300:621 Environmental Engineering Principles (4 Credits)
Corequisite: 4300:523. Provide the basic principles of chemical reaction engineering, microbiology, environmental regulations, and contaminant migration required for the understanding and solving environmental problems.

4300:622 Aquatic Chemistry (3 Credits)
Prerequisites: 3150:151 and 3150:153 or permission. Quantitative treatment of variables that govern the chemistry of aquatic systems. Emphasis on carbonate in open-closed systems, metal complexation and solubility, and oxidation-reduction reactions.

4300:623 Physical/Chemical Treatment Processes (3 Credits)
Prerequisite or corequisite: 4300:621. Theory, current research associated with physical/chemical processes, the impact on design-coagulation/flocculation, sedimentation, filtration, absorption processes emphasized.

4300:624 Biological Treatment Processes (3 Credits)
Prerequisite or corequisite: 4300:621. Theory, current research associated with biological processes, related physical/chemical processes, the impact on design-activated sludge, fixed film processes, gas transfer, sludge stabilization, sludge dewatering processes emphasized.

4300:625 Water Treatment Plant Design (3 Credits)
Prerequisite: 4300:623. Design of water treatment plants for potable, industrial and commercial uses. Development of water sources, treatment methods and financing used to design best practical methods in terms of cost-benefits.
4300:526 Wastewater Treatment Plant Design (3 Credits)
Prerequisite: 4300:624. Application of theory and fundamentals to
design of wastewater treatment plants. System design methods used for
biological and chemical stabilization of wastewater to meet water quality
criteria. Economic analyses made to determine best practical designs to
be utilized.

4300:627 Environmental Operations Laboratory (2 Credits)
Prerequisite: 4300:426 or permission of instructor. Conduction of
laboratory experiments related to the design and operation of water and
wastewater treatment processes. Experimental design, data collection,
analysis and report preparation.

4300:628 Advanced Chemical Oxidation Process (3 Credits)
Prerequisites: 3150:151 and 3150:153 or permission. Qualitative and
quantitative treatment of variables that govern process chemistry and
kinetics in water. Emphasis on ozone, hydrogen peroxide, and ultra-violet
light (UV).

4300:631 Soil Remediation (3 Credits)
Prerequisite: 4300:621 or permission. Provide a thorough understanding of site characterization, traditional soil remediation technologies, as well as present new and emerging remediation technologies.

4300:635 Air Pollution Control (3 Credits)
Prerequisite: 4300:621 or permission. Introduction to air pollution control philosophies, approaches, regulations, and modeling. Also contains an in-depth evaluation/design approach for the control of particular matter, SOx, and NOx.

4300:640 Advanced Fluid Mechanics (3 Credits)
Prerequisite: 4500:310 or permission. Basic equations, Navier-Stokes
equations. Analysis of potential flow, turbulence, hydraulic transients.
Solution of typical fluid mechanics problems. Analysis of water hammer in pipe networks by method of characteristics.

4300:644 Open Channel Hydraulics (3 Credits)
Application of basic principles of fluid mechanics to flow in open
channels. Criteria for analysis of uniform, gradually varied and rapidly
varied flows. Study of movement and transportation of sediments. Design
problems utilizing numerical techniques.

4300:645 Applied Hydrology (3 Credits)
Discussion of water cycle such as precipitation, evaporation, stream
flows, floods, infiltration. Methods of analysis and their application to
studies of water demand, storage, transportation including mathematical
modeling of urban runoff and statistical hydrology.

4300:646 Coastal Engineering (3 Credits)
Characteristics of linear and nonlinear wave theories. Interaction of
structures, waves; design analysis of shore, offshore structures.
Movement, transportation of sediments in lake shore areas.

4300:663 Advanced Transportation Engineering I (3 Credits)
Prerequisites: 4300:361 and 4300:466, or permission. Highway and
parking facility design, transportation planning, highway capacity
estimates, signal systems and optimization, incident detection and
management, freeway ramp metering, and highway traffic safety.

4300:664 Advanced Transportation Engineering II (3 Credits)
Prerequisites: 4300:361 and 4300:466 or permission. Highway and
parking facility design, transportation planning, highway capacity
estimates, signal systems and optimization, incident detection and
management, freeway ramp metering, and highway traffic safety.

4300:665 Traffic Detection and Data Analysis (3 Credits)
Prerequisite: 4300:361 or consent of instructor. Theory and application of
pressure tubes, loop detectors, and imaging sensing, microwave, infrared,
ultrasonic, laser detectors. Parameter estimation, reliability, and data
mining and fusion.

4300:681 Advanced Engineering Materials (3 Credits)
Selected topics on principles governing mechanical behavior of materials
with respect to elastic, plastic and creep responses, stress rupture,
low and high cycle and thermal fatigue. Failure theories and fracture
phenomena in brittle and ductile materials. Crack propagation and life
prediction of engineering materials.

4300:682 Elasticity (3 Credits)
Prerequisite: 4300:202. Plane stress, plane strain. Two-dimensional
problems in rectangular, polar coordinates. Strain-energy methods.

4300:683 Plasticity (3 Credits)
Prerequisite: 4300:682, 4600:622 or equivalent. Mathematical formulation
of constitutive equations with focus on their use in structural analysis.
Internal variables. Isotropic, kinematic hardening. Nonisothermal

4300:684 Advanced Reinforced Concrete Design (3 Credits)
Prerequisite: 4300:403. Slab systems. Equivalent frame properties. Limit
Biaxial column action.

4300:685 Advanced Steel Design (3 Credits)
Prerequisite: 4300:401. Properties of steel, fasteners, bearing, friction
joints, Gusset plates, bolts in tension, end plates, weld joints, cyclic loads,
fatigue analysis, types of detail, torsion, stability design.

4300:686 Experimental Methods in Structural Mechanics (3 Credits)
Prerequisite: 4300:682. Electrohydraulic closed-loop test systems.
Methods for specimen heating. Strain measurement techniques for room
and elevated temperatures. Design of computer controlled experiments
investigating deformation and failure under complex stress states.

4300:687 Limit Analysis in Structural Engineering (3 Credits)
Prerequisites: 4300:454, 4300:554, 4300:682. Fundamental theorems of
limit analysis. The lower-bound and upper-bound solutions. Applications
to frames, plates and plane stress and plane strain problems.
Design considerations. Mathematical programming and computer
implementation.

4300:694 Advanced Seminar in Civil Engineering (1-3 Credits)
Prerequisite: permission. Advanced projects, reading, studies, or
experimental in various areas of civil engineering.

4300:697 Engineering Report (2 Credits)
Prerequisite: Permission of advisor. A relevant problem in civil engineering for students electing the non-thesis option. The final
engineering report must be approved by the advisor and the advisory
committee.

4300:698 Master's Research (1-6 Credits)
Prerequisite: Permission of advisor. (May be repeated.) Research on a
suitable topic in civil engineering culminating in a master's thesis.

4300:699 Master's Thesis (1-6 Credits)
Prerequisite: permission. Research and thesis on some suitable topic in
civil engineering as approved by department. Defense of thesis is by final
examination.
4300:701 Earthquake Engineering (3 Credits)

4300:702 Plates & Shells (3 Credits)

4300:703 Viscoelasticity & Viscoplasticity (3 Credits)

4300:704 Finite Element Analysis II (3 Credits)

4300:710 Advanced Composite Mechanics (3 Credits)

4300:712 Dynamic Plasticity (3 Credits)
Prerequisite: 4300:683 or 4300:703. Impulsive and transient loading of structural elements (beams, plates, shells, etc.) in which inelastic deformation occurs. Topics include: longitudinal and transverse plastic wave propagation in thin rods, propagation of plastic hinges, rate-dependent viscoplastic waves, transverse impact on beams and plates, high-rate forming, blast loading, plate perforation, shock waves in solids.

4300:717 Soil Dynamics (3 Credits)
Prerequisite: 4300:614 or permission. Vibration and wave propagation theory relating to soils, soil structures and foundations. Dynamic behavior of soils. Design of foundations for dynamic loading impact, pulsating and blast loads.

4300:731 Bioremediation (3 Credits)
Prerequisite: 4300:621 or permission. Provide the fundamentals required for understanding and successfully implementing the biodegradation of hazardous compounds coupled with the design and operational techniques of bioremediation systems.

4300:745 Seepage (2 Credits)
Discussion of parameters determining permeability of various soils. Analytical, numerical and experimental methods to determine two- or three-dimensional movement of groundwater. Unsteady flows.

4300:898 Preliminary Research (1-15 Credits)
(May be repeated for a total of 15 credits.) Prerequisite: approval of dissertation director. Preliminary investigations prior to the submission of a dissertation proposal to the interdisciplinary Doctoral Committee.

4300:899 Doctoral Dissertation (1-15 Credits)
(May be taken more than once.) Prerequisite: acceptance of research proposal by the Interdisciplinary Doctoral Committee and approval of the dissertation director. Original research by the doctoral student.