4553 Instrumental Characterization of Organic Compounds (2) Prereq.: CHEM 2001, 2002 and 4532. 6 hrs. lab. In this laboratory course, students learn the principles of some basic instrumental methods of analysis.

4556 Analytical Spectroscopy (3) Prereq.: CHEM 2001 and credit or registration in CHEM 3491. Basic principles of spectroscopy for chemical analysis emphasizing optical methods: UV/VIS absorbance, fluorescence, vibrational spectroscopy, and NMR.

4557 Analytical Separations (3) Prereq.: CHEM 2001 and credit or registration in CHEM 3492. Basic principles of chemical separations and analytical separations and chromatography. Gas chromatography, liquid chromatography, electrophoresis, and related detection techniques.

4558 Mass Spectrometry (3) Prereq.: CHEM 2001 and credit or registration in CHEM 3492. Fundamentals of mass spectrometry, including ion formation, mass separation, detection and structure determination.

4559 Electroanalytical Chemistry (3) Prereq.: CHEM 2001 and credit or registration in CHEM 3491. Basic principles of electrochemical reactions, electroanalytical voltammetry methods for analysis, the chemistry of heterogeneous electron transfer, electrochemical instrumentation, micro- and nanoelectrodes, surface modification for electro-catalysis and sensing.

4561 Intermediate Physical-Organic Chemistry (3) F Prereq.: CHEM 2452 or 2462 and 3492. Selected topics in kinetics, reaction mechanisms, applications of quantum mechanics to organic chemistry, and related topics in physical-organic chemistry.

4562 Intermediate Organic Chemistry (3) F Prereq.: CHEM 2262 or 2462. Selected topics in synthesis, natural products chemistry, reaction mechanisms, and related topics in structural and synthetic organic chemistry.

4563 Problems in Organic Structure Elucidation (3) Prereq.: CHEM 2262 or 2462 and 3492. Focus on interpretation of multiple types of NMR spectra, mass spectra or other spectra relevant to structure elucidation; extensive utilization of actual spectra in problem solving sessions.

4564 Advanced Organic and Inorganic Laboratory (3) Prereq.: CHEM 2364 or equivalent. 1 hr. lecture; 6 hrs. lab. Laboratory usage deposit. Organic and inorganic preparation and characterization of synthetic methods and modern characterization techniques.

4570 Advanced General Inorganic Chemistry (3) Prereq.: credit or registration in CHEM 3492. For advanced undergraduate and beginning graduate students. Principles in advanced inorganic chemistry; modern interpretations.

4571 Organometallic Chemistry (3) Prereq.: CHEM 2262 or 2462 and credit or registration in CHEM 3492. Chemistry and principles of metal bonds with metal to carbon sigma and pi bonds; bonding concepts, electronic structure, periodic trends and fundamental reaction mechanisms; applications to homogeneous catalysis.

4572 Fundamentals of Bio-Organic Chemistry (3) S Prereq.: CHEM 3492 or BIOL 4001. Concepts of coordination chemistry, biochemistry, and physical methods used in the coordination chemistry of biology with application to selected chemical problems.

4581 Introduction to Mathematical Chemistry (3) V Prereq.: MATH 2057 and credit or registration in CHEM 3491. Mathematical methods of chemistry, with application to selected chemical problems.

4594 Introduction to Quantum Chemistry (3) V Prereq.: CHEM 3492 and MATH 2057. Basic ideas of quantum mechanics; application to atomic and molecular structure.

4596 Chemical Thermodynamics (3) V Prereq.: CHEM 2262 or 2462 and 3492. Principles of macroscopic thermodynamics and application to systems of chemical relevance.

4597 Introduction to Statistical Thermodynamics (3) V Prereq.: CHEM 3492 and MATH 2057. Introductory quantum and classical statistical thermodynamics of some simple systems of chemical relevance.

6001 Chemistry Instruction Through Demonstration and Experiments (3) Prereq.: one year of college chemistry. 2 hrs. lecture; 3 hrs. lab. Demonstration techniques for junior and senior chemistry laboratory experiments. Hands-on experience.

6002 Chemical Principles for Teachers (3) Su-V Prereq.: credit for CHEM 2012 or 1422 or equivalent. For high school and junior college teachers; part of the MNS degree program. May be taken for a max. of 6 sem. hrs. of credit when topics vary.

7010 Microscale Systems III (3) F Prereq.: CHEM 4010. Introduction to representative classes of macromolecules; emphasis on polymerization mechanisms and techniques of polymer analysis, including synthesis of inorganic polymers, biopolymers, and conjugated polymers.

7011 Macromolecular Systems IV (3) S Prereq.: CHEM 4011. Structure property relationships for materials such as liquid crystals; polymer blends, and block copolymers; polymer/nanocomposites and nanotechnology related materials.

7221 Chemical Dynamics and Kinetics (3) Prereq.: CHEM 4591 and 3492. Reaction rates in the gas phase and in solution; chemical dynamics; gas phase and solution kinetics; applications of kinetics and chemical dynamics to mechanistic studies; modern experimental techniques.

7261 Polymerization and Polycrystallization Processes (4) S V or CH. May be taken four times for credit.

7272 Inorganic Chemistry of Transitional Elements (2) V Prereq.: CHEM 4570 or equivalent. Chemistry of transitional elements including structural chemistry, coordination chemistry, organometallic chemistry; theories of the coordinate bond and their application to spectra, magnetism, and kinetics and mechanisms of complexes.

7290 Statistical Mechanics and Thermodynamics (3) V Methods of statistical mechanics of independent and inter-acting particles including ideal gases, real gases, crystal structures, phase transitions, chemical equilibrium, and chemical equilibria; advanced topics and areas of current research.

7291 Quantum Chemistry (3) V Methods of quantum mechanics applied to chemical bonding, and other chemical properties; oscillators, rotors, hydrogen-like wave functions, perturbation and variation theories, configuration interaction, pi-electron systems, spin, and empirical methods.

7292 Special Topics in Chemical Physics (2-3) May be taken 4 times for credit. Specialized areas of physical chemistry.

7750 Special Topics in Analytical Chemistry (3-5) May be taken 4 times for credit. Modern methods and techniques of analytical chemistry.

7760 Special Topics in Organic Chemistry (2-3) May be taken 4 times for credit. Specialized areas of current interest in organic chemistry.

7770 Special Topics in Inorganic Chemistry (2-3) May be taken 4 times for credit. Advanced treatment of area of current interest in modern inorganic chemistry.

7780 Special Topics in Macromolecular Chemistry (2-3) May be taken 4 times for credit. Advanced treatment of specialized subjects of importance to current macromolecular research.

7800 Seminar (1) May be taken 6 times for credit. Pass-fail grading. All graduate students are expected to participate in report and discussion groups in field of chemistry of their particular interest.

7901 Speaking of Macromolecules (1) May be taken for a max. of 3 sem. hrs. of credit. Pass-fail grading. Also offered as CHE 7901. For students who desire to learn to speak in public about their research concerning macromolecules.

8000 Thesis Research (1-2 per sem.) Students who receive credit or registration in CHEM 8000 or 8900. 3 hr. credit. Credit will not be given for this course and ME 3133.

9000 Procedures and Problems in Chemical Research (1-2) Open only to students of proven ability or exceptional potential. Students who receive 6 hrs. of credit for CHEM 8900. 5 "Y" grading.

9090 Procedures and Problems in Chemical Research (1-2 per sem.) Prereq.: 6 hrs. of credit in CHEM 8000 or 8900. 5 "Y" grading.

**4553 Intermediate Mandarin Chinese (4) Prereq.:** CHEM 2001. Continuation of the study of basic lexicon and structural elements for further development of speaking, writing, and reading skills.

**2070 Chinese Cinema (3)** Students from the Special Topics in Chinese and Japanese Literature; emphasis on critical reading.

**3801 Traditional East Asian Literature (3)** Taught in English; knowledge of East Asian languages not required. Also offered as JAPN 3801. Introduction to the genres, themes, and representative works of traditional Chinese and Japanese literature; emphasis on critical reading.

**3802 Modern East Asian Literature (3)** Taught in English; knowledge of East Asian languages not required. Also offered as JAPN 3802. Introduction to the genres, themes, and representative works of modern Chinese and Japanese literature; emphasis on critical reading.

**4400 Topics in Chinese Culture (3)** May be taken for a max. of 6 sem. hrs. of credit when topics vary. Introduction to the study of Chinese arts, literature, society, and culture. All readings in English.

**4915 Independent Work (1-3)** May be taken for a max. of 6 sem. hrs. of credit. Permission of department required. Directed readings in classical Chinese or Chinese literature.

**7000 Chinese Culture and Literature** Introduction to the field of Chinese culture with a focus on business; basic Chinese language for business.

**CIVIL ENGINEERING • CE**

In the Department of Civil Engineering, the second digi of the course number denotes the subject area of the course, as follows: 0 (construction, excluding 8000, 9000); 1 (environmental); 2 (water resources); 3 (geotechnical); 4 (structures); 5 (surveying); 6 (transportation); 7 (general).

**2200 Fluid Mechanics (3) Prereq.: grade of "C" or better in CE 2450. Statics and dynamics of continuous liquids and gases; control volume laws; conservation of mass, momentum, and energy; dimensional analysis and similarity; applications to pipe flows.

**2250 Fluid Mechanics Laboratory (3) Prereq.: CE 2200 and grade of "C" or better required in CE 2200. 3 hrs. lab. Measurement and calibration of hydraulic machinery; pump and turbine efficiency; flow in pipelines; viscosity.

**2450 Statics (3) Prereq.: grade of "C" or better in MATH 1550, 1552 and PHYS 2101. Vectorial treatment of resolving forces, centroids and centris of gravity, fluid statics, friction.

**2460 Dynamics and Vibrations (3) Prereq.: grade of "C" or better in CE 2450 and credit or registration in MATH 2065. Credit will not be given for this course and ME 3133. Treatment of kinematics and kinetics of particles and rigid bodies; force, movement, velocity, acceleration; impulse and momentum; work and energy; dynamics and vibration; concepts applied to structural and machine components.

**2700 Introduction to Civil Engineering Practice (2)** Designed for civil engineering majors; open to nonmajors by consent of department. 1 hr. lecture; 3 hrs. lab. Credit will not be given for this course and E&V 2000. Students will conduct three individual projects including civil engineering construction descriptions. Basic technical and professional aspects of civil engineering construction practice.

**2720 Computational Methods in Civil and Environmental Engineering (3) Prereq.: MATH 1550 (a grade of "C" or better is required in MATH 1550). Fundamental computational numerical and statistical techniques for solving standard types of partial differential equations: numerical analysis; numerical interpolation; root finding; and numerical integration and differentiation techniques for civil and environmental engineering.

**3300 Geotechnical Engineering I (3) Prereq.: GEOL 1001, CHEM 2002, CE 2200, and credit or registration in CE 4570. Prereq.: grade of "C" or better in CE 2002 or equivalent. Introduction to properties and engineering behavior of soil as a native earth material, an
4420 Principles of Prestressed Concrete (3) Prereq.: CE 4410. Analysis and design of prestressed concrete structural elements. Emphasis on serviceability; load and strength requirements; code criteria for bridges, buildings, and other structures.

4425 Principles of Wood Mechanics and Timber Design (3) Prereq.: CE 3415 or equivalent. Basic principles of mechanics, elasticity, rheology, and failure as applied to wood. Emphasis on strength, design of sawn lumber, plywood, and glulam timber structures and structural components.

4430 Structural Analysis (3) Prereq.: CE 4750, 4440, and 4410, or equivalent. Fundamental principles applied to planning, analysis, and design of structures; introduction to computational and structural engineering problems using mainframe and microcomputer software.

4435 Indeterminate Structural Analysis (3) Prereq.: CE 3415. Analysis of statically indeterminate structures; methods of consistent deformations, elastic energy, virtual work, slope deflection, moment distribution, and matrix formulations.

4440 Advanced Mechanics of Materials (3) Prereq.: CE 3400 and MATH 2065 (a grade of **C** or better is required in CE 3400). Mechanics of materials; emphasis on needs of students interested in structural and machine design.

4445 Hurricane Engineering (Prereq.: CE 3415 and CE 2200 or equivalent. Credit will not be given for both this course and CE 4455 Hurricane Engineering). Engineering impacts and implications of hurricanes, floods, earthquakes, and other natural hazards; design; hurricane preparedness, response and recovery issues; design strategies for life safety and damage mitigation; building resistant design; hurricane evacuation and sheltering; damage implications of hurricanes, floods, earthquakes, and other natural hazards; design; hurricane preparedness, response and recovery issues; design strategies for life safety and damage mitigation; building resistant design; hurricane evacuation and sheltering; damage.

4450 Finite Element Methods (3) Prereq.: CE 3400; and either MATH 2090 or 2097 or 2070 (a grade of **C** or better is required in CE 3400). Basic theory of finite element methods; methods and applications to civil engineering problems; matrix representation of stress, strain, and material relations; principle of virtual work, discrete finite element models of continuous systems, construction of basic finite element algorithms, and solutions of physical problems by using existing finite element computer programs.

4460 Design of Bridges (Prereq.: CE 4440, CE 4410, and CE 4470, and credit or registration in CE 4440 or CE 4420, or equivalent. 2 hrs. lecture; 3 hrs. lab. Design of concrete and steel bridges; construction, welding, and corrosion; bridge specifications; understanding of theoretical background behind the codes such as risk and reliability concepts; load rating of bridges, and hands-on bridge design using computer software and hand calculations.

4500 Geodetic and Photogrammetric Surveying (5) Prereq.: CE 3500 or equivalent. 2 hrs. lecture; 3 hrs. lab. Geodetic surveying for control surveys; photogrammetry and photointerpretation; calculation and field procedures used in ground control surveys and photogrammetry.

4520 Advanced Surveying (3) Prereq.: CE 3500 or equivalent. 2 hrs. lecture; 3 hrs. lab. Electronic surveying, simultaneous position fixing, real-time GPS surveys, flood plain management, state plane coordinates, solar azimuths, horizontal and vertical curves, and earthwork.

4530 Contouring (Prereq.: CE 3500 or equivalent surveying course. 2 hrs. lecture; 3 hrs. lab. Understanding of spatial positioning capabilities available in various surveying techniques; contouring; surveying tasks; contouring tasks. Funneling and drawing, topographic mapping, and orthophotography.

4540 Engineering Implications of Remote Sensing (3) Prereq.: consent of instructor. 2 hrs. lecture; 3 hrs. lab. Photographic and digital image processes related to interpretations, methods of evaluation and applications.

4550 Boundary Surveying (3) Prereq.: CE 3500 or equivalent. 2 hrs. lecture; 3 hrs. lab. Design of boundary surveying procedures for both urban and rural areas, design of layout surveys; and computer applications to design problems.

4620 Transportation Engineering (3) Prereq.: CE 3600 or equivalent. History and applications of transportation systems; planning, design, construction, maintenance, and operation of air, highway, pipeline, rail, and water transportation facilities-vehicles, guideways, and terminals.

4650 Introduction to Asphalt Mixtures Design (3) Prereq.: CE 3400 and credit or registration in CE 3700 (a grade of **C** or better is required in CE 3400). Engineering principles of design and practice of hot mix asphalt mixture design; fundamental properties and analysis of binder rheology, asphalt concrete, aggregate, and bitumen. Laboratory and pilot studies of asphalt mixtures.

4670 Fundamentals of Pavement Design (3) F Prereq.: CE 3600 or equivalent. Flexible and rigid pavement design processes; design of rigid pavements; asphalt design; structure design; effective stresses; loads; stresses in pavement systems; material characteristics; pavement response models; pavement performance models; flexible pavement systems; effects of natural forces; and construction practices.

4730 Risk and Reliability Analysis in Civil and Environmental Engineering (3) Prereq.: CE 2270 and EXST 2210. Decision making under certainty; probability distributions and their characteristics relevant to civil and environmental engineering systems; data gathering and analysis; extraction of information; entropy theory; estimation of distribution parameters; error and uncertainty analysis; reliability analysis and estimation; risk analysis and estimation; model selection; and reliability-based civil and/or environmental engineering design.

4745 Natural Hazards and the Built Environment (3) Prereq.: CE 3400, CE 4410, and CE 4450. A survey of natural hazards and their impacts on buildings and infrastructure systems; understanding of meteorological concepts, legal doctrines, and the civil engineers’ role in planning and design. The built environment is the focus of the course, but the emphasis is on the study of hazards and their impact on the environment; impact of hazards on buildings and infrastructure systems; damage mechanisms; principles of wind, flood, and seismic resistant design; hurricane and flood engineering preparedness, response and recovery issues; design strategies for life safety and damage mitigation; building resistant design; hurricane evacuation and sheltering; damage.

4750 Professional Issues and Concept Design in Civil Engineering (Prereq.: CE 2270 and senior standing. 1 hr. lecture; 2 hrs. lab. Civil engineering design processes and systems; constructability and sustainability; use of consultants and contractors; project management; scheduling; economics and costing; ethical, health, and safety; social, political, and environmental considerations. 7110 Operations and Processes in Sanitary Engineering Lab (3) Prereq.: CE 3400, 3700, 4400, 4410 or equivalent credit. 1 hr. lecture; 2 hrs. lab. Credit will not be given for both this course and CE 4710. Engineering impacts and implications of hurricanes, floods, earthquakes, and other natural hazards; design; hurricane preparedness, response and recovery issues; design strategies for life safety and damage mitigation; building resistant design; hurricane evacuation and sheltering; damage.

4770 Professionalism and Ethical Practice of Civil Engineering (1) Prereq.: senior standing in civil engineering. Role of professionalism in engineering education and practice; the civil engineer's responsibility in preserving the environment and protecting the safety, health, and welfare of the public.

4780 Special Topics in Civil Engineering Science (3) Prereq.: senior standing and departmental approval. May be taken for a max. of 6 hrs. of credit. More than one section may be taken concurrently when topics differ. Topics in specialized civil engineering technical or analysis areas.

4785 Special Topics in Civil Engineering Design (3) Prereq.: senior standing and departmental approval. May be taken for a max. of 6 hrs. of credit when topics vary. More than one section of this course may be taken for credit concurrently when topics differ. Selected topics in civil engineering design.

7100 Theory and Operation of Wastewater Treatment Facilities (3) Prereq.: EVEG 3110; or equivalent undergraduate preparation, or consent of instructor. Theoretical principles, design criteria, and analysis of treatment systems for domestic and industrial wastewater and sludges; includes modeling of ideal biochemical reactors and design criteria for suspended-growth and biofilm processes applicable to wastewater treatment facilities and design of water and wastewater treatment processes.

7115 Water Quality Management (3) Prereq.: CE 3415, CE 3500, CE 4450, or equivalent. Analysis of water quality management; water quality; governmental agencies, regulations, and technological limits affecting water and wastewater treatment, solid waste treatment and disposal.

7120 Sanitary Engineering Operations and Processes Lab (Prereq.: CE 4310, 7100, and credit or registration in CE 7110). 1 hr. lecture; 2 hrs. lab. Laboratory measurement of properties, biological phenomena as such phenomena influence the engineering design, systems; planning, design, construction, maintenance, and operation of air, highway, pipeline, rail, and water transportation facilities-vehicles, guideways, and terminals.

7135 Advanced Topics in Biodegradation (3) Prereq.: biological wastewater treatment applications in civil and environmental engineering design; engineering principles of design and practice of hot mix asphalt mixture design; fundamental properties and analysis of binder rheology, asphalt concrete, aggregate, and bitumen. Laboratory and pilot studies of asphalt mixtures.
engineering, including current and emerging techniques for characterization, analysis, control, and mathematical modeling of hydraulic processes in municipal and industrial waste treatment systems. 7145 Biological Treatment of Recirculating Systems in Aquaculture (3) Prereq.: CE 3350. Treatment of wastewater and management of fixed film biofouling processes used to recondition water in recirculating aquaculture systems and to provide tertiary treatment of wastewater, and industrial wastes characterized by low substrate regimes. 7180 Water Quality Simulations (3) Prereq.: CE 4130. Water quality with particular emphasis on the prediction of unconfined aquifer flow; pollution transport; and fate and transport of aqueous pollutants. 7255 Advanced Hydraulics (3) Prereq.: CE 2290. Transient flow in rivers, subterranean systems, and municipal systems; flood routing and urban drainage systems. 7265 Advanced Water Quality and Hydraulics (3) Prereq.: CE 2295. Properties of porous media and fluid mixtures; dynamics of flow in single phase and multiphase flow systems; movable and immovable fluid; basic concepts in saturated and unsaturated flow; solution procedures and applications in engineering design; physics and mathematics of transport processes in ground water; governing equations, solution procedures, and applications; waste management and pollution control in subsurface environments. 7270 Hydrologic Systems (3) Prereq.: CE 4220. Techniques of systems analysis; application to hydraulic processes including runoff, stream flow routing, infiltration, evapotranspiration, and watershed yield; development of watershed models. CE 7265 and CE 7275. 7280 Aquatic Ecology (3) Prereq.: CE 4560. Analysis of the effect of compositional and environmental changes on population, community, ecosystem, and landscape systems; population, community, ecosystem, landscape, and riverine systems. 7285 Advanced Geotechnical Engineering I: Stress Distribution, Seepage, Compressibility (3) Prereq.: CE 3500 and 3550. Soil mechanics including stress distribution, seepage through soils, consolidation, and settlement analysis; their applications in foundation engineering. 7305 Numerical Methods in Geotechnical Engineering (3) Prereq.: CE 4390. Numerical analysis of problems of seepage, consolidation, stress-deformation, slope stability, and wave equation for piles. 7310 Advanced Geotechnical Engineering II: Shear Strength, Bearing Capacity, Slope Stability (3) Prereq.: CE 7200. Shear strength of cohesive and cohesionless soils; stability problems including bearing capacity, slope stability, and earth structures. 7315 Principles of Soil Behavior (3) Prereq.: CE 3500. Analysis of the effect of compositional and environmental changes on population, community, ecosystem, and landscape systems; population, community, ecosystem, landscape, and riverine systems. 7335 Soil Improvement and Stabilization (3) Prereq.: CE 4390. Methodology and analysis of soil placement and improvement techniques; properties of mineral and organic soils, principles of soil compaction; methods of soil placement and improvement, chemical stabilization of soils, lime treatment, stone columns, ultimate strength and bearing capacity of columns, compression by surcharging and drains, dynamic consolidation, vibro stabilization, thermal properties of soils, thermal stabilization. 7340 Theory and Practice of Geotechnical Laboratory Experiments (3) Prereq.: CE 3300, 3350, and 4300; or equivalent. 2 hrs. lecture; 3 hrs. lab. Theory and practice of laboratory procedures. CE 7345, 7350, and advanced geotechnical in-situ testing methods (i.e. piezo-cone penetrometer, self-boring pressure meter, dilatometer, etc.) 7350 Soil Evaporation to Earthquake Engineering (3) Prereq.: CE 7310. Theory and practice related to soil-strata systems subject to time dependent loading; various media, soil and rock; state and transient vibration of formations, measurement of dynamic soil parameters, analysis and design procedures; influence of soils on ground water; physical and chemical causes of soil failure during liquefaction; liquefaction. 7355 Environmental Geotechnics (3) Prereq.: CE 3300, 3350. Geotechnical management; soil transport in saturated media, flow in partially saturated media, diffusion in soil, sorption, hydraulic conductivity, soil-pore fluid interactions, compaction, clay and flexible membrane liners; stability/settlement considerations, remediation techniques. 7405 Statically Indeterminate Structures (3) Prereq.: CE 4415. Analysis and statically indeterminate structures by modern methods. 7409 Advanced Concrete Technology (3) Analysis and design of reinforced concrete and prestressed concrete; use of prestressed concrete and related to soil construction. Failure design theories of reinforced concrete and prestressed concrete; use of prestressed concrete and related to soil construction. 7420 Limit State Design (3) Prereq.: credit or registration in CE 4415. Analysis of steel structural behavior beyond elastic limit; design for ultimate load and use of load combination factors, and material strength factors and other computational techniques to optimization of structures designed by aid of concepts of limit analysis. 7430 Structural Design for Dynamic Loads (3) Sources, intensities, and methods of transmission of dynamic loads; response of structural systems to dynamic loading; modern computer techniques. 7455 Finite Element Method in Engineering (3) Prereq.: CE 4450. Finite element method as an extended Ritz technique based on variational principles for continuum with assumptions to heat transfer, flow through porous media, fluid dynamics, elasticity, plasticity, and stability and vibrations of elastic systems. 7460 Theory of Plates (3) Prereq.: credit or registration in CE 4440. Laterally loaded plates with various boundary conditions; approximate methods of plate analysis; large deflections of plates. CE 7455. 7470 Theory of Elastic and Plastic Stability (3) Prereq.: credit or registration in CE 4451. Beam columns, elastic and plastic stability of beams, buckling, lateral bending of beams, elastic and plastic stability of frames, plate and shell buckling, approximate and special methods, and high speed computer techniques. 7475 Solid Mechanics (3) Prereq.: CE 4440 and credit or registration in MATH 4038 or MATH 4540 or ME 4656. Mathematical approach to statics and dynamics of deformable solids; tensors in curvilinear coordinates and variational calculus used to formulate elasticity and viscoelasticity theory, energy theorems and conservation laws. 7480 Plasticity and Viscoelasticity: Theory and Applications (3) Prereq.: CE 4440. Elements of the theory of anisotropic, viscoelastic, and plastic constitutive equations for perfectly plastic and strain hardening materials; boundary value problems of plasticity; the slip-line theory and applications; constitutive equations of viscoelastic bodies and methods of solution of the boundary value problems of viscoelasticity. 7485 Mechanics of Composite Materials (3) Prereq.: CE 4390. Modeling of the mechanical behavior of fibrous composites for application to structural components; emphasis on interlaminar stresses, strength and failure theories, thermal effects, nonlinear material response, test methods, and micromechanics. 7490 Damage Mechanics in Metals and Matrix Composites (3) Prereq.: CE 4440 or equivalent. Theoretical formulation and application of the different constitutive models to metals and metal matrix composites, but with consideration of composite behavior; analysis of isotropic and anisotropic damage in materials. 7500 Remote Sensing in Engineering Research (3) Prereq.: CE 4390. Applications of遥控 dynamic relations for present and future sensors, and laboratory and field instrument; computer analysis of spectra data to include classification algorithms, enhancement, calibration, geo-referencing, overlay, and data base image processing; environmental applications. 7600 Transportation Engineering Data Collection Methods (3) Prereq.: EXST 7003, or CE 3500, or equivalent. Applications of sampling theory to data collections for transportation studies; determination of sample sizes; calculation of sampling error; expansion of sample survey data; survey methodologies, including interviews, counting programs, moving observer surveys, self-administered surveys, and mail surveys; field data collection instruments; conduct of data collection activities; data reduction techniques. 7610 Traffic Engineering Operations and Control (3) F-O Prereq.: CE 3600 or equivalent. Traffic regulations, operational problems, and engineering organization; theory and practice of traffic engineering; traffic operations, speed, flow, and capacity; traffic control devices; methods and devices studied include signing, markings, delineation and illumination, signals and lights, and operating procedures; emphasis on traffic operations, speed zoning, and freeway monitoring and control. 7612 Traffic Flow and Analysis (3) S-O Prereq.: CE 4600 or consent of instructor. Traffic flow theory and the techniques used to analyze traffic operations and highway capacities; traffic data; traffic flow, including current research in the field; application of analytical procedures used to assess the efficiency of highway operations. 7614 Intelligent Transportation Systems (3) V Theories and Applications of Intelligent Transportation Systems (ITS). 7615 Advanced Highway Design and Traffic Safety (3) Analysis of roadway traffic safety; analysis of accident rates and factors affecting safety; development and application of highway design principles, particularly as they relate to safety; analysis of accident rates and factors affecting safety; development and application of highway design principles, particularly as they relate to safety. 7616 Urban Traffic Planning and Modeling (3) Applications of methods of transportation planning; characteristics of travel, politics, decision making and models of decision makers; systems analytic approaches to transportation planning; inventory, data management, and spatial representation of data; land use and transportation; inputs to travel forecasting. 7641 Urban Transportation Planning Models (4) S-E Prereq.: CE 4390 and ECON 5600. 3 hrs. lecture; 2 hrs. lab. Theories of travel demand modeling; conventional four-step modeling procedures; network design problems with travel demand uncertainty; optimization concepts in transportation network modeling. 7650 Bituminous Materials and Mixtures (3) S-O Prereq.: CE 3700 or equivalent. 3 hrs. lecture; 3 hrs. lab. Properties of asphalts and tars used in bituminous materials; historical developments; properties and design of bituminous mixtures; theory and practice of asphalt concrete mix design for pavements and bases including specification and construction methods for hot-mixes and surface treatments. 7652 Transportation Engineering - Materials (3) Prereq.: CE 4390 or equivalent. Quantitative methods for analysis of transportation systems; basic network algorithms; macroscopic and microscopic traffic simulation models; dynamic traffic assignment approaches; network design problems with travel demand uncertainty; optimization concepts in transportation network modeling. 7655 Pavement Materials Characterization (3) F-O Prereq.: CE 3600 or equivalent. Properties and design of bituminous materials; properties and design of bituminous mixtures; theory and practice of asphalt concrete mix design for pavements and bases including specification and construction methods for hot-mixes and surface treatments. 7672 Pavement Management Systems (3) S-O Prereq.: CE 3600 or equivalent. Concepts of pavement, evaluation of pavement performance, serviceability concepts, structural evaluation, safety, maintenance and rehabilitation, economic considerations, selection of alternatives, and life cycle cost analysis. 7673 Pavement Maintenance and Rehabilitation (3) S-E Prereq.: CE 3700 or equivalent. Concepts of pavement maintenance and rehabilitation; pavement evaluation technique; pavement maintenance versus rehabilitation versus replacement alternatives. 7700, 7701 Special Topics in Civil Engineering (3) Prereq.: permission of department. Each course may be taken for a max. of 6 hrs. of credit. Specialized civil engi- neering areas. 7750 Master's Thesis Report (3) Comprehensive report with oral defense on subject approved by the major professor. 7750 Seminar (1) All graduate students are expected to enroll every semester. Only one hour of credit will be allowed toward degree. Pass-fail grading. 8000 Thesis Research (1-12 per sem.) 3,5,7,9 grading. 9000 Dissertation (0,3) 9 credit hours beyond 7750; 12 credit hours beyond 7750. 9 credit hours beyond 7750; 12 credit hours beyond 7750.