

# CIVIL ENGINEERING (CVEN)

## Courses

### CVEN 1027 (3) Civil Engineering Drawing

Develops drawing and drafting skills for civil engineering projects in both hand drawing and software tools. Students will learn to read and interpret design and construction drawings.

**Requisites:** Restricted to Civil Engineering (CVEN) majors and IUT on track students only.

**Additional Information:** Departmental Category: Miscellaneous

### CVEN 1317 (1) Introduction to Civil and Environmental Engineering

Surveys the broad subject of civil and environmental engineering and professional practice. Includes the subdisciplines of structures, water resources, geotechnics, transportation, environment, and construction. Discusses professional ethics, important skills for engineers, and the engineering design process as it fulfills multiple objectives.

**Requisites:** Restricted to students with 0-56 credits (Freshmen or Sophomore) College of Engineering majors only.

**Additional Information:** Departmental Category: Miscellaneous

### CVEN 1837 (1-3) Special Topics

Supervised study of special topics of interest to student under instructor guidance.

**Repeatable:** Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**Additional Information:** Departmental Category: Miscellaneous

### CVEN 2012 (3) Introduction to Geomatics

Presents basic techniques of land and construction surveying, including measurement of position, elevation, orientation and length of lines, area, volume and layout calculations. Optical, GPS and GIS equipment and methods are included.

**Requisites:** Restricted to Architectural (AREN) or Civil (CVEN) or Integrated Design (IDEN) Engineering majors and IUT on track students only.

**Additional Information:** Departmental Category: Surveying and Transportation

### CVEN 2017 (1) Excel Matlab R Primer

Introduces basic usage of Excel, Matlab, and R software programs. Includes overview of fundamental operations such as data input and output, arithmetic, graphics, and programming syntax; more specific operations such as algebraic functions, linear algebra, plotting, loops, conditional statements, statistics and data analysis. Students will complete a final programming project with one of the software programs.

**Requisites:** Requires prerequisite course of CSCI 1200 or CHEN 1310 or CSCI 1300 or ECEN 1310 (all minimum grade C-). Restricted to College of Engineering majors or IUT on track students only.

**Recommended:** Corequisite APPM 2360.

### CVEN 2121 (3) Analytical Mechanics 1

Applies mechanics to the study of static equilibrium of rigid and elastic bodies. Includes composition/resolution of forces; moments/couples; equivalent force systems; free-body diagrams; equilibrium of particles and rigid bodies; forces in trusses/beams; frictional forces; first/second moments of area; moments and products of inertia.

**Equivalent - Duplicate Degree Credit Not Granted:** GEEN 2851 and MCEN 2023

**Requisites:** Requires a prereq course of PHYS 1110 (min grade C-).

Requires a prereq or coreq course of APPM 2350 or MATH 2400 (min grade C-). Restricted CVEN or EVEN or AREN or AMEN or EPEN or IDEN majors with a CIV, ENR or ARC subplan or IUT on track students.

**Additional Information:** Departmental Category: Mechanics

### CVEN 2545 (3) Construction Materials

Introduce material science of engineering materials, such as atomic and crystal structures, defects, and phase diagrams; discusses in details three construction materials: Portland cement concrete, metals, and asphalts including classification and composition, engineering properties, and testing methods. Covers basic information of two materials: fiber reinforced polymers and wood.

**Requisites:** Restricted to students with 27-180 credits (Sophomores, Juniors or Seniors) College of Engineering students only.

**Recommended:** Prerequisite CVEN 2121.

**Grading Basis:** Letter Grade

### CVEN 2837 (1-3) Special Topics

Supervised study of special topics of interest to student under instructor guidance.

**Repeatable:** Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**Additional Information:** Departmental Category: Miscellaneous

### CVEN 3022 (3) Construction Surveying

Studies construction and highway surveying, horizontal and vertical curves, earthwork, and analysis of data.

**Requisites:** Requires prerequisite course of CVEN 2012 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Surveying and Transportation

### CVEN 3032 (3) Photogrammetry

Familiarizes students with characteristics of aerial photographs. Measures and interprets aerial photos for planimetric, topographic, hydrological, soil, and land use surveys. Analyzes and presents field measurements over extensive reaches.

**Additional Information:** Departmental Category: Surveying and Transportation

### CVEN 3042 (3) Advanced Engineering Drawing for Infrastructure

Applying drawing and drafting skills for infrastructure projects using advanced CAD software tools. This course will provide an overview of general CAD standards related to civil engineering. Students will create and modify 3D infrastructure CAD models. Students will learn advanced topics, including terrain surface modeling and grading, earthwork calculations, horizontal and vertical alignment design, subsurface pipe design, and development of construction plans.

**Requisites:** Requires prerequisite course of CVEN 1027 (minimum grade C-). Restricted to College of Engineering students only.

**Grading Basis:** Letter Grade

**CVEN 3111 (3) Analytical Mechanics 2**

Studies the motion (kinematics) of particles and rigid bodies, and the forces that cause the motion (kinetics). Newton's laws as well as energy methods are used to study the motion of particles and rigid bodies in two and three dimensions.

**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 2043

**Requisites:** Requires prerequisite courses of CVEN 2121 or GEEN 2851 or MCEN 2023 or ASEN 2001 or ASEN 2701 (all minimum grade C-). Restricted to AREN, CVEN, EVEN, or IDEN majors only.

**Additional Information:** Departmental Category: Mechanics

**CVEN 3141 (2) Engineering Materials Lab**

**Additional Information:** Departmental Category: Mechanics

**CVEN 3161 (3) Mechanics of Materials 1**

Addresses concepts of stress and strain; material properties, axial loading, torsion, simple bending, and transverse shear; analysis of stress and strain; and deflections of beams. Includes selected experimental and computational laboratories.

**Equivalent - Duplicate Degree Credit Not Granted:** MCEN 2063

**Requisites:** Requires prereq of (CVEN 2121 or GEEN 2851 or MCEN 2023 or ASEN 2001 or ASEN 2701) and prereq or coreq of (APPM 2360 or (MATH 2130 and 3430)) (all min grade C-). Restricted to AREN, CVEN, EVEN, or IDEN majors with CIV, ENR or ARC subplan.

**Additional Information:** Departmental Category: Mechanics

**CVEN 3227 (3) Probability, Statistics and Decision**

Introduces uncertainty based analysis concepts and applications in the planning and design of civil engineering systems emphasizing probabilistic, statistics, and design concepts and methods.

**Requisites:** Restricted to students with 57-180 credits (Junior or Senior) College of Engineering students only.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 3246 (3) Introduction to Construction**

Provides a broad view of concerns, activities, and objectives of people involved in construction: the owner, architect/engineer, contractor, labor and inspector. Interactive gaming situation relates these people to the construction contract, plans/specifications, estimates/bids, scheduling, law and financial management. Students with a Business School Real Estate emphasis may be considered for this course.

**Requisites:** Restricted to junior or senior Civil (CVEN) or Architectural (AREN), Environmental (EVEN) or Integrated Design (IDEN) Engineering majors only.

**Additional Information:** Departmental Category: Construction

**CVEN 3256 (3) Construction Equipment and Methods**

Integrated study of construction equipment, methods, and economics. Topics include equipment productivity, equipment selection, and construction engineering design within economic constraints. Examples include earthmoving, concrete formwork, and temporary construction.

**Requisites:** Requires prerequisite course of CVEN 3246 (minimum grade C-). Restricted to Architectural (AREN) or Civil (CVEN) or Integrated Design (IDEN) Engineering majors only.

**Additional Information:** Departmental Category: Construction

**CVEN 3313 (3) Theoretical Fluid Mechanics**

Basic principles of fluid mechanic. Covers fluid properties, hydrostatics, fluid flow concepts, including continuity, energy, momentum, dimensional analysis and similitude and flow in closed conduits.

**Equivalent - Duplicate Degree Credit Not Granted:** CHEN 3200 and MCEN 3021

**Requisites:** Requires prerequisite course of CVEN 2121 or GEEN 2851 or ASEN 2001 or ASEN 2701 or MCEN 2023 (all min grade C-). Restricted to Civil (CVEN) or Environmental (EVEN) majors, or Integrated Design Engineering (IDEN-BSIDE) majors with a CIV or ENR subplan.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 3323 (3) Hydraulic Engineering**

Studies hydraulic engineering theory and applications. Topics include incompressible flow in conduits, pipe system analysis and design, open channel flow, flow measurement, analysis and design of hydraulic machinery.

**Requisites:** Requires prerequisite course of CVEN 3313 or MCEN 3021 or AREN 2120 or CHEN 3200 (all minimum grade C-). Restricted to Civil (CVEN), Environmental (EVEN), Architectural (AREN) or Integrated Design (IDEN) Engineering majors only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 3414 (3) Fundamentals of Environmental Engineering**

Emphasizes chemical, ecological and hydrological fundamentals and importance of mass and energy balances in solving environmental engineering problems related to water quality, water and wastewater treatment, air pollution, solid and hazardous waste management, sustainability and risk assessment.

**Requisites:** Requires prereq courses CHEN 1201 or CHEN 1211 or CHEM 1113 or MCEN 1024 and APPM 1360 or MATH 2300 (all min grade C-). Restricted to CVEN, AREN, EVEN, MCEN, CHEN, IDEN or AMEN majors only.

**Additional Information:** Departmental Category: Environmental

**CVEN 3424 (3) Water and Wastewater Treatment**

Introduces design and operation of facilities for treatment of municipal water supplies and wastewater. Provides an engineering application of physical, chemical, and biological unit processes and operations for removal of impurities and pollutants. Involves an integrated design of whole treatment systems combining process elements.

**Requisites:** Requires prerequisite course of CVEN 3414 (minimum grade C-).

**Additional Information:** Departmental Category: Environmental

**CVEN 3434 (3) Introduction to Applied Ecology**

Emphasizes the integration of physical, chemical and biological processes in controlling terrestrial and aquatic ecosystems. Ecosystem concepts are applied to current environmental and water quality problems. Includes field trips and a group project.

**Equivalent - Duplicate Degree Credit Not Granted:** ENVS 3434

**Requisites:** Requires prereq courses of (CHEN 1201 or CHEN 1211 or CHEM 1113 or CHEM 1400 or MCEN 1024) and (CHEM 1114 or CHEM 1221) (all min grade C-). Restricted to students w/ 57-180 credits (Jr or Sr) Civil (CVEN), Environ (EVEN) or Arch Eng (AREN) or (IDEN) mjrs

**Additional Information:** Arts Sci Gen Ed: Distribution-Natural Sciences  
Departmental Category: Environmental

**CVEN 3525 (3) Structural Analysis**

Studies structural analysis of statically determinate and indeterminate systems, deflections, energy methods, and force and stiffness methods.

**Requisites:** Requires prerequisite course of CVEN 3161 or MCEN 2063 (minimum grade C-). Restricted to Civil (CVEN), Environmental (EVEN), Architectural (AREN), Integrated Design (IDEN) or Applied Mathematics (AMEN) majors only.

**Additional Information:** Departmental Category: Structures

**CVEN 3602 (3) Transportation Systems**

Introduces the principles of transportation systems with a focus on highway engineering and traffic analysis. Provides the basic skill set that will allow students to solve transportation problems related with highway design and traffic control and analysis. Provides an introduction to technology, operating characteristics, and relative merits of highway, airway, waterway, railroad, pipeline, and convey or transportation systems.

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**Additional Information:** Departmental Category: Surveying and Transportation

**CVEN 3698 (3) Engineering Geology**

Highlights the role of geology in engineering minerals; rocks; surficial deposits; rocks and soils as engineering materials; distribution of rocks at and below the surface; hydrologic influences; geologic exploration of engineering sites; geologic hazards; mapping; and geology of underground excavations, slopes, reservoirs and dam sites.

**Requisites:** Requires prereq or coreq courses of (CVEN 2121 or GEEN 2851 or ASEN 2001 or ASEN 2701 or MCEN 2023) and (APPM 2350 or MATH 2400) (all minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 3708 (3) Geotechnical Engineering 1**

Covers basic engineering characteristics of geological materials; soil and rock classifications; site investigation; physical, mechanical, and hydraulic properties of geologic materials; the effective stress principle; soil and rock improvement; seepage analysis; stress distribution; and consolidation and settlement analyses. Selected experimental and computational laboratories.

**Requisites:** Requires prerequisite course of CVEN 3161 or MCEN 2063 (minimum grade C-). Restricted to Civil (CVEN), Environmental (EVEN), Architectural (AREN), Integrated Design (IDEN) or Applied Mathematics (AMEN) majors only.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 3718 (3) Geotechnical Engineering 2**

Covers stress analysis and plastic equilibrium, shear strength of soil, bearing capacity, lateral earth pressures, slope stability and underground construction. Analysis and design of shallow and deep foundations, retaining walls and other earth and rock structures. Selected experimental and computational laboratories.

**Requisites:** Requires prerequisite course of CVEN 3708 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 3837 (1-3) Special Topics**

Supervised study of special topics of interest to student under instructor guidance.

**Repeatable:** Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 4147 (3) Civil Engineering Systems**

Theory and application of the principles of engineering economics and classical and metaheuristic optimization techniques for evaluating problems in civil and environmental engineering.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5147

**Requisites:** Restricted to students with 87-180 credits (Senior, Fifth Year Senior) College of Engineering majors only.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 4157 (3) A Systems Approach to Global Engineering**

Introduces engineering students to the global context in which engineers are asked to operate in the 21st century using system dynamics tools and other decision-making tools (network analysis, agent based modeling, etc.) necessary to analyze the uncertainty and complexity inherent in global projects.

**Equivalent - Duplicate Degree Credit Not Granted:** EDEN 4147, CVEN 5157 and EDEN 5147

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**CVEN 4161 (3) Mechanics of Materials 2**

Covers advanced topics in the mechanics of solids. Some topics such as asymmetric bending of beams, torsion of non-circular cross-sections, are extensions of topics seen in CVEN 3161. Others like 3-D stress and strain analysis, failure theories and stability of columns and frames are new. Includes selected laboratory experiments.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5161

**Requisites:** Requires prerequisite course of CVEN 3161 (minimum grade C-).

**Additional Information:** Departmental Category: Mechanics

**CVEN 4303 (3) Analysis of Urban Water Systems**

Examines water systems in the urban environment in an integrated manner. Focus is placed on analyzing the behavior of urban water distribution and collection systems using model applications. Students completing this course will be able to understand local urban water resources problems, effectively use complementary urban water models, and examine the interactions between water supply, drainage systems, surface water, and groundwater.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5303

**Requisites:** Requires prerequisite course of CVEN 3313 or MCEN 3021 or CHEN 3200 or AREN 2120 (minimum grade C-). Restricted to College of Engineering students only.

**Recommended:** Prerequisite CVEN 3323 (Hydraulic Engineering).

**CVEN 4323 (3) Water Resources Engineering Design**

Studies principles and techniques of water resources engineering design. Introduces environmental modeling under uncertainty, stormwater design, precipitation estimation and flow routing. Surveys hydropower, reservoir management and water resources economics.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5423

**Requisites:** Restricted to students with 57-180 credits (Junior or Senior) College of Engineering students only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 4333 (3) Engineering Hydrology**

Studies engineering applications of principles of hydrology, including hydrologic cycle, rainfall and runoff, groundwater, storm frequency and duration studies, stream hydrography, flood frequency, and flood routing.

**Requisites:** Requires prerequisite course of CVEN 3313 or AREN 2120 or CHEN 3200 or MCEN 3021 (all minimum grade C-). Requires prerequisite or corequisite course of CVEN 3227 or MCEN 3047 or CHEN 3010 or GEEN 3853 (all minimum grade C-).

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 4353 (3) Groundwater Engineering**

Studies the occurrence, movement, extraction for use, and quantity and quality aspects of groundwater. Introduces and uses basic concepts to solve engineering and geohydrologic problems.

**Requisites:** Requires prerequisite course of CVEN 3313 or MCEN 3021 or CHEN 3200 or AREN 2120 (minimum grade C-).

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 4383 (3) Applied Groundwater Modeling**

Studies analytical and numerical methods for solving problems of groundwater flow and chemical transport. Emphasizes fundamental modeling techniques and the relationship between the physical system and the model results. Applies models and modeling techniques to solve problems in ground water hydrology using contemporary software. Include computer laboratory sessions.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5383

**Requisites:** Requires prerequisite course of CVEN 3313 or MCEN 3021 or CHEN 3200 or AREN 2120 (minimum grade C-).

**Recommended:** Prerequisite CVEN 4353 (minimum grade C-).

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 4404 (3) Water Chemistry**

Introduces chemical fundamentals of inorganic aqueous compounds and contaminants in lecture and laboratory. Lecture topics include thermodynamics and kinetics of acids and base reactions, carbonate chemistry, air-water exchange, precipitation, dissolution, complexation, oxidation-reduction and sorption.

**Equivalent - Duplicate Degree Credit Not Granted:** EVEN 4404

**Requisites:** Requires prerequisite course of (CHEN 1203 or CHEN 1211 or CHEM 1133) and (CHEM 1221 or CHEM 1134) (all minimum grade C-). Requires corequisite course of CVEN 3414.

**Additional Information:** Departmental Category: Environmental

**CVEN 4414 (1) Water Chemistry Laboratory**

Reinforces chemical fundamentals of inorganic aqueous compounds and contaminants from CVEN/EVEN 4404 in laboratory experiments and reports. Topics include acids and bases, carbonate chemistry (alkalinity) and other water chemistry characteristics (hardness, dissolved oxygen); precipitation, complexation and oxidation-reduction reactions; and laboratory techniques and reporting.

**Equivalent - Duplicate Degree Credit Not Granted:** EVEN 4414

**Requisites:** Requires prerequisite courses of CHEN 1201, CHEN 1203, CHEM 1221 or CHEN 1211 or CHEM 1113 and CHEM 1133 (all minimum grade C-). Requires corequisite course of CVEN 4404. Restricted to Civil (CVEN) or Environmental (EVEN) Engineering majors only.

**Additional Information:** Departmental Category: Environmental

**CVEN 4424 (3) Environmental Organic Chemistry**

Examines the fundamental physical and chemical transformations affecting the fate and transport of organic contaminants in natural and treated waters. Emphasizes quantitative approach to solubility, vapor pressure, air-water exchange, sorption, hydrolysis and redox reactions, and photodegradation.

**Equivalent - Duplicate Degree Credit Not Granted:** EVEN 4424

**Requisites:** Requires prerequisite course of (CHEN 1211 or CHEN 1203 or CHEM 1133 or CHEM 2100) and CVEN 4404 (minimum grade C-).

**Additional Information:** Departmental Category: Environmental

**CVEN 4434 (4) Environmental Engineering Design**

Examines the design of facilities for the treatment of municipal water and wastewater, hazardous industrial waste, contaminated environmental sites and sustainable sanitation in developing countries. Economic, societal and site specific criteria impacting designs are emphasized.

**Equivalent - Duplicate Degree Credit Not Granted:** EVEN 4434

**Requisites:** Requires prerequisite course of CVEN 3414 and CVEN 4464 or CVEN 3424 (minimum grade C-).

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Environmental

**CVEN 4464 (3) Environmental Engineering Processes**

Develops and utilizes analytic solutions for environmental process models that can be used in a) reactor design for processes used in the treatment of water, wastewater and hazardous waste and b) process analysis of natural systems, such as streams and groundwater flow. Models facilitate the tracking of contaminants in engineered and natural systems.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5464 and EVEN 4464

**Requisites:** Requires prerequisite courses of (CVEN 3313 or CHEN 3200 or MCEN 3021 or AREN 2120) and CVEN 3414 (all minimum grade C-).

**Additional Information:** Departmental Category: Environmental

**CVEN 4474 (3) Hazardous and Industrial Waste Management**

Evaluates processes used for treatment of wastes requiring special handling and disposal: toxic organic chemicals, heavy metals, acidic, caustic and radioactive waste material. Discusses techniques for destruction, immobilization and resource recovery and assessment of environmental impact of treatment process end products.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5474

**Requisites:** Requires prerequisite course of CVEN 3414 (minimum grade C-). Restricted to College of Engineering majors only.

**Additional Information:** Departmental Category: Environmental

**CVEN 4484 (3) Integrative Environmental and Molecular Microbiology**

Surveys microbiology topics germane to modern civil and environmental engineering. Provides fundamentals needed to understand microbial processes and ecology in engineered and natural systems and reviews applications emphasizing the interface between molecular biology and classical civil engineering.

**Equivalent - Duplicate Degree Credit Not Granted:** EVEN 4484, CVEN 5484, and EVEN 5484

**Requisites:** Requires prerequisite courses of CHEN 1211 or CHEN 1201 or CHEM 1113 and CHEM 1221 and APPM 1350 or MATH 1300 (all minimum grade C-).

**Additional Information:** Departmental Category: Environmental



**CVEN 4511 (3) Introduction to Finite Element Analysis**

Covers systematic formulation of finite element approximation and isoparametric interpolation (weighted residual and energy methods, triangular and quadrilateral elements). Includes computation applications to the solution of one- and two-dimensional stress-deformation problems and steady and transient heat conduction.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5511

**Requisites:** Requires prerequisite courses of CVEN 3161, CVEN 3525 and (APPM 2360 or (MATH 2130 and 3430)) (all minimum grade C-).

**Additional Information:** Departmental Category: Mechanics

**CVEN 4525 (3) Computational Structural Analysis 1**

Covers the principles and formulations of the direct stiffness method and its transition to the finite element method with the computational modelling and analysis of framed structures in 2D plane and 3D space. The dynamic analysis and the introduction to the nonlinear structural problems are provided. Familiarity with the modern computing and programming environments is increased to address the needs in the structural engineering and mechanics area. Computer programming is applied to the solution of problems in structural analysis.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5525

**Requisites:** Requires prerequisite course of CVEN 3525 (minimum grade C-).

**Additional Information:** Departmental Category: Structures

**CVEN 4537 (3) Numerical Methods in Civil Engineering**

Introduces the use of numerical methods in the solution of civil engineering problems, emphasizing obtaining solutions with high-speed electronic computers. Applies methods to all types of civil engineering problems.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5537

**Requisites:** Restricted to students with 87-180 credits (Senior, Fifth Year Senior) College of Engineering majors only.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 4545 (3) Steel Design**

Applies basic principles of structural engineering and mechanics to design of steel structures; design of tension members, columns, beams, open-web joists, steel decks, bolts, bolted connections, welding processes, and welded connections.

**Requisites:** Requires prerequisite course of CVEN 3525 (minimum grade C-).

**Additional Information:** Departmental Category: Structures

**CVEN 4554 (3) Fundamentals of Air Quality Management**

Introduces engineering methods for the study of air quality. Topics include: indoor air quality, greenhouse gases, dispersion modeling, source apportionment modeling, chemistry of combustion, pollution sources and controls, human exposure to air pollutants. A focus on Engineering for Developing Communities runs throughout. Elective for the EVEN air quality track or an environmental concentration course for CVEN.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5554

**Requisites:** Requires prerequisite courses of APPM 2360 or MATH 2130 and MATH 3430 and CVEN 3313 or CHEN 3200 or MCEN 3021 (all minimum grade C-).

**Additional Information:** Departmental Category: Environmental

**CVEN 4555 (3) Reinforced Concrete Design**

Applies basic principles of structural engineering and mechanics to the design of reinforced concrete structures, including design of beams, columns, slabs, and footings; continuous beams and frames; cast-in-place buildings.

**Requisites:** Requires prerequisite course of CVEN 3525 (minimum grade C-).

**Additional Information:** Departmental Category: Structures

**CVEN 4565 (3) Design of Wood Structures**

Applies basic principles of structural engineering and mechanics to the design of wood structures, including the design and analysis of columns, trusses, beams and connections using dimensional lumber, glulam and cross-laminated timber.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5565

**Requisites:** Requires prerequisite course of CVEN 3525 (minimum grade C-).

**Additional Information:** Departmental Category: Structures

**CVEN 4594 (3) Water Reuse and Reclamation**

Explores development of a safe, reliable and acceptable program for reusing impaired waters. As fresh water becomes scarcer around the world, communities are looking for security through development of new water resources. Reuse of impaired water is one solution to the growing water crisis. Focus is on advanced treatment technologies with emphasis on public perception, economics and regulations.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5594

**Requisites:** Requires prerequisite course of CVEN 3414 (minimum grade C-). Restricted to College of Engineering students with 57-180 credits (Juniors or Seniors).

**Recommended:** Prerequisite CVEN 3424.

**Additional Information:** Departmental Category: Environmental

**CVEN 4718 (3) Mechanics and Dynamics of Glaciers**

Develops a quantitative physical basis for understanding the functions of snow, ice and glaciers in the environment, with emphasis on developing an understanding of continuum mechanics and thermodynamics and their application to Earth systems.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5718

**Requisites:** Requires prereq course of (APPM 2350 or MATH 2400) and (APPM 2360 or (MATH 2130 and 3430)) and (AREN 2110 or GEEN 3852 or MCEN 3012 or ASEN 2002) and (CHEN 1310 or CSCI 1200 or CSCI 1300 or ASEN 1320 or ECEN 1310) (all min. grade C-).

**Additional Information:** Departmental Category: Geotechnical

**CVEN 4728 (3) Foundation Engineering**

Focuses on geotechnical design of shallow and deep foundations, including spread footings, mats, driven piles and drilled piers. Coverage includes bearing capacity, settlement, group effects and lateral load capacity of the various foundation types. The application of lower and upper bound plasticity analyses for the structural and geotechnical design of foundation systems, and how these relate to design codes, is additionally covered.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 5728

**Requisites:** Requires prerequisite course of CVEN 3718 (minimum grade C-).

**Additional Information:** Departmental Category: Geotechnical

**CVEN 4833 (1-3) Special Topics**

**Repeatable:** Repeatable for up to 18.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to students with 57-180 credits (Junior or Senior) College of Engineering students only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 4834 (1-3) Special Topics**

Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to College of Engineering (ENGRU) undergraduates only.

**Additional Information:** Departmental Category: Environmental

**CVEN 4835 (1-3) Special Topics**

Supervised study of special topics of interest to students under instructor guidance.

**Repeatable:** Repeatable for up to 15.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to students in College of Engineering and Applied Science (ENGR) only.

**Additional Information:** Departmental Category: Structures

**CVEN 4836 (1-3) Special Topics**

Offers a supervised study of special topics, under instructor guidance.

**Repeatable:** Repeatable for up to 3.00 total credit hours.

**CVEN 4837 (1-3) Special Topics**

Supervised study of special topics of interest to students under instructor guidance.

**Repeatable:** Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 4838 (1-3) Special Topics**

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 4839 (3-6) Special Topics for Seniors**

Offers a supervised study of special topics, under instructor guidance. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Special Topics

**CVEN 4849 (1-3) Independent Study**

Involves an independent, in-depth study, research, or design in a selected area of civil or environmental engineering. Offerings are coordinated with individual faculty. Students should consult the Department of Civil, Environmental, and Architectural Engineering.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Special Topics

**CVEN 4897 (2) Professional Issues in Civil Engineering**

Educates students about the knowledge and skills required for professional civil engineers. Students learn about the path to a professional license, prepare for the FE exam, analyze a situation involving multiple conflicting ethical interests, identify aspects of sustainability in civil engineering projects, and understand the role of project management, public policy, business and public administration, and leadership in civil engineering.

**Requisites:** Restricted to students with 87-180 credits (Seniors) Civil (CVEN), Environmental (EVEN), or Architectural Engineering (AREN) majors only.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 4899 (4) Civil Engineering Senior Project Design**

Provides a simulated real world design and construction planning experience where teams integrate across multiple civil engineering sub-disciplines to create a solution that satisfies multiple constraints, including design, client requirements, budget, schedule, technical, regulatory, and societal. Final deliverables include: detailed design drawings, specifications, cost estimate, project schedule, construction plan, oral and written presentation.

**Requisites:** Restricted to students with 87-180 credits (Senior) Civil (CVEN) or Integrated Design (IDEN) engineering majors only.

**Additional Information:** Departmental Category: Special Topics

**CVEN 4969 (3) Water and Sanitation in Developing Countries**

Studies the design and fundamentals behind effective treatment processes and engineering solutions targeted for developing countries.

Approaches to clean water and sanitation in lesser industrialized countries often demand alternative solutions to those developed for industrialized societies. Explores issues and solutions developed to tackle these problems.

**Equivalent - Duplicate Degree Credit Not Granted:** EVEN 4969

**Requisites:** Requires prerequisite course of CVEN 3414 (minimum grade C-). Restricted to students with 57-180 credits (Juniors or Seniors).

**Additional Information:** Departmental Category: Environmental

**CVEN 5006 (3) Construction Engineering and Management Fundamentals**

Provides an overview of the construction industry to establish a foundation for subsequent graduate courses in construction engineering and management. Students will be exposed to projects of varying funding sources, contracts, scope and complexity. Project phases will be established including planning, funding, design, construction, turnover, operation and maintenance. The course will focus on fundamental construction cost estimating, scheduling, delivery systems, contractual relationships, key contract clauses, risk allocation, building materials/systems and project controls. Previously offered as a special topics course.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Grading Basis:** Letter Grade

**CVEN 5109 (1) Introduction to Environmental and Development Economics for Engineers**

Addresses main development topics and their environmental implications based on a theoretical framework applied to practical real-life examples.

Students will be introduced to the history of economic thought, the process of economic reform, agricultural and industrial development, income distribution, health, education, and international economic relations. Students analyze how these apply to economic development and how this impacts poverty and environmental degradation in the global south. Furthermore, students will examine how engineering intersects the solutions space.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** of EVEN 2909 or CVEN 5919 or CVEN 5909.

**Grading Basis:** Letter Grade

**CVEN 5111 (3) Structural Dynamics**

Focuses on the response of single- and multi-degree of freedom structures subjected to harmonic, impulsive and arbitrary loads (including earthquake base excitation). Sources and modeling of damping will be discussed. Analytical and numerical solutions will be considered for both linear and nonlinear structural systems. Elastic and inelastic response spectra will be discussed.

**Requisites:** Restricted to College of Engineering (ENGR) graduate students or seniors or students with concurrent degree sub plans C-AREN, C-CVEN, C-MCEN or C-ASEN.

**Additional Information:** Departmental Category: Mechanics

**CVEN 5119 (1) Introduction to Global Health for Engineers**

Global Health, a multidisciplinary academic and professional discipline, works to address the unequal distribution of disease determinants and burden in low income communities. In this course, engineering students engaged in Global Engineering, poverty reduction efforts, technology and intervention design will be introduced to the conditions, context, and professional activities and standards of global health practice.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** of enrollment in Mortenson Center graduate program or instructor approval.

**Grading Basis:** Letter Grade

**CVEN 5129 (1) Program and Project Management**

Covers the principles, practice, and phases of international development program and project management including design, implementation, monitoring and evaluation, exit strategy, and scaling up. Emphasis will be posed on challenges and constraints related to the multidisciplinary, dynamic, and complex nature of global development projects. Students will be exposed to several methodologies and tools commonly used to identify needs and promote social change, including the Theory of Change and the Logical Framework Approach.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** of EVEN 2909 or CVEN 5919 or CVEN 5909.

**Grading Basis:** Letter Grade

**CVEN 5131 (3) Continuum Mechanics and Elasticity**

Provides foundation for advanced study of structural, mechanical and geo-material behavior and continuum theories in mechanics. Topics: Cartesian tensors, formulation of continuum mechanics for small and large deformation, constitutive laws for elastic solids, energy principles, methods of potentials, formulations and solutions of 2D and 3D elastostatic and elastodynamic problems, analytical and numerical formulations.

**Requisites:** Restricted to College of Engineering (ENGR) graduate students or seniors or students with concurrent degree sub plans C-AREN, C-CVEN, C-MCEN or C-ASEN.

**Recommended:** Prerequisite CVEN 3161.

**Additional Information:** Departmental Category: Mechanics

**CVEN 5139 (1) Solution Identification and Proposal Development**

Presents an overview of strategies and best practices to develop effective grant proposals for international development interventions, as well as major funding mechanisms and processes. This is a project-based course, students will work in teams with an NGO to develop a concept note for a current request for proposal. The proposal will have to respect priorities and requirements of the target population, principles and goals of the proposing NGO, and guidelines of the donor.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** of EVEN 2909 or CVEN 5919 or CVEN 5909.

**Grading Basis:** Letter Grade

**CVEN 5147 (3) Civil Engineering Systems**

Theory and application of the principles of engineering economics and classical and metaheuristic optimization techniques for evaluating problems in civil and environmental engineering.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4147

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 5151 (3) Wave Methods for Design and Characterization of Advanced Materials**

Covers key theoretical concepts and applications of wave propagation with the focus on ultrasonic scattering. The course material includes: (i) dispersion analysis for design and characterization of materials with random and periodic microstructure, and (ii) advanced elastodynamic formulations rooted in 2D and 3D boundary integral equations for the purpose of inverse scattering and imaging. The course is intended to be self-contained, research-oriented and accessible for multidisciplinary audience.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**CVEN 5157 (3) A Systems Approach to Global Engineering**

Introduces engineering students to the global context in which engineers are asked to operate in the 21st century using system dynamics tools and other decision-making tools (network analysis, agent based modeling, etc.) necessary to analyze the uncertainty and complexity inherent in global projects.

**Equivalent - Duplicate Degree Credit Not Granted:** EDEN 4147, CVEN 4157 and EDEN 5147

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**CVEN 5161 (3) Advanced Mechanics of Materials I**

Covers advanced topics in the mechanics of solids. Some topics such as asymmetric bending of beams, torsion of non-circular cross-sections, are extensions of topics seen in CVEN 3161. Others like 3-D stress and strain analysis, failure theories and stability of columns and frames are new. Includes selected laboratory experiments.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4161

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Mechanics

**CVEN 5206 (3) Design Development**

Provides an overview of the development process and proforma, investigates the interrelationship between design decisions and building costs, and evaluates the impact of each major building system on the development budget and schedule. Provides a simulated development experience where students respond to a Request for Proposal, including proformas, design, estimates and outline specifications. Department consent required. Taught intermittently.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Construction

**CVEN 5226 (3) Construction Safety**

Comprehensively studies construction safety in the construction industry. Focuses on advanced safety management issues such as accident causation theory, economic modeling, safety risk quantification and analysis, design for safety, predictive analytics and learning. Skills developed in this course will prepare graduate students to be effective quality and safety managers or researchers.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Construction

**CVEN 5246 (3) Legal Aspects of Construction**

Applies law in engineering practice; contracts, construction contract documents, construction specification writing, agency, partnership, and property; types of construction contracts; and legal responsibilities and ethical requirements of the professional engineer. Taught intermittently.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** graduate standing or department consent required.

**Additional Information:** Departmental Category: Construction

**CVEN 5276 (3) Engineering Risk and Decision Analysis**

Acquaints students with the fundamental principles and techniques of risk and decision analysis. Oriented toward project-level decisions in which risk or uncertainty plays a central role. Introduces students to Monte Carlo analyses, and various types of multicriteria decision analyses. Culminates in a larger term project.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisite CVEN 3227 and graduate standing or instructor consent required.

**Additional Information:** Departmental Category: Construction

**CVEN 5286 (3) Design Construction Operations**

Considers effective/efficient design of construction operations. Front end planning; construction labor relations; productivity management. Emphasizes construction productivity improvement by group field studies and discrete event simulation modeling. How overtime, changes, weather, and staffing levels influence productivity. Industrial engineering techniques are applied to the construction environment to improve the use of equipment, human, and material resources.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** graduate standing or department consent required.

**Additional Information:** Departmental Category: Construction

**CVEN 5303 (3) Analysis of Urban Water Systems**

Examines water systems in the urban environment in an integrated manner. Focus is placed on analyzing the behavior of urban water distribution and collection systems using model applications. Students completing this course will be able to understand local urban water resources problems, effectively use complementary urban water models, and examine the interactions between water supply, drainage systems, surface water, and groundwater.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4303

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**CVEN 5313 (3) Environmental Fluid Mechanics**

Analysis of viscous incompressible flows, with first-principle solutions for environmental fluid flows in oceans, rivers, lakes and the atmosphere. Topics include the Navier-Stokes equations, kinematics, vorticity dynamics, geophysical fluid dynamics, and density stratification.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** Prerequisites APPM 2350 and APPM 2360 and CVEN 3313.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5323 (3) Applied Stream Ecology**

Emphasizes the integration of hydrologic, chemical, and biological processes in controlling river, stream, and reservoir ecosystems at several spatial scales. Students apply ecosystem concepts to current environmental and water quality problems and learn field methods in field trips and a team project.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5333 (3) Physical Hydrology**

Introduces hydrology as a quantitative science describing the occurrence, distribution and movement of water at and near the surface of the earth. Develops a quantitative understanding of atmospheric water, infiltration, evapotranspiration and surface runoff. Studies global climatology and large scale climate drivers of regional hydrology at interannual time scales. Solves engineering problems related to water resources.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** Prerequisite CVEN 4333.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5343 (3) Transport and Dispersion in Surface Water**

Studies transport and dispersion of introduced contaminants in turbulent surface water flows. Emphasizes developing a physical understanding of fluid processes responsible for turbulent dispersion. Includes analytical development, numerical modeling, and experimental approaches to the problem.

**Requisites:** Restricted to graduate students and Engineering Management BAM students only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5346 (3) Managing Construction and Engineering Projects and Organizations**

Explores organizational and managerial issues and concerns facing executives in engineering and construction organizations. Through readings, case studies, simulation exercises, and projects, students are introduced to and apply concepts of strategy, core competencies, vision, innovation, team dynamics, interpersonal influence, organizational design issues, and global projects to engineering and construction organizations.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Construction

**CVEN 5353 (3) Groundwater Hydrology**

Studies the occurrence, movement, extraction for use, and quantity and quality aspects of groundwater. Introduces and uses basic concepts to solve engineering and geohydrologic problems.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** Prerequisites CVEN 3313 or AREN 2120 or CHEN 3200 or GEEN 3853 or MCEN 3021 and APPM 2360.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources



**CVEN 5363 (3) Modeling of Hydrologic Systems**

Introduces students to modeling techniques. Focus areas include physical hydrology and hydrometeorology; measurement and inference; climate change impacts; role of scale in hydrology; uncertainty analysis; and a case study project. Projects will examine hydrologic impacts of various drivers such as climate warming or land cover change, utilizing an assessment of historic conditions to better understand and model future disturbance scenarios.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5373 (3) Water Law, Policy, and Institutions**

Discusses contemporary issues in water management based on legal doctrine. Identifies legal issues in water resources problems and discusses in close relationship with technical, economic, and political considerations.

**Requisites:** Restricted to students with 87-180 credits (Seniors), graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5383 (3) Applied Groundwater Modeling**

Studies analytical and numerical methods for solving problems of groundwater flow and chemical transport. Emphasizes fundamental modeling techniques and the relationship between the physical system and the model results. Applies models and modeling techniques to solve problems in ground water hydrology using contemporary software. Includes computer laboratory sessions.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4383

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** Prerequisites APPM 2360 and CVEN 4353 or CVEN 5353.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5393 (3) Water Resources System and Management**

Introduces water resources planning and management as an integrated systems problem that satisfies multiple competing objectives under constraints and uncertainty. Includes problem formulation and solution using decision support systems, optimization with and without uncertainty, stochastic simulation, and multiobjective optimization. Introduces water resources economics and planning under uncertainties such as climate change and increasing urbanization.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5404 (3) Water Chemistry**

Introduces chemical fundamentals governing the chemistry of natural and treated waters. Topics include thermodynamics and kinetics of acid and base reactions, carbonate chemistry, air-water exchange, precipitation, dissolution, complexation, oxidation-reduction, and sorption.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5414 (3) Water Chemistry Laboratory**

Uses experimental and analytical laboratory techniques to develop a better understanding of the concepts of aquatic chemistry and to investigate water chemistry in treated and natural water systems. Techniques include titration, spectrophotometry, gas chromatography, other advanced instrumentation, sampling, portable analyses, and basic statistics and experimental design. Course focuses on water chemistry of Boulder Creek and other local waters.

**Requisites:** Requires prerequisite course of CVEN 5404 or GEOL 5280 (minimum grade C-). Requires corequisite course of CVEN 5424.

Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5423 (3) Water Resources Engineering Design**

Studies principles and techniques of water resources engineering design. Introduces environmental modeling under uncertainty, stormwater design, precipitation estimation and flow routing. Surveys hydropower, reservoir management and water resources economics.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4323

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5424 (3) Environmental Organic Chemistry**

Examines the fundamental physical and chemical processes that impact the fate and transport of organic contaminants in natural and engineered systems. Emphasizes both equilibrium and kinetic aspects, including solubility, vapor pressure, air-water exchange, sorption, abiotic redox reactions, and photodegradation.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5434 (3) Environmental Engineering Design**

Team-based design of facilities or processes for water or wastewater or solid waste treatment or remediation under multiple real-world constraints. Department consent required.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Recommended:** Prerequisite CVEN 5524 or CVEN 5534 or CVEN 5474.

**Additional Information:** Departmental Category: Environmental

**CVEN 5444 (3) Municipal Des Proj**

**Additional Information:** Departmental Category: Environmental

**CVEN 5446 (3) Infrastructure Asset Management**

Introduces a framework that combines engineering principles with economic theory to facilitate a more organized and logical approach to decision-making in the management of infrastructure. Topics covered include asset valuation, modeling infrastructure deterioration, life-cycle cost analysis, and optimization. Although the concepts introduced in this course are applicable to different infrastructure systems, especial emphasis will be given to transportation projects.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**CVEN 5454 (3) Statistical Methods for Natural and Engineered Systems**

Applies traditional and modern probability and statistical methods to environmental, hydrological, climatological and engineering data analysis. Topics include: basic probability, data visualization, fitting univariate and multivariate distributions, Monte Carlo simulations, extreme value distributions, confidence intervals and hypothesis testing, nonparametric density estimators, linear regression, and Bayesian analysis. The data analysis tool, R, is used throughout the course.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Environmental

**CVEN 5464 (3) Environmental Engineering Processes**

Develops and utilizes analytic solutions for environmental process models that can be used in a) reactor design for processes used in the treatment of water, wastewater and hazardous waste and b) process analysis of natural systems, such as streams and groundwater flow. Models facilitate the tracking of contaminants in engineered and natural systems.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4464 and EVEN 4464

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5474 (3) Hazardous and Industrial Waste Management**

Evaluates processes used for treatment of wastes requiring special handling and disposal: toxic organic chemicals, heavy metals, acidic, caustic and radioactive waste material. Discusses techniques for destruction, immobilization and resource recovery and assessment of environmental impact of treatment process end products.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4474

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5484 (3) Integrative Environmental and Molecular Microbiology**

Surveys microbiology topics germane to modern civil and environmental engineering. Provides fundamentals needed to understand microbial processes and ecology in engineered and natural systems and reviews applications emphasizing the interface between molecular biology and classical civil engineering.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4484, EVEN 4484, and EVEN 5484

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Environmental

**CVEN 5494 (3) Surface Water Quality Modeling**

Examines the relationships among air, water, and landpollution, water quality, and beneficial uses. Using models, develops the ability to quantify and predict the impacts of pollutants in the aquatic environment, and to develop approaches to minimize unfavorable water quality conditions. Department consent required.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5511 (3) Introduction to Finite Element Analysis**

Covers systematic formulation of finite element approximation and isoparametric interpolation (weighted residual and energy methods, triangular and quadrilateral elements). Includes computation applications to the solution of one- and two-dimensional stress-deformation problems and steady and transient heat conduction.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4511

**Requisites:** Restricted to College of Engineering (ENGR) graduate students or seniors or students with concurrent degree sub plans C-AREN, C-CVEN, C-MCEN or C-ASEN.

**Additional Information:** Departmental Category: Mechanics

**CVEN 5514 (3) Bioremediation**

Advanced study on biological processes used to treat toxic organic and inorganic compounds contained in contaminated water, air, and soil; design and evaluation of in situ toxic compound biotransformation; fundamentals of phytoremediation; critical reviews of current literature on bioremediation.

**Equivalent - Duplicate Degree Credit Not Granted:** EVEN 5514

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisite CVEN 4484 or CVEN 5424 or CVEN 5484.

**Additional Information:** Departmental Category: Environmental

**CVEN 5524 (3) Drinking Water Treatment**

Provides advanced study on theory-of-treatment processes, including design and operation of municipal water supplies.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Recommended:** Prerequisite CVEN 4464 or CVEN 5464 or graduate standing or instructor consent required.

**Additional Information:** Departmental Category: Environmental

**CVEN 5525 (3) Computational Structural Analysis 1**

Covers the principles and formulations of the direct stiffness method and its transition to the finite element method with the computational modelling and analysis of framed structures in 2D plane and 3D space. The dynamic analysis and the introduction to the nonlinear structural problems are provided. Familiarity with the modern computing and programming environments is increased to address the needs in the structural engineering and mechanics area. Computer programming is applied to the solution of problems in structural analysis.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4525

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Structures

**CVEN 5534 (3) Wastewater Treatment**

Covers the processes used to treat municipal wastewater, focusing on biological processes. Includes: design of aerobic, anoxic, anaerobic and suspended growth technologies to remove and transform pollutants; design and assessment of treatment approaches that recover energy, nutrients and water from wastewater; application of fundamental concepts of aquatic chemistry, environmental microbiology and computational models.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Recommended:** Prerequisites CVEN 5404 and CVEN 5484 and CVEN 5464.

**Additional Information:** Departmental Category: Environmental

**CVEN 5537 (3) Numerical Methods in Civil Engineering**

Introduces the use of numerical methods in the solution of civil engineering problems, emphasizing obtaining solutions with high-speed electronic computers. Applies methods to all types of civil engineering problems.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4537

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 5544 (3) Solid Waste Management and Resource Recovery**

Covers the scope of the nonhazardous solid waste problem and regulations that drive its management; discussions of nonengineering factors that impact waste management and recycling; design of incinerators, composting facilities, and landfills used to treat and dispose of solid waste.

**Equivalent - Duplicate Degree Credit Not Granted:** EVEN 5544 EVEN 4544

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** Prerequisite CVEN 3414.

**Additional Information:** Departmental Category: Environmental

**CVEN 5554 (3) Fundamentals of Air Quality Management**

Introduces engineering methods for the study of air quality. Topics include: indoor air quality, greenhouse gases, dispersion modeling, source apportionment modeling, chemistry of combustion, pollution sources and controls, human exposure to air pollutants. A focus on Engineering for Developing Communities runs throughout. Required for CVEN environmental engineering graduate students.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4554

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5564 (3) Water Profession: Communication and Utility Finance**

Develops and improves the skills and tools needed for graduate students and young professionals. Focusing on highly effective leaders; leadership with impact; effective communication tools; and communicating with teams, city councils, governing boards, and the public.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Environmental

**CVEN 5565 (3) Design of Wood Structures**

Applies basic principles of structural engineering and mechanics to the design of wood structures, including the design and analysis of columns, trusses, beams and connections using dimensional lumber, glulam and cross-laminated timber.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4565

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Structures

**CVEN 5574 (3) Water Utility Management: Current Issues and Future Challenges**

Develops the skills and tools for graduate students and young professionals to work in the water profession. Focuses on management, leadership, communication and utility financial in the new water profession era. Undergraduate seniors may contact instructor for permission to enroll.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5575 (3) Advanced Topics in Steel Design**

Covers steel structure design and analysis. Includes plate girders, moment connections for beams, design of multistory frames, and other topics determined by class interest. Undergraduate may enroll with permission of the instructor.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisite CVEN 4545.

**Additional Information:** Departmental Category: Structures

**CVEN 5584 (3) Water Profession: Leadership and Management**

Develops the skills and tools for graduate students and young professionals to work in the water profession. Focuses on financing water services, capital planning, rates, management planning, staffing and organization and critical thinking. Undergraduates may request instructor permission to enroll.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Environmental

**CVEN 5585 (3) Advanced Topics in Reinforced Concrete Design**

Covers design and analysis topics for prestressed concrete and/or reinforced concrete structures. Includes review of the current ACI design code, slabs, prestressed concrete, seismic design, folded plates and shells, finite element analysis, and other topics determined by class interest. Undergraduates may enroll with the permission of the instructor.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisite CVEN 4555.

**Additional Information:** Departmental Category: Structures

**CVEN 5594 (3) Water Reuse and Reclamation**

Explores development of a safe, reliable and acceptable program for reusing impaired waters. As fresh water becomes scarcer around the world, communities are looking for security through development of new water resources. Reuse of impaired water is one solution to the growing water crisis. Focus is on advanced treatment technologies with emphasis on public perception, economics and regulations.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4594

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Recommended:** Prerequisites CVEN 3141 and CVEN 3424.

**Additional Information:** Departmental Category: Environmental

**CVEN 5604 (3) UV Disinfection and Advanced Oxidation**

Provides a fundamental basis for design of UV processes in water and wastewater treatment. Includes principles of photochemistry and photobiology. Applications to disinfection of water and degradation of chemical compounds in the environment. Design of UV disinfection systems and reactors and advanced oxidation processes. Environmental UV-based decay of pollutants.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisites CVEN 3414 and CVEN 3424.

**Additional Information:** Departmental Category: Environmental

**CVEN 5614 (3) Bioenergy & Bioresource Recovery**

Introduces fundamental theories and applied technologies used in production and conversion of renewable biomass including waste materials into bioenergy and other value-added products. Conducts quantitative evaluations on conversion processes such as renewable biogas production, electricity generation, liquid fuels, metal and nutrients recovery and organic chemical production.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisite CVEN 4484.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Environmental

**CVEN 5628 (3) Seepage and Slopes**

Covers fundamental principles of seepage in soils under both saturated and unsaturated conditions and limit equilibrium solution to slope stability problems. The seepage effects on slope stability are analyzed in detail and both conventional slope stability method and the finite element technique are applied to solving the engineering problems.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisites CVEN 3708 and CVEN 3718.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5678 (3) Soil Improvement and Reinforcement**

Provides students with principles and working knowledge of design and construction procedures in soil stabilization, retaining structures, geosynthetics, and soil reinforcement.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisite CVEN 3718.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5688 (3) Environmental Geotechnics**

Provides an understanding of the use of geotechnical concepts in the analysis and design of environmental systems. Focus is placed on the evaluation of waste containment facilities. Including relevant saturated, unsaturated, and multiphase flow mechanisms in cover and liner systems. Includes stability analyses for landfills and geosynthetic interface shear strength. Covers relevant aspects of mining geotechnics and remediation technologies of contaminated sites.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5708 (3) Soil Mechanics**

Offers an advanced course in soil mechanics. Coverage includes basic principles of continuum mechanics; elasticity, viscoelasticity, and plasticity theories applied to soils; effective stress principle; consolidation; shear strength; critical state concepts; and constitutive, numerical, and centrifuge modeling.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5718 (3) Mechanics and Dynamics of Glaciers**

Develops a quantitative physical basis for understanding the functions of snow, ice and glaciers in the environment, with emphasis on developing an understanding of continuum mechanics and thermodynamics and their application to Earth systems.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4718

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5728 (3) Foundation Engineering**

Focuses on geotechnical design of shallow and deep foundations, including spread footings, mats, driven piles and drilled piers. Coverage includes bearing capacity, settlement, group effects and lateral load capacity of the various foundation types. The application of lower and upper bound plasticity analyses for the structural and geotechnical design of foundation systems, and how these relate to design codes, is additionally covered.

**Equivalent - Duplicate Degree Credit Not Granted:** CVEN 4728

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5738 (3) Applied Geotechnical Analysis**

Studies applications of limiting equilibrium and limit plasticity analysis methods to stability problems in geotechnical engineering, such as slopes, lateral earth pressures on retaining structures, and bearing capacities of foundations. Also includes elastic and consolidation analysis of deformations in soil structures.

**Requisites:** Requires a prerequisite course of CVEN 5708 (minimum grade C-). Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5748 (3) Design of Earth Structures**

Covers theory, design, and construction of earth embankments and waste facilities, including isolation systems. Uses published data, field exploration, and laboratory tests on soils and rock in investigating foundations and construction materials. Involves principles of compaction and settlement, permeability analysis, landslide recognition and control, use of composite clay, and liner systems.

**Requisites:** Requires a prerequisite course of CVEN 5708 (minimum grade C-). Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5758 (3) Flow Processes in Soils**

Examines fundamental principles of flow through porous media and related engineering problems. Topics include the saturated seepage theory and flow nets; the unsaturated flow theory; suction-saturation and saturation-hydraulic conductivity relationships; nonlinear finite strain consolidation and desiccation theory; laboratory and field testing methods for determining material characteristics; and numerical models for flow-related engineering problems.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisite CVEN 3718.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5768 (3) Introduction to Rock Mechanics**

Nature of rocks and rock masses; engineering properties rock and rock mass; rock mass classifications; planes of weakness; application of rock mechanics to design of rock slopes, underground excavations, and foundations.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisites CVEN 3708 and CVEN 3718.

**Additional Information:** Departmental Category: Geotechnical



**CVEN 5788 (3) Computational Modeling in Geotechnical Engineering**

Introduces computational modeling for geotechnical engineering applications such as the Discrete Element Method (DEM) for granular materials, nonlinear Finite Element Analysis (FEA) of seepage, coupled soil elastoplastic consolidation, elastoplasticity models for soil and rock, and advanced computational methods for failure in soil and rock. Uses DEM, FEA, and other software programs for analysis. Recommended Prereq: CVEN 5708

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5798 (3) Dynamics of Soils and Structures**

Covers fundamental characterization of soils, foundations and structures under general dynamic and earthquake loads. Principles of vibrations and wave propagation for 1D, 2D, 3D. In-situ and laboratory determination of dynamic soil properties; methods for site response analysis, foundation vibrations, dynamic soil-structure interaction and liquefaction problems.

**Requisites:** Restricted to College of Engineering (ENGR) graduate students or seniors or students with concurrent degree sub plans C-AREN, C-CVEN, C-MCEN or C-ASEN.

**Recommended:** Prerequisite CVEN 3708.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5818 (3) Geotechnical Earthquake Engineering**

Familiarizes students with the fundamentals of engineering seismology, soil and structural dynamics, and the modern practice of geotechnical earthquake engineering. Focuses on describing earthquake hazards and methods for seismic analysis and design.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** Prerequisite CVEN 5798.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5822 (3) Geographical Information Systems for Civil and Environmental Systems**

Theory and use of geographical information systems in civil engineering, environmental studies, natural resources and other related disciplines. Topics include spatial data models, data capture, global positioning system, database linkage, use in design, analysis and implementation. Laboratory work includes applications of Arc-View and Arc-GIS software.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Surveying and Transportation

**CVEN 5830 (1-3) Special Topics for Seniors/Grads**

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Building Systems

**CVEN 5831 (3) Special Topics**

Supervised study of special topics of interest to students under instructor guidance. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Mechanics

**CVEN 5833 (1-3) Special Topics**

Supervised study of special topics of interest to students under instructor guidance.

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 5834 (1-3) Special Topics**

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.

**Additional Information:** Departmental Category: Environmental

**CVEN 5835 (1-3) Special Topics for Seniors/Grads**

Supervised study of special topics of interest to students under instructor guidance.

**Repeatable:** Repeatable for up to 15.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Structures

**CVEN 5836 (1-3) Special Topics for Seniors/Grads**

Supervised study of special topics of interest to students under instructor guidance. Department consent required.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Additional Information:** Departmental Category: Construction

**CVEN 5837 (1-3) Special Topics for Seniors/Grads**

Supervised study of special topics of interest to students under instructor guidance.

**Repeatable:** Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 5838 (1-3) Special Topics**

**Repeatable:** Repeatable for up to 12.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 5849 (1-6) Independent Study**

Available only through approval of graduate advisor. Subject arranged to fit needs of student.

**Repeatable:** Repeatable for up to 6.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Special Topics

**CVEN 5899 (1) Graduate Engineering Internship Experience**

An academically supervised graduate-level engineering experience that is integral to the students' graduate research and study by connecting classroom instructions to professional practice. Requires a pre-approved written plan of the proposed graduate-level work experience and a signed cooperative agreement or offer letter from employer. The 1-unit course will count toward the graduate student's degree together with the required minimum of 30 credit hours of regular core and elective courses in the student's major.

**Repeatable:** Repeatable for up to 3.00 total credit hours.

**Requisites:** Restricted to graduate students only.

**CVEN 5909 (3) Hazards, Resilience, and Sustainability for the Natural and Built Environments**

Introduces students to the effects of global climate change on natural and built environments, including its impact on the frequency and intensity of hazards and climatic extremes, social inequalities, and opportunities in engineering design for adaptation and mitigation, providing a survey approach to understanding major hazards and emerging engineering solutions.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** of enrollment in Mortenson Center graduate program or instructor approval.

**Grading Basis:** Letter Grade

**CVEN 5919 (3) Global Development for Engineers**

Focuses on the fundamental tools necessary to address sustainable community development projects in low-income communities (LICs). Topics include: human development, sustainable development, and presentation of an integrative and participatory framework for development projects in LICs. The framework consists of a combination of development and engineering project management tools. Framework is illustrated through case studies and student-driven team projects.

**Requisites:** Restricted to students with sub-plan of Engineering Developing Communities (EDC) or certificate (ENDC-CERG) only.

**Additional Information:** Departmental Category: Special Topics

**CVEN 5929 (3) Sustainable Community Development 2**

Covers the principles, practices and strategies of appropriate technology as part of an integrated and systems approach to community-based development. Course content areas include technical issues in development, environmental health and communicable disease, appropriate and sustainable technologies with hands-on workshops, and global cooperation in development.

**Requisites:** Requires prerequisite course of CVEN 5919 (minimum grade C-). Restricted to students with Engineering Developing Communities (EDC) sub-plan or EDC certificate (ENDC-CERG).

**Additional Information:** Departmental Category: Special Topics

**CVEN 5939 (3) Global Engineering and Hazard Resilience Practicum**

Provides students with a field-based and/or team project-based opportunity to synthesize and integrate knowledge acquired in Mortenson Center courses and other learning experiences, and to apply theory and principles in a situation that approximates professional practice in global engineering and hazard resilience.

**Requisites:** Requires prerequisite course CVEN 5919 or CVEN 5909 (minimum grade C-). Restricted to students with sub-plan of Global Engineering/Engineering Developing Communities (EDC) or certificate (ENDC-CERG) only.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 5969 (1-3) Water, Sanitation, and Hygiene**

Studies the fundamentals behind effective hygiene and remediation processes and engineering solutions developed/designed for specific international problems. Approaches to hygiene, clean water and sanitation in lesser industrialized countries often demand alternative solutions to those developed for industrialized societies. Explores issues and solutions developed to tackle these problems.

**Repeatable:** Repeatable for up to 3.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** Prerequisites CVEN 3424 and CVEN 3414.

**Additional Information:** Departmental Category: Environmental

**CVEN 5979 (1) Community Appraisal**

Provides conceptual and methodological tools that can be employed in different phases of international development projects and studies. Community appraisal methods will be presented with emphasis on participatory research approaches, need assessment tools, and ethnographic methods; related cultural, ethical, and personal issues will be also discussed. Students will be introduced to secondary data gathering, and the usage of the main data resources on food and water security, energy access, and health status.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** of EVEN 2909 or CVEN 5919 or CVEN 5909.

**Grading Basis:** Letter Grade

**CVEN 5989 (1) Study Design and Impact Evaluation**

Covers the characteristics of the different study designs that can be used to assess the impact of international development interventions. Students will be introduced to the main types of study design, including randomized controlled trials, quasi-experimental studies, and interrupted time series. Ethical considerations faced when conducting research on human subjects and the compliance process to obtain approval from the Institutional Review Board will be presented.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** EVEN 2909 or CVEN 5919 or CVEN 5909.

**Grading Basis:** Letter Grade

**CVEN 5999 (1) Data Analytics for Development**

Provides students with skills in using the collection of R tidyverse packages as a tool for data analysis, reproducible research and communication. Lectures will be delivered through participatory live coding for students to learn how to write code in code-along exercises. We will use publicly available data related to waste management, air quality, water, and sanitation. Students will learn how to build upon the obtained skills to apply them to their data analysis projects.

**Requisites:** Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

**Recommended:** Prerequisites of EVEN 2909 or CVEN 5919 or CVEN 5909.

**Grading Basis:** Letter Grade

**CVEN 6161 (3) Advanced Mechanics of Materials 2**

Fundamentals of continuum mechanics, finite deformations, Lagrangian finite strains, Cauchy and Piola Kirchoff stress tensors, plasticity and thermo-elasticity, elements of damage mechanics, elements of fracture mechanics, rheological and viscoelastic theories, and modern experimental techniques.

**Recommended:** Prerequisite CVEN 5161.

**Additional Information:** Departmental Category: Mechanics

**CVEN 6333 (3) Introduction to Multi-Scale Variability and Scaling in Hydrology**

Provides a foundational physical understanding of channel networks, runoff, precipitation, and evapotranspiration at multiple spatial scales of drainage basins using modern analytical concepts for understanding non-linear phenomena, e.g., fractals, multifractals, statistical scaling, criticality, and renormalization.

**Requisites:** Requires a prerequisite course of CVEN 5333 (minimum grade C-).

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 6383 (3) Flow and Transport through Porous Media**

Studies basic physics of flow and transport of water, air, and other fluid mixtures through a porous medium. Course topics are relevant to applications in contaminant hydrology, contaminant transport in aquifers, hazardous waste management, geohydrology, soil physics, and geoenvironmental engineering.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 6393 (1) Hydrologic Sciences and Water Resources Engineering Seminar**

Provides a broad introduction to a variety of research topics from hydrologic sciences and water resources engineering. Offered as a one-hour weekly seminar by the departmental water faculty, graduate students, and external speakers.

**Requisites:** Restricted to graduate student Civil (CVEN) Engineering students only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 6414 (3) Aquatic Surfaces and Particles**

Examines the role of surfaces and particles in the fate and transport of contaminants in the aquatic environment. Emphasizes modeling of absorption, dissolution, precipitation, surface-catalyzed reactions, and coagulation and filtration kinetics.

**Requisites:** Requires prerequisite course of CVEN 5404 or GEOL 5280 (minimum grade C-).

**Additional Information:** Departmental Category: Environmental

**CVEN 6511 (3) Nonlinear Finite Element Analysis of Solids and Porous Media**

Covers constitutive modeling, multiphase mechanics, and finite element implementation of constitutive models and coupled solid-fluid mechanical governing equations for inelastic porous media at small strain. Considers transient and steady state conditions. Analyzes structural, geotechnical, geological, mechanical, biomechanical, and other related modern engineering problems. Uses general purpose finite element software program for implementation and analysis.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Mechanics

**CVEN 6525 (3) Computational Structural Analysis 2**

Covers theoretical underpinnings of nonlinear analysis of framed structure in terms of the direct stiffness method along with its transition to the finite element method. Computational modelling and nonlinear analysis of geometric and material nonlinearities are explored. Familiarity with the modern computing and programming environments is increased to address the needs in the structural engineering and mechanics area. Computer programming is applied to the solution of problems in nonlinear structural analysis.

**Requisites:** Restricted to graduate students only.

**Grading Basis:** Letter Grade

**Additional Information:** Departmental Category: Structures

**CVEN 6595 (3) Earthquake Engineering**

Analyzes and designs structures for earthquake load covering: properties of earthquake ground motions, ground motion prediction equations, seismic hazard analysis, response spectra, response of linear and nonlinear structures, construction of design spectra, seismic design methods, and building code requirements.

**Requisites:** Requires prerequisite course of CVEN 5111 (minimum grade of C-). Restricted to graduate students only.

**Additional Information:** Departmental Category: Structures

**CVEN 6830 (3) Special Topics**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Building Systems

**CVEN 6831 (3) Special Topics**

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Mechanics

**CVEN 6833 (1-3) Special Topics**

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Requisites:** Restricted to graduate students only.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 6834 (1-3) Special Topics**

**Repeatable:** Repeatable for up to 9.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Environmental

**CVEN 6835 (3) Special Topics**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Structures

**CVEN 6836 (3) Special Topics**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Construction

**CVEN 6837 (3) Sp Tpcs Comp Graphics**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 6838 (3) Special Topics**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 6839 (1-3) Special Topics**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Special Topics

**CVEN 6943 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 6944 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**Additional Information:** Departmental Category: Environmental

**CVEN 6945 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**Additional Information:** Departmental Category: Structures

**CVEN 6946 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**Additional Information:** Departmental Category: Construction

**CVEN 6947 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 6948 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 6949 (1) Master's Candidate for Degree**

Registration intended for students preparing for a thesis defense, final examination, culminating activity, or completion of degree.

**Additional Information:** Departmental Category: Special Topics

**CVEN 6951 (1-4) Master's Thesis**

**Additional Information:** Departmental Category: Mechanics

**CVEN 6952 (1-4) Master's Thesis**

**Additional Information:** Departmental Category: Surveying and Transportation

**CVEN 6953 (1-6) Master's Thesis**

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 6954 (1-6) Master's Thesis**

**Additional Information:** Departmental Category: Environmental

**CVEN 6955 (1-6) Master's Thesis**

**Additional Information:** Departmental Category: Structures

**CVEN 6956 (1-6) Master's Thesis**

**Additional Information:** Departmental Category: Construction

**CVEN 6957 (1-4) Master's Thesis**

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 6958 (1-6) Master's Thesis**

**Additional Information:** Departmental Category: Geotechnical

**CVEN 6959 (1-4) Master's Thesis**

**Additional Information:** Departmental Category: Special Topics

**CVEN 6961 (1-3) Master's Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Mechanics

**CVEN 6962 (1-3) Master's Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Surveying and Transportation

**CVEN 6963 (1-3) Master's Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 6964 (1-3) Master's Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Environmental

**CVEN 6965 (1-3) Master's Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Structures

**CVEN 6966 (1-3) Master's Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Construction

**CVEN 6967 (1-3) Master's Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 6968 (1-3) Master's Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 6969 (1-3) Masters Report**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Special Topics

**CVEN 7111 (3) Advanced Structural Dynamics**

Includes general vibrations of civil engineering structures and their response to various types of time-dependent loads.

**Requisites:** Requires prerequisite course of CVEN 5111 (minimum grade C-).

**Additional Information:** Departmental Category: Mechanics

**CVEN 7141 (3) Plates and Shells**

Teaches mathematical theories of plate and shell structures and their applications. Involves numerical finite element solutions of plates and shells of various shapes under static and dynamic loadings.

**Requisites:** Requires prerequisite courses of CVEN 5131 or CVEN 5161 (minimum grade C-).

**Additional Information:** Departmental Category: Mechanics

**CVEN 7161 (3) Fracture Mechanics**

Includes three parts: 1) fundamentals through rigorous mathematical formulations of linear/nonlinear elastic fracture mechanics, 2) materials' theoretical strength, including metals, granular materials, polymers and steel, 3) numerical (finite element) methods in fracture mechanics. Heavy emphasis on project and independent work.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Additional Information:** Departmental Category: Mechanics



**CVEN 7511 (3) Computational Finite Inelasticity and Multiphase Mechanics**

Covers kinematics, thermodynamics, coupled balance equations and constitutive models, numerical time integration, and finite element implementation of finite strain inelasticity and multiphase mechanics. Kinematics of multiplicative decomposition, and finite strain mixture theory. Linearization for global nonlinear Newton-Raphson and solution algorithm of nonlinear constitutive models and coupled balance equations.

**Requisites:** Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

**Recommended:** Prerequisites CVEN 5131 and CVEN 5511 and CVEN 6511.

**Additional Information:** Departmental Category: Mechanics

**CVEN 7718 (3) Engineering Properties of Soils**

Emphasizes engineering aspects of soil mechanics. Implications of soil strength, volume change, consolidation behavior in engineering problems such as slope stability, deformation of retaining walls, surface subsidence due to tunneling. Time effects in soil/long-term bearing capacity of piles. Laboratory determination of constitutive parameters of soils. Field tests/their correlations with soil properties. Case studies using finite element software.

**Requisites:** Requires prerequisite course of CVEN 5708 (minimum grade of C-).

**Additional Information:** Departmental Category: Geotechnical

**CVEN 7788 (3) Soil Behavior**

Topics include soil mineralogy, formation of soils through sedimentary processes and weathering, determination of soil composition, soil water, colloidal phenomena in soils, fabric property relationships, analysis of mechanical behavior including compressibility, strength and deformation, and conduction phenomena in terms of physicochemical principles. Involves applications for stabilization and improvement of soils, and disposal of waste materials.

**Recommended:** Prerequisite CVEN 3718.

**Additional Information:** Departmental Category: Geotechnical

**CVEN 7831 (1-3) Sp Tpc-Constitutive Mech**

**Repeatable:** Repeatable for up to 10.00 total credit hours. Allows multiple enrollment in term.

**Additional Information:** Departmental Category: Mechanics

**CVEN 7838 (3) Special Topics**

**Additional Information:** Departmental Category: Geotechnical

**CVEN 7849 (1-3) Independent Study**

**Repeatable:** Repeatable for up to 6.00 total credit hours.

**Additional Information:** Departmental Category: Special Topics

**CVEN 8991 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Mechanics

**CVEN 8992 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Surveying and Transportation

**CVEN 8993 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Fluid Mechanics and Water Resources

**CVEN 8994 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Environmental

**CVEN 8995 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Structures

**CVEN 8996 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Construction

**CVEN 8997 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Miscellaneous

**CVEN 8998 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Geotechnical

**CVEN 8999 (1-10) Doctoral Dissertation**

**Additional Information:** Departmental Category: Special Topics