MAE 3780/3783 Mechatronics
Spring 2024

Description: Mechatronics sits at the intersection of mechanical and electrical engineering. Many modern mechanical systems (e.g. vehicles) includes embedded electronics and microcontrollers. This course introduces students to mechatronic systems with a hands-on focus on circuits that interact with the physical world via sensors and actuators. Students will learn the underlying theory behind circuit behavior along with extensive circuit prototyping and debugging. The course will culminate in the design, fabrication, and programming of a mechatronic system, a robot, that will compete in head-to-head competition with other robots.

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Time and Location:
Lectures:

Mon, Wed, Fri	11:15 AM – 12:05 PM	Hollister Hall B14

Lab sections:

Monday	2:30 – 4:25 PM	Upson 264
Tuesday	12:20 – 2:15 PM	Upson 264
Tuesday	2:30 – 4:25 PM	Upson 264
Wednesday	12:20 – 2:15 PM	Upson 264
Wednesday	2:30 – 4:25 PM	Upson 264
Thursday	12:20 – 2:15 PM	Upson 264
Thursday	2:30 – 4:25 PM	Upson 264
Friday	12:20 – 2:15 PM	Upson 264
Friday	2:30 – 4:25 PM	Upson 264

Important Dates:

Prelim Exam	March 19th, 7:30 PM	Uris Hall, G01
Robot Competition	May 3rd, 9:30 AM	Duffield Atrium

Prerequisites: MATH 2930 and PHYS 2213. Knowledge of basic programming, ordinary differential equations and linear algebra is expected.

Required technology: Students in the class must have access to a computer (for programming an Arduino, downloading files from the oscilloscope, working with TinkerCad) and a camera (for taking photos and videos of circuits). We will be using pollEverywhere in class so students will need either a laptop or a smartphone to participate. Students must have a way to upload these photos and videos to the course Canvas site.

Students who do not have access to a computer and/or camera, should contact Prof. Nunez ASAP so that we can find a solution.

Expectations:
- Engineering solves world problems by using technology creatively. We invite and expect every student to contribute creatively as part of their learning process.
- Success in engineering depends critically on teamwork. We invite and expect every student to engage in constructive discourse, to bring their perspective, and to be accepting of others' opinions.
- Degrading, abusing, harassing, silencing, or dismissing others in the process is not acceptable behavior. It is also bad engineering.
- We expect all students to strictly adhere to university guidelines regarding COVID-19 protocols.

Accommodations:
- **Disability:** If you require accommodation for a disability, contact Student Disability Services as soon as possible so we can make arrangements.
- **Personal Emergencies:** For a serious personal emergency (illness/hospitalization, death in the family, etc.) that will affect your ability to attend class or complete work on time, please contact Engineering Advising via email (adv engineering@cornell.edu), phone (607-255-7414), or in person (180 Rhodes Hall). They will help you develop a plan and will formally contact faculty on your behalf with a "Request for Academic Consideration."
- **Mental health:** If you are struggling with mental health issues, please reach out to Cornell CAPS. There is also a link summarizing available resources on the Canvas site. Prof. Nunez is happy to talk about mental health issues in academia and engineering but she is not a trained mental health professional.

Academic integrity: Students are expected to follow Cornell's Code of Academic Integrity which can be found at http://theuniversityfaculty.cornell.edu/academic-integrity/code-of-academic-integrity/. The purpose of this code is to provide for an honest and fair academic environment. As such, it should be clear to students what is expected of them in the course (see the collaboration policy), and in case of doubt, students should ask Prof. Nunez. Copying work, allowing others to copy work, submitting work as someone else, or asking someone to submit work as someone else are considered violations of Cornell's code.

For fairness to all students and to discourage inappropriate behavior, violations of the code related to any homework, assignment or quiz, will result in an automatic zero. In addition, at the discretion of Prof. Nunez, violators will be prosecuted.

Course content
Topics:
- **Circuits:** Kirchoff's laws, mesh and mode analysis, passive elements (resistors, capacitors, inductors), voltage and current sources, transient response of first and second order circuits, frequency response, filters, operational amplifiers, transistors, H-bridge motor controllers, DC motors, servo motors, sensors, analog to digital conversion, logic gates

- **Microcontrollers (Arduino):** basic operation, power, introduction to programming in C, inputs and outputs, registers, interrupts, timers
- **Laboratory skills:** circuit prototyping with breadboards, measurement tools (multimeter and oscilloscope), troubleshooting and debugging, reading datasheets

References:
- **Recommended (not required) textbook:** Rizzoni, G., Principles and Applications of Electrical Engineering, 5th Edition, McGraw-Hill, 2003.
- Schwarz, S.E., and Oldham, W.G., Electrical Engineering an introduction, 2nd Edition, Oxford University Press, 1993.
- Free online book: Practical Electronics for Inventors (link on Canvas)

Hands-on activities

Creating mechatronic systems requires hands-on practice; in this course students will gain this experience through three different types of activities:
- **Individual kits:** All students will receive a kit that will be used for individual, hands-on homework assignments. Note that several items from the kit must be returned after the semester is done.
- **Labs:** Students will work in groups of two to perform four labs during the semester. To do a lab, students must come prepared by completing the pre-lab assignment.
   1. **Introduction to Instrumentation**. Students will become familiar with the electronic proto- typing boards, simple measurements and digital oscilloscopes.
   2. **Debugging circuits**. Students will gain experience debugging circuits that are not behaving as expected.
   3. **H-Bridge and DC motor**. Students will build a circuit that can control the speed and direction of a DC motor using an H-bridge and an Arduino.
   4. **Working with sonar sensor**. Students will write Arduino code to use the sonar sensor, a range sensor, and analyze its performance under different conditions.
- Robot competition: Students will work in groups of three to compete in the Cube Craze robot competition that will take place on (nearly) the last day of class (May 3).

Communication

Course website: Through the Cornell Canvas site http://www.canvas.cornell.edu. In case of a conflict between the syllabus and the course website, students should follow the information on the website.

The course website will be used to post course material, lecture notes, homework and lab assignments, solutions, grades and announcements. It is the responsibility of the students to check the website frequently.

Office hours: Office hours will take place in Upson 264; times will be posted on Canvas. Weeks that do not have a scheduled lab, lab time will be used as extra office hours.

Ed discussion: Students are highly encouraged to post questions and answers on the course Ed discussion site, which is accessible through the "Ed discussion" link on the canvas site. The site will be monitored daily by the course staff. Students are expected to communicate in a professional manner.

Email communication: Non-technical questions or concerns only. To facilitate email communication between students and Prof. Nunez and TAs, professional email etiquette is necessary to elicit useful replies. The following guidelines improve student's chances of receiving a helpful response:
- The subject of the email should contain the course number and a short description of the content of the email. Writing MAE3780 in the subject ensures the email goes through the right filter and will receive the proper attention.

- The email should be formally addressed, with the proper title (e.g. Prof. Nunez), to the person the email is intended to, and it should be signed with the sender's full name. This way your email is less likely to be mistaken for a mass-email or for spam.
- The body of the email should be grammatically correct, use full sentences and be succinct. Emails are often misunderstood, so taking the time to clarify your intent will increase the chances of getting a helpful reply.

All technical questions must be posted on Ed discussion. The course Ed discussion will be monitored daily. Technical questions sent via email to the professor or the TAs will not be answered. The rationale for this policy is to streamline help given to students; if a student has a question, chances are other students could benefit from the question and answer. Furthermore, posting centrally allows the course staff to answer in a timely manner.

Grading

PollEverywhere assignments	10%
Homework	20%
Labs	20%
Prelim	20%
Final project	30%

PollEverywhere: PollEverywhere will be used during lectures for in-class assignments.

Multiple questions will be asked in class. Each question will be graded; 2 points for a correct answer, 1 point for an incorrect answer and 0 points for no answer. The worst 5% of answers will be dropped for the final grade.

Homework assignments: Homework assignments will include written answers and circuit building and analysis using kit components. They are due at 11:00 PM (Ithaca time) on the given due date (typically on Friday). Assignments will be uploaded to Gradescope (the login is through the Canvas site).

Labs: In order to get a grade in the class, students must complete all 4 labs. To participate in a lab students must show up on time with a completed prelab assignment. Student will not be allowed to participate in a lab if they are more than 15 minutes late OR they have not completed the prelab assignment.

Makeup labs: The process for making up a lab is:
1. Student notifies the lab section's TAs that they cannot attend as soon as possible but no later than 24 hours before the lab section.
2. If there is an available slot in another section the TAs will notify the student so that the lab can be done in the same week.
3. If there are no available slots, the student will make up the lab in one of the lab makeup sessions: TBD.

Prelim: There will be one prelim in this class, on March 19. A study guide will be posted on Canvas several weeks before the exam.

Grading Flexibility/Accommodations: It is understandable that things come up during a busy semester, such as illness, interviews, other course deadlines, project team/club/athletic travel, personal challenges, etc. The following is a list of grading accommodations that you can use to flexibly support your work in this course:
- *PollEverywhere/Class participation:* The worst 5% of answers will be dropped for the final grade – this will include non-answers for absences.
- *Assignment slip days:* Individual assignments (~6 during the semester) are typically due Fridays at 11pm. Each student will get a total of **TBD slip days** for these assignments, each of which allows a 24 hour, no-cost delay in submitting. No more than 2 slip days per

assignment can be used, as we will typically post solutions and grades within a week of the due date.

- *Assignment due times:* Individual assignments are typically **due Fridays at 11pm**; Gradescope will mark as late (or use of a slip day) any assignment after 11:59pm. Due times with slip days are 24hrs after the original due day/time (i.e. 11pm Sat or Sun).
- *Lab report slip days:* Each lab group will get a total of **TBD slip days** for lab reports. Please work together in groups to decide how to use these. No more than 2 slip days per lab can be used.

Collaboration policy: The following describes what students are encouraged to do and what is not allowed. Violations of this policy are considered violations of academic integrity.

- **PollEverywhere assignments:** Some assignments will be individual (typically at the beginning of class, covering prior material) and some will be collaborative. Prof. Nunez will let you know which is which.
- **Homework:** Students are encouraged to work together on homework in order to enhance learning. Discussing the problem, talking about the steps that need to be taken, giving and receiving guidance are all permitted. Rote copying of solutions (from any source) is not allowed. You will be asked to name all collaborators and all sources on each homework.
- **Labs:** Pre-lab assignments have the same collaboration rules as the homework - discussion is encouraged, copying is forbidden. Labs will be done in pairs - write-ups and final reports will be group efforts. All students in the group are expected to contribute to each report.
- **Prelim:** No collaboration is permitted.
- **Final project:** Details regarding collaboration on the project will be provided with the project description document.