

Civil and Environmental Engineering (ENGRCEE)

Courses

ENGRCEE 11. Methods II: Probability and Statistics. 4 Units.

Modeling and analysis of engineering problems under uncertainty. Engineering applications of probability and statistical concepts and methods.

(Design units: 0)

Prerequisite: (ENGRCEE 20 or EECS 10 or EECS 12 or ENGRMAE 10 or I&C SCI 31) and MATH 3A

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 20. Introduction to Computational Problem Solving. 4 Units.

Introduction to computer programming within a numerical computing environment (MATLAB or similar) including types of data representation, graphical display of data, and development of modular programs with application to engineering analysis and problem solving.

(Design units: 1)

Corequisite: MATH 3A

Overlaps with BME 60B.

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 21. Computational Problem Solving. 4 Units.

Engineering analysis and problem solving using MATLAB (or similar), including matrix algebra, solving systems of linear and nonlinear equations, numerical integration of ordinary differential equations (ODEs) and coupled ODEs, and analysis of numerical errors.

(Design units: 1)

Corequisite: MATH 3D

Prerequisite: (ENGRCEE 20 or BME 60B) and (MATH 3A or I&C SCI 6N)

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 30. Statics. 4 Units.

Addition and resolution of forces, distributed forces, equivalent system of forces centroids, first moments, moments and products on inertia, equilibrium of rigid bodies, trusses, beams, cables. Course may be offered online.

(Design units: 0)

Corequisite: MATH 2D

Prerequisite: MATH 2D and PHYSICS 7C

Same as ENGR 30, ENGRMAE 30.

Restriction: School of Engineering students have first consideration for enrollment.

ENGRCEE 40. Fundamentals of Economic Analysis for Scientists and Engineers. 4 Units.

Introduction to microeconomics and cost benefit analysis. Integration of economic, social, and behavioral considerations into the engineering design process. Applications to contemporary problems via case studies.

(III)

ENGRCEE 60. Contemporary and Emerging Environmental Challenges. 4 Units.

Introduces contemporary and emerging environmental challenges, illustrates links between human behavior, environmental policy, and engineering practices, examines policy options in the context of current institutions, and introduces tools and frameworks to reach sound economic, social, and environmental solutions.

(Design units: 0)

(III)

ENGRCEE 80. Dynamics. 4 Units.

Introduction to the kinematics and dynamics of particles and rigid bodies. The Newton-Euler, Work/Energy, and Impulse/Momentum methods are explored for ascertaining the dynamics of particles and rigid bodies. An engineering design problem using these fundamental principles is also undertaken.

(Design units: 0.5)

Prerequisite: MATH 2D and PHYSICS 7C

Same as ENGR 80, ENGRMAE 80.

Restriction: Mechanical Engineering Majors have first consideration for enrollment. Aerospace Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Materials Science and Engr Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 81A. Civil Engineering Practicum I. 3 Units.

Introduction to civil engineering through presentations on structural, environmental, water, and transportation systems. Introduction to graphics. Graphical visualization and communication using hand and computer sketching. Fundamentals of Computer Aided Design (CAD) using AutoCad. Laboratory sessions. Materials fee.

(Design units: 2)

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 81B. Civil Engineering Practicum II. 3 Units.

Principles of surveying; fundamentals of Geographic Information Systems (GIS); introduction to the state-of-the-art and future areas of the profession, including applications of advanced technology and computers; Introduction to visualization and communication of design concepts; laboratory sessions. Materials fee.

(Design units: 1)

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 110. Methods III: Modeling, Economics, and Management. 4 Units.

Analysis, modeling, and management of civil engineering systems. Statistics and system performance studies, probabilistic models and simulation, basic economics and capital investments, project elements and organization, managerial concepts and network technique, project scheduling. Emphasis on real-world examples. Laboratory sessions.

(Design units: 1)

Prerequisite: ENGRCEE 11

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 111. Methods IV: Systems Analysis and Decision-Making. 4 Units.

Analysis and optimization for decision-making in civil and infrastructural systems. Topics include linear programming formulations and solution algorithms, network models, and logistical models. Emphasis is on project-level and managerial decision-making and selection from alternative designs.

(Design units: 1)

Prerequisite: (MATH 3A or I&C SCI 6N) and MATH 3D

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 114. GIS for Civil and Environmental Engineering. 4 Units.

GIS for CEE provides an introduction to Geographic Information Systems (GIS) and their various applications in civil and environmental engineering. Topics include GIS data formats, data queries, spatial and attribute data, spatial data analysis, coordinate systems, and raster data analysis.

Concurrent with ENGRCEE 214.

ENGRCEE 121. Transportation Systems I: Analysis and Design. 4 Units.

Introduction to analysis and design of fundamental transportation system components, basic elements of geometric and pavement design, vehicle flow and elementary traffic, basic foundations of transportation planning and forecasting. Laboratory sessions.

(Design units: 2)

Prerequisite: ENGRCEE 11 and ENGRCEE 81A

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 122. Transportation Systems II: Operations and Control. 4 Units.

Introduction to fundamentals of urban traffic engineering, including data collection, analysis, and design. Traffic engineering studies, traffic flow theory, traffic control devices, traffic signals, capacity and level of service analysis of freeways and urban streets. Laboratory sessions.

(Design units: 2)

Prerequisite: ENGRCEE 11 and ENGRCEE 121

Restriction: Civil Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 229A.

ENGRCEE 123. Transportation Systems III: Planning and Forecasting. 4 Units.

Theoretical foundations of transportation planning, design, and analysis methods. Theory and application of aggregate and disaggregate models for land use development, trip generation, destination, mode, and route choice. Transportation network analysis. Planning, design, and evaluation of system alternatives.

(Design units: 2)

Corequisite: ENGRCEE 110

Prerequisite: ENGRCEE 121

Restriction: Civil Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 223.

ENGRCEE 124. Transportation Systems IV: Freeway Operations and Control. 4 Units.

Fundamentals of traffic on urban freeways, including data collection analysis, and design. Traffic engineering studies, traffic flow theory, freeway traffic control devices, capacity, and level of service analysis of freeways and highways. Laboratory sessions.

(Design units: 2)

Prerequisite: ENGRCEE 121

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 125. Transportation and the Environment. 4 Units.

Analysis of the impacts of motor vehicle transportation on the environment. Introduction to life cycle analysis applied to transportation. Basic economic tools for transportation externalities. Transportation planning, urban form, health, and the environment. Transportation sustainability.

(Design units: 0)

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 130. Soil Mechanics. 4 Units.

Mechanics of soils, composition and classification of soils, compaction, compressibility and consolidation, shear strength, seepage, bearing capacity, lateral earth pressure, retaining walls, piles.

(Design units: 0)

Corequisite: ENGRCEE 130L

Prerequisite: ENGRCEE 150 and ENGRCEE 170

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 130L. Soil Mechanics Laboratory. 1 Unit.

Laboratory procedures of soil testing for engineering problems. Materials fee.

(Design units: 0)

Corequisite: ENGRCEE 130

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 149. Introduction to Earthquake Engineering. 4 Units.

Plate tectonics. Structural dynamics. Earthquake magnitude, intensity, and frequency. Seismic damage to structures. Earthquake load prediction including response spectra, normal mode, and direct integration techniques. The basis of building code earthquake load requirements for buildings.

(Design units: 2)

Prerequisite: ENGRCEE 11 and ENGRCEE 20 and ENGRCEE 151A

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 150. Mechanics of Materials. 4 Units.

Stresses and strains, strain-stress diagrams, axial deformations, torsion, bending and shear stresses in beams, shear force and bending moment diagrams, combined stresses, principal stresses, Mohr's circle, deflection of beams, columns.

(Design units: 1)

Prerequisite: ENGRCEE 30 or ENGRMAE 30 or ENGR 30. ENGRCEE 30 with a grade of C- or better. ENGRMAE 30 with a grade of C- or better. ENGR 30 with a grade of C- or better

Overlaps with ENGR 150, ENGRMAE 150.

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 150L. Mechanics of Materials Laboratory. 1 Unit.

Experimental methods and fundamentals for mechanics of materials analysis. Materials fee.

(Design units: 0)

Prerequisite or corequisite: (ENGRCEE 30 or ENGRMAE 30 or ENGR 30) and ENGRCEE 150. ENGRCEE 30 with a grade of C- or better. ENGRMAE 30 with a grade of C- or better. ENGR 30 with a grade of C- or better

Overlaps with ENGRMAE 150L.

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 151A. Structural Analysis. 4 Units.

Fundamentals of structural analysis and loading. Deformation of statically determinate and indeterminate structures. Influence lines. Structural systems.

(Design units: 0)

Prerequisite: ENGRCEE 150 or ENGRMAE 150

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 151B. Structural Timber Design. 4 Units.

Design of timber structures. Beams, columns, beam-columns, roof, and connections.

(Design units: 3)

Prerequisite: ENGRCEE 151A

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 151C. Reinforced Concrete Design. 4 Units.

Ultimate strength design. Design of reinforced concrete beam sections. Design for shear and deflection. Design of columns. Design of isolated and combined footings. Laboratory sessions. Materials fee.

(Design units: 3)

Prerequisite: ENGRCEE 151A

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 152. Computer Methods in Structural Analysis and Design. 4 Units.

Matrix techniques for indeterminate framed structures. Computer implementation using the stiffness method. Software packages for design of reinforced concrete, steel, and/or timber structures.

(Design units: 2)

Prerequisite: ENGRCEE 151C

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 155. Structural Steel Design. 4 Units.

Design in steel of tension members, beams, columns, welded and bolted connections; eccentrically loaded and moment resistant joints; plate girders. Plastic design; load and resistance factor design. Composite construction; introduction to computer-aided design.

(Design units: 4)

Prerequisite: ENGRCEE 151A

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 156. Foundation Design. 4 Units.

Applications of soil mechanics principles to the analysis and design of shallow foundations, retaining walls, pile foundations, and braced cuts. Design criteria: bearing capacity, working loads and tolerable settlements, structural integrity of the foundation element. Damage from construction operations.

(Design units: 3)

Prerequisite: ENGRCEE 130 and ENGRCEE 151C

Restriction: Civil Engineering Majors have first consideration for enrollment.

ENGRCEE 160. Environmental Processes. 4 Units.

Introduction to environmental processes in air and water, mass balances, and transport phenomena. Fundamentals of water-quality engineering including water and wastewater treatment.

(Design units: 1)

Prerequisite: (CHEM 1B or CHEM H2B) and ENGRCEE 170

Restriction: Civil Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 162. Introduction to Environmental Chemistry. 4 Units.

Basic concepts from general, physical, and analytical chemistry as they relate to environmental engineering. Particular emphasis on the fundamentals of equilibrium and kinetics as they apply to acid-base chemistry, gas solubility, and redox reactions. Laboratory sessions. Materials fee.

(Design units: 0)

Prerequisite: (ENGR 1A or CHEM 1A or CHEM H2A) and (CHEM 1B or CHEM H2B) and (CHEM 1LC or CHEM 1LE or CHEM H2LB or CHEM M2LB) and (CHEM 51A or CHEM H52A)

Restriction: Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 163. Wastewater Treatment Process Design. 4 Units.

Design of biological treatment processes. Topics include attached and suspended growth, aeration, anaerobic systems, process control, and economics. Design projects included. Materials fee.

(Design units: 4)

Prerequisite: ENGRCEE 160

Restriction: Civil Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 164. Carbon and Energy Footprint Analysis. 4 Units.

Process design for wastewater treatment. Mass- and energy-balance analysis applied to water and wastewater treatment systems. Case studies include analysis of water supply, treatment, reclamation, and reuse.

(Design units: 2)

Prerequisite: ENGRCEE 163 or ENGRCEE 165

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 264.

ENGRCEE 165. Physical-Chemical Treatment Processes. 4 Units.

Theory and dynamics of physical and chemical separation processes in water and wastewater treatment. Topics include coagulation, sedimentation, filtration, gas-transfer, membrane separations, and adsorption.

(Design units: 2)

Prerequisite: ENGRCEE 160 and (ENGRMAE 91 or CBE 40C)

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 265.

ENGRCEE 169. Environmental Microbiology for Engineers. 4 Units.

Fundamental and applied principles of microbiology. Structures and functions of microorganisms, the microbiology of water, wastewater and soil used in environmental engineering, and the impact of microorganisms on human and environmental health.

(Design units: 0)

Prerequisite: ENGRCEE 160

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 170. Introduction to Fluid Mechanics. 4 Units.

Thermodynamic and mechanical fluid properties; fluid statics; control volume and differential approaches for mass, momentum, and energy; dimensional analysis and similarity.

(Design units: 1)

Corequisite: MATH 2E and ENGRCEE 20

Prerequisite: PHYSICS 7C

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 171. Water Resources Engineering. 4 Units.

Principles governing the analysis and design of water resource systems including pressurized pipelines, pipe networks, channels, and ground water. Coverage of fluid mass, momentum and energy conservation, flow resistance, and related laboratory measurements in different systems. Materials fee.

(Design units: 2)

Prerequisite: ENGRCEE 170

Restriction: Chemical Engineering Majors have first consideration for enrollment. Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 172. Groundwater Hydrology. 4 Units.

Topics include conservation of fluid mass, storage properties of porous media, matrix compressibility, boundary conditions, flow nets, well hydraulics, groundwater chemistry, and solute transport. Design projects and computer applications included.

(Design units: 2)

Prerequisite: ENGRCEE 170 or ENGRMAE 130A or CBE 120A

Restriction: Civil Engineering Majors have first consideration for enrollment. Chemical Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 272.

ENGRCEE 173. Watershed Modeling. 4 Units.

Basic principles of hydrologic modeling are practiced. Concepts of watershed delineation, land use change impact, design studies, and GIS tools are discussed. Focus on the USACE (HEC) software tools (HEC-HMS, and HEC-RAS) along with their associated GIS interfaces.

(Design units: 1)

Prerequisite: ENGRCEE 170 and ENGRCEE 176

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 273.

ENGRCEE 176. Hydrology. 4 Units.

Elements of the hydrologic cycle including precipitation, infiltration, evapotranspiration, ground water, and runoff. Unit Hydrograph theory and routing methods. Introduction to precipitation/runoff relationship and watershed modeling. Statistical methods and flood frequency analysis.

(Design units: 2)

Prerequisite: ENGRCEE 170 or ENGRMAE 130A

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 276.

ENGRCEE 178. Fluid Mechanics of Open Channels. 4 Units.

Fundamentals of fluid motion in open channels. Navier-Stokes equations and one-dimensional momentum and energy principles. Topics include rapidly varied flow, flow resistance and turbulence, gradually varied flow, unsteady flow, and computational methods for channel flow modeling.

(Design units: 1)

Prerequisite: (ENGRCEE 20 or BME 60B or ENGRMAE 10) and (ENGRCEE 170 or ENGRMAE 130A or CBE 120A)

Restriction: Civil Engineering Majors have first consideration for enrollment. Environmental Engineering Majors have first consideration for enrollment.

ENGRCEE 181A. Senior Design Practicum I. 2 Units.

Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 1)

Prerequisite: ENGRCEE 81A and ENGRCEE 81B and ENGRCEE 110 and (ENGRCEE 121 or ENGRCEE 151C or ENGRCEE 162 or ENGRCEE 171). ENGRCEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.

Restriction: Seniors only. Civil Engineering Majors only. Environmental Engineering Majors only.

ENGRCEE 181B. Senior Design Practicum II. 2 Units.

Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 2)

Corequisite: ENGRCEE 130

Prerequisite: ENGRENGRCEE 181A. CEE 181A and ENGRCEE 181B and ENGRCEE 181C must be taken in the same academic year.

Grading Option: In Progress (Letter Grade with P/NP).

Restriction: Seniors only. Civil Engineering Majors only. Environmental Engineering Majors only.

ENGRCEE 181C. Senior Design Practicum III. 2 Units.

Team designs land development project including infrastructural, environmental, circulation aspects. Focus on traffic impact studies, design of roads, geometry, signals, geotechnical and hydrological analysis, design of structural elements, economic analysis. Oral/Written interim and final design reports. Laboratory sessions.

(Design units: 2)

Prerequisite: ENGRENGRCEE 181B. ENGRCEE 181A and CEE 181B and ENGRCEE 181C must be taken in the same academic year.

Restriction: Seniors only. Civil Engineering Majors only. Environmental Engineering Majors only.

ENGRCEE 195. Special Topics in Civil and Environmental Engineering. 1-4 Units.

Studies in selected areas of Civil and Environmental Engineering. Topics addressed vary each quarter.

(Design units: 1-4)

Prerequisite: Prerequisites vary.

Repeatability: Unlimited as topics vary.

ENGRCEE 198. Group Study. 1-4 Units.

Group study of selected topics in Civil and Environmental Engineering.

(Design units: 1-4)

Repeatability: May be repeated for credit unlimited times.

Restriction: Upper-division students only.

ENGRCEE 199. Individual Study. 1-4 Units.

For undergraduate Engineering majors in supervised but independent reading, research, or design. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)

Repeatability: May be taken for credit for 8 units.

ENGRCEE 199P. Individual Study. 1-4 Units.

Supervised independent reading, research, or design for undergraduate Engineering majors. Students taking individual study for design credit are to submit a written paper to the instructor and to the Undergraduate Student Affairs Office in the School of Engineering.

(Design units: 1-4)

Grading Option: Pass/no pass only.

Repeatability: May be repeated for credit unlimited times.

ENGRCEE 214. GIS for Civil and Environmental Engineering. 4 Units.

GIS for CEE provides an introduction to Geographic Information Systems (GIS) and their various applications in civil and environmental engineering. Topics include GIS data formats, data queries, spatial and attribute data, spatial data analysis, coordinate systems, raster data analysis.

Concurrent with ENGRCEE 114.

ENGRCEE 220A. Travel Demand Analysis I. 4 Units.

Fundamentals of transportation systems analysis. Theoretical aspects of travel demand. Travel behavior. Modeling of performance characteristics and costs of transportation modes. In-depth presentation of travel demand modeling techniques. Development of travel choice models including mode, route, and destination choice. Equilibrium.

Restriction: Graduate students only.

ENGRCEE 220B. Travel Demand Analysis II. 4 Units.

Methods of discrete choice analysis and their applications in the modeling of transportation systems. Emphasis on the development of a sound understanding of theoretical aspects of discrete choice modeling that are useful in many applications in travel demand analysis.

Prerequisite: ENGRCEE 220A

Restriction: Graduate students only.

ENGRCEE 220C. Travel Demand Analysis III: Activity-based Approaches. 4 Units.

The methodological underpinnings of activity-based travel demand modeling. Presents methodologies within the context of a generalization of discrete choice modeling approaches, emphasizing the distinctions that separate these two approaches and presenting appropriate mathematical and statistical tools to address these distinctions.

Prerequisite: ENGRCEE 220A

Restriction: Graduate students only.

ENGRCEE 221A. Transportation Systems Analysis I. 4 Units.

Introduction to mathematical methods and models to address logistics and urban transportation problems. Techniques include stochastic models, queueing theory, linear programming, and introductory non-linear optimization.

Restriction: Graduate students only.

ENGRCEE 221B. Transportation Systems Analysis II. 4 Units.

Advanced mathematical methods and models to address logistics and urban transportation problems. Topics include network flows, advanced optimization techniques, network models, and heuristic algorithms.

Prerequisite: ENGRCEE 221A

Restriction: Graduate students only.

ENGRCEE 222. Transit Systems Planning. 4 Units.

Planning methods for public transportation in urban areas. Technological and operating characteristics of vehicles, facilities, and systems. Short-range planning techniques: data collection and analysis, demand analysis, mode choice, operational strategies, financial analysis. Design of systems to improve performance.

Restriction: Graduate students only.

ENGRCEE 223. Transportation Systems III: Planning and Forecasting. 4 Units.

Theoretical foundations of transportation planning, design, and analysis methods. Theory and application of aggregate and disaggregate models for land use development, trip generation, destination, mode, and route choice. Transportation network analysis. Planning, design, and evaluation of system alternatives.

Restriction: Graduate students only.

Concurrent with ENGRCEE 123.

ENGRCEE 224A. Transportation Data Analysis I. 4 Units.

Statistical analysis of transportation data sources. Analysis of categorical and ordinal data. Regression and advanced multivariate analysis methods such as discriminant analysis, canonical correlation, and factor analysis. Sampling techniques, sample error and bias, survey instrument design.

Restriction: Graduate students only.

ENGRCEE 225B. Transportation Planning Models II. 4 Units.

Design and application of comprehensive transportation models. Network development, demand modeling, and equilibrium assignment. Model calibration, validation, prediction, and evaluation. Regional modeling, site impact analysis, and circulation studies. Design of transportation alternatives.

Prerequisite: ENGRCEE 223

Restriction: Graduate students only.

ENGRCEE 226A. Traffic Flow Theory I. 4 Units.

Traffic measurement and fundamental speed-density-flow relationships. Kinematic models. Shock waves. Statistical-kinetic theory of traffic. Introductory car-following principles and stability. Gap acceptance. Platoon dispersion. Two-fluid model. Queueing process. Multi-regime and catastrophe models. Higher-order continuum models. Microscopic and macroscopic simulation.

Restriction: Graduate students only.

ENGRCEE 226B. Traffic Flow Theory II. 4 Units.

Advanced mathematical analysis of vehicular flow. Detailed treatise on car-following models. Fourier and Laplace analysis of stability problems. Perturbation analysis. Derivation of macroscopic traffic flow relationships from microscopic considerations. Advanced hydrodynamic theory.

Prerequisite: ENGRCEE 226A

Restriction: Graduate students only.

ENGRCEE 228A. Urban Transportation Networks I. 4 Units.

Analytical approaches and algorithms to the formulation and solution of the equilibrium assignment problem for transportation networks. Emphasis on user equilibrium (UE) comparison with system optimal, mathematical programming formulation, supply functions, estimation. Estimating origin-destination matrices, network design problems.

Prerequisite: ENGRCEE 220A

Restriction: Graduate students only.

ENGRCEE 228B. Urban Transportation Networks II. 4 Units.

Advanced analysis, optimization, and modeling of transportation networks. Topics include advanced static and dynamic traffic assignment algorithms, linear and nonlinear multi-commodity network flow optimization, network simplex, and network control problems.

Prerequisite: ENGRCEE 221A and ENGRCEE 228A

Restriction: Graduate students only.

ENGRCEE 229A. Traffic Systems Operations and Control I. 4 Units.

Introduction to operation, control, and analysis of arterial and freeway traffic systems. Control concepts, traffic stream principles, detectors, local controllers, system masters, traffic signal and ramp metering timing principles, traffic measurement technologies, traffic delay principles.

Restriction: Graduate students only.

Concurrent with ENGRCEE 122.

ENGRCEE 229B. Traffic Systems Operations and Control II. 4 Units.

Advanced topics related to operation, control, and analysis of arterial and freeway traffic systems. Control concepts, traffic stream principles, detectors, local controllers, system masters, traffic signal and ramp metering timing principles.

Prerequisite: ENGRCEE 229A

Restriction: Graduate students only.

ENGRCEE 231. Foundation Engineering. 4 Units.

Essentials for design and analysis of structural members that transmit superstructure loads to the ground. Topics include subsurface investigations, excavation, dewatering, bracing, footing, mat foundations, piles and pile foundations, caissons and cofferdams, other special foundations.

Restriction: Graduate students only.

ENGRCEE 232. Geotech Earthquake Engineering. 4 Units.

In-situ and laboratory determination of dynamic soil properties, liquefaction of soil, cyclic softening of clays, seismic compression and settlement analyses, ground improvement methods, seismic slope stability, introduction to soil structure interaction.

Restriction: Graduate students only.

ENGRCEE 240. High Performance Materials. 4 Units.

Part I: Linear and nonlinear fracture mechanics, methodology, real-world case studies; Part II: Composite material toughening, underlying micromechanics, materials engineering towards microstructure tailoring and new material design approaches; Part III: Emerging high-performance engineering materials for safety, energy and the environment.

Restriction: Graduate students only.

ENGRCEE 242. Advanced Strength of Materials. 4 Units.

Beams on elastic foundations. Combined axial and lateral loads. Curved beams. Unsymmetric bending. Shear center. Stresses and strains. Basic equations for theory of elasticity. Energy principles. Theory of torsion. Combined bending and torsion.

Restriction: Graduate students only.

ENGRCEE 243. Mechanics of Composite Materials. 4 Units.

Stress-strain relationship for orthotropic materials; invariant properties of an orthotropic lamina; biaxial strength theory for an orthotropic lamina; mechanics of materials approach to stiffness; elasticity approach to stiffness; classical lamination theory; strength of laminates; statistical theory of fatigue damage.

Restriction: Graduate students only.

ENGRCEE 247. Structural Dynamics. 4 Units.

Vibration of discrete and continuous mass elastic systems. Isolation and transmissibility. Dynamic recording instruments. Introduction to nonlinear theory of vibration. Response of structures to earthquake, traffic, and wind loads. Response spectra concepts. Normal mode analysis. Numerical integration techniques.

Restriction: Graduate students only.

ENGRCEE 249. Earthquake Engineering. 4 Units.

Earthquake magnitude, intensity, and frequency. Seismic damage to structures. Earthquake load prediction including response spectra, normal mode, and direct integration techniques. The basis of building code earthquake load requirements for buildings. Seismic response of special structures. Lifeline engineering.

Restriction: Graduate students only.

ENGRCEE 250. Finite Element Method in Structural Engineering. 4 Units.

Finite element concepts in structural engineering including variational formulations, shape functions, elements assembly, convergence and computer programming. Stiffness of truss, beam, and frame members, two- and three-dimensional solids, plate and shell elements. Static, vibration, stability, and inelastic analysis.

Restriction: Graduate students only.

ENGRCEE 251. Performance-Based Structural Engineering. 4 Units.

Introduction and implementation of current approaches in performance-based assessment and design of building structures. Emphasis is on applied and evolving methods and tools for exercising performance-based engineering of building structures.

Prerequisite: ENGRCEE 247 and ENGRCEE 249

Restriction: Graduate students only.

ENGRCEE 252. Multiscale Modeling of Materials and Structures. 4 Units.

Introduction to modeling materials and structures across length.

Restriction: Graduate students only.

ENGRCEE 254. Advanced Reinforced Concrete Behavior and Design. 4 Units.

Flexural strength of reinforced concrete elements. Flexural ductility of unconfined and confined members with axial loads. Shear and torsional behaviors. Strength of reinforced concrete ductile frames and shear walls. Reinforced concrete detailing.

Restriction: Graduate students only.

ENGRCEE 255. Advanced Behavior and Design of Steel Structures. 4 Units.

Advanced principles of structural steel design. Analysis and design of beam-column members, braced and unbraced frames for buildings, and plate girders. Review of seismic design provisions. Design of connections.

Restriction: Graduate students only.

ENGRCEE 258. Earthquake Resistant Structural Design. 4 Units.

Objectives of seismic design. Cyclic load-distortion characteristics of typical structural elements. Desirable structural form. Ductility and methods of achieving it. Use of energy dissipators. Project involving design of multistory, multibay rigid-jointed plane frame.

Restriction: Graduate students only.

ENGRCEE 260. Desalination. 4 Units.

Introduction of state of technology, costs and benefits, environmental issues, and implementation issues related to desalination. Emphasis on membrane processes and biofouling prevention.

Restriction: Graduate students only.

ENGRCEE 261. Applied Environmental Microbiology. 4 Units.

Microbes in the environment and their impact on human interactions. Microbiological application in solving environmental engineering problems.

Restriction: Graduate students only.

ENGRCEE 262. Environmental Chemistry II. 4 Units.

Advanced concepts from physical and organic chemistry as they relate to environmental engineering. Emphasis on equilibrium and kinetics as they apply to redox reactions, coordination, absorption, gas phase reactions, and ion exchange.

Restriction: Graduate students only.

ENGRCEE 263. Advanced Biological Treatment Processes. 4 Units.

Analysis of biological processes in natural and engineered systems. Biological treatment processes, both aerobic and anaerobic, with emphasis on suspended growth systems including design consideration. Containment degradation or control covered. Includes laboratory on molecular tools used in wastewater treatment.

Restriction: Graduate students only.

ENGRCEE 264. Carbon and Energy Footprint Analysis. 4 Units.

Process design for wastewater treatment. Mass- and energy- balance analysis applied to water and wastewater treatment systems. Case studies include analysis of water supply, treatment, reclamation, and reuse.

Restriction: Graduate students only.

Concurrent with ENGRCEE 164.

ENGRCEE 265. Physical-Chemical Treatment Processes. 4 Units.

Theory and dynamics of physical and chemical separation processes in water and wastewater treatment. Topics include coagulation, sedimentation, filtration, gas transfer, membrane separations, and absorption.

Restriction: Graduate students only.

Concurrent with ENGRCEE 165.

ENGRCEE 266. Drinking Water and Wastewater Biotechnology. 4 Units.

Water and wastewater microbiology. Engineering principles, molecular aspects, and overview of microorganisms of importance to public health. Topics include aerobic and anaerobic wastewater treatment and disinfection of pathogens in water, wastewaters, and biosolids.

Restriction: Graduate students only.

ENGRCEE 269. Beach Dynamics. 4 Units.

Coastal erosion in California, human and natural influences on southern California beaches, and present-day challenges. Littoral cells and sediment budgets. Water wave theory. Littoral sediment transport and shoreline change modeling. Shoreline stabilization using green and gray infrastructure.

Restriction: Graduate students only.

ENGRCEE 270. Flood Risk and Modeling. 4 Units.

Global and national trends in flooding and related impacts including disasters; flood risk management; theory and numerical methods for flood inundation modeling; flood risk communication strategies including flood hazard visualizations.

ENGRCEE 271. Flow in Unsaturated Porous Media. 4 Units.

Fluid flow in the unsaturated zone (zone of aeration) of the subsurface. Soil-water physics, flow in regional groundwater systems, miscible displacement, mathematical modeling techniques.

Restriction: Graduate students only.

ENGRCEE 272. Groundwater Hydrology. 4 Units.

Topics include conservation of fluid mass, storage properties or porous media, matrix compressibility, boundary conditions, flow nets, well hydraulics, groundwater chemistry, and solute transport. Includes introduction to advanced topics in porous media. Design projects and computer applications included.

Restriction: Graduate students only.

Concurrent with ENGRCEE 172.

ENGRCEE 273. Watershed Modeling. 4 Units.

Basic principles of hydrologic modeling are practiced. Concepts of watershed delineation, land use change impact, design studies, and GIS tools are discussed. Focus on the USACE (HEC) software tools (HEC-HMS and HEC-RAS) along with their associated GIS interfaces.

Restriction: Graduate students only.

Concurrent with ENGRCEE 173.

ENGRCEE 274. Climate Data Analysis. 4 Units.

Trend analysis; statistical indices for diagnosing and detecting changes in extremes; nonstationary processes; extreme value analysis; multivariate extreme value methods; tail dependence estimation; uncertainties in observed and projected changes in climate extremes.

ENGRCEE 276. Hydrology. 4 Units.

Elements of the hydrologic cycle including precipitation, infiltration, evapotranspiration, ground water, and runoff. Unit Hydrograph theory and routing methods. Introduction to precipitation/runoff relationship and watershed modeling. Statistical methods and flood frequency analysis. Discussion section covers advanced topics.

Restriction: Graduate students only.

Concurrent with ENGRCEE 176.

ENGRCEE 277. Hydrologic Transport Fundamentals. 4 Units.

Process description, mathematical and numerical modeling of transport processes in surface and ground water. Topics include advection, molecular diffusion, Taylor dispersion, mechanical dispersion in porous media, shear flow dispersion in channels, and turbulent jets and plumes.

Restriction: Graduate students only.

ENGRCEE 279. Environmental Transport Modeling. 4 Units.

Computational modeling of multi-dimensional flow and scalar transport problems in surface and ground water. Topics include mathematical model formulation, numerical method selection, serial and parallel implementation, model verification and validation.

Restriction: Graduate students only.

ENGRCEE 281. Structural Reliability. 4 Units.

Applications of probability theory to reliability analysis of engineering structures. Theory of structural reliability. Estimation of static random loads. Reliability analysis of structural components and system. Monte Carlo simulation.

Restriction: Graduate students only.

ENGRCEE 283. Mathematical Methods in Engineering Analysis. 4 Units.

Matrices; vector calculus; eigenvalue problems; Fourier analysis; partial differential equations; special functions; numerical analysis; finite difference method.

ENGRCEE 289. Analysis of Hydrologic Systems. 4 Units.

Application of systems theory in hydrologic, land surface, biogeochemical modeling. Design, identification, and calibration of conceptual models. Principles of dynamic systems, modeling approaches, theory of linear systems, mathematical concepts of differential calculus, theoretical concepts of parameter estimation and optimization theory.

ENGRCEE 290. Merging Models and Data. 4 Units.

Introduction to optimization and data assimilation methods for model calibration and uncertainty quantification. Local, global and multi-method search. Bayesian analysis using Monte Carlo simulation with Random Walk Metropolis, and adaptive samplers. Filtering methods for recursive inference. Illustration using environmental models.

Restriction: Graduate students only.

ENGRCEE 291. Hydrologic Remote Sensing. 4 Units.

Introduction to principles of remote sensing and application in hydrology. Review of sensor systems, thermal and multispectral image processing, and image classification. Examples from remote sensing of hydrologic processes such as precipitation, soil moisture, and vegetation are covered.

Prerequisite: ENGRCEE 276

Restriction: Graduate students only.

ENGRCEE 292. Wavelets in Hydrology, Engineering, and Geoscience. 4 Units.

Multiscale analysis of hydrologic, engineering, and earth system processes; energy decomposition in the time-frequency domain via wavelets; applications to fluid flows, climate and mechanical signals for feature extraction, trend analysis, coherent structures, and upscaling/downscaling.

Restriction: Graduate students only.

ENGRCEE 295. Seminars in Engineering. 1-4 Units.

Seminars scheduled each year by individual faculty in major field of interest.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

ENGRCEE 296. Master of Science Thesis Research. 1-16 Units.

Individual research or investigation conducted in preparation of the thesis required for the M.S. degree in Engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

ENGRCEE 297. Doctor of Philosophy Dissertation Research. 1-16 Units.

Individual research or investigation conducted in preparation for the dissertation required for the Ph.D. degree in Engineering.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.

ENGRCEE 298. Special Topics in Civil and Environmental Engineering. 1-4 Units.

Presentation of advanced topics and special research areas in civil and environmental engineering.

Repeatability: Unlimited as topics vary.

Restriction: Graduate students only.

ENGRCEE 299. Individual Research. 1-16 Units.

Individual research or investigation under the direction of an individual faculty member.

Grading Option: Satisfactory/unsatisfactory only.

Repeatability: May be repeated for credit unlimited times.

Restriction: Graduate students only.