Department of Civil and Environmental Engineering

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Civil Engineering is the application of scientific knowledge to the analysis, design, operation, and maintenance of the built environment and its interfaces with the natural environment in order to sustainably and reliably meet human needs. The success of this endeavor is evident all around us. The arid plain which greeted the early settlers in Southern California has been transformed into a thriving regional community largely by the application of civil engineering.

The goal of the Civil Engineering curriculum is to prepare graduates for a career in practice, research, or teaching. Undergraduate students need to master a common core of fundamental subjects, before specializing in their senior year in one of the following areas: General Civil Engineering, Environmental Hydrology and Water Resource Engineering, Structural Engineering, and Transportation Systems Engineering. Graduate opportunities are in three major thrust areas: structural analysis, design, and reliability; transportation systems engineering; and water resources and environmental engineering.

Career opportunities in civil engineering are varied. Graduates may look forward to careers in major corporations, public bodies, the military, or private consulting firms. History has shown a civil engineering education is a solid foundation for many administrative and managerial positions.

Environmental Engineering involves designing environmental protection or remediation strategies for multiple resources—water, air, and soil, often with combinations of physical, chemical, and biological treatment methods in the context of a complex regulatory framework.

The goal of the Environmental Engineering curriculum is to provide graduates with a strong basic science background, particularly in chemistry and biology, and a broad exposure to several environmental engineering science disciplines. Courses relating to transport processes, water quality control, air quality control, and process design are included in the core.

Career opportunities in environmental engineering are diverse. Graduates generally find careers related to pollution control and the remediation of air, water, and soil environments in major corporations, public agencies, the military, or private consulting firms.

- Civil and Environmental Engineering, M.S.
- Civil and Environmental Engineering, Ph.D.
- Civil Engineering, B.S.
- Environmental Engineering, B.S.

Faculty

Mohammad Javad Abdolhosseini Qomi, Ph.D. Massachusetts Institute of Technology, *Associate Professor of Civil and Environmental Engineering* (mechanics and physics of multi-scale porous materials, interfacial phenomena, cement chemistry, geochemistry)

Adeyemi Adeleye, Ph.D. University of California, Santa Barbara, *Assistant Professor of Civil and Environmental Engineering* (water/environmental chemistry; environmental applications of nanotechnology, fate and effects of emerging contaminants (engineered nanomaterials, pharmaceuticals, and microplastics); nanotoxicity; water and wastewater treatment)

Amir Aghakouchak, Ph.D. University of Stuttgart, *Professor of Civil and Environmental Engineering; Earth System Science* (hydrology, climatology, remote sensing of environment, climate extremes, water-energy nexus, climate change, stochastic modeling, water resources management)

Alfredo H.-S. Ang, Ph.D. University of Illinois at Urbana-Champaign, *Professor Emeritus of Civil and Environmental Engineering* (structural and earthquake engineering, risk and reliability engineering)

Tirtha Banerjee, Ph.D. Duke University, *Assistant Professor of Civil and Environmental Engineering* (atmospheric boundary layer dynamics, turbulent fluid dynamics, land/water/vegetation - atmosphere interaction, wildfires, vegetation dynamics, carbon and water cycles, hydrology, wetlands and terrestrial aquatic interfaces)

William J. Cooper, Ph.D. University of Miami, *Professor Emeritus of Civil and Environmental Engineering* (environmental chemistry, advanced oxidation processes for water treatment, aquatic photochemistry of carbon cycling)

Kristen A. Davis, Ph.D. Stanford University, *Associate Professor of Civil and Environmental Engineering; Earth System Science* (coastal oceanography, fluid mechanics, turbulent flows)

Russell L. Detwiler, Ph.D. University of Colorado Boulder, *Associate Professor of Civil and Environmental Engineering* (groundwater hydrology, contaminant fate and transport, subsurface process modeling, groundwater/surface-water interaction)

Efi Foufoula-Georgiou, Ph.D. University of Florida, *Associate Dean of Research and Innovation for the Samueli School of Engineering and Distinguished Professor of Civil and Environmental Engineering; Earth System Science* (hydrology and geomorphology with emphasis on modeling the interactions between the atmosphere, land, and the terrestrial environment at plot to large-watershed scale)

Stanley B. Grant, Ph.D. California Institute of Technology, *Professor Emeritus of Civil and Environmental Engineering* (environmental engineering, inland and coastal water quality, coagulation and filtration of colloidal contaminants, environmental microbiology)

Gary L. Guymon, Ph.D. University of California, Davis, *Professor Emeritus of Civil and Environmental Engineering* (water resources, groundwater, modeling uncertainty)

Shakira Hobbs, Ph.D. Clemson University, *Samueli Faculty Development Chair and Assistant Professor of Civil and Environmental Engineering* (global sustainability, resource recovery from anthropogenic waste, and life cycle thinking applied to engineering equity at the food-energy-water nexus)

Kuo-Lin Hsu, Ph.D. University of Arizona, *Professor of Civil and Environmental Engineering* (remote sensing of precipitation, hydrologic systems modeling, stochastic hydrology, water resources systems planning)

Michael Hyland, Ph.D. Northwestern University, *Assistant Professor of Civil and Environmental Engineering* (modeling, design, control, and analysis of smart city transportation systems with emphases on shared-use autonomous mobility services and urban transit networks)

R. (Jay) Jayakrishnan, Ph.D. University of Texas at Austin, *Professor of Civil and Environmental Engineering* (transportation systems engineering, including traffic flow theory, dynamic traffic assignment and simulation for advanced network informatics, and advanced transit technologies)

C. Sunny Jiang, Ph.D. University of South Florida, *Professor of Civil and Environmental Engineering; Ecology and Evolutionary Biology; Environmental and Occupational Health* (water pollution microbiology, environmental technology, aquatic microbial ecology)

Wenlong Jin, Ph.D. University of California, Davis, *Professor of Civil and Environmental Engineering* (intelligent transportation systems, network traffic flow theory, transportation system analysis)

Joel Lanning, Ph.D. University of California, San Diego, *Assistant Professor of Teaching of Civil and Environmental Engineering* (seismic design of civil structures, large-scale testing, alternative building materials, teaching methods in engineering education)

Anne Lemnitzer, Ph.D. University of California, Los Angeles, *Associate Professor of Civil and Environmental Engineering* (geotechnical and earthquake engineering, soil structure interaction, large-scale testing of structural and geo-structural elements and systems, in-situ monitoring and field testing, infrastructure and hazard engineering)

Mo Li, Ph.D. University of Michigan, *Associate Professor of Civil and Environmental Engineering; Materials Science and Engineering* (novel infrastructure materials and advanced manufacturing methods, and their interfaces with structural engineering, sensing and health monitoring, energy and environment)

Michael G. McNally, Ph.D. University of California, Irvine, *Professor of Civil and Environmental Engineering; Urban Planning and Public Policy* (travel behavior, transportation systems analysis)

Ayman S. Mosallam, Ph.D. Catholic University of America, *Professor of Civil and Environmental Engineering* (advanced composites and hybrid systems, seismic repair and rehabilitation of structures, diagnostic/prognostic structural health monitoring techniques, 3D printing in Construction and sustainable and green building technology)

Phu Dinh Nguyen, Ph.D. University of California, Irvine, *Associate Adjunct Professor of Civil and Environmental Engineering* (hydrology, GIS, satellite precipitation estimation, databases and visualization tools for remotely-sensed data and information, crowdsourcing, water resources systems)

Christopher Olivares Martinez, Ph.D. University of Arizona, *Assistant Professor of Civil and Environmental Engineering* (environmental biotechnology, remediation, metabolomics, pollutant fate in natural and engineering systems, microbial toxicity, environmental organic chemistry)

Betty H. Olson, Ph.D. University of California, Berkeley, *Professor Emerita of Civil and Environmental Engineering* (molecular applications for optimizing biological processes in wastewater treatment, environmental health, drinking water microbiology)

Gerard C. Pardoen, Ph.D. Stanford University, *Professor Emeritus of Civil and Environmental Engineering* (structural analysis, experimental structural dynamics)

Wilfred W. Recker, Ph.D. Carnegie Mellon University, *Professor Emeritus of Civil and Environmental Engineering* (transportation systems modeling, traffic control, and urban systems analysis)

Stephen G. Ritchie, Ph.D. Cornell University, *Director of the Institute of Transportation Studies and Professor of Civil and Environmental Engineering* (intelligent and sustainable transportation systems planning and engineering, emerging technologies and sensors, freight transportation)

Diego Rosso, Ph.D. University of California, Los Angeles, *Director of the UCI Water-Energy Nexus Center (WEX) and Professor of Civil and Environmental Engineering; Chemical and Biomolecular Engineering* (environmental process engineering, mass transfer, wastewater treatment, carbon- and energy-footprint analysis)

Brett F. Sanders, Ph.D. University of Michigan, *Professor of Civil and Environmental Engineering; Urban Planning and Public Policy* (flood hazard modeling, flood risk management, sediment management, shallow-water hydrodynamics and morphodynamics, computational methods, remote-sensing with drones, translational research for flood modeling targeting community resilience, population health and poverty alleviation)

Jean-Daniel M. Saphores, Ph.D. Cornell University, *Department Chair and Professor of Civil and Environmental Engineering; Economics; Urban Planning and Public Policy* (transportation and environmental systems (with a focus on air pollution and energy use), travel behavior analysis, alternative fuel vehicles, automated vehicles, transit use, sustainable infrastructure management, and decision making under uncertainty using real options)

Jan W. Scherfig, Ph.D. University of California, Berkeley, *Professor Emeritus of Civil and Environmental Engineering* (water reclamation, waste treatment processes, environmental engineering)

Soroosh Sorooshian, Ph.D. University of California, Los Angeles, *Director of the Center for Hydrometeorology and Remote Sensing (CHRS) and Distinguished Professor of Civil and Environmental Engineering; Earth System Science* (hydrometeorology, water resources systems engineering, climate studies and application of remote sensing to earth science problems with special focus on the hydrologic cycle and water resources issues of arid and semi-arid zones)

Lizhi Sun, Ph.D. University of California, Los Angeles, *Professor of Civil and Environmental Engineering* (structural mechanics, finite element method, composites and nanocomposites, smart materials and structures, multiscale modeling, elastography)

Roberto Villaverde, Ph.D. University of Illinois at Urbana-Champaign, *Professor Emeritus of Civil and Environmental Engineering* (structural dynamics and earthquake engineering)

Jasper A. Vrugt, Ph.D. University of Amsterdam, *Professor of Civil and Environmental Engineering* (examining how (eco)systems work, why theories deviate from data, how scientists diagnose change, as applied to biogeosciences, ecology, geomorphology, geophysics, hydrology, soils)

Jann N. Yang, DSc Columbia University, *Professor Emeritus of Civil and Environmental Engineering* (system identification and damage detection, structural health monitoring, structural control, earthquake engineering, structural dynamics)

Farzin Zareian, Ph.D. Stanford University, *Professor of Civil and Environmental Engineering* (structural engineering, performance-based earthquake engineering, structural reliability, structural control, community resilience)

Affiliate Faculty

Jacob Brouwer, Ph.D. Massachusetts Institute of Technology, *Director of Advanced Power and Energy Program and Director of National Fuel Cell Research Center and Professor and Chancellor's Fellow of Mechanical and Aerospace Engineering; Chemical and Biomolecular Engineering; Civil and Environmental Engineering* (fuel cells, energy systems dynamics, electrochemical systems design and analysis, chemical kinetics, reacting flows)

Steven J. Davis, Ph.D. Stanford University, *Professor of Earth System Science; Civil and Environmental Engineering*

Derek Dunn-Rankin, Ph.D. University of California, Berkeley, *Professor Emeritus of Mechanical and Aerospace Engineering; Civil and Environmental Engineering; Environmental Health Sciences* (combustion, optical particle sizing, particle aerodynamics, laser diagnostics and spectroscopy)

James T. Randerson, Ph.D. Stanford University, *UCI Chancellor's Professor of Earth System Science; Civil and Environmental Engineering; Ecology and Evolutionary Biology*

Eric Rignot, Ph.D. University of Southern California, *Donald Bren Professor of Earth System Science; Civil and Environmental Engineering*

G. Scott Samuelsen, Ph.D. University of California, Berkeley, *Research Professor and Professor Emeritus of Mechanical and Aerospace Engineering; Civil and Environmental Engineering* (fuel cells, combustion, air quality, smart grid and microgrid technology, practical systems, energy and environmental conflict)

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.
Nature of earthquakes, hazard analyses, structural dynamics for earthquake engineering, seismic design force determination methods: ELF, modal response spectrum, nonlinear time history analyses. Diaphragm analyses, redundancy, nonlinear response, ductile systems, hysteretic behavior. Basics of seismic design for steel, timber, concrete.

(Design units: 2)

Prerequisite: ENGRCEE 11 and (ENGRCEE 20 or BME 60B) and ENGRCEE 151A

Restriction: Civil Engineering Majors have first consideration for enrollment.

Concurrent with ENGRCEE 249.

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)

Corequisite: ENGRCEE 150
Prerequisite: (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 166. Microbial Processes for Bioremediation. 4 Units.
Fundamental knowledge on microbiology, organic chemistry, biodegradability and persistence, reaction kinetics, and contaminant transport of water and soil remediation of organic contaminants under aerobic and anaerobic conditions. Overview of Environmental Law and Superfund. Design project of bioremediation for contaminated site.

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

Concurrent with ENGRCEE 206P.

ENGRCEE 168. Microorganisms and Climate Change. 4 Units.
Climate change and impacts on microbial processes: greenhouse gas generation, biogeochemical cycles, permafrost thawing, ocean acidification, eutrophication, pathogen proliferation. Microorganism-based solutions that can mitigate climate change impacts (microbial greenhouse control, production of lower carbon and energy footprint goods, carbon sequestration).

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 197. Civil and Environmental Engineering Internship. 2-12 Units.
Students majoring in CEE may receive credit for an approved internship, working at a company under the supervision of an industry mentor and a faculty advisor. Enables students to gain valuable experience in a professional setting and enhance their skills.

Grading Option: Pass/no pass only.

Repeatability: May be taken for credit 3 times.

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 201P. Life Cycle Assessment Methods. 4 Units.
Introduction and application of life cycle assessment methods for.

Restriction: Master of Engineering students only.

ENGRCEE 202P. Green Building Design. 4 Units.
Application of life cycle assessment methods to green and sustainable.

Restriction: Master of Engineering students only.

ENGRCEE 203P. Organizational Pollutant Emissions Accounting. 4 Units.
Application of life cycle assessment methods to account for emissions.

Restriction: Master of Engineering students only.

ENGRCEE 204P. Fundamentals of Sustainable Engineering. 4 Units.
Introduction to sustainability and its connection to environmental engineering infrastructure: economic/social sustainability, lifecycle assessment/cost, water and waste management, empathy in engineering, quantitative approaches for social sustainability, and decision-making across sustainability metrics. Includes guest lectures and field trips.

Restriction: Master of Engineering students only.

ENGRCEE 205P. Wastewater Treatment Process Design. 4 Units.
Process design for wastewater treatment. Topics include solids separation, biological treatment, aeration, sludge stabilization, process control, and economics. Design projects included.

Restriction: Master of Engineering students only.

Concurrent with ENGRCEE 163.

ENGRCEE 206P. Biological Processes for Bioremediation. 4 Units.
Fundamental knowledge on microbiology, organic chemistry, biodegradability and persistence, reaction kinetics, and for development of water and soil.

Restriction: Master of Engineering students only.

Concurrent with ENGRCEE 166.

ENGRCEE 207P. Introduction to Data Science Programming and Optimization. 4 Units.
Basics of object-oriented programming; data analysis using scientific programming packages; best programming practices; civil and environmental engineering analysis and design of linear systems; introduction to the analysis and design of non-linear systems in civil engineering.

Restriction: Graduate students only. Master of Engineering students only.

ENGRCEE 208P. Data Analytics for Civil Engineers. 4 Units.
Quantitative research methods and statistical techniques for analyzing and viewing civil and environmental engineering data. Descriptive statistics, hypothesis testing, linear and logical regression, clustering and introduction to machine learning.

Restriction: Graduate students only. Master of Engineering students only.

ENGRCEE 210P. Smart City Transport Systems. 4 Units.
Focuses on engineering methods and concepts associated with smart cities and applies these methods and concepts to analyze emerging and future.

Restriction: Master of Engineering students only.

ENGRCEE 211P. Sustainable Transportation. 4 Units.
Overview of the impacts of transportation on the environment, with an.

Restriction: Master of Engineering students only.

ENGRCEE 212P. Transportation Policy and Technology. 4 Units.
The process of planning, designing, and managing the transportation.

Restriction: Master of Engineering students only.

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. ENGRCEE 220A with a grade of B- or better

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 separtate these two approaches and presenting appropriate mathematical and statistical tools to address these distinctions.

Prerequisite: ENGRCEE 220A. ENGRCEE 220A with a grade of B- or better

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. ENGRCEE 221A with a grade of B- or better

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 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. ENGRCEE 226A with a grade of B- or better

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. ENGRCEE 220A with a grade of B- or better

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. ENGRCEE 221A with a grade of B- or better. ENGRCEE 228A with a grade of B- or better

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 230P. Introduction to Machine Learning. 4 Units.
Introduces fundamental concepts in programming and machine learning. The goal is to provide an accessible introduction to the field of machine learning and related techniques for students with a wide variety of engineering degrees.

Same as BME 230P, ENGR 230P, EECS 230P, ENGRMAE 230P.

Restriction: Master of Engineering 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 231P. 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: Master of Engineering 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 247. Structural Dynamics. 4 Units.
Vibration of discrete and continuous mass elastic systems. Isolation and transmissability. 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 247P. Structural Dynamics. 4 Units.
Dynamic equilibrium of structures. Response of a single degree of.

Restriction: Master of Engineering students only.

ENGRCEE 249. Earthquake Engineering. 4 Units.
Nature of earthquakes, hazard analyses, structural dynamics for earthquake engineering, seismic design force determination methods: ELF, modal response spectrum, nonlinear time history analyses. Diaphragm analyses, redundancy, nonlinear response, ductile systems, hysteretic behavior. Basics of seismic design for steel, timber, concrete.

Restriction: Graduate students only.

Concurrent with ENGRCEE 149.

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 250P. Finite Element Method in Structural Engineering. 4 Units.
Finite element concepts in structural engineering including.

Restriction: Master of Engineering 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. ENGRCEE 247 with a grade of B- or better. ENGRCEE 249 with a grade of B- or better

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 253. Micromechanics. 4 Units.
Micromechanics concepts in solid mechanics including eigenstrains, Eshelby equivalent inclusion theories, homogenization procedures, Mori-Tanaka method, self-consistent scheme, and effective mechanical behavior of composites.

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 254P. Advanced Reinforced Concrete Behavior and Design. 4 Units.
Centers on advanced concepts in the design of reinforced concrete structures, encompassing areas such as two-way slabs, flat plates, slender columns, member ductility, special moment frames, shear walls, and incorporating sustainability considerations.

Prerequisite: Knowledge of reinforced concrete design and introduction to earthquake engineering.

Restriction: Master of Engineering 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 255P. Advanced Structural Steel Design. 4 Units.
Advanced principles of structural steel design with special coverage on the.

Prerequisite: Knowledge of structural design engineering and seismic design provisions.

Restriction: Master of Engineering 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 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 264P. 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.

Prerequisite: Undergraduate-level introduction to environmental processes, mass balances, and transport phenomena.

Restriction: Master of Engineering students only.

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 266P. Biological Process Design. 4 Units.
Applied microbiology and engineering principles to understand and solve.

Restriction: Master of Engineering students only.

ENGRCEE 267. The Science and Engineering of Wildfires. 4 Units.
Covers the fundamental science of wildfire behavior, scales, modeling techniques, and emerging engineering solutions to mitigate wildfire risks.

Prerequisite: Recommended: ENGRCEE 11 and ENGRCEE 110.

Concurrent with CEE 167.

ENGRCEE 268. Environmental Fluid Mechanics and Turbulence. 4 Units.
Covers the nonlinear physics of turbulence flows with a focus on environmental applications.

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 269P. Beach Dynamics. 4 Units.
Provides an introduction to the processes that influence coastal.

Restriction: Master of Engineering 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 270P. Flood Risk and Modeling. 4 Units.
Introduction to flood risk management, including coverage of the consequences and causes of flooding, trends in flooding, how flood risk is managed, and modeling methods for supporting various aspects of flood management.

Restriction: Master of Engineering students only.

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 275. Stochastic Hydrology. 4 Units.
Statistical analysis and modeling of hydrologic and geophysical data for decision making, frequency analysis of extreme precipitation and floods for hydrologic design, time series analysis for hydrological simulation, spectral analysis, and geostatistical analysis of spatially correlated fields.

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 290A. Machine, Model, and Statistical Learning I. 4 Units.
Introduction to machine, model, and statistical learning, featuring a.

Prerequisite: Recommended: Foundational skills in Mathematics, Statistics, and MATLAB.

Restriction: Graduate students only.

ENGRCEE 290B. Machine, Model, and Statistical Learning II. 4 Units.
Advanced mathematical concepts in machine, model, and statistical learning. Linear algebra, information, probability, and set theory. Topics include sensitivity analysis, forecast verification, model selection, model averaging, data assimilation (Kalman filter), and sequential Monte Carlo (particle filter).

Prerequisite: ENGRCEE 290A. ENGRCEE 290A with a grade of B- or better

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. ENGRCEE 276 with a grade of B- or better

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 295P. Special Topics in Civil and Environmental Engineering. 4 Units.
Studies in selected areas of Civil and Environmental Engineering. Topics addressed vary each quarter.

Repeatability: May be taken for credit 1 times as topics vary.

Restriction: Master of Engineering 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.