

CIVIL, ENVIRONMENTAL & ARCHITECTURAL ENGINEERING

Civil Engineering

Civil engineering offers a wide range of careers for students interested in the planning, design, and construction management of facilities essential to modern life in both the public and private sectors. Varying widely in nature, size and scope, such facilities include buildings, bridges, tunnels, highways, transit systems, dams, airports, irrigation projects, water treatment and distribution facilities, waste treatment and processing facilities, structures for space exploration, and offshore engineering designs applications. This course of study fulfills the academic requirements for registration as a professional engineer.

In the coming decades, almost two billion more people will populate earth in both developed and developing countries. This growth will create unprecedented demands and opportunities for new methods and innovations in energy production, food supply, land development, water treatment, transportation systems, materials processing, waste disposal, healthcare delivery, environmental preservation and structural designs. Civil engineers play both direct and indirect roles in meeting many of these needs, with the goal of providing and improving the quality and infrastructure of life.

Environmental Engineering

Environmental engineering plays a vital role in maintaining the quality of both public health and the natural environment. Environmental engineering encompasses the scientific assessment and development of sustainable engineering solutions to environmental problems impacting the biosphere and land, water, and air quality. Environmental issues affect almost all commercial and industrial sectors, and are a central concern for the public, for all levels of government and in international relations. This course of study fulfills the academic requirements for registration as a professional engineer.

In common with other engineering fields, courses in solid mechanics, fluid dynamics, and thermal sciences are central to the environmental engineering degree. Coursework specific to environmental engineering includes environmental chemistry and microbiology, as well as treatment processes and approach.

Architectural Engineering

Architectural engineering prepares students for leadership careers in the building design, consulting, construction, and management industry and for research at the graduate level on building- and sustainability-related topics. In particular, the architectural engineering program prepares students to design, build and operate facilities that improve our quality of life. This course of study fulfills the academic requirements for registration as a professional engineer.

The architectural engineering curriculum is recommended for those wishing to specialize within the building industry in engineering design (heating, cooling, illumination, electrical, solar, and structures) or construction and contracting (facilities management). Architectural engineering students may select from several focus areas, including: electrical systems; lighting systems; heating, ventilating

and air conditioning (HVAC) systems; materials and structural systems; construction engineering and management.

Course codes for these programs are AREN, CVEN and EVEN.

Bachelor's Degrees

- Architectural Engineering - Bachelor of Science (BSARE) (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/architectural-engineering-bachelor-science-bsare/>)
- Civil Engineering - Bachelor of Science (BSCV) (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/civil-engineering-bachelor-science-bscv/>)
- Environmental Engineering - Bachelor of Science (BSEV) (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/environmental-engineering-bachelor-science-bsev/>)

Minors

- Architectural Engineering - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/architectural-engineering-minor/>)
- Civil Engineering - Minor (<https://catalog.colorado.edu/undergraduate/colleges-schools/engineering-applied-science/programs-study/civil-environmental-architectural-engineering/civil-engineering-minor/>)

Faculty

While many faculty teach both undergraduate and graduate students, some instruct students at the undergraduate level only. For more information, contact the faculty member's home department.

Amadei, Bernard (https://experts.colorado.edu/display/fisid_105978/)
Distinguished Professor; PhD, University of California, Berkeley

Amy, Gary L.
Professor Emeritus

Arehart, Joseph Hoberg (https://experts.colorado.edu/display/fisid_164349/)
Instructor; BS, University of Colorado Boulder

Baker, Kyri A. (https://experts.colorado.edu/display/fisid_159754/)
Assistant Professor; PhD, Carnegie Mellon University

Balaji, Rajagopalan (https://experts.colorado.edu/display/fisid_118480/)
Professor, Associate Chair; PhD, Utah State University

Bhaskar, Aditi
Associate Professor; Ph.D, University of Maryland, Baltimore County

Bielefeldt, Angela R. (https://experts.colorado.edu/display/fisid_110322/)
Professor; PhD, University of Washington; P.E.

Brandemuehl, Michael J. (https://experts.colorado.edu/display/fisid_102573/)
Professor Emeritus

Celoza, Amelia (https://experts.colorado.edu/display/fisid_172038/)
Assistant Professor; Ph.D., University of Texas at Austin

Chinowsky, Paul (https://experts.colorado.edu/display/fisid_125496/)
Professor; PhD, Stanford University

Cook, Sherri M. (https://experts.colorado.edu/display/fisid_154773/)
Assistant Professor; PhD, University of Michigan Ann Arbor

Corotis, Ross B. (https://experts.colorado.edu/display/fisid_100942/)
Professor Emeritus; PhD, Massachusetts Institute of Technology

Crimaldi, John P. (https://experts.colorado.edu/display/fisid_115733/)
Professor, Associate Chair; PhD, Stanford University

Dashti, Shideh (https://experts.colorado.edu/display/fisid_148493/)
Associate Professor, Faculty Director; PhD, University of California, Berkeley

Diekmann, James E.
Professor Emeritus

DiLaura, David L.
Professor Emeritus

Dow, John O.
Associate Professor Emeritus

Frangopol, Dan M.
Professor Emeritus

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Professor; PhD, University of Texas at Austin

Gooseff, Michael N. (https://experts.colorado.edu/display/fisid_155922/)
Professor; PhD, University of Colorado Boulder

Gupta, Vijay
Professor Emeritus

Halek, Milan F.
Senior Instructor Emeritus

Hallowell, Matthew Ryan (https://experts.colorado.edu/display/fisid_146163/)
Professor; PhD, Oregon State University

Hearn, George (https://experts.colorado.edu/display/fisid_101059/)
Associate Professor; PhD, Columbia University

Henze, Gregor P. (https://experts.colorado.edu/display/fisid_146496/)
Professor; PhD, University of Colorado Boulder

Hernandez, Mark T. (https://experts.colorado.edu/display/fisid_107635/)
Professor, Lecturer; PhD, University of California, Berkeley

Hubler, Mija H. (https://experts.colorado.edu/display/fisid_155134/)
Assistant Professor, Faculty Director; PhD, Northwestern University

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Associate Professor, Associate Professor, Associate Faculty Director;
PhD, Stanford University

Kasprzyk, Joseph R. (https://experts.colorado.edu/display/fisid_151506/)
Associate Professor, Associate Chair; PhD, Pennsylvania State University

Klees, Rita C. (https://experts.colorado.edu/display/fisid_145391/)
Associate Faculty Director, Scholar in Residence; PhD, University of Colorado

Ko, Hon-Yim
Professor Emeritus

Korak, Julie A. (https://experts.colorado.edu/display/fisid_155070/)
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Liel, Abbie B. (https://experts.colorado.edu/display/fisid_146431/)
Professor, Faculty Director, Associate Chair; PhD, Stanford University

Linden, Karl G. (https://experts.colorado.edu/display/fisid_143747/)
Professor, Chair; PhD, University of California, Davis

Livneh, Ben (https://experts.colorado.edu/display/fisid_151999/)
Assistant Professor; PhD, University of Washington

Madabhushi, Srikanth (https://experts.colorado.edu/individual/fisid_165826/)
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Mansfeldt, Cresten (https://experts.colorado.edu/display/fisid_165411/)
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McKnight, Diane M. (https://experts.colorado.edu/display/fisid_110517/)
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Molenaar, Keith Robert (https://experts.colorado.edu/display/fisid_102373/)
Professor, Dean; PhD, University of Colorado Boulder

Morris, Matthew R. (https://experts.colorado.edu/display/fisid_150037/)
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Professor, Associate Chair; PhD, New Mexico Institute of Mining and Technology

Pak, Ronald Y.S. (https://experts.colorado.edu/display/fisid_105977/)
Professor; PhD, California Institute of Technology

Pfeffer, Tad (https://experts.colorado.edu/display/fisid_100207/)
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Regueiro, Richard A. (https://experts.colorado.edu/display/fisid_134705/)
Professor, Associate Chair; PhD, Stanford University

Rosario-Ortiz, Fernando L. (https://experts.colorado.edu/display/fisid_146165/)
Director, Professor; DEnv, University of California, Los Angeles

Ryan, Joseph N. (https://experts.colorado.edu/display/fisid_101037/)
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Salvinelli, Carlo (https://experts.colorado.edu/display/fisid_159846/)
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Saouma, Victor E. (https://experts.colorado.edu/display/fisid_100429/)
Professor; PhD, Cornell University

Scheib, Jennifer G. (https://experts.colorado.edu/display/fisid_159887/)
Instructor; MS, University of Colorado Boulder

Sholtes, Joel Stephen (https://experts.colorado.edu/display/fisid_164757/)
Instructor; PhD, Colorado State University

Sholtes, Kari A. (https://experts.colorado.edu/display/fisid_164995/)
Instructor; MS, University of North Carolina Chapel Hill

Silverstein, JoAnn (https://experts.colorado.edu/display/fisid_101482/)
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Song, Jeong-Hoon (https://experts.colorado.edu/display/fisid_154468/)
Assistant Professor; PhD, Northwestern University

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Associate Professor, Faculty Director, Associate Chair; PhD, Stanford University

Straub, Anthony (https://experts.colorado.edu/display/fisid_165027/)
Assistant Professor; PhD, Yale University

Strzepek, Kenneth M.
Professor Emeritus

Sture, Stein
Professor Emeritus

Summers, Scott R. (https://experts.colorado.edu/display/fisid_113151/)
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Thomas, Evan (https://experts.colorado.edu/display/fisid_163895/)
Professor, Assistant Professor; PhD, University of Colorado Boulder

Tonon, Fulvio
Associate Professor Adjunct; PhD, University of Colorado Boulder

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Vàsconez, Sandra L. (https://experts.colorado.edu/display/fisid_144198/)
Senior Instructor; MA, University of Denver

Walker, Michael Edward (https://experts.colorado.edu/display/fisid_155103/)
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William, Kaspar J.
Professor Emeritus

Xi, Yunping (https://experts.colorado.edu/display/fisid_110518/)
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Zagona, Edith A. (https://experts.colorado.edu/display/fisid_106395/)
Research Professor; PhD, University of Colorado Boulder

Zhai, John Z. (https://experts.colorado.edu/display/fisid_130604/)
Professor; PhD, Massachusetts Institute of Technology

Zhang, Yida (https://experts.colorado.edu/display/fisid_158222/)
Assistant Professor; PhD, Northwestern University

Courses

Architectural Engineering

AREN 1027 (3) Engineering Drawing

Introduces engineering drawing including sections and dimensioning, print readings, computer 3D, and building information modeling (BIM).

Requisites: Restricted to Engineering Physics (EPEN), Architectural (AREN), Integrated Design Engineering (IDEN) or Civil (CVEN) Engineering majors only.

Additional Information: Departmental Category: Miscellaneous

AREN 1316 (1) Introduction to Architectural Engineering

Surveys the broad subject of architectural engineering and professional practices. Includes professional design services, design documents, methods of construction delivery, materials for construction, codes and standards, life safety, professional ethics, structural systems, mechanical systems, electrical systems, and building systems integration.

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

Additional Information: Departmental Category: Miscellaneous

AREN 2050 (3) Building Materials and Systems

Covers the broad subject of building materials and systems. Includes a practical approach to assembly details, methods of construction, codes, foundations, steel, concrete, masonry, cladding, doors and windows, interiors, finishes, mechanical, plumbing, electrical, life safety and conveyance. Includes investigation of an existing facility along with a team presentation trends in commercial building construction.

Requisites: Restricted to students with 27-180 credits (Sophomores, Juniors or Seniors) Civil (CVEN) or Architectural (AREN) or Integrated Design Engineering (IDEN) or Applied Mathematics (AMEN) majors only.

Additional Information: Departmental Category: Building Systems Engineering

AREN 2110 (3) Thermodynamics

Explores fundamental principles of thermodynamics, including first and second law of thermodynamics, thermophysical properties, power and refrigeration cycles, gas mixtures and psychrometrics.

Equivalent - Duplicate Degree Credit Not Granted: MCEN 3012 or GEEN 3852

Requisites: Requires a prereq course of PHYS 1110 (min grade C-) and a prereq or coreq course of APPM 1360 or MATH 2300 (min grade C-). Restricted to AREN, CVEN, EVEN, IDEN, or AMEN majors only.

Additional Information: Arts Sci Core Curr: Natural Science Non-Sequence Arts Sci Gen Ed: Distribution-Natural Sciences Departmental Category: Building Systems Engineering

AREN 2120 (3) Fluid Mechanics and Heat Transfer

Explores fundamental principles of fluid mechanics and heat transfer. Topics include fluid statics, momentum and energy conservations; laminar and turbulent viscous flows; conduction, convection and radiation heat transfer. Emphasizes topics and problems that are important to Architectural Engineers including flow of fluids in pipes and ducts, heat transfer in buildings and building systems.

Requisites: Requires corequisite courses of (APPM 2350 or MATH 2400) and (APPM 2360 or (MATH 2130 and 3430)) and prerequisite course of (AREN 2110 or GEEN 3852 or MCEN 3012 or ASEN 2002) (all minimum grade C-). Restricted to College of Engineering majors only.

Additional Information: Departmental Category: Building Systems Engineering

AREN 2121 (1) Heat Transfer

This is an elective course for students who want to obtain an AREN BS degree and have taken Fluid Mechanics course but not heat transfer. This course will fulfill their curriculum requirement and allow them to take the following courses that require heat transfer knowledge. Previously offered as a special topics course.

Requisites: Requires corequisite courses of (APPM 2350 or MATH 2400) and (APPM 2360 or (MATH 2130 and 3430)) and prerequisite course of (AREN 2110 or GEEN 3852 or MCEN 3012 or ASEN 2002) (all minimum grade C-). Restricted to College of Engineering majors only.

AREN 2830 (1-3) Special Topics

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

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

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

Additional Information: Departmental Category: Special Topics

AREN 3010 (3) Energy Efficient Buildings

Lecture course on the analysis and design of buildings and their systems to satisfy the requirements for a comfortable and healthy indoor environment. Examines psychometrics, thermal comfort, building heating and cooling loads, fluid flow basics, and HVAC components and systems.

Requisites: Requires prerequisite courses of AREN 2120 or MCEN 3021 and 3022 and AREN 2050 (all minimum grade C-). Restricted to College of Engineering majors only.

Additional Information: Departmental Category: Building Systems Engineering

AREN 3040 (3) Circuits for Architectural Engineers

This course will cover the basics of DC and AC circuit theory relevant to the modeling, design, and control of residential and commercial building systems, including Kirchoff's laws, Thevenin/Norton theorems, transient analysis of DC systems, three phase analysis, induction and synchronous motors, AC power (including real and reactive power analysis), power factor correction, and transformers.

Requisites: Requires prerequisite courses of (APPM 2360 or (MATH 2130 and 3430)) and PHYS 1120 (all minimum grade C-). Restricted to AREN, CVEN, and EVEN majors only.

AREN 3080 (3) Architectural Design Studio 1

Learn about the fundamentals of architectural design and the ways in which it compliments architectural engineering. This introductory studio welcomes students to explore the strategies and techniques through which architects design and communicate. As a studio, the course culminates in a small-scale architecture project through which students will explore and become trained in the architectural design process.

Requisites: Requires prerequisite of AREN 1027 (minimum grade C-). Restricted to Sophomores, Juniors, and Seniors.

AREN 3140 (3) Illumination Laboratory

Introduces the measurement of photometric and psychophysical quantities used in lighting. Experience is acquired in using light measurement instruments to evaluate lighting equipment and luminous environments. Taught intermittently.

Requisites: Requires prerequisite course of AREN 3540 (minimum grade C-).

Additional Information: Departmental Category: Building Systems Engineering

AREN 3430 (3) Architectural (Interior) Lighting Design

Studies the fundamentals of architectural illumination with an emphasis in design and application. Introduces and applies basic principles and vocabulary to problems in the lighting of interior environments for the performance of visual work, the proper interaction with architecture, and compliance of energy requirements.

Requisites: Restricted to students with 27-180 credits (Sophomores, Juniors or Seniors) only. College of Engineering majors are excluded from this course.

AREN 3440 (3) Architectural Daylighting Design

Enables students to develop sufficient working facility with the core principles and practices of architectural daylighting to allow for meaningful integration into future design work. Students work in active project-based environments to explore both quantitative and qualitative aspects of primary daylighting issues and precepts. Previously offered as a special topics course.

Requisites: Restricted to junior and above non-engineering majors only.

Recommended: Prerequisite AREN 3430.

AREN 3540 (3) Illumination I

Studies the fundamentals of architectural illumination. Introduces and applies basic principles and vocabulary to elementary problems in the lighting of environments for the performance of visual work and the proper interaction with architecture.

Requisites: Requires prerequisite courses of (CHEN 1310 or CSCI 1300 or ASEN 1320 or ECEN 1310) and (APPM 2350 or MATH 2400) (all minimum grade C-). Restricted to College of Engineering majors only.

Additional Information: Departmental Category: Building Systems Engineering

AREN 4010 (3) Energy System Modeling and Control

Engineering course devoted to building automation and control systems. Topics include HVAC control technology and strategies, measurement and device technologies, analysis and modeling of dynamic systems, simulation of conventional and advanced control approaches, assessment of control loop performance and hands-on direct digital control (DDC) programming exercises as used in current building control practice.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5010

Requisites: Requires prerequisite course of AREN 4110 (minimum grade C-).

Additional Information: Departmental Category: Building Systems Engineering

AREN 4080 (2) Architectural Design Studio 2

Provide an architectural design studio to accompany the integrated capstone design experience for architectural engineering students. In teams, students will build upon their architectural design knowledge to define the architectural program, analyze the site, and produce a schematic level architectural design for a commercial building.

Requisites: Requires prerequisite of AREN 3080 (minimum grade C-) and corequisite of AREN 4318.

AREN 4110 (3-4) HVAC System Design

Applies engineering principles to the design of heating, ventilating and air conditioning (HVAC) systems for buildings. Covers HVAC systems description, load estimation, psychometrics, coils and heat exchangers, air and water distribution systems and primary equipment and systems.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5110

Requisites: Requires prerequisite course of AREN 3010 (minimum grade C-).

Additional Information: Departmental Category: Building Systems Engineering

AREN 4130 (3) Optical Design for Illumination and Solid State Lighting

Covers the optical design process for illumination-based optics, emphasis on applications in architectural lighting. In-depth coverage of luminaire photometry, lamps, materials, manufacturing methods, product performance requirements. Projects utilize optical design software and include a variety of lamp types including LEDs using both reflector/lens optics.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5130

Requisites: Requires prerequisite course of AREN 3540 (minimum grade C-). Restricted to Architectural (AREN) or Civil (CVEN) Engineering majors only.

Additional Information: Departmental Category: Building Systems Engineering

AREN 4315 (3) Design of Masonry Structures

Covers modern masonry construction; properties and behavior of the reinforced masonry component materials, clay and concrete masonry units, mortar, grout, and steel reinforcement; vertical and lateral load types and intensities; and design of reinforced masonry walls, beams and columns by the strength design method.

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

Additional Information: Departmental Category: Structures

AREN 4318 (3) Architectural Engineering Design 1

Provides a capstone experience to AREN students. Students design a modest commercial building and complete an integrated engineering design of the building systems executed for the conceptual and schematic design phases. Students' teams work on structural, mechanical, electrical/lighting, and construction engineering management design. Each stage produces a professional-quality design document. Faculty and industry mentors participate in the teaching and evaluation.

Requisites: Requires prerequisites of AREN 4110 and AREN 4506 and AREN 4550 and (CVEN 4545 or 4555) (all minimum grade C-). Requires corequisites of AREN 4080 and AREN 4570.

AREN 4319 (2) Architectural Engineering Design 2

Continues the capstone experience for AREN students. Student teams continue their design of a modest commercial building through the Design Development phase with support from faculty and industry mentors. Additionally, topics of professionalism, engineering ethics, and life-long learning are covered.

Requisites: Requires prerequisites AREN 4318 and AREN 4080 (both minimum grade C-).

AREN 4440 (3) Lighting Design Capstone

Synthesizes and applies knowledge and skills from previous lighting design courses in the Lighting Design Certificate. Students work on a real-world lighting design project following industry-standard phases of design while learning about lighting design professional practice, current design topics, trends, and industry issues.

Requisites: Requires prerequisites of AREN 3430 and (AREN 4530 or AREN 4620 or THTR 3055) (all minimum grade C). Restricted to students in the Lighting Design Certificate (LGHT-CERU plan).

AREN 4506 (3) Pre-construction Estimating and Scheduling

Covers project management estimating and scheduling methods with an emphasis on the techniques used to create pre-construction estimates and schedules for architectural and civil engineering projects.

Requisites: Requires prerequisite course of CVEN 3246 (minimum grade C-). Restricted to students with 57-180 credits (Junior or Senior) Architectural (AREN), Civil (CVEN) or Integrated Design (IDEN) Engineering majors only.

Additional Information: Departmental Category: Construction

AREN 4530 (3) Advanced Lighting Design

Intended to help students understand light as a medium in design, begin the formulation of a philosophical perspective for its application, and continue to develop the skills required to design and implement lighting systems. Knowledge from previous lighting classes (Illumination I and Illumination II) is essential to this course.

Requisites: Requires prerequisite courses of (AREN 3540 and AREN 4550) (all minimum grade C-) or AREN 3430 (minimum grade C). Restricted to AREN majors or students in the Lighting Design Certificate (LGHT-CERU).

Additional Information: Departmental Category: Building Systems Engineering

AREN 4540 (3) Exterior Lighting Systems

Engages students in exploring and solving lighting problems for exterior environments. Provides an understanding of the design criteria and lighting equipment used in three primary exterior applications: parking lots and roadways, floodlighting of buildings, and sports facilities. Taught intermittently.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5540

Requisites: Requires prerequisite course of AREN 3540 (minimum grade C-).

Recommended: Prerequisite AREN 4550.

Additional Information: Departmental Category: Building Systems Engineering

AREN 4550 (3) Illumination 2

Applies the principles studied in Illumination 1. Provides further study in architectural lighting design methods. Uses lighting studio work to develop a broad knowledge of lighting equipment, design methods, and their application in a series of practical design problems in modern buildings.

Requisites: Requires prerequisite course of AREN 3540 (minimum grade C-).

Additional Information: Departmental Category: Building Systems Engineering

AREN 4560 (3) Luminous Radiative Transfer

Teaches fundamentals of radiative exchange as applied to illumination engineering. Describes and uses principal numerical techniques for radiative transfer analysis. Applies techniques to lighting design and analysis. AREN 4560.

Requisites: Requires prerequisite course of AREN 3540 (minimum grade C-).

Additional Information: Departmental Category: Building Systems Engineering

AREN 4570 (3) Building Electrical Systems Design 1

Introduces the generation and distribution of electrical power. Focuses on understanding the loads, control, and protection of secondary electrical distribution systems in building. Applies the national electric code to residential and commercial buildings.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5570

Requisites: Requires prerequisite course of AREN 3040 (minimum grade C-). Restricted to College of Engineering majors only.

Additional Information: Departmental Category: Building Systems Engineering

AREN 4580 (3) Daylighting

Applies the fundamental principles of illumination engineering to architectural daylighting design, exploring the quantitative methods and tools used to develop daylighting designs and evaluate their performance. Topics include solar resource models, energy transfer models, design methods, and controls for integration with electric lighting systems.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5580

Requisites: Requires prerequisite course of AREN 3540 (minimum grade C-).

Additional Information: Departmental Category: Building Systems Engineering

AREN 4590 (3) Computer Graphics in Lighting Engineering

Studies the numerical methods and computer implementation of computer graphics visualization for architectural lighting engineering and design. Implements finite element radiative transfer and ray-tracing in computer programs. Studies the use of computer graphics visualization in lighting analysis. Taught intermittently.

Requisites: Requires prerequisite courses of AREN 3540 and AREN 4560 (minimum grade C-).

Additional Information: Departmental Category: Building Systems Engineering

AREN 4606 (3) Construction Project Execution and Control

Integrates project execution and control techniques for construction scope, cost and schedule. Includes progress measurement, resource planning, earned value methods, productivity, risk management methods and key contract clauses.

Requisites: Requires prerequisite courses of CVEN 3246 and AREN 4506 (all minimum grade C-). Restricted to students with 57-180 credits (Junior or Senior) Civil (CVEN), Architectural (AREN) or Integrated Design (IDEN) Engineering majors only.

Additional Information: Departmental Category: Construction

AREN 4620 (3) Adaptive Lighting Systems

Builds on architectural lighting principles studied in Illumination 1 and 2. Explores quantitative methods and the design process to develop architectural lighting control solutions. Topics include adaptive lighting applications such as daylight integration and occupant well-being, as well as control system architecture and components, codes and standards, and design implementation.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5620

Requisites: Requires prerequisites AREN 3540 and AREN 4550 (both minimum grade C-), or prerequisite of AREN 3430 (minimum grade C) for students in the LGHT-CERU program.

Recommended: Prerequisite AREN 4130.

AREN 4830 (1-3) Special Topics for Seniors/Grads

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

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

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

Additional Information: Departmental Category: Special Topics

AREN 4849 (1-3) Independent Study

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

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

Additional Information: Departmental Category: Special Topics

AREN 4890 (3) Sustainable Building Design

Introduces green building design procedure/approach and provides insight into evolving design principles; explores aspects of building thermal/energy performance, indoor/outdoor environmental quality, occupant comfort and climate relevant to building design (structures not covered); emphasizes both comprehensive understanding and practical applications of sustainable building design strategies; applies prevailing simulation tools to assist green building design.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5890

Requisites: Requires a prerequisite course of AREN 3010 (minimum grade C-). Restricted to students with 87-180 credits (Senior, Fifth Year Senior) College of Engineering students only.

Additional Information: Departmental Category: Building Systems Engineering

AREN 4990 (3) Compu Fluid Dynamics (CFD) Analysis for Built/Natural Envmnts

Explores the fundamentals of simulating/analyzing civil and architectural environments with Computational Fluid Dynamics (CFD) method.

Run with two parallel sessions: fundamentals and applications, with fundamental lectures presenting the principles of CFD technologies, and application sessions demonstrating the application of CFD for resolving building and environmental engineering problems (different than MCEN/ASEN) with hands-on exercises.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5990

Requisites: Requires prerequisite courses of AREN 2120 and (APPM 2360) or (MATH 2130 and 3430)) (all minimum grade C-). Restricted to students with 57-180 credits (Junior or Senior) College of Engineering majors only.

Additional Information: Departmental Category: Building Systems Engineering

Civil Engineering

CVEN 1027 (3) Civil Engineering Drawing

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

Requisites: Restricted to Civil Engineering (CVEN) majors only.

Additional Information: Departmental Category: Miscellaneous

CVEN 1317 (1) Introduction to Civil and Environmental Engineering

Surveys the broad subject of civil and environmental engineering and professional practice. Includes the subdisciplines of structures, water resources, geotechnics, transportation, environment, and construction.

Discusses professional ethics, important skills for engineers, and the engineering design process as it fulfills multiple objectives.

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

Additional Information: Departmental Category: Miscellaneous

CVEN 1837 (1-3) Special Topics

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

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

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

Additional Information: Departmental Category: Miscellaneous

CVEN 2012 (3) Introduction to Geomatics

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

Requisites: Restricted to Architectural (AREN) or Civil (CVEN) or Integrated Design (IDEN) Engineering majors only.

Additional Information: Departmental Category: Surveying and Transportation

CVEN 2017 (1) Excel Matlab R Primer

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

Requisites: Requires prerequisite course of CSCI 1200 (minimum grade D-).

Recommended: Corequisite APPM 2360.

CVEN 2121 (3) Analytical Mechanics 1

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

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

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

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

Additional Information: Departmental Category: Mechanics

CVEN 2837 (1-3) Special Topics

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

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

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

Additional Information: Departmental Category: Miscellaneous

CVEN 3022 (3) Construction Surveying

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

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

Additional Information: Departmental Category: Surveying and Transportation

CVEN 3032 (3) Photogrammetry

Familiarizes students with characteristics of aerial photographs.

Measures and interprets aerial photos for planimetric, topographic, hydrological, soil, and land use surveys. Analyzes and presents field measurements over extensive reaches.

Additional Information: Departmental Category: Surveying and Transportation

CVEN 3042 (3) Advanced Engineering Drawing for Infrastructure

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

Requisites: Requires prerequisite course of CVEN 1027 (minimum grade C-).

Grading Basis: Letter Grade

CVEN 3111 (3) Analytical Mechanics 2

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

Equivalent - Duplicate Degree Credit Not Granted: MCEN 2043

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

Additional Information: Departmental Category: Mechanics

CVEN 3141 (2) Engineering Materials Lab

Additional Information: Departmental Category: Mechanics

CVEN 3161 (3) Mechanics of Materials 1

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

Equivalent - Duplicate Degree Credit Not Granted: MCEN 2063

Requisites: Requires prereq CVEN 2121 or GEEN 2851 or ASEN 2001 or MCEN 2023 (all min grade C-). Requires coreq APPM 2360 or (MATH 2130 3430). Restricted to Arch (AREN) or Civil (CVEN) or Environ (EVEN) or Integ Design (IDEN) majors with a CIV, ENR or ARC subplan

Additional Information: Departmental Category: Mechanics

CVEN 3227 (3) Probability, Statistics and Decision

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

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

Additional Information: Departmental Category: Miscellaneous

CVEN 3246 (3) Introduction to Construction

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

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

Additional Information: Departmental Category: Construction

CVEN 3256 (3) Construction Equipment and Methods

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

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

Additional Information: Departmental Category: Construction

CVEN 3313 (3) Theoretical Fluid Mechanics

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

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

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

Additional Information: Departmental Category: Fluid Mechanics and Water Resources

CVEN 3323 (3) Hydraulic Engineering

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

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

Additional Information: Departmental Category: Fluid Mechanics and Water Resources

CVEN 3414 (3) Fundamentals of Environmental Engineering

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

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

Additional Information: Departmental Category: Environmental

CVEN 3424 (3) Water and Wastewater Treatment

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

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

Additional Information: Departmental Category: Environmental

CVEN 3434 (3) Introduction to Applied Ecology

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

Equivalent - Duplicate Degree Credit Not Granted: ENVS 3434

Requisites: Requires prereq courses of (CHEN 1201 or CHEN 1211 or CHEM 1113 or CHEM 1400) and (CHEM 1114 or CHEM 1221) (all min grade C-). Restricted to students with 57-180 credits (Junior or Senior) Civil (CVEN), Environ (EVEN) or Arch Eng (AREN) or (IDEN) majors

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

CVEN 3525 (3) Structural Analysis

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

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

Additional Information: Departmental Category: Structures

CVEN 3602 (3) Transportation Systems

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

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

Additional Information: Departmental Category: Surveying and Transportation

CVEN 3698 (3) Engineering Geology

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

Requisites: Requires a prerequisite or corequisite course of CVEN 2121 or GEEN 2851 or ASEN 2001 or MCEN 2023 and APPM 2350 or MATH 2400 (all minimum grade C-). Restricted to College of Engineering majors only.

Additional Information: Departmental Category: Geotechnical

CVEN 3708 (3) Geotechnical Engineering 1

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

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

Additional Information: Departmental Category: Geotechnical

CVEN 3718 (3) Geotechnical Engineering 2

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

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

Additional Information: Departmental Category: Geotechnical

CVEN 3837 (1-3) Special Topics

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

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

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

Additional Information: Departmental Category: Miscellaneous

CVEN 4147 (3) Civil Engineering Systems

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5147

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

Additional Information: Departmental Category: Miscellaneous

CVEN 4157 (3) A Systems Approach to Global Engineering

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

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

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

CVEN 4161 (3) Mechanics of Materials 2

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5161

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

Additional Information: Departmental Category: Mechanics

CVEN 4323 (3) Water Resources Engineering Design

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5423

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

Additional Information: Departmental Category: Fluid Mechanics and Water Resources

CVEN 4333 (3) Engineering Hydrology

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

Requisites: Requires prerequisite course of CVEN 3313 or AREN 2120 or CHEN 3200 or MCEN 3021 (all minimum grade C-). Requires prerequisite or corequisite course of CVEN 3227 or APPM 4570 or MCEN 3047 or CHEN 3010 or GEEN 3853 (all minimum grade C-).

Additional Information: Departmental Category: Fluid Mechanics and Water Resources

CVEN 4353 (3) Groundwater Engineering

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

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

Additional Information: Departmental Category: Fluid Mechanics and Water Resources

CVEN 4383 (3) Applied Groundwater Modeling

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5383

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

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

Additional Information: Departmental Category: Fluid Mechanics and Water Resources

CVEN 4404 (3) Water Chemistry

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

Equivalent - Duplicate Degree Credit Not Granted: EVEN 4404

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

Requires corequisite course of CVEN 3414.

Additional Information: Departmental Category: Environmental

CVEN 4414 (1) Water Chemistry Laboratory

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

Equivalent - Duplicate Degree Credit Not Granted: EVEN 4414

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

Additional Information: Departmental Category: Environmental

CVEN 4424 (3) Environmental Organic Chemistry

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

Equivalent - Duplicate Degree Credit Not Granted: EVEN 4424

Requisites: Requires prerequisite course of CHEN 1211 or CHEM 1113 or CHEM 2100 (minimum grade C-).

Additional Information: Departmental Category: Environmental

CVEN 4434 (4) Environmental Engineering Design

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

Equivalent - Duplicate Degree Credit Not Granted: EVEN 4434

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

Grading Basis: Letter Grade

Additional Information: Departmental Category: Environmental

CVEN 4464 (3) Environmental Engineering Processes

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

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

Requisites: Requires prerequisite or corequisite courses of CVEN 3414 and CVEN 3313 or CHEN 3200 or GEEN 3853 or MCEN 3021 or AREN 2120 (all minimum grade C-).

Additional Information: Departmental Category: Environmental

CVEN 4474 (3) Hazardous and Industrial Waste Management

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5474

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

Additional Information: Departmental Category: Environmental

CVEN 4484 (3) Introduction to Environmental Microbiology

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

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

Requisites: Requires prerequisite courses of CHEN 1211 and CHEM 1221 or CHEM 1113 and CHEM 1114 and APPM 2350 or MATH 2400 (all minimum grade C-).

Additional Information: Departmental Category: Environmental

CVEN 4511 (3) Introduction to Finite Element Analysis

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5511

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

Additional Information: Departmental Category: Mechanics

CVEN 4525 (3) Matrix Structural Analysis

Covers matrix formulation of principles of structural analysis and development of direct stiffness and flexibility methods for analysis of 2D and 3D structures. Variational formulation of the finite element method. Geometric nonlinearity. Familiarity with Matlab programming is expected.

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5525

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

Additional Information: Departmental Category: Structures

CVEN 4535 (1-3) Construction Materials

Introduces material science of engineering materials, such as atomic and crystal structures, defects and phase diagrams; discusses in detail three construction materials: steel, Portland cement concrete and asphalt concrete including classification and composition, engineering properties and testing methods (with three lab sessions). Covers basic of three materials: wood, fiber reinforced polymers and masonry.

Repeatable: Repeatable for up to 3.00 total credit hours.

Requisites: Requires a prerequisite course of CVEN 3161 or MCEN 2063 (minimum grade C-). Restricted to College of Engineering majors only.

Additional Information: Departmental Category: Structures

CVEN 4537 (3) Numerical Methods in Civil Engineering

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5537

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

Additional Information: Departmental Category: Miscellaneous

CVEN 4545 (3) Steel Design

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

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

Additional Information: Departmental Category: Structures

CVEN 4554 (3) Fundamentals of Air Quality Management

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5554

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

Additional Information: Departmental Category: Environmental

CVEN 4555 (3) Reinforced Concrete Design

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

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

Additional Information: Departmental Category: Structures

CVEN 4565 (3) Design of Wood Structures

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

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

Additional Information: Departmental Category: Structures

CVEN 4594 (3) Water Reuse and Reclamation

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5594

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

Recommended: Prerequisite CVEN 3424.

Additional Information: Departmental Category: Environmental

CVEN 4718 (3) Mechanics and Dynamics of Glaciers

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5718

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

Additional Information: Departmental Category: Geotechnical

CVEN 4728 (3) Foundation Engineering

Focuses on geotechnical design of shallow and deep foundations, including spread footings, mats, driven piles and drilled piers. Coverage includes bearing capacity, settlement, group effects and lateral load capacity of the various foundation types. Additional topics include subsurface exploration, construction of deep foundations and analysis of pile behavior using wave equation and dynamic monitoring methods.

Equivalent - Duplicate Degree Credit Not Granted: CVEN 5728

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

Additional Information: Departmental Category: Geotechnical

CVEN 4833 (1-3) Special Topics

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

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

Additional Information: Departmental Category: Fluid Mechanics and Water Resources

CVEN 4834 (1-3) Special Topics

Department consent required.

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

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

Additional Information: Departmental Category: Environmental

CVEN 4835 (1-3) Special Topics

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

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

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

Additional Information: Departmental Category: Structures

CVEN 4836 (1-3) Special Topics

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

Repeatable: Repeatable for up to 3.00 total credit hours.

CVEN 4837 (1-3) Special Topics

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

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

Additional Information: Departmental Category: Miscellaneous

CVEN 4838 (1-3) Special Topics

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

Additional Information: Departmental Category: Geotechnical

CVEN 4839 (3-6) Special Topics for Seniors

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

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

Additional Information: Departmental Category: Special Topics

CVEN 4849 (1-3) Independent Study

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

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

Additional Information: Departmental Category: Special Topics

CVEN 4897 (2) Professional Issues in Civil Engineering

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

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

Additional Information: Departmental Category: Miscellaneous

CVEN 4899 (4) Civil Engineering Senior Project Design

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

Repeatable: Repeatable for up to 4.00 total credit hours.

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

Additional Information: Departmental Category: Special Topics

CVEN 4969 (3) Water and Sanitation in Developing Countries

Studies the design and fundamentals behind effective treatment processes and engineering solutions targeted for developing countries. Approaches to clean water and sanitation in lesser industrialized countries often demand alternative solutions to those developed for industrialized societies. Explores issues and solutions developed to tackle these problems.

Equivalent - Duplicate Degree Credit Not Granted: EVEN 4969

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

Additional Information: Departmental Category: Environmental

Environmental Engineering**EVEN 1000 (1) Introduction to Environmental Engineering**

Introduces first-year students to the environmental engineering program from an academic and a career perspective. Covers air quality, applied ecology, chemical processing, energy, engineering for developing communities, environmental remediation, and water resources and treatment. Includes reading and writing on the history of environmental engineering, major environmental issues, and professional ethics.

Requisites: Restricted to students with 0-60 units completed. Restricted to Environmental Engineering (EVEN) and Open Option Engineering (XXEN) majors only.

EVEN 1001 (3) Environmental Engineering 101: An Introduction to Pollution Science

Surveys the science and engineering needed to understand the environmental and energy challenges which face urbanizing society: air and water pollution, climate change, and mining. Introduces how environmental engineers leverage basic science concepts to reduce pollution and optimize energy use. Analyzes how the mainstream media presents the environmental science of climate change and modern environmental disasters.

EVEN 2840 (1-3) Independent Study: General Topics

General topics relating to environmental engineering. One-on-one assistance with an instructor.

EVEN 2909 (3) Introduction to Global Engineering

Introduces students to the emerging field of Global Engineering, concerned with the unequal and unjust distribution of access to basic services such as water, sanitation, energy, food, transportation and shelter. The course places an emphasis on identifying the drivers, determinants and solutions favoring equitable access. Topics include technology development and validation, data collection and impact evaluation. Formerly EVEN 2004.

Recommended: for engineering students.

EVEN 3012 (3) Thermodynamics for Environmental Science and Engineering

Introduces students to fundamentals of thermodynamics. Includes focused coverage of the laws of thermodynamics, system energy balances, state properties (internal energy, enthalpy, entropy, etc.) and property estimation for ideal gases and steam. Additionally, this course will introduce the following concepts: thermodynamic cycles, chemical reaction thermodynamics, psychrometrics, process devices (pumps, heat exchangers, etc.) and reversibility.

Requisites: Requires prerequisite courses of PHYS 1110 and APPM 1360 and CHEN 1211 (all minimum grade C-).

EVEN 3414 (3) Fundamentals of Environmental Engineering

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

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

EVEN 3550 (3) Sustainability Principles for Engineers

An introduction to sustainability principles in the field of environmental engineering. Students will apply these principles to engineering problems in order to evaluate the environmental, economic and social implications of engineering and design decisions. Topics include definitions of sustainability, main engineering sustainability challenges (e.g., water, climate and materials), pollution generation and prevention and sustainability assessment tools.

Requisites: Requires a corequisite course of CVEN 3414. Restricted to Environmental Engineering (EVEN) majors only.

EVEN 3650 (3) Sustainable Energy Systems Analysis

This course introduces students to the fundamentals of technology utilized in sustainable energy systems. Students will learn performance modeling, environmental life cycle assessment, and economic viability evaluation with a focus on the following: sensitivity analysis of cost-performance models, uncertainty and risk assessment, multi-criteria decision making and sustainability assessment. This course highlights the limits and obstacles facing the integration.

Requisites: Requires prerequisite courses of (MCEN 3012 or GEEN 3852 or AREN 2110 or EVEN 3012) AND PHYS 1120 AND (EVEN 3550 or MCEN 3032) (minimum grade D-).

EVEN 3830 (1-3) Special Topics

Study of technical topics within the field of environmental engineering. Subject matter to be selected from topics of current interest.

Repeatable: Repeatable for up to 9.00 total credit hours.

EVEN 4100 (3) Environmental Sampling and Analysis

Introduces students to techniques for characterization of surface water, subsurface water, soils and sediments, and air and planning of sampling and analysis efforts. Laboratories include stream sampling, drilling, monitoring well installation, water level, slug tests, air sampling.

Requisites: Requires prerequisite courses of CVEN 4404 and CVEN 4424 (all minimum grade C-). Restricted to Environmental Engineering (EVEN) majors only.

EVEN 4404 (3) Water Chemistry

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 4404

Requisites: Requires prerequisite course of (CHEN 1203 or CHEN 1211 or CHEM 1133) and (CHEM 1221 or CHEM 1134) (all minimum grade C-). Requires corequisite course of CVEN 3414. Restricted to Civil (CVEN) or Environmental (EVEN) Engineering majors only.

EVEN 4414 (1) Water Chemistry Laboratory

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 4414

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

EVEN 4424 (3) Environmental Organic Chemistry

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 4424

Requisites: Requires prereq course (CHEN 1211 or CHEN 1203 or CHEM 1133) and EVEN 4404 (min grade C-).

EVEN 4434 (4) Environmental Engineering Design

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

Equivalent - Duplicate Degree Credit Not Granted: CVEN 4434

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

Grading Basis: Letter Grade

EVEN 4464 (3) Environmental Engineering Processes

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

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

Requisites: Requires prerequisite courses of CVEN 3313 or CHEN 3200 or GEEN 3853 or MCEN 3021 or AREN 2120 and CVEN 3414 (all minimum grade C-).

EVEN 4484 (3) Introduction to Environmental Microbiology

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

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

Requisites: Requires prerequisite course of CHEN 1211 and CHEM 1221 or CHEM 1113 and CHEM 1114 and APPM 2350 or MATH 2400 (minimum grade C-).

EVEN 4494 (3) Contaminant Fate and Transport

The course requires students to design and conduct experiments, analyze, interpret data, and write technical engineering reports. This lab-based course gives students an understanding of processes that govern the behavior of pollutants in the environment. The subject includes aspects of intermedia contaminant transport, surface and groundwater hydrology, air pollution modeling, degradation processes and remediation, human exposure pathways and risk analysis.

Requisites: Requires prerequisite courses of CVEN 4404 or EVEN 4404 (minimum grade D-). Requires corequisite courses of CVEN 4424 or EVEN 4424.

Recommended: Prerequisite or corequisite EVEN 4464 (Environmental Engineering Processes).

EVEN 4830 (3) Special Topics

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

EVEN 4840 (1-3) Independent Study: General Topics

General topics relating to environmental engineering. One-on-one assistance with an instructor.

Repeatable: Repeatable for up to 6.00 total credit hours.

EVEN 4959 (3) International Environmental Impact Assessment

Provide elements needed to develop Environmental Impact Assessments (EIA) in countries around the world. Familiarizes students with terms and definitions used in environmental practice. Explains the application of methodologies/tools used globally in EIA studies, taking into consideration the cause-effect relationships between project activities and the environment. Overview of World Bank and regional evaluation criteria driven by local ecosystems, society, and regulations. Case studies focus on the application of tools/methodologies and criteria in various international scenarios.

Equivalent - Duplicate Degree Credit Not Granted: EVEN 5959

Requisites: Requires prerequisite or corequisite course of EVEN 3414 (minimum grade C-).

Recommended: Prerequisite or corequisite EVEN 3550.

EVEN 4969 (3) Water and Sanitation in Developing Countries

Studies the design and fundamentals behind effective treatment processes and engineering solutions targeted for developing countries. Approaches to clean water and sanitation in lesser industrialized countries often demand alternative solutions to those developed for industrialized societies. Explores issues and solutions developed to tackle these problems.

Equivalent - Duplicate Degree Credit Not Granted: CVEN 4969

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

EVEN 4980 (3) Senior Thesis 1

Provides faculty-supervised independent research in environmental engineering for students planning to complete a senior thesis. To be taken prior to EVEN 4990, during the final year before graduation. Department consent required.

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

EVEN 4990 (3) Senior Thesis 2

Continuation of EVEN 4980. Consists of final phase of faculty-supervised research, the preparation of a written thesis, and an oral defense of the research to

Requisites: Requires prerequisite course of EVEN 4980 (minimum grade C-).