ARCHITECTURAL ENGINEERING

Architectural engineering focuses on the design, construction and operation of buildings and the integration of their systems. The department offers Master of Science (MS) and Doctor of Philosophy (PhD) degrees in architectural engineering with a study emphasis (i.e., focus area) in:

- Building energy engineering
- Illumination engineering
- Materials and carbon
- Construction engineering and management

Graduate studies in architectural engineering are offered through the Department of Civil, Environmental and Architectural Engineering (http://www.colorado.edu/ceae/prospective-students/graduate-studies/). The Graduate Record Examination (GRE), consisting of the aptitude tests and advanced test in engineering, is used to evaluate MS and PhD candidates. Candidates who submit GRE scores are more likely considered for financial assistance.

Course code for this program is AREN.

Research Interests and Facilities

The Larson HVAC Laboratory has been a staple of the University of Colorado's building energy research activities and AREN program education. The laboratory has been the stepping stone for fundamental and applied research in building energy efficiency, energy controls, thermal comfort and indoor air quality. The newly renovated Larson HVAC Laboratory provides a unique facility that permits the evaluation of entire systems in a controlled dynamic environment, providing repeatable test conditions. The laboratory has been recently redesigned to allow maximum flexibility in conducting a wide variety of research and testing procedures. In particular, both the HVAC and control systems in the laboratory are reconfigurable in that components, subsystems or entire systems can be readily installed and tested. For instance, the performance of air handling units, displacement ventilation units, chilled beams and variable refrigerant flow units can be tested. In addition, coils, air mixers, dampers, filters and variable frequency drives can be evaluated. Moreover, the laboratory offers the possibility to test standalone HVAC and refrigeration systems including water heaters, boilers, thermal energy storage tanks and chillers.

The Lighting Laboratory is a learning and research space for lighting students in the AREN program. The lab has a dynamic ceiling with adjustable height to allow a wide range of academic and research exploration. Although the lab has a full-wall, with north-facing windows, there are blackout curtains installed to eliminate any undesirable external light. In addition, this lab houses a goniophotometer used to measure the intensity of light leaving a luminaire at various vertical and horizontal angles. The measured data allow establishing photometric light distribution of the luminaire and metrics such as total lumen output, luminaire luminance and zonal lumen summary. The lab also houses a small lighting sphere, which allows testing of lumen output of LED luminaires and LED chips. In addition, the lighting lab includes a studio space used primarily for lighting research. The lab has an extensive aluminum open ceiling grid that allows for quick electrical and physical connection of light sources and luminaires for research. For lighting design-oriented classes, students have access to theatrical-type and programmable color-changing luminaires to do mock-ups and study lighting effects.

The AREN laboratories offer state-of-the-art facilities to test a wide range of operational and control strategies for lighting and HVAC systems and subsystems. Indeed, several control projects have been carried out in the Larson HVAC laboratory including demand-ventilation controls, optimal chiller and thermal energy storage controls, outdoor air intake controls, and optimal operation of evaporative systems. In addition, fault diagnostic algorithms have been tested in the laboratory for specific HVAC equipment including for heating and cooling coils, chillers and outdoor air intake dampers.

Master's Degrees

- Architectural Engineering - Master of Science (MS) (https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/architectural-engineering/architectural-engineering-master-science-ms/)

Doctoral Degree

- Architectural Engineering - Doctor of Philosophy (PhD) (https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/architectural-engineering/architectural-engineering-doctor-philosophy-phd/)

Certificate

- Architectural Lighting - Graduate Certificate (https://catalog.colorado.edu/graduate/colleges-schools/engineering-applied-science/programs-study/engineering-applied-science/architectural-lighting-graduate-certificate/)

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

Goodrum, Paul M. (https://experts.colorado.edu/display/fisid_151965/)
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

Javernick-Will, Amy N. (https://experts.colorado.edu/display/fisid_146430/)
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/)
Assistant Professor; PhD, University of Colorado Boulder

Krarti, Moncef (https://experts.colorado.edu/display/fisid_104154/)
Professor; PhD, University of Colorado Boulder

Kuchenrither, Richard D. (https://experts.colorado.edu/display/fisid_143039/)
Scholar in Residence, Lecturer; PhD, University of Colorado Boulder

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/)
Assistant Professor; PhD, University of Cambridge (England)

Mansfeldt, Cresten (https://experts.colorado.edu/display/fisid_165411/)
Assistant Professor; PhD, Cornell University

McKnight, Diane M. (https://experts.colorado.edu/display/fisid_110517/)
Professor; PhD, Massachusetts Institute of Technology

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/)
Senior Instructor; MS, University of Colorado Boulder

Neupauer, Roseanna M. (https://experts.colorado.edu/display/fisid_134747/)
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/)
Professor, Lecturer; PhD, University of Washington

Porter, Keith Alan (https://experts.colorado.edu/display/fisid_145182/)
Research Professor, Professor Adjoint; PhD, Stanford University

Pourahmadian, Fatemeh (https://experts.colorado.edu/display/fisid_158562/)
Assistant Professor; PhD, University of Minnesota

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/)
Professor; PhD, Massachusetts Institute of Technology

Salvinelli, Carlo (https://experts.colorado.edu/display/fisid_159846/)
Instructor; PhD, Missouri University of Science and Technology

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/)
Professor Emeritus; PhD, University of California, Davis

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

Srubar, Wil V. III (https://experts.colorado.edu/display/fisid_153058/)
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/)
Professor; PhD, Stanford University

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

Torres-Machi, Cristina (https://experts.colorado.edu/display/fisid_159884/)
Assistant Professor; PhD, Universitat Politecnica de Valencia, Spain

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/)
Instructor; PhD, Illinois Institute of Technology

William, Kaspar J.
Professor Emeritus

Xi, Yunping (https://experts.colorado.edu/display/fisid_110518/)
Professor; PhD, Northwestern University

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

AREN 5001 (3) Building Science and Engineering 1
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 or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.
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 or concurrent degree students with sub-plans C-CVEN or C-ARENCVEN.
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, or C-EVENCVEN) only.
Recommended: Prerequisite AREN 4140.
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.
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 5050 (3) Advanced Solar Design
Predicts performance and analyzes economics of low-temperature, high-temperature, photovoltaic, and other innovative solar systems. Also includes performance prediction methods for solar processes. Taught intermittently.
Requisites: Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.
Additional Information: Departmental Category: Building Systems Engineering

AREN 5060 (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.
Requisites: Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.
Grading Basis: Letter Grade
Additional Information: Departmental Category: Building Systems Engineering

AREN 5070 (3) Thermal Analysis of Buildings
Examines response factors, conduction transfer functions and weighting factors for dynamic analysis of building envelopes. Also studies radiative and convective exchange in buildings, internal gains and infiltration analysis as modeled in hourly simulations. Taught intermittently.
Requisites: Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.
Additional Information: Departmental Category: 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 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 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.
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 (3-4) 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 4110
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 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 concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.
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) 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 4540
Requisites: Restricted to graduate students or concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, C-EVENCVEN or C-EVEN) only.
Recommended: Prerequisites AREN 3540 and AREN 4550.
Additional Information: Departmental Category: Building Systems Engineering

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-).

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 5002 (minimum grade D-).
Recommended: Prerequisite AREN 3030.

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-).

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 courses of AREN 3540 and AREN 4550 (minimum grade D-).
Recommended: Prerequisite AREN 4130.

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, C-EVENCVEN or C-EVEN) 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 concurrent degree sub plans (C-AREN, C-CVEN, C-ARENCVEN, or C-EVENCVEN) only.

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, C-EVENCVEN or C-EVEN) 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