Master Course Syllabus for EE 449 (ABET sheet)

Title: Robotics & Controls Capstone

Credits: 4

UW Course Catalog Description

Substantial team-based engineering design project involving robotics. Fabrication, assembly, and test of hardware that includes sensing, actuation, and computation in a feedback loop. Consideration of realistic constraints, engineering standards, and real-world consequences. Prerequisite: EE 447. Recommended: EE 448. Offered: Fall

Coordinator: S. Burden, Associate Professor, Electrical and Computer Engineering

(Team) Faculty who are willing to teach this course:
Linda Bushnell, Blake Hannaford, Kim Ingraham, Sep Makhsous

Goals: To provide students with engineering design experience with robots including team dynamics, project management, real-world considerations, and technical communication. Student teams design, build, and test robot hardware that involves feedback in a fundamental way. Builds on background knowledge in control systems, programming, circuits, and fabrication. The final product demonstrates technical proficiency but also a nuanced understanding of ethical, societal, and environmental impacts.

Learning objectives: At the end of this course, students will be able to:
1. *Manage* a 10-week project including a timeline with many deliverables.
2. *Manage* team dynamics including roles and responsibilities, conflicts, and equitable workloads.
3. *Construct* testable hypotheses about the outcome of simulation and hardware experiments.
4. *Interpret* the result of experiments with respect to a prototype's design.
5. *Compare* candidate designs based on their technical and societal merits.
6. *Assemble* hardware and software components into a functional robot.
7. *Present* project outcomes in written and oral communication.

Textbook: None.

Prerequisite courses:
EE 447: Control Systems Analysis (4) – covers mathematical and computational techniques for analysis and synthesis of control systems.

Prerequisites by topic:
1. Can use Python to run simulations and analyze data.
2. Can mathematically and computationally model control systems in time and frequency domain.
3. Can synthesize stabilizing controllers that meet performance specifications.

Topics:

- *Project management*, including a Gantt chart detailing deliverables.
- *Product requirements*, including an assessment of the business rationale and technical feasibility.
- *Real-world constraints*, including economic, environmental, and societal.
- *Engineering standards*, including safety, environmental, communication, physical.
- *System requirements*, including mechanical, communication, control, computation, software, data, interface, and safety.
- *Prototyping*, including design, fabrication, assembly, and test.
- *Experimentation*, including hypothesis testing, outcome measures, and uncertainty.
- *Real-world consequences*, including ethics, economics, environment, and society.

Course structure: Students work in instructor-assigned teams on a quarter-long capstone design project with regular check-ins and design reviews by the instructor and/or TAs. Weekly deliverables contribute sections toward a final project report. Teams are given access to a shared lab space with tools and machines for fabrication and assembly; it is the teams' responsibility to reserve time on the lab stations to make regular progress on their project. The final product should be a robot that incorporates feedback in a fundamental way. Projects may be provided by the instructor or conceived by the teams, depending on availability of resources and team preferences. Teams document their designs on a course wiki to transfer knowledge to future course offerings.

Computer resources: Completion of projects requires knowledge of Python and word processing software, and basic fabrication techniques including 3D printing and mechanical assembly.

Laboratory resources: Tables with power outlets and a lockable cabinet for storing project materials. Tools and machines for fabrication and assembly. This course will require a technology fee to support the hardware resources.

Grading: The grade is determined from four main elements which each have sub-elements.

- Meetings and project management: 20%
  - Weekly meetings: 10%
  - Revisions to project plan: 10%
- Project Report: 40%
  - Readability: 4%
  - Team agreement: 4%
  - Product Requirements Document: 4%
  - Realistic Constraints and Engineering Standards: 4%
  - System Requirements Document: 4%
  - Outline of Experiments: 4%
  - Prototype Designs: 4%
  - Experimental Outcomes: 4%
  - Impact and Consequences: 4%
  - Conclusions and Recommendations: 4%
- Documentation on course wiki: 20%
  - Clarity: 10%
  - Completeness: 10%
- Demonstration: 20%
  - Poster: 5%
  - Questions and Answers: 5%
  - Video recording: 5%
  - Meets specifications: 5%

The Project Report elements will be assessed both formatively and summatively: they will each originally be assigned to be due during an individual week in the quarter, in which will be assessed formatively; finally, they will be due in an overall Report, in which they will be assessed summatively.

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 nature of an open-ended engineering design assignment requires the ability to apply principles learned in prior coursework to solve complex engineering problems. Specific assignments will require formulation of testable hypotheses and critical evaluation of experimental results toward the creation of a functioning prototype.

(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)

Specific course materials and assignments will require students to critically evaluate the real-world constraints and consequences of their engineering design; the results of these analyses make up several sections of the final project report.

(3) *An ability to communicate effectively with a range of audiences.* (H)

Students will be required to communicate technical concepts with teammates, instructional staff, and other stakeholders. Technical documentation will be recorded on a course wiki. A final project report includes a section explaining and justifying the product concept to a lay audience.

(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.* (H)

Specific course materials and assignments will require students to critically evaluate ethical dimensions and real-world impacts of their project designs in economic, environmental, and societal contexts.

(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 receive training on team dynamics, collaboratively draft an agreement on roles and responsibilities, assign leads on deliverables, and track progress to ensure accountability.

(6) *An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions* (H)

Specific assignments concern the design, execution, and analysis of experiments to evaluate prototype designs with the goal of making informed engineering decisions about which product to pursue.

(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 instruct 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.

Prepared By: Sam Burden
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Additional information and resources regarding teaching ECE courses (e.g., links to course repositories for materials from previous course offerings; guidelines for using AI tools in courses; syllabus language for course accommodations, etc.) can be found on the UW ECE Intranet:
https://peden.ece.uw.edu/academic-ops/