497-8mcd2018

Master Course Description for EE-497, EE-498 (ABET sheet)

Title: Engineering Entrepreneurial Capstone I, II

Credits: 4, 4

UW Course Catalog Description

Coordinator: Payman Arabshahi, Associate Professor, Electrical and Computer Engineering

Goals: This is a two course sequence supporting an in-depth industrial system design and integration experience in small teams for electrical and computer engineering seniors. Student teams design, build, verify, and validate solutions to technical challenges in a real-world project jointly mentored by faculty and industry, developing hardware, software, or joint hardware/software prototypes or products. The work involves systems engineering, project planning and management, budgeting, intellectual property generation, written and oral technical communication, as well as analysis and consideration of risk and liability, ethics, regulatory compliance, societal impacts, environmental impacts, and cost and economics.

Learning Objectives: At the end of this course, students will be able to:

1. *Propose, formulate and solve* open-ended design problems in electrical and computer engineering.
2. *Design, build, and test* an engineering artifact of significant complexity, utility, and sophistication.
3. *Write* detailed and useful formal documentation about the design process and the artifact.
4. *Make* formal oral and poster presentations of the project.
5. *Work* in small teams with heterogeneous knowledge and skills to bring the project to completion.
6. *Apply* electrical and computer engineering knowledge and skills to system design and integration.
7. *Demonstrate* an awareness of current issues related to their project subject area.
8. *Describe* the organization, planning, and leadership required to bring the project to fruition.

Textbook: Class notes, technical papers, industry reports, documentation, reference designs, and web resources.

Reference Texts:

1. H.F. Hoffman, *The Engineering Capstone Course: Fundamentals for Students and Instructors*, Springer,
2. ISBN #: 978-3319058962.
3. *System Engineering Fundamentals*, Defense Acquisition University Press, 2001. ISBN #: 978-1537703466.
4. D.D. Walden, G.J. Roedler, K.J. Forsberg, R.D. Hamelin, and T.M. Shortell, *INCOSE Systems Engineering Handbook: A Guide for System Life Cycle Processes and Activities*, Wiley, 2015. ISBN #: 978-1118999400.
5. D.J. Hatley, P. Hruschka, I.A. Pirbhai, *Process for System Architecture and Requirements Engineering*, Dorset House, 2000. ISBN #: 978-0932633415.
6. C.S. Wasson, *System Engineering Analysis, Design, and Development: Concepts, Principles, and Practices*, Wiley, 2015. ISBN #: 978-1118442265.
7. J.R. Schermerhorn Jr. and D.G. Bachrach, *Exploring Management, 6th Ed.*, Wiley, 2017. ISBN #: 978-1119403388.

Prerequisites by Topic:

1. Completion of capstone prerequisites for any other (non-entrepreneurial) EE concentration capstone.
2. Senior standing
3. EE-496 is an optional but recommended prerequisite.

Topics:

Topics are project specific. They are taught and mentored by the project's faculty mentor. They cover the process of systems engineering, plus one or more of the following technical domains:

1. Biomedical instrumentation
2. Analog and mixed-signal integrated systems
3. Sensors and devices
4. Digital VLSI
5. Embedded computing systems
6. Electromagnetics
7. Digital signal and image processing
8. Machine learning
9. Communications
10. Power systems
11. Power electronics and drives
12. Controls

Course Structure: System design problems are sought over Spring and Summer quarters from local, national, or international industry. Preliminary projects including scope and deliverables, desired student team skillsets, and required resources are identified. Industry mentors are selected, and a university-industry agreement committing both sides to the project (pending assignment of a student team) and covering intellectual property rights is signed by Fall. The projects must focus on the full system design experience, from ideation to design, build, and test, and be open-ended in nature, requiring students to consider alternatives and perform tradeoff analyses based on various criteria.

In Fall quarter, students have the option of taking a 2-credit course (EE-496, not a prerequisite for EE-497/498) on systems engineering fundamentals, fiscal management, procurement, project management, intellectual property, confidentiality, and presentation/writing skills. During this quarter companies present projects to class on the annual Capstone Pitch Day Event. Students rank order the projects, submit their resumes to faculty, and complete a questionnaire on their technical skills and personal learning objectives for the ranked projects.

Teams of 3-4 students are then assigned by faculty, matching project technical needs to student skillsets and project rankings. Companies are then informed of a team assignment, and invoiced for the project fee. All student team members sign a project agreement, covering confidentiality. Student teams will be multidisciplinary in nature. They may include members from the ECE Department, but with different areas of concentration, experience, strengths, or interests. They may also include members from other Departments in the College of Engineering. Team assignment and all paperwork will be complete by the end of Fall quarter.

Starting in Winter, assigned EE 497/498 teams meet with their industry and faculty mentors on a weekly basis, for at least one hour per week. They start with further refinement of the scope and vision of the projects, perform risk assessment and budget and cost/benefit analysis, produce a formal requirements document and undergo a systems requirements review. They then proceed with project work, prototyping, verifying, and validating an instance of their project (hardware, software, or joint hardware/software) with set milestones, a work breakdown structure, and a timeline, and undergo a number of regular reviews (conceptual design review, preliminary design review, critical design review) through the end of Spring quarter. These reviews will include PowerPoint slides, videos, and/or in-lab demonstrations.

In addition to weekly team meetings with their faculty and industry mentors, the teams meet biweekly with the faculty course coordinator and teaching assistants. These stand-up 15-30 minute meetings focus on (1) work done during the past two weeks, (2) work planned for the next two weeks, and (3) challenges and impediments that need to be resolved. On the same biweekly schedule, individual team members also perform reviews of their peers in the team; these reviews are made available to course instructors only and are meant to be used to address any personal challenges or friction in the team via later one-on-one meetings. Peer reviews are not used for grading purposes.

Throughout the project, each group maintains a secure website with all designs, reports, code, meeting minutes, and other documentation. Exercises are also assigned related to project safety (during development, and safety for the user after completion), milestones, standards and, when relevant, ethical, societal, or environmental concerns.

The two course sequence concludes at the end of Spring quarter with delivery of (1) a final written report detailing the complete system design, together with discussion of design alternatives, with hyperlinks to supporting software, data, videos, simulations and other resources, (2) a poster summarizing the final report, and (3) a full package of deliverables including the prototype or product itself, list of components, validation and verification results, detailed diagrams, flow charts, source code, mechanical drawings, and any other details necessary for prototype completion. Student teams will present the poster at the annual Capstone Showcase event at the end of Spring quarter.

Computer Resources: Depending on the topic and domain, the projects may involve embedded computers (e.g., Arduino, Raspberry Pi), FPGAs, software defined radios, or GPU computing facilities, as well as simulations and/or programming on PCs, laptops, smartphones, or tablets using software packages such as HSPICE, PSPICE, Mathcad, MATLAB, LabVIEW, TensorFlow, Caffe, or Android Studio. HSPICE, PSPICE, and MATLAB are available in all of the general purpose computing laboratories in the ECE Department. LabVIEW is available in the room 137 EE1 laboratory, integrated with hardware for data acquisition. Other packages are distributed to students as needed. Cloud computing resources such as Amazon Web Services, Google Cloud, or Microsoft Azure may also be used.

Laboratory Resources: Dedicated project space in the ECE building and Sieg Hall is provided for all project teams that require it. This includes benches, seating, storage, and power and network access. Students also have access to general purpose computing laboratories in the ECE Department, and the main electronics laboratory in room 137 with benches equipped with oscilloscopes, power supplies, function generators, digital multimeters, test leads, and computers equipped with data acquisition pods. Access to other specialized instructional or research laboratories is arranged as needed. Laboratory parts and components are available from the ECE Stores. Students often purchase components or platforms of their own choosing from local or online vendors using an online streamlined purchase approval and processing system at the Department.

Grading: Project work accounts for nearly all of the course grade. This is broken up into supporting activities (biweekly meeting attendance, peer reviews) which account for 5% of the grade; and project work (project exercises, progress reports, reviews, and final report and poster) which account for 95%. 1. Biweekly meeting attendance and performing peer reviews, 5% 2. Project exercises/assignments, 15% 3. Biweekly progress reports, 10% 4. Winter quarter review, 15% 5. Spring quarter review, 15% 6. Final report, review, and poster, 40%

Grades are assigned by groups, but adjusted based on assessment of individual contributions and individual performance. Assessment is performed in close collaboration between course instructors (faculty course coordinator, teaching assistants), and faculty mentoring the project.

At the end of EE-497, students will receive an “N” grade. Then a final grade (same grade) for both EE-497 and EE-498 will be entered upon completion of EE-498.

ABET Student Outcome Coverage: This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

(1) *An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics* **(H)** The design of systems incorporating sensing, computing, communication, control, power, electronics, signal processing, machine learning, and other systems by its very nature demands constant use of knowledge of mathematics, science and engineering. The various components of the design interact in ways based on science, and described mathematically. The design of a system to a given set of objectives is a fundamental application of engineering knowledge. Thus, a successful design shows the student's achievement of this outcome. The design problem presents itself as a series of interconnected engineering problems. In the open-ended design environment, the engineering problems are not explicitly stated, but must be identified by the design team before they can be solved. Students are expected to use software and hardware tools in their project design, testing and analysis. Evidence of following the design process, identifying and formulating the principle issues associated with the engineering problem at hand, and use of appropriate tools should appear in the project final report and progress reports (including the individual team web pages).

(2) *An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors* (**H**) The students are guided to develop specifications imposing realistic constraints on the operation of their systems. Much of this is driven by considerations of cost, safety and reliability. Other considerations include size, weight, power consumption, alignment ease, component variation, manufacturability, user interface, and user experience. Students must choose among design alternatives on the basis of these considerations. Specific consideration of safety issues and engineering design standards is required.

(3) *An ability to communicate effectively with a range of audiences* (**H**) Teams must prepare web documentation of their project, regular progress reports, a final report as well as oral presentations and a poster. Emphasis is placed upon clear descriptions of system design, build, and test steps, analysis of tradeoffs, results of verification and validation, illustrative block diagrams, industry acceptable schematic diagrams, a formal bill of materials with full component (software or hardware) sourcing, and proper discussions and references to engineering design standards.

(4) *An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact*

of engineering solutions in global, economic, environmental, and societal contexts (**M**) During team presentations, the course instructor and TA ask specific questions regarding these issues, which are incorporated in student team progress reports.

(5) *An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives* (**H**) Students operate in teams of 3-4 to solve the design problem and prepare a final report. Team members naturally tend to specialize in one aspect of the design problem, such as security analysis versus economics, creating a multi-disciplinary environment within the team. The students organize themselves and divide up the work among them.

(6) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions* (**H**) Students must devise their own experiments to test their designs and make engineering judgments based on those outcomes to redesign the system to meet specifications. This process occurs many times in the course of the design process, and is documented in the project final and progress reports.

(7) *An ability to acquire and apply new knowledge as needed, using appropriate learning strategies* (**M**) The course material distributed does not contain all of the information necessary to solve the design problem. Students must consult reference sources and inform themselves concerning many aspects of the design problem. This helps students realize that they need to be able to learn material on their own, and gives them some of the necessary skills.

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