

ARCHITECTURAL ENGINEERING (AREN)

Courses

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 and to IUT On Track students.

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 or IUT On Track students 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 or to IUT On Track students 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 prereq or coreq of (APPM 2350 or MATH 2400) (APPM 2360 or (MATH 2130 3430)) prereq course (AREN 2110 or GEEN 3852 or MCEN 3012 or ASEN 2002 or ASEN 2702) (all min grade C-). Restricted to Coll of Engineering mjrs IUT on track students 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 prereq or coreq courses (APPM 2350 or MATH 2400) (APPM 2360 or (MATH 2130 3430)) prerequisite course (AREN 2110 or GEEN 3852 or MCEN 3012 or ASEN 2002 or ASEN 2702) (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 2050 and (AREN 2120 or ((MCEN 3022 or AREN 2121) and (CVEN 3313 or MCEN 3021 or CHEN 3200))) (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 students with 27-180 credits (Sophomores, Juniors or Seniors) College of Engineering majors only.

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 (CSCI 1200 or 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 4040 (3) Building Energy Audits

Provides students with the fundamental tools and procedures required to perform energy audits of building systems typically required for energy efficiency projects including performance contracting and retro-commissioning projects.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5020

Requisites: Requires prerequisite course of AREN 3010 (minimum grade C-). Restricted to students with 57-180 credits (Juniors or Seniors).

AREN 4061 (3) Distributed Electricity Generation

Introduces basic distributed generation (DG) technologies including fuel-based systems and renewable energy technologies and overview approaches to conduct energy, economical, and environmental analysis of selected DG technologies using state-of-the-art analysis tools to evaluate optimal hybrid distributed generation systems to meet required electrical loads specific to urban centers, campuses, and residential communities.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5061

Requisites: Requires prerequisite course of AREN 3010 (minimum grade C-). Restricted to juniors and seniors.

Grading Basis: Letter Grade

AREN 4110 (3) Building Energy Systems Engineering

Prepares students for professional practice in building energy systems engineering, i.e., analysis and design of residential and commercial buildings, including district energy systems. Upon completion, students possess the skills to calculate heating, cooling, and ventilation requirements, as well as analyze, design, and evaluate integrated building energy systems to meet the following goals: indoor environmental health, safety, and productivity (codes and standards); economic drivers (affordability, life cycle cost), and societal needs (environmental equity, energy justice, decarbonization).

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 (5) 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 3080, AREN 4110, AREN 4506 and AREN 4550. Requires prerequisite or corequisite of AREN 4570 and (CVEN 4545 or 4555) (all minimum grade C-).

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 of 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 4540 (3) Architectural Exterior and Landscape Lighting Design

Introduces the fundamentals of nighttime illumination for architectural exteriors and landscapes. Students will learn about the interaction of light and human vision at night; lighting technologies used in outdoor settings; societal, environmental and ecological issues related to the application of light at night; lighting design principles and techniques that use light and darkness both creatively and responsibly.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5540

Requisites: Requires prerequisite course of AREN 3430 (minimum grade C-). Restricted to junior and above non-engineering majors only.

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.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5550

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.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5560

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 of AREN 3040 or ECEN 2250 or MCEN 3017 or GEEN 3010 (all 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 courses of AREN 4130 and AREN 4550 (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 4630 (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. Formerly AREN 4530.

Equivalent - Duplicate Degree Credit Not Granted: AREN 5630

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 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

AREN 5001 (3) Building Science and Engineering I

Prepares graduate students with general knowledge and skills that are required by advanced AREN technical courses. Covers two parts of materials: Building Lighting Systems and Building Electrical Systems.

Requisites: Restricted to graduate students in the College of Engineering.

Grading Basis: Letter Grade

Additional Information: Departmental Category: Building Systems Engineering

AREN 5002 (3) Building Science and Engineering II

Introduces AREN fundamentals to new graduate students entering the Architectural Engineering Program (AREN) but without general Civil or Architectural Engineering background. This course is part of a two-course set with AREN 5001: Building Science and Engineering I. This course covers two parts: (1) building thermal science and engineering; (2) building material science and engineering.

Requisites: Restricted to graduate students in the College of Engineering.

Grading Basis: Letter Grade

AREN 5010 (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 4010

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

Recommended: Prerequisite AREN 4110 or AREN 5110.

Additional Information: Departmental Category: Building Systems Engineering

AREN 5020 (3) Building Energy Audits

Analyzes and measures performance of HVAC systems, envelopes, lighting and hot water systems, and modifications to reduce energy use. Emphasizes existing buildings.

Equivalent - Duplicate Degree Credit Not Granted: AREN 4040

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

Recommended: Prerequisite AREN 3010 or AREN 5002.

Additional Information: Departmental Category: Building Systems Engineering

AREN 5030 (3) Data Science for Energy and Buildings

Establishing hands-on skills along with understanding of underlying mathematical concepts of current machine learning approaches including: ordinary least squares, quantile, logistic, and local regression; unsupervised methods including principal component analysis and clustering; tree-based models such as regression trees and random forests; kernel-based methods such as support vector and Gaussian process regression; Bayesian inference; as well as shallow and deep neural networks. Numerous examples and case studies applicable to thermal/building/renewable/district energy systems will be used. Undergraduate seniors will be allowed with instructor consent.

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

AREN 5061 (3) Distributed Electricity Generation

Introduces basic distributed generation (DG) technologies including fuel-based systems and renewable energy technologies and overview approaches to conduct energy, economical, and environmental analysis of selected DG technologies using state-of-the-art analysis tools to evaluate optimal hybrid distributed generation systems to meet required electrical loads specific to urban centers, campuses, and residential communities. Formerly AREN 5060.

Equivalent - Duplicate Degree Credit Not Granted: AREN 4061

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

Recommended: Prerequisite AREN 3040 or AREN 5001.

Grading Basis: Letter Grade

Additional Information: Departmental Category: Building Systems Engineering

AREN 5080 (3) Computer Simulation of Building Energy Systems

Introduces major simulation programs for analysis of building energy loads and system performance. Focuses on one hourly simulation program to develop capability for analysis of multizone structure.

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

Recommended: Prerequisite AREN 3010 or AREN 5002.

Additional Information: Departmental Category: Building Systems Engineering

AREN 5090 (3) Optimizing Grid Connected Systems

Address the challenges that the electric power grid is facing from a technical perspective, using grid modeling, mathematics (optimization and linear algebra) and programming (Python). The course will also touch on a variety of topics such as electricity markets, renewable energy integration, and distributed energy resources, including how buildings can help the broader electrical grid. Students will gain skills that will help them prepare for careers in building controls, renewable energy, energy policy, and more. Do not take this class if you have already taken a power systems optimization course.

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

Recommended: Prerequisites students should have prior experience/ coursework in programming (beyond Excel) and linear algebra before taking this course.

Grading Basis: Letter Grade

AREN 5110 (3) Building Energy Systems Engineering

Prepares students for professional practice in building energy systems engineering, i.e., analysis and design of residential and commercial buildings, including district energy systems. Upon completion, students possess the skills to calculate heating, cooling, and ventilation requirements, as well as analyze, design, and evaluate integrated building energy systems to meet the following goals: indoor environmental health, safety, and productivity (codes and standards); economic drivers (affordability, life cycle cost), and societal needs (environmental equity, energy justice, decarbonization).

Equivalent - Duplicate Degree Credit Not Granted: AREN 4110

Requisites: Requires prerequisite of (AREN 5001 and AREN 5002) or AREN 3010, all minimum grade C-. Restricted to graduate and students accepted in the Bachelor Accelerated Masters (BAM) program.

Grading Basis: Letter Grade

Additional Information: Departmental Category: Building Systems Engineering

AREN 5130 (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 4130

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

Recommended: Prerequisite AREN 3540.

Additional Information: Departmental Category: Building Systems Engineering

AREN 5510 (3) Architectural Lighting I

Teaches the fundamentals of architectural lighting systems and the human responses to those systems. Describes the properties of light sources, how light interacts with architectural elements, and how light affects human visual and non-visual responses. Provides a broad overview of the holistic effects of light on building occupants, as well as the implications for building energy use and sustainability. Previously offered as a special topics course.

Requisites: Restricted to non-degree (NDGR) graduate students only.

AREN 5520 (3) Architectural Lighting II

Builds on the fundamentals taught in AREN 5500 with a detailed look at how technical information about lighting systems can be used for design concepts and analyses. Provides an examination of daylighting in buildings. Describes the latest research and design standards for color rendering, glare, flicker, circadian rhythms, and alerting effects. Concludes by considering case studies of various project types.

Requisites: Open to Non-degree, Non sponsored Students only.

AREN 5530 (3) Architectural Lighting Capstone

Concludes the nine-credit Professional Graduate Certificate in Architectural Lighting with an immersive hands-on experience. Concepts learned in the two prior online courses will be demonstrated and experienced using facilities and equipment available on the CU Boulder campus. A culminating, comprehensive project submittal that includes content developed during the entire three-course sequence will be submitted following the on-campus experience.

Requisites: Requires prerequisite courses of AREN 5510 and AREN 5520 (all minimum grade C-). Restricted to non-degree (NDGR) graduate students only.

AREN 5540 (3) Architectural Exterior and Landscape Lighting Design

Introduces the fundamentals of nighttime illumination for architectural exteriors and landscapes. Students will learn about the interaction of light and human vision at night; lighting technologies used in outdoor settings; societal, environmental and ecological issues related to the application of light at night; lighting design principles and techniques that use light and darkness both creatively and responsibly.

Equivalent - Duplicate Degree Credit Not Granted: AREN 4540

Requisites: Requires prerequisite course of AREN 4550 for BAM students or (AREN 5001 and AREN 5550) for graduate students, all minimum grade C-. Restricted to graduate students and students accepted in the Bachelor Accelerated Masters (BAM) program.

Additional Information: Departmental Category: Building Systems Engineering

AREN 5550 (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.

Equivalent - Duplicate Degree Credit Not Granted: AREN 4550

Requisites: Requires corequisite course of AREN 5001 for graduate students. Restricted to graduate students and students in the Bachelor Accelerated Masters (BAM) program.

Grading Basis: Letter Grade

AREN 5560 (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.

Equivalent - Duplicate Degree Credit Not Granted: AREN 4560

Requisites: Requires prerequisite course of AREN 3540 or AREN 5001 (minimum grade C-). Restricted to graduate students and students in the Bachelor Accelerated Masters (BAM) program.

AREN 5570 (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. Previously offered as a special topics course.

Equivalent - Duplicate Degree Credit Not Granted: AREN 4570

Requisites: Requires prerequisite course of AREN 5001 or AREN 3040 or ECEN 2250 or MCEN 3017 or GEEN 3010 (all minimum grade C-). Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

AREN 5580 (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 4580

Requisites: Requires prerequisite course of AREN 3540 or AREN 5001 (minimum grade C-). Restricted to graduate students or students accepted in the AREN, CVEN or EVEN Bachelor Accelerated Masters (BAM) programs.

AREN 5620 (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. Previously offered as a special topics course.

Equivalent - Duplicate Degree Credit Not Granted: AREN 4620

Requisites: Requires prerequisite course of AREN 4550 or AREN 5550 (minimum grade C-).

Recommended: Prerequisite AREN 4130.

AREN 5630 (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.

Equivalent - Duplicate Degree Credit Not Granted: AREN 4630

Requisites: Requires prerequisite course of AREN 4550 for BAM students or AREN 5001 and AREN 5550 for graduate students (all minimum grade C-). Restricted to graduate students and students in the Bachelor Accelerated Masters (BAM) program.

Grading Basis: Letter Grade

AREN 5650 (3) Forensic Engineering

Identify and explore the physical, chemical, mechanical, and biological deterioration mechanisms in the most common construction materials; concrete, masonry, metals, wood, polymers, and fiber-reinforced composites. Course topics include an introduction to failure analysis; materials science; ion diffusion; electrochemistry (corrosion); fracture, fatigue, and creep; and diagnostic, retrofit, and rehabilitation strategies for extended service life.

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

AREN 5660 (3) Embodied Carbon in Buildings

Introduces students to whole building life cycle assessment (LCA) and embodied carbon in buildings. Topics include LCA methodologies, whole-building LCA tools, materials science of low-carbon and carbon-storing building materials, and strategies for reducing embodied carbon.

Requisites: Restricted to graduate students only, or BAM students with C-AREN, C-CVEN, or C-ARENCVEN subplan.

Recommended: Prerequisite AREN 5002.

AREN 5830 (1-3) Architectural Engineering Special Topic

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

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

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

AREN 5849 (1-3) Independent Study in Architectural Engineering

The topics and the goals of this course are tailored to fit the needs of the student in various areas related to the Architectural Engineering program. These topics and goals, documented in the course agreement form at the start of the semester, include but are not limited to areas of building energy engineering, building illumination systems, construction engineering and management, building materials and resources, and building electrical systems.

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

Grading Basis: Letter Grade

AREN 5890 (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 4890

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

Recommended: Prerequisite AREN 3010 or AREN 5002.

Additional Information: Departmental Category: Building Systems Engineering

AREN 5990 (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 4990

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

Recommended: Prerequisites AREN 2120 and APPM 2360.

Additional Information: Departmental Category: Building Systems Engineering

AREN 6940 (1) Master's Candidate for Degree

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

Additional Information: Departmental Category: Building Systems Engineering

AREN 6950 (1-6) Master's Thesis

Additional Information: Departmental Category: Building Systems Engineering

AREN 6960 (1-3) Master's Report

Repeatable: Repeatable for up to 3.00 total credit hours.

Additional Information: Departmental Category: Building Systems Engineering

AREN 8990 (1-10) Doctoral Dissertation

A minimum of 30 credit hours is required.

Additional Information: Departmental Category: Building Systems Engineering