CIVIL AND ENVIRONMENTAL ENGINEERING (CEEN)

CEEN198. SPECIAL TOPICS. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CEEN199. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CEEN210. INTRODUCTION TO CIVIL INFRASTRUCTURE. 2.0 Semester Hrs.
An introduction to civil infrastructure systems, including the analysis, design and management of infrastructure that supports human activity, including transportation (road, rail, aviation), water and wastewater, communications and power.

CEEN241. STATICS. 3.0 Semester Hrs.
Forces, moments, couples, equilibrium, centroids and second moments of areas, volumes and masses, hydrostatics, and friction. Applications of vector algebra to structures. 3 hours lecture; 3 semester hours. Prerequisite: PHGN100 and credit or concurrent enrollment in MATH112.

CEEN267. DESIGN II: CIVIL ENGINEERING. 3.0 Semester Hrs.
Equivalent with EPIC267,
Design II builds on the design processes introduced in Design I, focusing on open-ended problem solving in which students integrate teamwork and communication with the use of computer software, AutoCAD and Civil3D, as tools to solve engineering problems. Projects often include planning, due diligence, construction document preparation, and site certification processes in the context of land development projects. Prerequisite: EDNS151 or EDNS155 or EDNS192 or HNRS115 or Grandey First-Year Honors Experience (HNRS198A and HNRS198B.

CEEN298. SPECIAL TOPICS. 6.0 Semester Hrs.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CEEN299. INDEPENDENT STUDY. 1-6 Semester Hr.
(I, II) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: Independent Study form must be completed and submitted to the Registrar. Variable credit; 1 to 6 credit hours. Repeatable for credit.

CEEN301. FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: WATER. 3.0 Semester Hrs.
This course introduces fundamentals of environmental science & engineering as applied to water resource management and environmental problem solving. Topics include environmental regulation, toxicology, material balance, applications in environmental chemistry, hydrology, water quality management, water supply and treatment, and wastewater treatment and reuse. Topical discussions will address major sources and concerns in measurement, practice and underlying theory in the field of environmental engineering. The course also includes field trips to local water and wastewater treatment facilities to integrate theory with practice. 3 hours lecture; 3 semester hours. Prerequisite: CHGN122, PHGN100.

CEEN302. FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING: AIR AND WASTE MANAGEMENT. 3.0 Semester Hrs.
Introductory level fundamentals in atmospheric systems, air pollution control, solid waste management, hazardous waste management, waste minimization, pollution prevention, role and responsibilities of public institutions and private organizations in environmental management (relative to air, solid and hazardous waste). 3 hours lecture; 3 semester hours. Prerequisite: CHGN122, PHGN100 and MATH213 or consent of instructor.

CEEN303. ENVIRONMENTAL ENGINEERING LABORATORY. 3.0 Semester Hrs.
Equivalent with ESGN355,
This course introduces the laboratory and experimental techniques used for generating and interpreting data in environmental science and engineering related to water, land, and environmental health. An emphasis is placed on quantitative chemical and microbiological analysis of water and soil samples relevant to water supply and wastewater discharge. Topics include basic water quality measurements (pH, conductivity, etc.) and quantitative analysis of chemicals by chromatographic and mass spectrometric techniques. Advanced topics include quantitative and qualitative analysis of bioreactor performance, bench testing for water treatment, and measurement and control of disinfection by-products. Prerequisite: CEEN301 or CEEN302.

CEEN310. FLUID MECHANICS FOR CIVIL AND ENVIRONMENTAL ENGINEERING. 3.0 Semester Hrs.
The study and application of principles of incompressible fluid mechanics. Topics include: hydrostatic forces on submerged surfaces, buoyancy, control volume analysis, conservation of mass, fluid motion, Bernoulli's equation and conservation of energy, momentum, dimensional analysis, internal flow (pipe systems), external flow (drag and lift), flow in open channels, and hydraulic jumps. The course will also introduce concepts about municipal water supply networks and storm water drainage and wastewater collection and treatment systems. May not also receive credit for PEGN251 or MEGN351. Prerequisites: PHGN100, CEEN241. 3 lecture hours, 3 semester hours.
Course Learning Outcomes

- Distinguish what physical aspects of fluid flow are most critical and have the greatest impact on a given problem and design.
- Establish an intuition for fluid behavior, analyze its effects in a given problem, and apply knowledge to propose design solutions.
- Leverage improved proficiency in critical thinking skills, technical writing skills, and oral communication skills.
- Calculate pressure forces on submerged surfaces and explain and apply measurement of pressures (fluid statics).
- Apply differential conservation-of-mass and linear-momentum equations and material derivatives to the solution of flow problems.
- Model laminar and turbulent pipe flow systems.
- Design and size pumps for system requirements.
- Explain the concepts of open-channel flow as found in rivers and fluid conduits and sewer and storm sewer design.
- Derive and solve mass conservation, momentum, and energy equations for steady-state fluid-flow systems, including open-channel flows (control-volume analyses).

CEEN311. MECHANICS OF MATERIALS. 3.0 Semester Hrs.
Fundamentals of stress, strain, deformation, and material properties. Mechanics of members subjected to axial, torsional, bending, and combined loads; beam deflection; static indeterminacy; Euler buckling; stress transformation and principal stresses; thermal stress, strain, and deformation; thin-walled pressure vessels; Allowable Stress Design; and stress concentrations. May not also receive credit for MEGN212. Prerequisite: CEEN241.

CEEN312. SOIL MECHANICS. 3.0 Semester Hrs.
An introductory course covering the engineering properties of soil, soil phase relationships and classification. Principle of effective stress. Seepage through soils and flow nets. Soil compressibility, consolidation and settlement prediction. Shear strength of soils. 3 hours lecture; 3 semester hours. Prerequisite: CEEN311.

CEEN312L. SOIL MECHANICS LABORATORY. 1.0 Semester Hr.
Introduction to laboratory testing methods in soil mechanics. Classification, permeability, compressibility, shear strength. 3 hours lab; 1 semester hour. Co-requisite: CEEN312.

CEEN314. STRUCTURAL ANALYSIS. 3.0 Semester Hrs.
Analysis of determinate and indeterminate structures for both forces and deflections. Influence lines, work and energy methods, moment distribution, matrix operations, computer methods. 3 hours lecture; 3 semester hours. Prerequisite: CEEN311.

CEEN315. CIVIL AND ENVIRONMENTAL ENGINEERING TOOLS. 1.0 Semester Hr.
Students in this project-based course will be introduced to and implement useful, industry standard tools from Civil and Environmental Engineering fields. Although unlimited, subjects presented may include: introduction to industry software, data analysis, materials testing, design preparation/presentation, or hands-on exercises illustrating concepts presented in lecture. Content will be presented in modules that occur over three to five-week periods. Modules indicative of the breadth of the profession will be offered. Credit hours will be awarded based on the completion of least three modules encompassing 15 weeks. Co-requisite: CEEN310, CEEN311.
Course Learning Outcomes

- Analyze data to help draw conclusions and drive decisions.
- Demonstrate competency and understanding of industry-based practices including such content as lab procedures or design software.
- Solve engineering problems using engineering tools to formulate conclusions.
- Develop a knowledge base surrounding industry practice.
- Validate equations and models learned in lecture through lab/field exercises.

CEEN330. ENGINEERING FIELD SESSION, ENVIRONMENTAL. 3.0 Semester Hrs.
The environmental module is intended to introduce students to laboratory and field analytical skills used in the analysis of an environmental engineering problem. Students will receive instruction on the measurement of water quality parameters (chemical, physical, and biological) in the laboratory and field. The student will use these skills to collect field data and analyze a given environmental engineering problem. Three weeks in summer session. 9 hours lab; 3 semester hours. Prerequisite: CEEN301, CEEN303.

CEEN331. ENGINEERING FIELD SESSION, CIVIL. 3.0 Semester Hrs.
The theory and practice of modern surveying. Lectures and hands-on field work teaches horizontal, vertical, and angular measurements and computations using traditional and modern equipment. Subdivision of land and applications to civil engineering practice, GPS and astronomic observations. Three weeks (6 day weeks) in summer field session; 9 hours lab; 3 semester hours. Prerequisite: EDNS251, CEEN267.

CEEN340. COOPERATIVE EDUCATION. 3.0 Semester Hrs.
(I,II,S) Supervised full-time engineering-related employment in which specific educational objectives are set and achieved. The co-op differs from a typical internship in both the length and scope of responsibilities. Students must meet with the CEE Co-op Advisor prior to enrolling to determine the appropriateness of the engagement, clarify the educational objectives, set expectations, and receive written approval for their specific Co-op program. This prior approval of the CEE Co-op Advisor and completion of paperwork with the Career Center is required prior to beginning the work portion of the program. The co-op occurs during academic fall or spring semester(s) and may overlap with a summer session, with a typical length of six months total. 3.0 credit hours. This course is repeatable. Prerequisite: Second semester sophomore status or above and a cumulative grade-point average of at least 2.00.

CEEN350. CIVIL AND CONSTRUCTION ENGINEERING MATERIALS. 3.0 Semester Hrs.
This course deals with the nature and performance of civil engineering materials and evaluation of their physical and mechanical properties. This course focuses on materials used in construction and maintenance of building and infrastructure such as metals (steel and aluminum), aggregates, Portland cement, concrete, shotcrete, asphalt, wood, recycled materials, and composites. The course covers standards describing materials and tests for determining material properties and includes a lab component where students conduct tests, analyze the resulting data, and prepare technical reports. Laboratory tests include evaluation of behavior of civil engineering materials under a wide range of conditions. 2 hours lecture; 3 hours lab, 3 semester hours. Prerequisite: CEEN311.
Course Learning Outcomes

- Describe the basic properties of a variety of civil engineering materials including metals, concrete, aggregates, asphalt, and wood.
- Identify and explain significant considerations in choosing a material for a specific application including, for example, mechanical properties, durability, and sustainability.
- Follow standards to conduct tests of material properties and perform the calculations necessary to analyze and interpret test results.
- Explain the importance of standards in the context of civil engineering materials.
- Work effectively in teams to perform experimental tasks.
- Write formal technical report and convey engineering message efficiently.
- Use commercial engineering test equipment to determine mechanical properties of engineering materials.
- Design and make conventional and high performance Portland cement concrete mixtures and evaluate their fresh and hardened properties.
- Apply the field quality control procedures in the manufacturing and placing of Portland cement concrete and hot-mix asphalt

CEEN360. INTRODUCTION TO CONSTRUCTION ENGINEERING. 3.0 Semester Hrs.
(II) Overview of the construction process for civil construction (spanning the building, transportation, and infrastructure sectors), including procurement methods and project delivery methods, codes, regulations, tests, standards, and Risk estimation and management. Construction

methods and materials. Construction contracts, including drawings and specifications. Construction administration, including submittals, requests for information, change orders, special instructions, claims, disputes, arbitration, litigation, and project close-out. Project scheduling using the Critical Path Method. Construction project management. Construction safety and OSHA. Quantity takeoffs and construction estimating. Application of engineering analysis and design to construction projects. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- Explain and describe common construction processes and procedures; compare procurement methods and project delivery methods.
- Describe the engineering decision#making process for selection of various construction materials and systems; choose appropriate construction materials and assemblies for a given set of constraints; apply engineering criteria to compare various construction means and methods for a given set of constraints.
- Analyze a professional set of construction documents, including the front#end documents, general conditions, supplementary conditions, drawings, and specifications.
- Write a construction specification section.
- Perform quantity take#offs and estimates using hand methods and software analysis.
- Design and optimize a schedule for a construction project using the Critical Path Method.
- Explain common construction administration activities, such as submittal review, requests for information, change orders, special instructions, claims and disputes, litigation and arbitration, and project close#out procedures.
- Analyze OSHA requirements for construction safety and apply those requirements to a construction project.

CEEN381. HYDROLOGY AND WATER RESOURCES ENGINEERING. 3.0 Semester Hrs.

Equivalent with CEEN481,ESGN459,

This course introduces the principles of physical hydrology and fundamentals of water resources engineering. Topics include groundwater, surface water, precipitation, infiltration, evapotranspiration, sediment transport, flood and drought analysis, lake and reservoir analysis, water-resources planning, water quality engineering, stormwater management, and engineering design problems. 3 hour lecture; 3 semester hours. Prerequisite: CEEN310.

CEEN398. SPECIAL TOPICS IN CIVIL AND ENVIRONMENTAL ENGINEERING. 6.0 Semester Hrs.

(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CEEN399. INDEPENDENT STUDY. 1-6 Semester Hr.

Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Variable credit; 1 to 6 credit hours. Repeatable for credit. Prerequisite: Independent Study form must be completed and submitted to the Registrar.

CEEN401. LIFE CYCLE ASSESSMENT. 3.0 Semester Hrs.

Which is more sustainable: paper vs plastic, hybrid vs electric vehicles? LCA is a powerful tool used to answer these questions; LCA quantifies the environmental sustainability of a product or process. Students will learn to conduct an LCA during a semester-long project of their choosing. At the end of the course students should be able to sit for the ACLCA professional LCACP certification exam. Prerequisite: Junior standing.

Course Learning Outcomes

- 1. Identify environmental sustainability challenges and opportunities for engineered systems from a life-cycle perspective
- 2. Draw a process flow diagram and Create a life cycle inventory
- 3. Understand and calculate different environmental impact categories
- 4. Conduct a simple life cycle assessment for a product or process
- 5. Utilize LCA results for decision making
- 6. Understand the process for conducting an ISO 14000 series certified LCA

CEEN402. PROJECT ENGINEERING. 3.0 Semester Hrs.

Project Engineers - through their "big picture" understanding of overall project completion requirements, technical knowledge of the components that have to be coordinated & assembled, and application of people skills - get things done. This career-oriented course focuses on the roles & responsibilities, skills, and character of the Project Engineer as a problem-solver, integrator, and leader. Content, procedural, and relationship project needs essential for project execution success are identified. Practical instruction and exercises are given - formulated around industry documents and templates - on key project execution best practices such as estimating (cost, weight, etc.), scheduling, quality, earned value, constructability, risk management, and root-cause analysis. Emotional Intelligence is introduced along with identification of skills that are essential for leading projects and people to success. Management, leadership, and ethical principles and best practices are illustrated through case studies of complex, high-profile domestic and international projects. Prior to taking the course, design and analysis courses along with any project/construction management experience beneficial but not expected. Courses recommended concurrently include courses equivalent to CEEN591, CEEN594, EBGN553, and MNGN509 are advantageous but not required. 3 hours lecture; 3 semester hours. Prerequisite: CEEN360.

Course Learning Outcomes

- Differentiate the unique roles & responsibilities and skill set requirements of a Project Engineer
- Organize a Work Breakdown Structure, use it as a basis for developing estimates for cost and schedule, and critically assess project progress by calculating Earned Value
- Develop a simple project schedule using manual Arrow-on-Node and electronic Microsoft Project methods; propose schedule compression options and their impact on a troubled project
- Develop a simple Constructability Register with a fundamental understanding of engineer vs. constructor motivations
- Develop a simple Risk Register, Risk Matrix, and Risk Mitigation Plan
- Identify the management and emotional skills that enable a Project Engineer to achieve effective project delivery and personal integrity and success

CEEN405. NUMERICAL METHODS FOR ENGINEERS. 3.0 Semester Hrs.

Introduction to the use of numerical methods in the solution of problems encountered in engineering analysis and design, e.g. linear simultaneous equations (e.g. analysis of elastic materials, steady heat flow); roots of nonlinear equations (e.g. vibration problems, open channel flow); eigenvalue problems (e.g. natural frequencies, buckling and elastic stability); curve fitting and differentiation (e.g. interpretation of

experimental data, estimation of gradients); integration (e.g. summation of pressure distributions, finite element properties, local averaging); ordinary differential equations (e.g. forced vibrations, beam bending). All course participants will receive source code consisting of a suite of numerical methods programs. 3 hours lecture; 3 semester hours. Prerequisite: CSCI200 or CSCI260 or CSCI261 or MATH307, MATH225.

CEEN406. FINITE ELEMENT METHODS FOR ENGINEERS. 3.0 Semester Hrs.
A course combining finite element theory with practical programming experience in which the multidisciplinary nature of the finite element method as a numerical technique for solving differential equations is emphasized. Topics covered include simple structural elements, beams on elastic foundations, solid elasticity, steady state analysis and transient analysis. Some of the applications will lie in the general area of geomechanics, reflecting the research interests of the instructor. Prerequisite: CEEN311 or MEGN212, MATH225.

CEEN410. ADVANCED SOIL MECHANICS. 3.0 Semester Hrs.
Advanced soil mechanics theories and concepts as applied to analysis and design in geotechnical engineering. Topics covered will include seepage, consolidation, shear strength and probabilistic methods. The course will have an emphasis on numerical solution techniques to geotechnical problems by finite elements and finite differences. 3 hour lectures; 3 semester hours. Fall even years. Prerequisite: CEEN312.

CEEN411. UNSATURATED SOIL MECHANICS. 3.0 Semester Hrs.
Equivalent with CEEN512,
Systematic introduction of soil mechanics under partially saturated conditions. Topics include principles of seepage under variably saturated conditions, principle of the effective stress, shear strength theory, and hydraulic and mechanical properties. When this course is cross-listed and concurrent with CEEN511, students that enroll in CEEN511 will complete additional and/or more complex assignments. Prerequisite: CEEN312.

CEEN415. FOUNDATION ENGINEERING. 3.0 Semester Hrs.
Techniques of subsoil investigation, types of foundations and foundation problems, selection of basis for design of foundation types. Open-ended problem solving and decision making. Prerequisite: CEEN312. 3 hours lecture; 3 semester hours.

CEEN419. RISK ASSESSMENT IN GEOTECHNICAL ENGINEERING. 3.0 Semester Hrs.
Soil and rock are among the most variable of all engineering materials, and as such are highly amenable to a probabilistic treatment. Assessment of the probability of failure or inadequate performance is rapidly gaining ground on the traditional factor of safety approach as a more rational approach to design decision making and risk management. Probabilistic concepts are also closely related to system reliability and Load and Resistance Factor Design (LRFD). When probability is combined with consequences of failure, this leads to the concept of risk. This course is about the theory and application of various tools enabling risk assessment in engineering with an emphasis on geotechnical applications.
Course Learning Outcomes

- Understand basic principles of probability theory and apply them to the geotechnical engineering applications.
- Understand the consequences of design failure and risk in geotechnical engineering
- Have the ability to compute probability in geotechnical engineering using hand and computational tools
- Successfully complete homework assignments and exam questions

CEEN421. HIGHWAY AND TRAFFIC ENGINEERING. 3.0 Semester Hrs.
(I) The emphasis of this class is on the multi-disciplinary nature of highway and traffic engineering and its application to the planning and design of transportation facilities. In the course of the class the students will examine design problems that will involve: geometric design, surveying, traffic operations, hydrology, hydraulics, elements of bridge design, statistics, highway safety, transportation planning, engineering ethics, soil mechanics, pavement design, economics, environmental science. 3 credit hours.

CEEN423. SURVEYING FOR ENGINEERS AND INFRASTRUCTURE DESIGN PRACTICES. 3.0 Semester Hrs.
Applications of civil engineering skills using the engineer's level, total station, GPS receiver, and commercial software for field data collection, design, and layout of civil infrastructure including survey control, roadways, intersections, and utilities such as water and sewer. The course includes basic road design, horizontal design, vertical design, centerline layout, slope/cross section staking, earthwork volume calculations, engineering astronomy, and preparation of plan/profile drawings. Some discussion of concepts and mathematics of applying GPS data to engineering projects and the principles of map projections (Mercator, Lambert, UTM, State Plane, etc.) and coordinate systems such as (North American Datum) NAD '27, NAD '83, and other reference networks is included. Prerequisite: CEEN331. 2 hours lecture; 8-9 field work days; 3 semester hours.

CEEN425. CEMENTITIOUS MATERIALS FOR CONSTRUCTION. 3.0 Semester Hrs.
(II) Cementitious materials, as the most commonly used construction materials, are the main focus of this course and variety of cementitious materials including Portland and non-Portland cements, supplementary cementitious materials, concrete and sprayed concrete (shotcrete), and grouts with their needed additional constituents are covered in this course. This course provides a comprehensive treatment of engineering principles and considerations for proper design, production, placement and maintenance of high quality cementitious materials for infrastructure. In addition, cementitious materials and techniques used for ground improvement purposes are covered in this course. Spring odd years. Prerequisite: CEEN 311.
Course Learning Outcomes

- 1. Describe the main properties of concrete constituents and their influence on the behavior • Describe the cement composition, phases, types, and the hydration process • List the different types of cements and their proper applications • Select the right types of admixtures to be used in different applications and situations • Describe the effects of supplementary cementitious materials on concrete properties
- 2. Design and Test Cementitious Construction materials to meet specifications • Design conventional and high performance Portland cement concrete mixtures with supplementary cementitious materials to meet specifications • Design concrete mix for spraying applications to meet the requirements for ground support needs • Identify the appropriate testing method for evaluation of concrete properties
- 3. Propose ground improvement solutions for different ground conditions using Cementitious Materials • Describe the different ground improvement techniques and explain the differences among current techniques • Identify the appropriate type of ground improvement and specify the requirements for the materials needed
- 4. Apply the concepts learned in the class in understanding the nature, types and applications of cementitious materials by • Selecting a topic of interest related to Cementitious Materials •

Conducting research in groups • Presenting the work in written and oral presentation formats

CEEN426. DURABILITY OF CONCRETE. 3.0 Semester Hrs.
(II) This course will provide an in-depth overview of concrete properties relevant to deterioration, including transport, mechanical, physical, and chemical properties. After this course, students should be able to identify, quantify, and mitigate against various deterioration mechanisms, such as freezing and thawing, sulfate attack, alkali-aggregate reactions, acid attack, and corrosion of steel rebar. This course will also illustrate how to test materials for durability (hands-on activities included) and ways in which construction methods may affect durability. Students will learn the strengths and limitations of the worlds most ubiquitous building material.
Course Learning Outcomes

- 1. Explain how the microstructure of concrete develops.
- 2. Explain how the microstructure of concrete affects engineering properties.
- 3. Identify different deterioration mechanisms that affect concrete and explain how they impact concrete durability.
- 4. Explain the principles behind various durability tests.
- 5. Conduct durability tests and assess the performance.

CEEN430. ADVANCED STRUCTURAL ANALYSIS. 3.0 Semester Hrs.
Introduction to advanced structural analysis concepts. Nonprismatic structures. Arches, Suspension and cable-stayed bridges. Structural optimization. Computer Methods. Structures with nonlinear materials. Internal force redistribution for statically indeterminate structures. Graduate credit requires additional homework and projects. 3 hour lectures; 3 semester hours. Prerequisite: CEEN314.

CEEN433. MATRIX STRUCTURAL ANALYSIS. 3.0 Semester Hrs.
Equivalent with CEEN533,
Focused study on computer oriented methods for solving determinate and indeterminate structures such as trusses and frames. Classical stiffness based analysis method will be introduced with hands-on practice to develop customized matrix analysis program using Matlab. Commercial structural analysis programs will also be introduced during the class and practiced through class projects. When this course is cross-listed and concurrent with CEEN533, students that enroll in CEEN533 will complete additional and/or more complex assignments. 3 lecture hours, 3 semester hours. Prerequisite: CEEN314.

CEEN442. DESIGN OF WOOD STRUCTURES. 3.0 Semester Hrs.
(II) The course develops the theory and design methods required for the use of wood as a structural material. The design of walls, beams, columns, beam-columns, shear walls, and structural systems are covered with consideration of gravity, wind, snow, and seismic loads. Prerequisite: CEEN311.

CEEN443. DESIGN OF STEEL STRUCTURES. 3.0 Semester Hrs.
To learn application and use the American Institute of Steel Construction (AISC) Steel Construction Manual. Course develops an understanding of the underlying theory for the design specifications. Students learn basic steel structural member design principles to select the shape and size of a structural member. The design and analysis of tension members, compression members, flexural members, and members under combined loading is included, in addition to basic bolted and welded connection design. 3 hours lecture; 3 semester hours. Prerequisite: CEEN314.

CEEN445. DESIGN OF REINFORCED CONCRETE STRUCTURES. 3.0 Semester Hrs.
This course provides an introduction to the materials and principles involved in the design of reinforced concrete. It will allow students to develop an understanding of the fundamental behavior of reinforced concrete under compressive, tensile, bending, and shear loadings, and gain a working knowledge of strength design theory and its application to the design of reinforced concrete beams, columns, slabs, and footings. Prerequisite: CEEN314. 3 hours lecture; 3 semester hours.

CEEN448. STRUCTURAL LOADS. 3.0 Semester Hrs.
Students will be introduced to the load types and load combinations required to design structures in compliance with building code requirements. Students will learn the theory and methods to determine the magnitude and application of loads associated with structure self-weight and occupancy. Students will be introduced to the physics underlying the requirements for environmental loads and to the accepted methods used to calculate environmental loads due to wind, snow, rain, floods, and avalanches. Students will become familiar with the common approaches used to deal with tsunami loads and blast loads. Students will learn the importance of and to recognize the load paths required to transmit applied loads from the structure to the foundation. Course offered every third semester. Prerequisite: CEEN314.
Course Learning Outcomes

- Students are expected to attend class, ask questions, utilize office hours when needed, and come to class prepared.
- Students are expected to display academic integrity (see Academic Integrity Section).
- Students will be able to determine to applicable loads to be used to design a structure, be able to calculate their magnitudes and directions, and specify load path.

CEEN449. INTRODUCTION TO THE SEISMIC DESIGN OF STRUCTURES. 3.0 Semester Hrs.
This course provides students with an introduction to seismic design as it relates to structures. Students will become familiar with the sources of seismic disturbances, the physics of seismic energy transmission, and the relationship between ground disturbance and the resulting forces experienced by structures. The theory and basis for existing building code provisions relating to seismic design of structures will be introduced. Building code requirements and design methodologies will be examined and applied. Advanced performance based seismic design method will also be introduced. Prerequisite: CEEN443, or CEEN445, or CEEN442 Co-requisite: N/A.
Course Learning Outcomes

- Gain fundamental understanding on earthquake hazard and how it is characterized for structural design.
- Understand typical lateral load path for building structures.
- Gain fundamental understanding of structural dynamics related to earthquake engineering.
- Get familiar with Seismic Design sections in ASCE7, and be able to use ASCE7 to conduct simple seismic design using equivalent lateral force procedure.
- Understand the concept of performance based seismic design method.

CEEN460. MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT. 3.0 Semester Hrs.
(I) Essentially, this course will be an introduction to the field of environmental microbiology. Although not titled as such, we will focus on all aspects of environmental microbiology including those of engineered systems. We will be particularly considering things that pertain to life in all of its forms. Expect to engage in diverse conversations pertaining to life in any of its habitats. The class has THREE ESSENTIAL ELEMENTS.

The first is the lectures and the material that I, or any of the guest speakers happen to cover. The second is the material that has been assigned in the textbook. Please read the assigned textbook sections thoroughly before coming to class. Also, at times, I will be assigning current papers to read, please read them as assigned. The third is YOUR PARTICIPATION in discussions. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- Have a thorough understanding of the microbial world, as of the Fall of 2018.
- Have a new understanding of what life means.
- Have a new understanding of the Earth.
- Have a new understanding of your body.
- Have a new understanding of the rock record and a new perspective on what it means to be a civil / environmental engineer going into the future.

CEEN461. FUNDAMENTALS OF ECOLOGY. 3.0 Semester Hrs.
Biological and ecological principles discussed and industrial examples of their use given. Analysis of ecosystem processes, such as erosion, succession, and how these processes relate to engineering activities, including engineering design and plant operation. Criteria and performance standards analyzed for facility siting, pollution control, and mitigation of impacts. North American ecosystems analyzed. Concepts of forestry, range, and wildlife management integrated as they apply to all of the above. Three to four weekend trips will be arranged during the semester. Semester offering based on faculty availability.

CEEN470. WATER AND WASTEWATER TREATMENT PROCESSES. 3.0 Semester Hrs.
Equivalent with BELS453,EGGN453,ESGN453,
The goal of this course is to familiarize students with the unit operations and processes involved in water and wastewater treatment. This course will focus on the physical, chemical, and biological processes for water and wastewater treatment and reclamation. Treatment objectives, process theory, and practice are considered in detail. Prerequisite: CEEN301.

CEEN472. ONSITE WATER RECLAMATION AND REUSE. 3.0 Semester Hrs.
Appropriate solutions to water and sanitation in the U.S. and globally need to be effective in protecting public health and preserving water quality while also being acceptable, affordable and sustainable. Onsite and decentralized systems have the potential to achieve these goals in rural areas, peri-urban developments, and urban centers in small and large cities. Moreover they can improve water use efficiency, conserve energy and enable distributed energy generation, promote green spaces, restore surface waters and aquifers, and stimulate new green companies and jobs. A growing array of approaches, devices and technologies have evolved that include point-of-use water purification, waste source separation, conventional and advanced treatment units, localized natural treatment systems, and varied resource recovery and recycling options. This course will focus on the engineering selection, design, and implementation of onsite and decentralized systems for water reclamation and reuse. Topics to be covered include process analysis and system planning, water and waste stream attributes, water and resource conservation, confined unit and natural system treatment technologies, effluent collection and clustering, recycling and reuse options, and system management. Prerequisite: CEEN301. 3 hours lecture; 3 semester hours.

CEEN473. HYDRAULIC PROBLEMS. 3.0 Semester Hrs.
Review of fundamentals, forces on submerged surfaces, buoyancy and flotation, gravity dams, weirs, steady flow in open channels, backwater curves, hydraulic machinery, elementary hydrodynamics, hydraulic structures. Prerequisite: CEEN310 or CBEN307.

CEEN475. HAZARDOUS SITE REMEDIATION ENGINEERING. 3.0 Semester Hrs.
This course describes the engineering principles and practices associated with the characterization and remediation of contaminated sites. Methods for site characterization and risk assessment will be highlighted while the emphasis will be on remedial action screening processes and technology principles and conceptual design. Common isolation and containment and in-situ and ex-situ treatment technology will be covered. Computerized decision-support tools will be used and case studies will be presented. Prerequisite: CHGN121.

CEEN478. WATER TREATMENT DESIGN AND ANALYSIS. 3.0 Semester Hrs.
The learning objectives of this class are to build off of the information and theories presented in CEEN 470 and apply them to the design of water and wastewater treatment systems. Students will be presented with project-based assignments and, with the help of the instructors and associated lectures, will use fundamentals and commercial software to develop preliminary designs of water and wastewater systems. Students will gain experience in conventional and advanced treatment system design, software utilized by environmental consulting companies, and professional communication through the completion of this class. Course lectures will include fundamentals of design, guest lectures from practitioners, and tours of local treatment plants. Regional water and wastewater treatment employers (e.g., consultants, municipalities, industry, regulators) are actively searching for students with applied experience and this class will help promote the advancement of employment in the water and wastewater treatment field. Prerequisite: CEEN470.

Course Learning Outcomes

- Use fundamentals and commercial software to design and analyze water treatment systems.
- Integrate design aspects for development of integrated water systems to treat variable water resources.
- Summarize design components into drawings and diagrams.
- Communicate solutions and designs to practitioners through technical reports and presentations.

CEEN479. AIR POLLUTION. 3.0 Semester Hrs.
This course familiarizes students with the basic physics, chemistry and biology of major air pollutants, related health impacts, and engineered approaches used to mitigate the effects of common air pollutants. This course is also designed to provide a solid foundation in air pollution topic areas found on the FEE or PE exam. Critical US air pollution legislation is discussed. The sources of particulate and gaseous pollutants from both stationary and mobile sources, associated key chemical reactions, and approaches for control are considered. Indoor air pollution and the Gaussian dispersion model for air pollutants are discussed. Prerequisite: CEEN302. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- Characterize and compare the various types of air pollutants, their sources, fate, and health and environmental risks and impacts.
- Summarize current air quality standards and legislation.

- Identify, characterize, and assess different methods of pollution prevention and source control devices for particulate matter and other air pollutants.
- Predict downwind concentrations of pollutants under varying conditions using air pollution modeling.

CEEN480. CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT. 3.0 Semester Hrs.
Equivalent with ESGN440,
This course describes the environmental behavior of inorganic and organic chemicals in multimedia environments, including water, air, sediment and biota. Sources and characteristics of contaminants in the environment are discussed as broad categories, with some specific examples from various industries. Attention is focused on the persistence, reactivity, and partitioning behavior of contaminants in environmental media. Both steady and unsteady state multimedia environmental models are developed and applied to contaminated sites. The principles of contaminant transport in surface water, groundwater and air are also introduced. The course provides students with the conceptual basis and mathematical tools for predicting the behavior of contaminants in the environment. Prerequisite: CEEN301.

CEEN482. HYDROLOGY AND WATER RESOURCES LABORATORY. 3.0 Semester Hrs.
This course introduces students to the collection, compilation, synthesis and interpretation of data for quantification of the components of the hydrologic cycle, including precipitation, evaporation, infiltration, and runoff. Students will use hydrologic variables and parameters to evaluate watershed processes and behavior. Students will also survey and apply measurement techniques necessary for watershed studies. Advanced topics include development, construction, and application of analytical models for selected problems in hydrology and water resources. Prerequisite: CEEN381. 2 hours lecture; 3 hours lab; 3 semester hours.

CEEN491. EROSION CONTROL AND LAND RESTORATION. 3.0 Semester Hrs.
People have been the main cause of soil erosion for over 1,000 years. Studies suggest that human activities can cause about ten times more erosion than all natural processes together. It is well known that the rates of soil erosion surpass those of soil formation. Worldwide, millions of acres of productive land are lost every year because of inappropriate land management practices. The course is oriented to graduate and undergraduate students from any field in which the relationship among soil, water, and plant is altered, with the purpose of applying the right technique to bring back the productivity of land, in a sustainable way. The student will learn about erosion processes and how to stop them, and by the end of the course the student should be able to: (1) Identify erosive processes affecting certain area; (2) Evaluate the level of soil erosion, its origin and consequences to make further management decisions; and (3) Select and design the most appropriate erosion control/land restoration technique to apply, based on cost-effectiveness, giving emphasis to maximizing environmental benefits (i.e. using plants as a main stabilization system). Prerequisite: CEEN381.
Course Learning Outcomes

- Identify erosive processes affecting certain area.
- Evaluate the level of soil erosion, its origin and consequences, to make further management decisions.
- Select and design the most appropriate erosion control technique to apply, based on cost-effectiveness, giving emphasis to minimizing cost and maximizing environmental benefits (i.e. using plants as a main stabilization system).

CEEN492. ENVIRONMENTAL LAW. 3.0 Semester Hrs.
Equivalent with CEEN592,PEGN530,
Specially designed for the needs of the environmental quality engineer, scientist, planner, manager, government regulator, consultant, or advocate. Highlights include how our legal system works, environmental law fundamentals, all major US EPA/state enforcement programs, the National Environmental Policy Act, air and water pollutant laws, risk assessment and management, and toxic and hazardous substance laws (RCRA, CERCLA, TSCA, LUST, etc). Prerequisites: CEEN301 or CEEN302. 3 hours lecture; 3 semester hours.

CEEN493. SUSTAINABLE ENGINEERING DESIGN. 3.0 Semester Hrs.
This course provides a comprehensive introduction to concepts of sustainability and sustainable development from an engineering point of view. Environmental and health impacts are quantitatively considered in engineering and design analysis through a Life Cycle Assessment (LCA) tool. Social considerations, a key aspect of sustainable engineering design, are integrated throughout the design analysis. Prerequisite: Senior or graduate standing.
Course Learning Outcomes

- Demonstrate sufficient familiarity with the terminology associated with sustainability and sustainable engineering to speak and write effectively about the topic.
- Compare and contrast traditional engineering design and analysis approaches with those associated with sustainable design, in particular those that go beyond the triple-bottom-line approach to include considerations of social justice and socio-technical integration.
- Apply a working knowledge of a commercially available LCA tool to an engineering design problem.
- Work in teams to effectively (1) write a project report and (2) give a presentation, both of which describe the connection between the concepts of sustainable engineering and their work, the approach they took and their conclusions and recommendations for future work.

CEEN497. PRACTICES AND PRINCIPLES OF ENVIRONMENTAL CONSULTING. 3.0 Semester Hrs.
This course provides an in-depth understanding of the environmental consulting industry with a particular focus on problem solving and project delivery to meet expectations of professional services organizations (environmental consulting firms). Using case studies, real-life consulting assignments, and business scenarios, the course offers exposure to the technical, ethical, and business challenges of winning and executing environmental projects.
Course Learning Outcomes

- 1. Understand the drivers and policies that protect our environmental and water resources.
- 2. Apply knowledge gained in the course from pragmatic problems taken from real scenarios experienced within the consulting industry
- 3. Develop an appreciation for investigations and data interpretation making science-based decisions where possible and determine when decisions may require additional information.
- 4. Know the basic process of project initiation, budgeting, management, and effective delivery in executing environmental projects.
- 5. Work with a team to interpret given data to understand what information is important to advise alternatives, planning, decisions, and design.

- 6. Consider how to tailor designs to meet objectives that protect public health and to meet environment objectives and requirements.
- 7. Use data and engineering judgement to calculate sizing of infrastructure and to develop solutions to solve local environmental problems; research and consider social and economic project considerations and outcomes
- 8. Effectively deliver quality technical products to communicate issues and basis of design; develop communication and presentations skills that effectively share information to an appropriate audience; present technical materials to instructors and peers; provide constructive feedback to peers.

CEEN498. SPECIAL TOPICS IN CIVIL AND ENVIRONMENTAL ENGINEERING. 1-6 Semester Hr.
(I, II) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once. Prerequisite: none. Variable credit; 1 to 6 credit hours. Repeatable for credit under different titles.

CEEN499. INDEPENDENT STUDY. 1-6 Semester Hr.
Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Variable credit; 1 to 6 credit hours. Repeatable for credit. Prerequisite: Independent Study form must be completed and submitted to the Registrar.

CEEN501. LIFE CYCLE ASSESSMENT. 3.0 Semester Hrs.
(I, II) Which is more sustainable: paper vs plastic, hybrid vs electric vehicles? LCA is a powerful tool used to answer these questions; LCA quantifies the environmental sustainability of a product or process. Students will learn to conduct an LCA during a semester-long project of their choosing. At the end of the course students should be able to sit for the ACLCA professional LCACP certification exam. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- 1. Identify environmental sustainability challenges and opportunities for engineered systems from a life-cycle perspective
- 2. Draw a process flow diagram and Create a life cycle inventory
- 3. Understand and calculate different environmental impact categories
- 4. Conduct a simple life cycle assessment for a product or process
- 5. Utilize LCA results for decision making
- 6. Understand the process for conducting an ISO 14000 series certified LCA

CEEN505. NUMERICAL METHODS FOR ENGINEERS. 3.0 Semester Hrs.
(II) Introduction to the use of numerical methods in the solution of commonly encountered problems of engineering analysis. Structural/solid analysis of elastic materials (linear simultaneous equations); vibrations (roots of nonlinear equations, initial value problems); natural frequency and beam buckling (eigenvalue problems); interpretation of experimental data (curve fitting and differentiation); summation of pressure distributions (integration); beam deflections (boundary value problems). All course participants will receive source code of all the numerical methods programs published in the course textbook which is coauthored by the instructor. 3 hours lecture; 3 semester hours.

CEEN506. FINITE ELEMENT METHODS FOR ENGINEERS. 3.0 Semester Hrs.
(II) A course combining finite element theory with practical programming experience in which the multidisciplinary nature of the finite element method as a numerical technique for solving differential equations is emphasized. Topics covered include simple structural elements, beams on elastic foundations, solid elasticity, steady state analysis and transient analysis. Some of the applications will lie in the general area of geomechanics, reflecting the research interests of the instructor. Students get a copy of all the source code published in the course textbook. 3 hours lecture; 3 semester hours. Prerequisite: Consent of the instructor.

CEEN510. ADVANCED SOIL MECHANICS. 3.0 Semester Hrs.
(I) Advanced soil mechanics theories and concepts as applied to analysis and design in geotechnical engineering. Topics covered will include seepage, consolidation, shear strength, failure criteria and constitutive models for soil. The course will have an emphasis on numerical solution techniques to geotechnical problems by finite elements and finite differences. 3 Lecture Hours, 3 semester hours. Fall even years. Prerequisite: A first course in soil mechanics.

CEEN511. UNSATURATED SOIL MECHANICS. 3.0 Semester Hrs.
(I) The focus of this course is on soil mechanics for unsaturated soils. It provides an introduction to thermodynamic potentials in partially saturated soils, chemical potentials of adsorbed water in partially saturated soils, phase properties and relations, stress state variables, measurements of soil water suction, unsaturated flow laws, measurement of unsaturated permeability, volume change theory, effective stress principle, and measurement of volume changes in partially saturated soils. The course is designed for seniors and graduate students in various branches of engineering and geology that are concerned with unsaturated soil's hydrologic and mechanics behavior. When this course is cross-listed and concurrent with CEEN412, students that enroll in CEEN511 will complete additional and/or more complex assignments. 3 hours lecture; 3 semester hours. Prerequisite: CEEN312.

CEEN512. SOIL BEHAVIOR. 3.0 Semester Hrs.
(I) The focus of this course is on interrelationships among the composition, fabric, and geotechnical and hydrologic properties of soils that consist partly or wholly of clay. The course will be divided into two parts. The first part provides an introduction to the composition and fabric of natural soils, their surface and pore-fluid chemistry, and the physico-chemical factors that govern soil behavior. The second part examines what is known about how these fundamental characteristics and factors affect geotechnical properties, including the hydrologic properties that govern the conduction of pore fluid and pore fluid constituents, and the geomechanical properties that govern volume change, shear deformation, and shear strength. The course is designed for graduate students in various branches of engineering and geology that are concerned with the engineering and hydrologic behavior of earth systems, including geotechnical engineering, geological engineering, environmental engineering, mining engineering, and petroleum engineering. When this course is cross-listed and concurrent with CEEN411, students that enroll in CEEN512 will complete additional and/or more complex assignments. 3 hours lecture; 3 semester hours.

CEEN513. ADVANCED GEOMATERIAL MECHANICS. 4.0 Semester Hrs.
(I) This course deals with the classification and engineering behavior of soil and rock materials as well as materials used in underground construction such as structural steel, aggregates, cement, timber, concrete, shotcrete, accelerators and ground conditioning agents. This course presents an advanced treatment of soil and rock mechanics with focus on the following topics: Index and classification properties of soils, Physical properties and classification of intact rock and rock masses, Fluid flow in soils and rocks, Compressibility of soils and rocks, Failure theories and strength testing of soils and rocks, Shear strength of soils

and rocks, Stresses and deformations around underground openings, Laboratory and field methods for evaluation of soil and rock properties, and Analytical and empirical approaches for the design and construction of structures in soil and rock materials. Undergraduate degree in a pertinent discipline of engineering or equivalent and undergraduate level knowledge of material behavior. 4 hours lecture; 4 semester hours. Co-requisite: GEGN561.

Course Learning Outcomes

- 1. Understand the behavior of coarse- and fine-grained soils in dry and saturated conditions
- 2. Understand the stress-strain-strength behavior of soils in drained and undrained conditions
- 3. Estimate the soil and rock shear strength properties for design purposes
- 4. Evaluate the engineering properties of soils and rocks and determine appropriate input parameters for numerical models
- 5. Evaluate the potential deformation of soil and rock and the stability of structure during staged construction
- 6. Identify and explain significant considerations in choosing a material for a specific application including mechanical properties, durability, and sustainability.
- 7. Follow standards to conduct tests of material properties and perform the calculations necessary to analyze and interpret test results.
- 8. Work effectively in teams to perform experimental tasks and write formal technical report and convey engineering message efficiently.
- 9. Use commercial engineering test equipment to determine mechanical properties of soil, rock, and construction materials
- 10. Design and make conventional and high performance concrete and shotcrete mixtures and evaluate their fresh and hardened properties.

CEEN515. HILLSLOPE HYDROLOGY AND STABILITY. 3.0 Semester Hrs.

(I) Introduction of shallow landslide occurrence and socio-economic dynamics. Roles of unsaturated flow and stress in shallow landslides. Slope stability analysis based on unsaturated effective stress conceptualization. Computer modeling of unsaturated flow and stress distributions in hillslope. Prediction of precipitation induced shallow landslides. Prerequisite: CEEN312. 3 hours lecture; 3 semester hours.

CEEN519. RISK ASSESSMENT IN GEOTECHNICAL ENGINEERING. 3.0 Semester Hrs.

(I) Soil and rock are among the most variable of all engineering materials, and as such are highly amenable to a probabilistic treatment. Assessment of the probability of failure or inadequate performance is rapidly gaining ground on the traditional factor of safety approach as a more rational approach to design decision making and risk management. Probabilistic concepts are also closely related to system reliability and Load and Resistance Factor Design (LRFD). When probability is combined with consequences of failure, this leads to the concept of risk. This course is about the theory and application of various tools enabling risk assessment in engineering with an emphasis on geotechnical applications. Prerequisite: CEEN312. 3 hours lecture; 3 semester hours.

Course Learning Outcomes

- Learn the basics of risk assessment in geotechnical engineering

CEEN523. UNDERGROUND CONSTRUCTION ENGINEERING IN SOFT GROUND. 4.0 Semester Hrs.

Design and construction of water, wastewater, transportation and utility tunnels, underground space and shafts/excavations in soft ground conditions (soil and weak rock). Addresses geotechnical site characterization, selection of design parameters, stability and deformation analysis of the ground and overlying structures, and construction methods. Includes design of temporary and permanent structural ground support according to ASD (allowable stress design) and LRFD (load resistance factor design) approaches, and design of ground improvement schemes and instrumentation/monitoring approaches to mitigate risk. This course requires post-graduate level knowledge of soil mechanics, fundamental understanding of engineering geology, and an undergraduate level knowledge of structural analysis and design. Prerequisites: CEEN312. 4 semester hours.

Course Learning Outcomes

- 1. Understand the variety of underground construction methodologies, their application, strengths and limitations
- 2. Characterize, through analytical and numerical techniques, the 3d stress and deformation fields, and stability in various shaped shallow and deep underground openings (tunnels, caverns, shafts)
- 3. Analyze and design both temporary and permanent structural support/lining for underground openings (tunnels, caverns, shafts)
- 4. Understand and design ground improvement techniques
- 5. Analyze and design for groundwater control
- 6. Estimate deformation and damage to adjacent structures due to underground construction of tunnels, caverns, shafts
- 7. Implement a formal risk assessment and management process for underground construction
- 8. Identify appropriate geotechnical parameters and their uncertainties for analysis and design of underground spaces
- 9. In a team environment, analyze and design critical elements of a real-world underground construction project

CEEN525. CEMENTITIOUS MATERIALS FOR CONSTRUCTION. 3.0 Semester Hrs.

(II) Cementitious materials, as the most commonly used construction materials, are the main focus of this course and variety of cementitious materials including Portland and non-Portland cements, supplementary cementitious materials, concrete and sprayed concrete (shotcrete), and grouts with their needed additional constituents are covered in this course. This course provides a comprehensive treatment of engineering principles and considerations for proper design, production, placement and maintenance of high quality cementitious materials for infrastructure. In addition, cementitious materials and techniques used for ground improvement purposes are covered in this course. 3 semester hours.

Course Learning Outcomes

- 1. Describe the main properties of concrete constituents and their influence on the behavior • Describe the cement composition, phases, types, and the hydration process • List the different types of cements and their proper applications • Select the right types of admixtures to be used in different applications and situations • Describe the effects of supplementary cementitious materials on concrete properties
- 2. Design and Test Cementitious Construction materials to meet specifications • Design conventional and high performance Portland cement concrete mixtures with supplementary cementitious materials to meet specifications • Design concrete mix for spraying applications

to meet the requirements for ground support needs • Identify the appropriate testing method for evaluation of concrete properties

- 3. Propose ground improvement solutions for different ground conditions using Cementitious Materials • Describe the different ground improvement techniques and explain the differences among current techniques • Identify the appropriate type of ground improvement and specify the requirements for the materials needed
- 4. Apply the concepts learned in the class in understanding the nature, types and applications of cementitious materials by • Selecting a topic of interest related to Cementitious Materials • Conducting research in groups • Presenting the work in written and oral presentation formats

CEEN526. DURABILITY OF CONCRETE. 3.0 Semester Hrs.
This course will provide an in-depth overview of concrete properties relevant to deterioration, including transport, mechanical, physical, and chemical properties. After this course, students should be able to identify, quantify, and mitigate against various deterioration mechanisms, such as freezing and thawing, sulfate attack, alkali-aggregate reactions, acid attack, and corrosion of steel rebar. This course will also illustrate how to test materials for durability (hands-on activities included) and ways in which construction methods may affect durability. Students will learn the strengths and limitations of the worlds most ubiquitous building material. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- 1. Explain how the microstructure of concrete develops.
- 2. Explain how the microstructure of concrete affects engineering properties.
- 3. Identify different deterioration mechanisms that affect concrete and explain how they impact concrete durability.
- 4. Explain the principles behind various durability tests.
- 5. Conduct durability tests and assess the performance.

CEEN530. ADVANCED STRUCTURAL ANALYSIS. 3.0 Semester Hrs.
(I) Introduction to advanced structural analysis concepts. Nonprismatic structures. Arches, Suspension and cable-stayed bridges. Structural optimization. Computer Methods. Structures with nonlinear materials. Internal force redistribution for statically indeterminate structures. Graduate credit requires additional homework and projects. Prerequisite: CEEN314. 3 hour lectures, 3 semester hours.

CEEN531. STRUCTURAL DYNAMICS. 3.0 Semester Hrs.
An introduction to the dynamics and earthquake engineering of structures is provided. Subjects include the analysis of linear and nonlinear single-degree and multi-degree of freedom structural dynamics. The link between structural dynamics and code-based analysis and designs of structures under earthquake loads is presented. The focus applications of the course include single story and multi-story buildings, and other types of structures that under major earthquake may respond in the inelastic range. Prerequisite: CEEN314. 3 hour lectures, 3 semester hours.

CEEN532. UNDERGROUND INFRASTRUCTURE CONSTRUCTION MANAGEMENT. 3.0 Semester Hrs.
In this course students will learn the fundamental and practical aspects of underground infrastructure construction management. Underground infrastructure includes tunnels for road, rail, transit, water, and utilities; shafts for tunnel access, ventilation, and pump stations; and excavations for underground transit stations, commercial, and recreational space, all of which comprises the civil infrastructure required for societies to grow and prosper. Through lectures, reading/viewing materials, case studies, assignments/exercises, and class discussions, as developed by current & former construction managers, students will gain practical instruction and practice on the traditional civil construction management process areas of contracts, procurement methods for public infrastructure, estimating and costs, scheduling, quality, safety, performance and risk management, and decision-making, all with a focus on underground infrastructure. Industry standards, specifications, and best practices that will be taught. Students will be exposed to what an underground infrastructure construction manager does on site: their roles & responsibilities, essential skillsets, and effective character attributes. Course topics also delve into the people management areas of communications, conflict resolution, stakeholder engagement, emotional intelligence, and leadership.

CEEN533. MATRIX STRUCTURAL ANALYSIS. 3.0 Semester Hrs.
Equivalent with CEEN433,
(II) Focused study on computer oriented methods for solving determinate and indeterminate structures such as trusses and frames. Classical stiffness based analysis method will be introduced with hands-on practice to develop customized matrix analysis program using Matlab. Commercial structural analysis programs will also be introduced during the class and practiced through class projects. When this course is cross-listed and concurrent with CEEN433, students that enroll in CEEN533 will complete additional and/or more complex assignments. 3 lecture hours, 3 semester hours. Prerequisite: CEEN314.
Course Learning Outcomes

- At the completion of this course, students will: 1. Gain fundamental understanding on Matrix analysis method and procedure, understand how commercial structural FEM packages work at a fundamental level 2. Be able to program basic linear member finite element code using Matlab 3. Use principle of virtual work to formulate matrix structural analysis elements 4. Use commercial structural analysis software to solve typical structural analysis problems 5. Gain fundamental Matlab programming and data process techniques # At the completion of CEEN533, students will be able to use Matlab to program matrix structural analysis code to solve determinate and indeterminate 3D truss and frame problems. This outcome will be measured by the completion of the programming tasks required in this class. Students' program will be evaluated and graded for correctness. # They will also be able to use a commercial structural analysis software package to construct 3D models for real structures, analyze the model under different static and dynamic loading conditions. This outcome will be measured by the completion of group project of modeling and analyzing a real structure using a commercial software program provide in the computer lab. # They will also be able to derive simple 2D line element stiffness matrix using the principle of virtual work. This outcome will be evaluated by a mid-term exam.

CEEN541. DESIGN OF REINFORCED CONCRETE STRUCTURES II. 3.0 Semester Hrs.
Advanced problems in the analysis and design of concrete structures, design of slender columns; biaxial bending; two-way slabs; strut and tie models; lateral and vertical load analysis of multistory buildings; introduction to design for seismic forces; use of structural computer programs. Course offered every third semester. 3 hours lecture; 3 semester hours. Prerequisite: CEEN445.

CEEN542. DESIGN OF WOOD STRUCTURES. 3.0 Semester Hrs.
The course develops the theory and design methods required for the use of wood as a structural material. The design of walls, beams, columns, beam-columns, shear walls, and structural systems are covered with consideration of gravity, wind, snow, and seismic loads. Prerequisite: CEEN314 or equivalent.

Course Learning Outcomes

- Gain fundamental knowledge on engineered wood products, be able to recognize these products and find their design values in the code reference material
- Be able to navigate NDS code and SDPWS provisions
- Be able to design and check light frame wood structural components and simple systems
- Be able to design and check typical mass timber structural components and simple systems

CEEN543. ADVANCED DESIGN OF STEEL STRUCTURES. 3.0 Semester Hrs.
The course extends the coverage of steel design to include the topics: slender columns, beam-columns, frame behavior, bracing systems and connections, stability, moment resisting connections, composite design, bolted and welded connections under eccentric loads and tension, and semi-rigid connections. 3 hours lecture; 3 semester hours. Course offered every third semester. Prerequisite: CEEN443 or equivalent.

CEEN544. STRUCTURAL PRESERVATION OF EXISTING AND HISTORIC BUILDINGS. 3.0 Semester Hrs.
A broad discussion of historic structural systems in the United States, including stone and brick masonry, terra cotta, timber, cast and wrought iron, early steel, and early concrete. Combines research of historic manuals with contemporary analysis. Introduces nondestructive tests for historic structures. Enables prediction of deterioration mechanisms and structural deficiencies. Synthesizes structural retrofit solutions with preservation philosophy and current building codes. Emphasizes the engineer's role in stewardship of historic buildings. Every odd year Fall. 3 hours lecture and discussion; 3 semester hours. Prerequisite: CEEN443 and CEEN445.

CEEN545. STEEL BRIDGE DESIGN. 3.0 Semester Hrs.
Students are introduced to, and will develop an understanding of, the theory, analysis, and AASHTO code requirements for the design of steel bridge superstructures. The students will become familiar with bridge types, required loadings, composite action, plate girder design, and the Load and Resistance Factor Design method. The students will recognize the design requirements for a steel bridge superstructure and perform calculations for member loads and the loadings it transfers to the substructure. Course offered every third semester. Prerequisite: CEEN443.
Course Learning Outcomes

- Recognize requirements for steel bridge design
- Perform calculations to determine component loadings
- Analyze for effects of fatigue on welded bridge details
- Perform an approximate structural analysis of a multi-span steel bridge

CEEN546. STATISTICAL METHODS FOR RELIABILITY AND ENGINEERING DESIGN. 3.0 Semester Hrs.
(I, II) The course will introduce methods and principles that help quantifying the effects of uncertainty in the performance prediction of civil infrastructure systems. Students will learn to apply quantitative risk analysis and modeling approaches relevant to design problems in civil engineering. The course emphasizes that the systematic treatment of uncertainty and risk quantification are essential for adequate engineering planning, design, and operation of systems. The statistical approaches fundamental to engineering design and theory of reliability in structural and underground infrastructure design will be the focus of the course and examples. 3 hours lecture; 3 semester hours. Prerequisite: CEEN443.
Course Learning Outcomes

- Gain fundamental understanding on statistical and reliability methods and concepts.
- Be able to program basic statistical procedures using Matlab, and apply them to their research work including experimental data analysis and experiment design.
- Use first order second moment method and simulation method to estimate system reliability, understand how safety is ensured in design codes at a fundamental level.
- Gain basic understanding and simple application of performance based design

CEEN547. DESIGN OF PRESTRESSED CONCRETE STRUCTURES. 3.0 Semester Hrs.
Recognize the fundamental principles of prestressed concrete design and the behavior of prestressed members. Selecting the appropriate materials used to construct prestressed members. Perform the required calculations for the analysis and development of basic designs for prestressed beams, one-way slabs and bridge girders. Recognize the principles governing basic AASHTO prestressed concrete girder design. Read and interpret the applicable building code documents that govern prestressed concrete design. Course offered every third semester. Prerequisite: CEEN445.
Course Learning Outcomes

- 1. Recognize the fundamental principles of prestressed concrete design and the behavior of prestressed members.
- 2. Select the appropriate materials used to construct prestressed members.
- 3. Perform the required hand calculations for the analysis and development of basic designs for prestressed beams, one-way slabs and bridge girders.
- 4. Interpret the output of a common Post-Tension Concrete Design computer program.
- 5. Recognize the principles governing basic AASHTO prestressed concrete girder design.
- 6. Read and interpret the applicable building code documents that govern prestressed concrete design.

CEEN548. STRUCTURAL LOADS. 3.0 Semester Hrs.
Students will be introduced to the load types and load combinations required to design structures in compliance with building code requirements. Students will learn the theory and methods to determine the magnitude and application of loads associated with structure self-weight and occupancy. Students will be introduced to the physics underlying the requirements for environmental loads and to the accepted methods used to calculate environmental loads due to wind, snow, rain, floods, and avalanches. Students will become familiar with the common approaches used to deal with tsunami loads and blast loads. Students will learn the importance of and to recognize the load paths required to transmit applied loads from the structure to the foundation. Course offered every third semester. Prerequisite: CEEN314.
Course Learning Outcomes

- Students are expected to attend class, ask questions, utilize office hours when needed, and come to class prepared. Students are expected to display academic integrity (see Academic Integrity Section). Students will be able to determine to applicable loads to be

used to design a structure, be able to calculate their magnitudes and directions, and specify load path.

CEEN549. INTRODUCTION TO THE SEISMIC DESIGN OF STRUCTURES. 3.0 Semester Hrs.
This course provides students with an introduction to seismic design as it relates to structures. Students will become familiar with the sources of seismic disturbances, the physics of seismic energy transmission, and the relationship between ground disturbance and the resulting forces experienced by structures. The theory and basis for existing building code provisions relating to seismic design of structures will be introduced. Building code requirements and design methodologies will be examined and applied. Advanced performance based seismic design method will also be introduced. Prerequisite: CEEN443, or CEEN445, or CEEN442 Co-requisite: None.
Course Learning Outcomes

- 1)
- 2)
- 3)
- 4)

CEEN550. PRINCIPLES OF ENVIRONMENTAL CHEMISTRY. 3.0 Semester Hrs.
(I) This course provides an introduction to chemical equilibria in natural waters and engineered systems. Topics covered include chemical thermodynamics and kinetics, acid/base chemistry, open and closed carbonate systems, precipitation reactions, coordination chemistry, adsorption and redox reactions. 3 hours lecture; 3 semester hours. Prerequisite: none.

CEEN551. ENVIRONMENTAL ORGANIC CHEMISTRY. 3.0 Semester Hrs.
A study of the chemical and physical interactions which determine the fate, transport and interactions of organic chemicals in aquatic systems, with emphasis on chemical transformations of anthropogenic organic contaminants. Offered in alternate years. (Last offered Spring 23.) 3 semester hours.

CEEN555. LIMNOLOGY. 3.0 Semester Hrs.
(II) This course covers the natural chemistry, physics, and biology of lakes as well as some basic principles concerning contamination of such water bodies. Topics include heat budgets, water circulation and dispersal, sedimentation processes, organic compounds and their transformations, radionuclide limnochronology, redox reactions, metals and other major ions, the carbon dioxide system, oxygen, nutrients; planktonic, benthic and other communities, light in water and lake modeling. 3 hours lecture; 3 semester hours. Prerequisite: none.

CEEN556. MINING AND THE ENVIRONMENT. 3.0 Semester Hrs.
(I) The course will cover many of the environmental problems and solutions associated with each aspect of mining and ore dressing processes. Mining is a complicated process that differs according to the type of mineral sought. The mining process can be divided into four categories: Site Development; Extraction; Processing; Site Closure. Procedures for hard rock metals mining; coal mining; underground and surface mining; and in situ mining will be covered in relation to environmental impacts. Beneficiation, or purification of metals will be discussed, with cyanide and gold topics emphasized. Site closure will be focused on; stabilization of slopes; process area cleanup; and protection of surface and ground water. After discussions of the mining and beneficiation processes themselves, we will look at conventional and innovative measures to mitigate or reduce environmental impact.

CEEN560. MOLECULAR MICROBIAL ECOLOGY AND THE ENVIRONMENT. 3.0 Semester Hrs.
This course explores the diversity of microbiota in a few of the countless environments of our planet. Topics include microbial ecology (from a molecular perspective), microbial metabolism, pathogens, extreme environments, engineered systems, oxidation / reduction of metals, bioremediation of both organics and inorganics, microbial diversity, phylogenetics, analytical tools and bioinformatics. The course can have an integrated laboratory component (depends on timing) for applied molecular microbial ecology to learn microscopy, DNA extraction, PCR, gel electrophoresis, cloning, sequencing, data analysis and bioinformatic applications.

CEEN562. ENVIRONMENTAL GEOMICROBIOLOGY. 3.0 Semester Hrs.
(II) This course explores the functional activities and biological significance of microorganisms in geological and engineered systems with a focus on implications to water resources. Topics include: microorganisms as geochemical agents of change, mechanisms and thermodynamics of microbial respiration, applications of analytical, material science and molecular biology tools to the field, and the impact of microbes on the fate and transport of problematic water pollutants. Emphasis will be placed on critical analysis and communication of peer-reviewed literature on these topics. 3 hours lecture and discussion; 3 semester hours.

CEEN564. ENVIRONMENTAL TOXICOLOGY. 3.0 Semester Hrs.
This course provides an introduction to general concepts of ecology, biochemistry, and toxicology. The introductory material will provide a foundation for understanding why, and to what extent, a variety of products and by-products of advanced industrialized societies are toxic. Classes of substances to be examined include metals, coal, petroleum products, organic compounds, pesticides, radioactive materials, and others. Prerequisite: none. 3 hours lecture; 3 semester hours.

CEEN566. MICROBIAL PROCESSES, ANALYSIS AND MODELING. 3.0 Semester Hrs.
(II) Microorganisms facilitate the transformation of many organic and inorganic constituents. Tools for the quantitative analysis of microbial processes in natural and engineered systems will be presented. Stoichiometries, energetics, mass balances and kinetic descriptions of relevant microbial processes allow the development of models for specific microbial systems. Simple analytical models and complex models that require computational solutions will be presented. Systems analyzed include suspended growth and attached growth reactors for municipal and industrial wastewater treatment as well as in-stu bioremediation and bioenergy systems. 3 hours lecture; 3 semester hours.

CEEN570. WATER AND WASTEWATER TREATMENT. 3.0 Semester Hrs.
(I, II) Unit operations and processes in environmental engineering are discussed in this course, including physical, chemical, and biological treatment processes for water and wastewater. Treatment objectives, process theory, and practice are considered in detail. 3 hours lecture; 3 semester hours. Prerequisite: none.

CEEN571. ADVANCED WATER TREATMENT ENGINEERING AND WATER REUSE. 3.0 Semester Hrs.
This course presents issues relating to theory, design, and operation of advanced water and wastewater treatment unit processes and water reuse systems. Topics include granular activated carbon (GAC), advanced oxidation processes (O3/H2O2), UV disinfection, pressure-driven, current-driven, and osmotic-driven membranes (MF, UF, NF, RO, electrodialysis, and forward osmosis), and natural systems such as riverbank filtration (RBF) and soil-aquifer treatment (SAT). The course

is augmented by CEEN571L offering hands-on experience using bench- and pilot-scale unit operations. 3 hours lecture; 3 semester hours. Prerequisite: CEEN470 or CEEN478 or CEEN570 or CEEN572.

CEEN572. ENVIRONMENTAL ENGINEERING PILOT PLANT LABORATORY. 4.0 Semester Hrs.
(II) This course provides an introduction to bench and pilot-scale experimental methods used in environmental engineering. Unit operations associated with water and wastewater treatment for real-world treatment problems are emphasized, including multi-media filtration, oxidation processes, membrane treatment, and disinfection processes. Investigations typically include: process assessment, design and completion of bench- and pilot-scale experiments, establishment of analytical methods for process control, data assessment, upscaling and cost estimation, and project report writing. Projects are conducted both at CSM and at the City of Golden Water Treatment Pilot Plant Laboratory. 6 hours laboratory; 4 semester hours. Prerequisite: CEEN550 and CEEN570.

CEEN573. RECLAMATION OF DISTURBED LANDS. 3.0 Semester Hrs.
Basic principles and practices in reclaiming disturbed lands are considered in this course, which includes an overview of present legal requirements for reclamation and basic elements of the reclamation planning process. Reclamation methods, including recontouring, erosion control, soil preparation, plant establishment, seed mixtures, nursery stock, and wildlife habitat rehabilitation, will be examined. Environmental policy, law and North America / global case studies also provide foundation to understand the field. Practitioners in the field will discuss their experiences.

CEEN575. HAZARDOUS WASTE SITE REMEDIATION. 3.0 Semester Hrs.
(I) This course covers remediation technologies for hazardous waste contaminated sites, including site characteristics and conceptual model development, remedial action screening processes, and technology principles and conceptual design. Institutional control, source isolation and containment, subsurface manipulation, and in situ and ex situ treatment processes will be covered, including unit operations, coupled processes, and complete systems. Case studies will be used and computerized tools for process selection and design will be employed. 3 hours lecture; 3 semester hours. Prerequisite: CEEN550 and CEEN580.

CEEN578. WATER TREATMENT DESIGN AND ANALYSIS. 3.0 Semester Hrs.
The learning objectives of this class are to build off of the information and theories presented in CEEN 470 and apply them to the design of water and wastewater treatment systems. Students will be presented with project-based assignments and, with the help of the instructors and associated lectures, will use fundamentals and commercial software to develop preliminary designs of water and wastewater systems. Students will gain experience in conventional and advanced treatment system design, software utilized by environmental consulting companies, and professional communication through the completion of this class. Course lectures will include fundamentals of design, guest lectures from practitioners, and tours of local treatment plants. Regional water and wastewater treatment employers (e.g., consultants, municipalities, industry, regulators) are actively searching for students with applied experience and this class will help promote the advancement of employment in the water and wastewater treatment field. Prerequisite: CEEN470.
Course Learning Outcomes

- At the completion of this course, students will: 1) Use fundamentals and commercial software to design and analyze water treatment systems. 2) Integrate design aspects for development of integrated water systems to treat variable water resources. 3) Summarize design components into drawings and diagrams. 4) Communicate solutions and designs to practitioners through technical reports and presentations.

CEEN580. CHEMICAL FATE AND TRANSPORT IN THE ENVIRONMENT. 3.0 Semester Hrs.
(I, II) This course describes the environmental behavior of inorganic and organic chemicals in multimedia environments, including water, air, sediment and biota. Sources and characteristics of contaminants in the environment are discussed as broad categories, with some specific examples from various industries. Attention is focused on the persistence, reactivity, and partitioning behavior of contaminants in environmental media. Both steady and unsteady state multimedia environmental models are developed and applied to contaminated sites. The principles of contaminant transport in surface water, groundwater, and air are also introduced. The course provides students with the conceptual basis and mathematical tools for predicting the behavior of contaminants in the environment. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- No change

CEEN581. WATERSHED SYSTEMS MODELING. 3.0 Semester Hrs.
(II) Introduction to surface water modeling, including rainfall-runoff analysis, input data, uncertainty analysis, lumped and distributed modeling, parameter estimation and sensitivity analysis. Course is heavy on application of models across a range of diverse watersheds for streamflow and snowmelt predictions. In general, theoretical topics are covered in the first meeting each week, followed by hands-on application of concepts and models in the second meeting. Laptops and student Matlab licenses will be required for in-class activities. 3 hours lecture per week; 3 semester hours.

CEEN582. VADOSE ZONE HYDROLOGY. 3.0 Semester Hrs.
Introduction of soil chemical compositions and water properties. Introduction of soil classifi cation.Introduction of hydrological processes in vadose zone. Introduction of chemical potentialresponsible for soil water physical interactions: capillarity, cavitation, and adsorption. Introduction ofthermodynamic laws for multiphase, and multi-physics water movement and distribution in vadosezone. Introduction of concepts of soil water potential, matric potential, soil water retention curve, andhydraulic conduction function. Introduction of laws for capillary water fl ow, fi lm water fl ow, and vaporfl ow in soil. Introduction of governing equations for spatial-temporal distributions of soil moisture andmatric potential in vadose zone. Introduction of interactions between land surface and atmosphere,and between vadose zone and groundwater zone. Introduction of techniques for measuring soilwater retention curve and hydraulic conductivity function. Prerequisites: CEEN580 and knowledge of basic statistics and computer programming.
Course Learning Outcomes

- 1) Understand the Soil Water Potential concept to determine its components of the gravitational potential, capillary potential, and adsorptive potential
- 2) Understand techniques to measure Soil Water Retention Curve and Hydraulic Conductivity Function
- 3) Understand the laws governing fluid and vapor flows in vadose zone.
- 4) Understand the governing time-space equations for transient water flows in vadose zone.

- 5) Apply the fundamental principles to find the analytical and numerical solutions of multi-phase water distribution in vadose zone
- 6) Quantify and measure constitutive relations of Soil Water Retention Curve and Hydraulic Conductivity Function

CEEN583. SURFACE WATER QUALITY MODELING. 3.0 Semester Hrs.
This course will cover modeling of water flow and quality in rivers, lakes, and reservoirs. Topics will include introduction to common analytical and numerical methods used in modeling surface water flow, water quality, modeling of kinetics, discharge of waste water into surface systems, sedimentation, growth kinetics, dispersion, and biological changes in lakes and rivers. Prerequisites: CEEN480 or CEEN580 recommended. 3 hours lecture; 3 semester hours.

CEEN584. SUBSURFACE CONTAMINANT TRANSPORT. 3.0 Semester Hrs.
This course will investigate physical, chemical, and biological processes governing the transport and fate of contaminants in the saturated and unsaturated zones of the subsurface. Basic concepts in fluid flow, groundwater hydraulics, and transport will be introduced and studied. The theory and development of models to describe these phenomena, based on analytical and simple numerical methods, will also be discussed. Applications will include prediction of extents of contaminant migration and assessment and design of remediation schemes. Prerequisites: CEEN580. 3 hours lecture; 3 semester hours.

CEEN585. FLUID MECHANICS FOR HYDROLOGY. 2.0 Semester Hrs.
(I) This class focuses on the fundamental concepts of engineering fluid mechanics as they relate to the study of hydrology. Topics include fluid statics, dynamics, continuity, energy and momentum, dimensional analysis and open channel flow. Cross-listed with GEGN585. 2 semester hours.
Course Learning Outcomes

- 1. Students will solve problems on fundamental fluid mechanics concepts including hydrostatics, momentum, pressure and flow and energy systems.
- 2. Students will conduct simple dimensional analysis and explain its application to hydrologic research.
- 3. Students will solve problems related to flow measurement, fluid properties, and fluid statics.
- 4. Students will solve problems related to energy, impulse, and momentum equations.
- 5. Students will solve problems related to pipe and other internal flow.
- 6. Student will explain (or demonstrate or predict or describe or evaluate) how fluid mechanics relates to hydrological systems.

CEEN586. HYDROMETEOROLOGY. 3.0 Semester Hrs.
Hydrometeorology lies at the intersection of meteorology and hydrology, and covers key atmospheric processes relevant to flood prediction, droughts, heatwaves, streamflow, and energy transfer between the land surface and the atmosphere. In this course, you will be introduced to the conceptual foundations of hydrometeorology as they pertain to water prediction and water resource management. The course will cover weather and climate fundamentals, observational methods used in hydrometeorology, and data analysis methods relevant to decision-making and weather and water prediction.
Course Learning Outcomes

- 1)
- 2)
- 3)
- 4)

CEEN587. HYDROCHEMICAL AND TRANSPORT PROCESSES. 3.0 Semester Hrs.
(II) Analysis of the chemistry of natural waters in the context of hydrologic systems. The course focuses on sources and dynamic behavior of common natural and anthropogenically introduced solutes of interest, their interactions with minerals, and fate and transport in subsurface and surface environments. Students should NOT enroll in CEEN587 if they enroll(ed) in either CEEN580 or CEEN550. 3 hours lecture; 3 semester hours.
Course Learning Outcomes

- 1. Evaluate the chemistry of groundwater and surface water samples
- 2. Understand the sources and behavior of common solute of interest in natural systems
- 3. Apply chemical reaction kinetic equations to evaluate the dynamic behavior of common solutes of interest in natural systems
- 4. Evaluate fate and transport of contaminants in surface water and groundwater systems.

CEEN589. WATER SUSTAINABILITY AND ENERGY PRODUCTION: CURRENT SCIENCE AND PRACTICE. 1.0 Semester Hr.
This course is designed to provide students with valuable communication and professional skills while exploring in depth the topic of joint sustainability of water and unconventional petroleum energy production. A survey of current literature combined with key speakers will introduce the students to the field, while class sessions and practical exercises will help develop important communication, research, and interpersonal skills needed for future professionals. Course curriculum includes specific topics such as speaking/writing for a variety of audiences and critical thinking and analysis. This course is required for all ConocoPhillips - WE2ST Fellows, but is also open to any interested graduate students. 1 hour seminar; 1 semester hour.
Course Learning Outcomes

- Relevant Terminology and Current State of Hydraulic Fracturing
- Current State of Water Resources in CO in Relation to Users and Overall Water Budget
- Connections between Energy Development and Water Use
- Interpersonal Skill Development
- Technical Writing for a Variety of Audiences
- Technical Speaking for a Variety of Audiences
- Critical Analysis of Technical Issues
- Community Perceptions of Technical Topics

CEEN590. CIVIL ENGINEERING SEMINAR. 0.0 Semester Hrs.
(I,II) Introduction to contemporary and advanced methods used in engineering design. Includes, need and problem identification, methods to understand the customer, the market and the competition. Techniques to decompose design problems to identify functions. Ideation methods to produce form from function. Design for X topics. Methods for prototyping, modeling, testing and evaluation of designs. Embodiment and detailed design processes. Equivalent senior design project experience or industrial design experience, graduate standing. (Two semesters required.).

CEEN592. ENVIRONMENTAL LAW. 3.0 Semester Hrs.
Equivalent with CEEN492,PEGN530,

This is a comprehensive introduction to U.S. Environmental Law, Policy, and Practice, especially designed for the professional engineer, scientist, planner, manager, consultant, government regulator, and citizen. It will prepare the student to deal with the complex system of laws, regulations, court rulings, policies, and programs governing the environment in the USA. Course coverage includes how our legal system works, sources of environmental law, the major USEPA enforcement programs, state/local matching programs, the National Environmental Policy Act (NEPA), air and water pollution (CAA, CWA), EPA risk assessment training, toxic/hazardous substances laws (RCRA, CERCLA, EPCRA, TSCA, LUST, etc.), and a brief introduction to international environmental law. Taught on Demand. 3 hours lecture; 3 semester hours.

CEEN594. RISK ASSESSMENT. 3.0 Semester Hrs.
This course evaluates the basic principles, methods, uses, and limitations of risk assessment in public and private sector decision making. Emphasis is on how risk assessments are made and how they are used in policy formation, including discussion of how risk assessments can be objectively and effectively communicated to decision makers and the public. Prerequisite: CEEN592 and one semester of statistics. 3 hours lecture; 3 semester hours.

CEEN595. ANALYSIS OF ENVIRONMENTAL IMPACT. 3.0 Semester Hrs.
Techniques for assessing the impact of mining and other anthropogenic activities on various components of the global ecosystem are considered. The National Environmental Policy Act of 1970 (NEPA) fundamentally changed how the environment is to be considered in any federal decision within the US and has become a model for nations worldwide. Training in the procedures of preparing Environmental Impact Statements (EIS) and Environmental Assessments (EA) are discussed with a particular emphasis on case studies of each, mostly focused on the western US, though all 50 states are considered. Course includes a review of pertinent laws and acts (i.e., NEPA, Endangered Species Act (ESA), Clean Water Act (CWA), Clean Air Act (CAA), Federal Land Policy Management Act (FLPMA), etc.) as well as organic acts that created the National Park Service (NPS), the US Forest Service (USFS) and the Bureau of Land Management (BLM) that deal with environmental impacts. Some field trips.

CEEN596. ENVIRONMENTAL SCIENCE AND ENGINEERING SEMINAR. 0.0 Semester Hrs.
Research presentations covering current research in a variety of environmental topics.. (Two semesters required.).

CEEN597. PRACTICES AND PRINCIPLES OF ENVIRONMENTAL CONSULTING. 3.0 Semester Hrs.
This course provides an in-depth understanding of the environmental consulting industry with a particular focus on problem solving and project delivery to meet expectations of professional services organizations (environmental consulting firms). Using case studies, real-life consulting assignments, and business scenarios, the course offers exposure to the technical, ethical, and business challenges of winning and executing environmental projects.
Course Learning Outcomes

- 1. Understand the drivers and policies that protect our environmental and water resources.
- 2. Apply knowledge gained in the course from pragmatic problems taken from real scenarios experienced within the consulting industry
- 3. Develop an appreciation for investigations and data interpretation making science-based decisions where possible and determine when decisions may require additional information.
- 4. Know the basic process of project initiation, budgeting, management, and effective delivery in executing environmental projects.
- 5. Work with a team to interpret given data to understand what information is important to advise alternatives, planning, decisions, and design.
- 6. Consider how to tailor designs to meet objectives that protect public health and to meet environment objectives and requirements.
- 7. Use data and engineering judgement to calculate sizing of infrastructure and to develop solutions to solve local environmental problems; research and consider social and economic project considerations and outcomes
- 8. Effectively deliver quality technical products to communicate issues and basis of design; develop communication and presentations skills that effectively share information to an appropriate audience; present technical materials to instructors and peers; provide constructive feedback to peers.

CEEN598. SPECIAL TOPICS IN CIVIL AND ENVIRONMENTAL ENGINEERING. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

CEEN599. INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree.

CEEN698. SPECIAL TOPICS IN CIVIL AND ENVIRONMENTAL ENGINEERING. 6.0 Semester Hrs.
(I, II, S) Pilot course or special topics course. Topics chosen from special interests of instructor(s) and student(s). Usually the course is offered only once, but no more than twice for the same course content. Prerequisite: none. Variable credit: 0 to 6 credit hours. Repeatable for credit under different titles.

CEEN699. ADVANCED INDEPENDENT STUDY. 0.5-6 Semester Hr.
(I, II, S) Individual research or special problem projects supervised by a faculty member, also, when a student and instructor agree on a subject matter, content, and credit hours. Prerequisite: ?Independent Study? form must be completed and submitted to the Registrar. Variable credit: 0.5 to 6 credit hours. Repeatable for credit under different topics/experience and maximums vary by department. Contact the Department for credit limits toward the degree.

CEEN707. GRADUATE THESIS / DISSERTATION RESEARCH CREDIT. 1-15 Semester Hr.
(I, II, S) Research credit hours required for completion of a Masters-level thesis or Doctoral dissertation. Research must be carried out under the direct supervision of the student's faculty advisor. Variable class and semester hours. Repeatable for credit.