Syllabus*

EENG450AB: Systems Exploration, Engineering, and Design Laboratory

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Department of Electrical Engineering and Computer Science
Colorado School of Mines

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Syllabus

Course Info

- Class meeting schedule: 11:00AM - 12:30PM, Monday and Wednesday.
- Class location: Brown Building 304 and 305.
- Course Webpages:
  - Canvas (http://elearning.mines.edu/). All current CSM students should have a Canvas account, and students registered for this course will be automatically enrolled. Check with CCIT if you do not have a Canvas account.

Instructors

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Instructional Activity: 3 hours lab, 1 semester hours.

Course designation: Elective/Major Requirement (EE)

Course description:

This laboratory is a semester-long design and build activity centered around a challenge problem that varies from year to year. Solving this problem requires the design and prototyping of a complex system and utilizes concepts from multiple electrical engineering courses. Students work in intra-disciplinary teams, with students focusing on either embedded systems or control systems.

Objectives

Students will be able to:

- Design and debug integrated systems as an intra-disciplinary team.
- Design experiments and gather data to solve engineering problems and/or demonstrate performance of sub-systems or systems.
- Predict the performance of a designed system and verify their predictions experimentally.
- Work effectively in intra-disciplinary teams to solve engineering problems.
- Engage in reflective learning and demonstrate an ability to engage in life-long learning.

Section Specific Objectives: Embedded Systems

Students will be able to:

- Interface various kinds of sensors to a microcontroller.
- Use a microcontroller to drive and control motors.
- Implement communication between processors using wired and wireless protocols.
- Design a user interface to enable a human being to interact with their integrated system.
- Exploit built-in features within a microcontroller such as ADCs, DACs, and timers to design an efficient system.

Section Specific Objectives: Control Systems

Students will be able to:

- Use Simulink to model a dynamic system.
- Design and execute experiments to find unknown parameters describing a dynamic system.
- Design and implement a PI controller to regulate the speed of a motor.
- Design and implement a controller to steer a two wheel mobile robot.

Project Description

Your employer would like to develop an automated warehouse with small robots that will carry goods from where they are stored to where they are packed and shipped. Your team is assigned to design and build a prototype device. This prototype must be able to following the directions around the warehouse, which are given by signs. The signs include left arrows, right arrows, and stop signs. The robot should be able to detect a sign, travel towards it, and then follow the directions (turn left, turn right, or stop).

For convenience, some aspects of the design have been fixed: the motors, wheels, battery size, available sensors, and available embedded processors. However, you are free to choose all other elements of the design, including the construction of the robot frame (within the available Actobotics elements) placement of elements on the frame, and of course, all control systems, signal processing, and embedded system implementation.

Group Work

You will be working in groups to complete the activities in this lab. This is done for several reasons. Researchers have shown that students that students working in small groups tend to learn more of what is taught and retain it longer than when the same content is presented in other instructional formats. In addition, the ability to work in a diverse group is an educational objective in itself, and one of the student outcomes that we are required to measure for accreditation of the electrical engineering degree is the ability to function on multidisciplinary teams.

We will model a multidisciplinary team by having members concentration on different aspects of the system. Even though you are all electrical engineers, you will need to learn how to cooperate and communicate with team members whose expertise is different from yours.

Group Leader

Each group will select a team leader. The team leader should schedule the team meetings and ensure that all necessary objectives of the meetings are met. The team leader is also responsible for attending the SEED Lab review meetings, which are held on Friday at 11:00.

CATME

In order to assist in the formation and monitoring of the teams, we will use the CATME website. You will also be using CATME when you are in senior design. You will first fill out a team maker questionnaire with information about your background and skills. We will then use CATME to form balanced teams. Before each demonstration, you will use CATME to fill out an evaluation of your team members. This will allow us to give feedback to you as to how you are working within the group.

Work Process

Although we will be meeting in lab for 3 hours a week, it is expected that you will be working outside of lab as well to complete this course. You should plan on 1 to 3 hours of work per week outside of the designated lab hours, including time for meetings and communicating with your group members.

On Canvas, you will find a short document from the Derek Bok Center for Teaching and Learning, Harvard University, on best practices for working in groups. All students are expected to have read this document and are ready to participate in their groups once they are assigned.

Lab Availability/Office Hours

MON	TUES	WED	THURS	FRI
10:00am-11:00am Megan Office Hours **11:00am-12:30pm** SEED Lab **12:30pm-1:30pm** Yang Office Hours	Lab Not Available	**10:00am-11:00am** Megan Office Hours **11:00am-12:30pm** SEED Lab **12:30pm-1:30pm** Yang Office Hours	Lab Not Available	**11:00am-11:30pm** SEED Lab Review Meeting **11:30pm-1:30pm** Henry Office Hours

Grading Scale

Teams earn points up to the total listed in the grading scale below.

Available Points

Stage	Assignment	Points
Arduino/PI Intro	Documentation/Demo	50 points
Sim/Comm/Comp Vision	Documentation/Demo	50 points
Mini-project	Documentation/Demo	100 points
Demo 1	Documentation	150 points
	Performance	150 points
Demo 2	Documentation	100 points
	Performance	100 points
Final Demo	Documentation	100 points
	Performance	200 points
Total		1000 points

Performance Scoring

The performance will be judged in certain criteria. The score for each category is determined as follows:

- Best score in category (B): 55 points
- Other scores (S):
  - Time and distance: $\frac{B}{S} \times 50$
  - Failures: $50 - (S - B) \times 10$

Teams earn the sum over all available categories, up to the maximum listed above.

Weights for Performance Scoring

The performance score will be weighted according to the effort and contribution to the team as judged by your teammates. Each member of the team will fill out a form similar to the following.

Your name:	`Joe Smith`	
Other group members:	`John Doe`	`Mary Public`
% Effort	`40`	`60`

The information you provide will not be given out to anyone, including your other group members.

The following grid will be set up for each group:

	Joe Smith	John Doe	Mary Public
Joe Smith	x	40%	60%
John Doe	50%	x	50%
Mary Public	50%	50%	x
Total (max 110%)	100%	90%	110%
Performance Score: 140			
Weighted Score	140	126	154

In this case, one group member thought that John Doe was not pulling his weight, thus his share of the grade is lower. Notice, however, that you cannot affect your own grade. Mary Public distributed the weight evenly between her partners, but she ended up with the highest grade. Also, the weighting cannot exceed 110%.

Demos

For the challenge project, there will be three demonstrations during the semester, and the robots will be judged in each category at this time. The demonstration times will open and close as shown in the schedule at the end of the syllabus. If a group gives a demonstration at the beginning of the demonstration time, they will receive full points. The points are reduced each class period after that, with 10% reduction for one class period and 30% reduction for two class periods. For example, of the demonstration starts on a Monday, groups receive full points that day, 90% of points if they demo on Wednesday, and 70% of the points the next Monday, at which point the demonstration period will close and the team will score 0 for performance for that demo. Best scores in categories are established on the first demo day at least one team participates. (Note: this reduction does not apply to the mini-project demos, but the sooner your can finish the mini-project, the sooner you can begin the main challenge project.)

Demo Presentations

In order to participate in a demo day, the team must first qualify. This qualification includes a presentation that discusses their design, and quantifies the expected performance of the design, as if presenting to higher management in your company. Both design optimization and expected performance should be determined using well documented simulation and experiments. This presentation must convince the instructors that the groups design and implementation is robust enough that a demo is likely to result in a successful run. If groups attempt a demo and are not successful due to software or hardware failures, they can demo on another day, but their score is reduced by an additional 10%.

Performance Criteria: Demo 1

In the first demo, the robot must be able to perform certain critical tasks. Multiple runs are taken to compute the performance metrics. The tasks are

- Detect and recognize a sign. Calculate the angle required to rotate the robot in order to reach the sign by moving forward.
- Move along a semicircle of specified radius at a specified speed, stopping after a specified distance.

The performance metrics for the robot are

- Sensing 1: Number of failures to detect the correct sign.
- Sensing 2: Average error in reported angle to sign.
- Accuracy 1: Average over runs of the maximum distance the robot deviates from semicircle.
- Accuracy 2: Average error between desired and actual speed.

Performance Criteria: Demo 2

In the second demo, the robot must be able to detect a sign, move towards the sign and correctly turn right or left. Multiple runs are taken to compute the performance metrics. For this, the performance metrics for the robot are

- Sensing: Number of failures to stop and/or turn correct direction when reaching the sign.
- Speed: Average time in seconds to reach sign.
- Accuracy: Average lateral distance in inches from center of sign when the sign is reached.

Performance Criteria: Demos 3

In the third demo an additional performance metric measures the ability of the robot to be able to follow multiple signs to complete a complex path. For this demo the performance metrics are

- Measured by approaching single sign:
  - Sensing: Number of failures to stop and/or turn correct direction when reaching the sign.
  - Speed: Average time in seconds to reach sign.
  - Accuracy: Average lateral distance in inches from center of sign when the sign is reached.
- Measured upon completion of complex path:
  - Robustness: Number of restarts required before complex path is completed.
  - Speed: Time in seconds to complete path.

Documentation

The documentation score for the demos includes the following

- CATME (score for completion on catme.org).
- Reflection logs (score for completion, submitted on Canvas).
- Weekly team work log - work plan, team member obligations, problems, solutions (score for completion, presented at weekly SEED Lab review meeting).
- Presentations.

Reflection

After each demo is the time for reflection. Teams should reflect on what when right and what went wrong, and consider adjustments to the work process, or design, need for further simulation or experiments, or other adjustments as necessary. A discussion of these adjustments should show up in your team minutes. In addition, each will discuss the scores from the CATME team with the instructors. Groups may be subject to change based on the results of these ratings.

Collaboration Applications

In order to collaborate as a team, you will need to have a common area to save files, work on software, work on reports. etc. Your team should investigate and select the appropriate applications necessary. Dropbox, google drive, github, and slack, are examples of collaboration applications.

Lab and Equipment Safety

The equipment you will be working with is sensitive electronic equipment, and you are responsible for knowing the limitations and proper handling of this equipment. The equipment that you will be provided must be returned in good working condition. The team is jointly responsible for damaged equipment. An updated inventory of your teams equipment will be provided.

- When wiring external circuits and equipment to the the Arduino, care is needed to avoid damaging over-voltage or shorting conditions. You are responsible for reading and understanding the following documents:
  - http://www.ruggedcircuits.com/10-ways-to-destroy-an-arduino/
  - http://playground.arduino.cc/Main/ArduinoPinCurrentLimitations

  After studying this material, you should take the quiz on Canvas. A score above 70% is required in order to begin work in the lab.
- The robots are fairly lightweight, but the motors are strong enough to move the robot around at high speed. Take care and be aware any time you are operating the robot. Also, the motor gears are can be damaged if the motors shaft is hit (say, by dropping it) or if excessive weight is applied to the robot, or if the motors are repeatedly cycled back and forth at maximum torque.
- You will be working with batteries with significant energy storage. If the batteries are shorted, a large current can occur, causing heat and perhaps fire. Be aware of potential short circuits.
- The batteries are 6 V 2.8Ah sealed lead acid batteries. **The batteries should always be stored fully charged**. You have enough batteries that you can always be charging one battery, and you should cycle through your batteries as they become charged. If the batteries are discharged and left discharged for a period of time, the battery capacity can be diminished. Load tests have been performed on all the batteries you have been provided. If you return a battery with reduced capacity, it will be considered damaged.

Absenteeism

From the bulletin:

> Class attendance is required of all undergraduates unless the student is representing the School in an authorized activity, in which case the student will be allowed to make up any work missed. Students who miss academic work (including but not limited to exams, homework, labs) while participating in school sponsored activities must either be given the opportunity to make up this work in a reasonable period of time or be excused from such work. It is the responsibility of the student to initiate arrangements for such work. Proof of illness may be required before makeup of missed work is permitted. Excessive absence may result in a failing grade in the course. Determination of excessive absence is a departmental prerogative.
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> The Office of the Dean of Students, if properly informed, will send a notice of excused absence *of three days or more* to faculty members for (1) an absence because of illness or injury for which documentation will be required; (2) an absence because of a death in the immediate family, i.e., a spouse, child, parent, grandparent, or sibling. For excused absences the student must be provided the opportunity to make up all missed work.

Academic Honesty

The Colorado School of Mines affirms the principle that all individuals associated with the Mines academic community have a responsibility for establishing, maintaining and fostering an understanding and appreciation for academic integrity. In broad terms, this implies protecting the environment of mutual trust within which scholarly exchange occurs, supporting the ability of the faculty to fairly and effectively evaluate every student's academic achievements, and giving credence to the university's educational mission, its scholarly objectives and the substance of the degrees it

awards. The protection of academic integrity requires there to be clear and consistent standards, as well as confrontation and sanctions when individuals violate those standards. The Colorado School of Mines desires an environment free of any and all forms of academic misconduct and expects students to act with integrity at all times.

Academic misconduct is the intentional act of fraud, in which an individual seeks to claim credit for the work and efforts of another without authorization, or uses unauthorized materials or fabricated information in any academic exercise. Student Academic Misconduct arises when a student violates the principle of academic integrity. Such behavior erodes mutual trust, distorts the fair evaluation of academic achievements, violates the ethical code of behavior upon which education and scholarship rest, and undermines the credibility of the university. Because of the serious institutional and individual ramifications, student misconduct arising from violations of academic integrity is not tolerated at Mines. If a student is found to have engaged in such misconduct sanctions such as change of a grade, loss of institutional privileges, or academic suspension or dismissal may be imposed.

The complete policy is online.

Disability Support Statement:

The Colorado School of Mines is committed to ensuring the full participation of all students in its programs, including students with disabilities. If you are registered with Disability Support Services (DSS) and your instructor has received your letter of accommodations, please contact them at your earliest convenience todiscuss your needs in this course. For questions or other inquiries regarding disabilities, please visit disabilities.mines.edu for more information.

1 Schedule

This is a suggested schedule for activities in the lab. Deliverables are due at the demonstrations shown in red, but the rest of the schedule is flexible.