Master Course Description for EE-448,449 (ABET sheet)

Title: Systems, Controls and Robotics Capstone-1,2

Credits: 4,4

UW Course Catalog Description

Coordinator: Sam Burden, Associate Professor, Electrical and Computer Engineering

Goals: This is an in-depth control engineering design experience in small design teams. Includes project planning and management, reporting, and technical communication. Student teams design, implement, test, and report on their project results. The course will include lectures on select topics (eg., project management, intellectual property, and some control engineering topics).

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

1. *Propose*, *formulate* and *solve* open-ended design problems in the controls and robotics area.
2. *Write* formal project reports.
3. *Make* formal project presentations.
4. *Work* in teams with heterogeneous knowledge and skills.
5. *Apply* controls engineering, computer simulation, signal processing and other Electrical Engineering knowledge and skills to a physical system to obtain a design solution.
6. *Demonstrate* an awareness of current issues in systems, controls and robotics design.

Textbook: Class notes, technical papers and reports.

Prerequisites by Topic:

1. Control system design and analysis (as in EE-447)
2. Linear systems methods (as in EE-235)
3. Computer literacy with word processing, presentation and spreadsheet software, and technical tools such as Matlab.
4. *(Desired, not required)* Exposure to embedded systems, programming (C or C++)

Topics: A few lectures are given in supplemental topics including:

1. State space systems
2. Digital control
3. Linear quadratic regulators
4. Simple optimization
5. Intellectual property protection
6. Project management

Course Structure: The class has a reserved time slot of three times per week, each consisting of 50-minute sessions. Students form teams (of 3-4), and prepare a project proposal. This is done in consultation with the Professor and TA. The proposal follows a structure provided, and includes a budget, proposed milestones, and timeline.

After project approval, students work in teams. Most weeks there are project review meetings with each team, and seminars on relevant topics during scheduled class meeting times. Approximately every third week, a progress report is presented the entire class (either with powerpoint slides, videos or in-lab demonstrations). Throughout the project, each group maintains a website with all designs, reports and other documentation. This includes exercises related to project safety (during development, and safety for the user after completion). It also includes exercises related to standards and, when relevant, ethical concerns.

At the end of the two quarter course, each group will submit a paper in standard IEEE conference paper format (with hyperlinks to supporting software, data, videos, simulations and other resources). Each group will give a one hour final presentation. There is also a poster session, where each group can present to non-class members.

Computer Resources: Most projects involve embedded computers (e.g., Arduino, Raspberry Pi), as well as simulation and/or programming on PCs, laptops or tablets. Some projects involve application programming on smart phones.

Grading: Project work accounts for the all of the course grade. Grades are assigned by groups, but adjusted based on individual performance. At the end of EE-448, students will receive an "N" grade. Then a final grade (same grade) for both EE-448 and EE-449 will be entered upon completion of EE-449.

Laboratory Resources:A dedicated lab space is provided for all project teams that require it (some use researcher labs, if they are sponsored by such labs).

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 devices incorporating robotics, control, and other systems hardware 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. Students are expected to use software and hardware tools in their project design, testing and analysis. This is reflected in student reports. 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. Evidence of this should appear in the project 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 devices. Much of this is driven by considerations of cost, safety and reliability. Students must choose among design alternatives on the basis of these considerations. Specific consideration of safety issues is required.

(3) *An ability to communicate effectively with a range of audiences* **(H)** Teams must prepare web documentation of their project, progress reports, a final report as well as oral presentations and a poster

(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 issues regarding the impact of engineering solutions in a global, economic, environmental, and societal context, and a knowledge of contemporary issues which are incorporated in student team progress reports. The projects use currently available technological components, and are directed toward innovative designs. In team interaction with the Professor and TA, these issues are discussed.

(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 three 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 something of a multi-disciplinary environment within the team.

(6) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.* **(M)** The design process has an analysis step in which the students must design and conduct experiments, and interpret the results to determine whether their design meets specifications. This process occurs many times in the course of the design process, and is documented in the project report.

(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 certain 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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