

ARCHITECTURAL ENGINEERING (AREN)

Architectural Engineering Graduate Courses

AREN 8000 ARCHITECTURAL ENGINEERING GRADUATE SEMINAR (1 credit)

Literature Review, reading and evaluation of technical publications concerned with theory and/or experimental data in various areas of Architectural Engineering, attendance at Architectural Engineering Graduate Project and Team Design presentations, preparation of the Master of Architectural Engineering graduate project proposal, assignments related to improving written and oral communication skills.

AREN 8010 GRADUATE INDIVIDUAL MASTERY PROJECT I (2 credits)

This is the first of the Graduate Individual Mastery Project two-course sequence, which requires a self-directed project that results in a professionally written report and oral presentation. Successful completion of this sequence will demonstrate a high-level of written and oral communication skills and show individual student mastery of a topic related to architectural engineering.

Prerequisite(s): AREN 8000. Not open to non-degree graduate students.

AREN 8020 GRADUATE INDIVIDUAL MASTERY PROJECT II (1 credit)

This is the second of the Graduate Individual Mastery Project two-course sequence, which requires a self-directed project that results in a professionally written report and oral presentation. Successful completion of this sequence will demonstrate a high-level of written and oral communication skills and show individual student mastery of a topic related to architectural engineering. Notes: Students are permitted to enroll in this course twice. If a passing grade is not achieved after two attempts, the AE graduate committee will consider termination of the master's program for that student.

Prerequisite(s): AREN 8010. Not open to non-degree graduate students.

AREN 8030 INTERDISCIPLINARY TEAM DESIGN PROJECT I (4 credits)

This course is the first semester of the capstone design sequence in architectural engineering. Develop and design the electrical, lighting, mechanical, and structural systems for a building, from programming through design development phase, as an interdisciplinary team effort.

Prerequisite(s): (Acoustics/Mechanical option) AREN 4150 or AE 4150, AREN 4300 or AE 4300; (Electrical/Lighting option) AREN 4250 or AE 4250, AREN 8220 or AE 8220; (Structural option) CIVE 444. Not open to non-degree graduate students.

AREN 8040 INTERDISCIPLINARY TEAM DESIGN PROJECT II (1 credit)

Develop and design the electrical/lighting, mechanical/acoustical, and structural systems for a building, through the design development phase, as an interdisciplinary team effort. This course is intended to be taken the semester following AREN 8030. AREN 8040 is the 2nd semester of the capstone design sequence in architectural engineering.

Prerequisite(s): AREN 8030. Not open to non-degree graduate students.

AREN 8050 INTERNSHIP IN ARCHITECTURAL ENGINEERING (1 credit)

This course requires participation in a full time summer internship associated with an Architectural Engineering related entity. The course includes weekly assignments and a final presentation designed to create interaction between the AE entity and the intern associated with the business side of the entity. General topics include Business Plans, Marketing, Finance and Budgets, Contacts, Legal issues and professionalism.

Prerequisite(s): Not open to non-degree graduate students.

AREN 8060 PROFESSIONAL PRACTICE AND ETHICS (2 credits)

Investigation of issues related to the integration of building design processes with professional architectural engineering practice. Aspects of building design project finance, budgets, contracts, legal issues, professional licensure and professional responsibility. The perspective of life-cycle costing. Professional ethics will be thoroughly integrated with all course topics.

Prerequisite(s): CONE 2060.

AREN 8070 ARCHITECTURAL ENGINEERING PROFESSIONAL PRACTICE II (3 credits)

Continuation of investigation of issues related to the integration of building design processes with professional architectural engineering design practice. Building design specifications, estimating, bidding, building construction contract negotiations, building design project management, project team personnel management, project risk, and key regulatory measures.

Prerequisite(s): ISMG 2060; AREN 8060 or AE 8060

AREN 8080 APPLIED EXPERIMENTAL DESIGN AND STATISTICAL ANALYSIS (3 credits)

Overview of advanced experimental design methods and statistical analysis techniques. Application of these to the planning, execution, analysis, and description of research in architectural engineering.

Prerequisite(s): STAT 3800

AREN 8090 SUSTAINABLE BUILDING DESIGN (3 credits)

Integrates building design with the principles of minimum resource use, energy conservation, and healthy indoor environments.

Prerequisite(s): CIVE 341 and (AREN 3100, AE 3100, AREN 8410 or AE 8410). Not open to non-degree graduate students.

AREN 8110 INDOOR AIR QUALITY ENGINEERING (3 credits)

Indoor air quality, codes, standards, HVAC equipment, commissioning, operation, maintenance, investigation, and remediation.

Prerequisite(s): AREN 3100 or AE 3100

AREN 8120 BUILDING CONTROL AND AUTOMATION SYSTEMS (3 credits)

Fundamental concepts of building control theory and automation. Building control: state-variable plant and closed-loop system representation, time and frequency response, stability, root-locus methods and design of building control systems. Automation: thermostats, dampers, valves, direct digital control, control of air handling units, terminal units, primary building systems, supervisory control and system optimization, communication systems, BACnet, and DDC system design and implementation.

AREN 8140 BUILDING ENERGY III: ADVANCED BUILDING ENERGY SYSTEM MODELING (3 credits)

Advanced Analysis, Modeling, Dynamics and Optimization of Building Energy Systems. Be familiar with Engineering Equation Solver (EES) Programming; Be able to build models for Air Handling Unit Systems and Vapor Compression Cycle Equipment; Be able to analyze building operating efficiency and identify faulty operating conditions; Be able to conduct retrofit energy efficiency analysis and feasibility study.

Prerequisite(s): AREN 3100 or AE 3100; AREN 4120 or AE 4120; or instructor permission.

AREN 8150 BUILDING ENERGY SIMULATION AND PERFORMANCE CONTRACTING (3 credits)

Integrated approach to deliver energy improvement retrofit projects that provide economical and ecological benefits. Proficiency in EnergyPlus or DOE-2 and in retrofit cost estimation will be attained and integrated into an engineering economic analysis. Partnering configurations, contracts, financing, and measurement and verification. Concepts applied to a practical class project.

AREN 8170 THEORY AND APPLICATION OF THERMAL SYSTEMS MEASUREMENT (3 credits)

Analysis, theory, and methods of instrumentation for thermal system energy consumption measurement and scientific research testing. Emphasis placed on sensors, transducers, and error analysis.

Prerequisite(s): STAT 8805 or equivalent.

AREN 8180 INDOOR AIR QUALITY DESIGN (3 credits)

Engineering approach to indoor air quality design. Topics include modeling and calculation methods to predict and design for acceptable indoor air quality.

Prerequisite(s): (AREN 3120 or AE 3120) and (AREN 4110, AE 4110, AREN 8110 or AE 8110)

AREN 8206 LIGHTING II: THEORY, DESIGN & APPLICATION (3 credits)

Design and analysis of lighting systems; the emphasis is on the integration between the lighting design process and the technical foundations for building lighting; topics include design criteria; lighting design procedures, lighting modes and subjective effects; calculation tools. Lab sessions include photometric measurements and computer applications. (Cross-listed with AREN 4200).

Prerequisite(s): AREN 3200 or AE 3200

AREN 8210 LIGHTING III: ADVANCED DESIGN PRACTICE (3 credits)

Design and analysis of lighting for outdoor sports, floodlighting and interior applications; economic analysis; modeling algorithms; advanced photometrics.

Prerequisite(s): AREN 8206 or AE 8206.

AREN 8220 ELECTRICAL SYSTEMS FOR BUILDINGS II (3 credits)

Power systems analysis and design, integration of electrical system components into functional, safe, and reliable power distribution systems for commercial and industrial facilities. Per Unit Analysis, Fault Analysis, Power Quality, Grounding, Overcurrent Protection Coordination, Complete power system design.

Prerequisite(s): AREN 3220 or AE 3220

AREN 8230 LIGHT SOURCES (3 credits)

Fundamental science and principles of light generation in modern electric light sources; characteristics that influence applications of light sources.

Prerequisite(s): AREN 8206 or AE 8206.

AREN 8240 LIGHTING METRICS (3 credits)**AREN 8250 DAYLIGHTING (3 credits)**

Use of natural light in building design. Solar position, sky luminance, distribution models, daylighting equipment, calculation methods, and psychological concepts. Extensive use of computer modeling and scale models.

Prerequisite(s): AREN 4200, AE 4200, AREN 8206 or AE 8206

AREN 8260 BUILDING COMMUNICATION SYSTEMS (3 credits)

Integration of voice, data and video systems into overall building design. Topics include: scalability, wireless systems; interference; project management; current industry standards and protocols.

Prerequisite(s): AREN 3220 or AE 3220. Not open to non-degree graduate students.

AREN 8280 APPLIED PHOTOVOLTAIC AND RENEWABLE ENERGY SOURCES (3 credits)

Introduction to integration of renewable energy sources in the electric grid and built environment. Study of various renewable energy sources with a focus on photovoltaic (PV) systems detailing theory of operation, design methodologies, system components, NEC requirements and simulation software for stand-alone, utility-interactive and multi-mode systems.

Prerequisite(s): AREN 8220

AREN 8306 ADVANCED NOISE CONTROL (3 credits)

Characterization of acoustic sources; use and measurement of sound power and intensity; sound-structure interaction; acoustic enclosures and barriers; muffling devices; vibration control; and active noise control. (Cross-listed with AREN 4300).

Prerequisite(s): AREN 3300 or AE 3300

AREN 8330 ADVANCED ARCHITECTURAL ACOUSTICS (3 credits)

Advanced study of the behavior of sound in rooms. Design of acoustical spaces; physical and computational modeling; measurement techniques; and introduction to sound reinforcement in rooms.

Prerequisite(s): AREN 3300 or AE 3300

AREN 8350 ELECTROACOUSTICS (3 credits)

Electrical-mechanical-acoustical circuit analogies; transducers, loudspeakers, microphones, and accelerometers; directivity; calibration techniques; and sound reinforcement systems in rooms.

AREN 8426 HEALTHCARE DESIGN AND CONSTRUCTION (3 credits)

Introduction to the design and construction of healthcare facilities. Healthcare regulations and standards, infection control, interim life safety measures, code requirements, medical equipment selection and coordination, healthcare design and construction techniques, and best practices will be addressed. Provides guidance in preparation for the Certified Healthcare Constructor credential offered by the American Healthcare Association. (Cross-listed with AREN 4420, CNST 842, CNST 442).

Prerequisite(s): Senior or graduate standing

AREN 8510 MASONRY AND TIMBER DESIGN (3 credits)

Masonry as a structural material, unreinforced masonry design, reinforced masonry design, state-of-the-art assessment methods for existing masonry structures, timber as a structural material, timber design.

Prerequisite(s): CIVE 440 and CIVE 441 or equivalents

AREN 8600 SMART BUILDING SENSORS AND PROGRAMMING (3 credits)

Principles of modeling, interfacing, and signal conditioning of sample building sensors, and acquisition and analysis of data utilizing engineering programming language such as LabVIEW and analysis of data from different types of building sensors. Overview of current sensing technology and control in buildings. (Cross-listed with AREN 4600).

Prerequisite(s): CIST 1400 or CIST 1600

AREN 8626 MEMS SENSORS DYNAMICS (3 credits)

Study of the dynamics of Microelectromechanical system (MEMS) beam-structures. Modeling principles and data analysis from different types of MEMS will be explained along with deep theoretical and experimental investigation of nonlinear MEMS dynamics. Learn to conduct experiments using state-of-the-art MEMS characterization tools. (Cross-listed with AREN 4620).

Prerequisite(s): Instructor Permission

AREN 8800 GRADUATE SEMINAR IN ARCHITECTURAL ENGINEERING AND CONSTRUCTION (1 credit)

The objectives of this course are to broaden student knowledge on engineering topics, improve presentation and professional skills, as well as learn about professional development resources available on campus. To pass the course, a student must attend a minimum of 15 Durham School Graduate Student Seminars, MAE project presentations, and/or MS/PhD thesis presentations in the College of Engineering. The student must also present one seminar within the Durham School Graduate Student Seminar series, prior to the final oral examination. All MS and PhD graduate students in architectural engineering must enroll within their first 3 semesters of matriculation.

Prerequisite(s): Not open to non-degree graduate students.

AREN 8920 INDIVIDUAL INSTRUCTION IN ARCHITECTURAL ENGINEERING (1-3 credits)

Individual instruction in Architectural Engineering at the graduate level in a selected area, under the supervision and guidance of an Architectural Engineering faculty member.

AREN 8940 SPECIAL TOPICS IN ARCHITECTURAL ENGINEERING (3 credits)

Special topics in Architectural Engineering at the graduate level that are not yet covered in other courses in the Architectural Engineering curriculum.

Prerequisite(s): Permission.

AREN 8950 INDIVIDUAL INSTRUCTION IN ARCHITECTURAL ENGINEERING (1-3 credits)

Individual instruction in Architectural Engineering at the graduate level in a selected area, under the supervision and guidance of an Architectural Engineering faculty member.

AREN 8990 MASTER'S THESIS (1-10 credits)

Masters Thesis.

Prerequisite(s): Admission to Architectural Engineering masters degree program and permission of major advisor. Not open to non-degree graduate students.

AREN 9160 BUILDING ENERGY SYSTEMS MODELING, CONTROL, AND OPTIMIZATION (3 credits)

Modeling, control and optimization of the secondary building energy systems; building envelope, room comfort zones, air handling units, cooling and heating water loops.

Prerequisite(s): AREN 4100, AE 4100, AREN 8120 or AE 8120

AREN 9180 COMPUTATIONAL FLUID DYNAMICS MODELING OF INDOOR ENVIRONMENTS (3 credits)

Application of computational fluid dynamics software to modeling of indoor environments. Topics include turbulence modeling, boundary conditions, natural and forced convection flows, species transport, and fire modeling.

Prerequisite(s): AREN 4110, AE 4110, AREN 8116 or AE 8116

AREN 9200 COLOR THEORY (3 credits)

Theories of color vision; theoretical and mathematical basis for chromaticity, color temperature, color rendering metrics, color matching functions, and color spaces; spectral weighting functions; measurement of color.

Prerequisite(s): AREN 4200, AE 4200, AREN 8206 or AE 8206

AREN 9210 CURRENT RESEARCH IN ILLUMINATING ENGINEERING (3 credits)

Examination of the most current research in illuminating engineering. Study of experimental methodologies and research practices. Analysis of technical papers from current lighting journals.

Prerequisite(s): Graduate standing and permission of instructor.

AREN 9220 BEHAVIORAL SCIENCES FOR LIGHTING RESEARCH (3 credits)

Overview of experimental design methods and statistical analysis techniques, specifically as these are applied to the planning, execution, analysis and description of lighting experiments.

AREN 9300 CURRENT TOPICS IN ARCHITECTURAL ACOUSTICS (3 credits)

A review of current topics in architectural acoustics. Subjects may include objective versus subjective measures in performance spaces, electronic enhancement of rooms, advanced computational modeling techniques, and auralization.

Prerequisite(s): AREN 8330 or AE 8330

AREN 9970 RESEARCH OTHER THAN THESIS (1-6 credits)

Supervised non-thesis research and independent study.

AREN 9980 SPECIAL TOPICS (1-3 credits)

Advanced topics in architectural engineering not covered in other 9000 level courses.

AREN 9990 DOCTORAL DISSERTATION (1-24 credits)

(1-24 credits, max 55)

Prerequisite(s): Admission to doctoral degree program and permission of supervisory committee chair