Sample Syllabus

ME 454
MECHATRONICS
COURSE SYLLABUS
Fall 2024

Lectures, labs and office hours are by default held in-person by the instructor or TAs unless otherwise noted.

Lectures: Delivered *in person* **M/W** 1:25 PM – 2:15 PM in room 101 Thomas

Instructor: Dr. Chris Rahn, 301C Reber Bldg., cdr10@psu.edu
Office Hours*:* **M/W** 2:30 PM – 3:30 PM or by appointment. We'll meet at the front desk of the classroom and, depending on the number of people and type of questions, we may need to move to Reber/Zoom.

Course TA: Eric Jurado (exj5139@psu.edu), Office hours: **F** 12 – 2, 339 Reber.

Labs: Held in 339 Reber starting the first week of class.

Section 1: **Tu** 08:00 AM - 9:55 AM
Lab TA: Aneesh Batchu (abb6486@psu.edu), Office hours: **Tu** 10 – 11
(alternate TA: Alex Sakal)

Section 2: **Tu** 11:15 AM - 01:10 PM
Lab TA: Zach Jester (zpj1@psu.edu), Office hours: **Tu** 2 – 3
(alternate TA: Alex Sakal)

Section 3: **Tu** 03:35 PM - 05:30 PM
Lab TA: Alex Sakal (ams9454@psu.edu), Office hours: **Tu** 6 – 7
(alternate TA: Aneesh Batchu)

Section 4: **Th** 08:00 AM - 9:55 AM
Lab TA: Ali Zaman (mjz5532@psu.edu), Office hours: **Th** 10 – 11
(alternate TA: Alex Sakal)

Section 5: **Th** 11:15 AM - 01:10 PM
Lab TA: Shashank Vyas (sbv5192@psu.edu), Office hours: **Th** 2 – 3
(alternate TA: Alex Sakal)

Section 6: **Th** 3:35 PM - 05:30 PM
Lab TA: Finn Beck (fhb5024@psu.edu), Office hours: **Th** 6 – 7
(alternate TA: Alex Sakal)

All sections and office hours are held in person in 339 Reber. Access to the room is only possible with coordination with the teaching assistants or the professor. For lab computer access, you want to make sure that you have an ME account.

Where to go if you have questions:
For lab related (including grading) questions, please contact your lab TA. For lecture, homework, and quiz questions, please contact the course TA. The TAs' office hours are held in the lab, 339 Reber, unless otherwise indicated. If they cannot answer your question, please contact Dr. Rahn.

Prerequisite: ME 348 (previously ME 345). Failure to meet the prerequisites may result in automatic removal from the course, so students in violation of this must carefully coordinate with the course professor during the registration process.

Course Topics: This class introduces the electrical and mechanical building blocks of a mechatronic system (e.g., passive electrical components, transistors, logic gates, microcomputers, sensors and motors), how to interface these analog or digital devices, the computer logics and theories for controlling mechatronic systems, and techniques for data acquisition and data analysis.

A core goal of the course is to train students on how to communicate complex systems concepts in a clear, verifiable, and general manner. Thus, the class includes graded items that develop and exercise written and oral communication skills.

This class has one module per week, with 2 lectures per module, and 10 labs. Later in the semester, the labs become more difficult and so some labs will cover multiple weeks. See the detailed course schedule and topics on the last page of the syllabus.

Course Objectives:
The following are the list of the course objectives, along with the associated level of the Bloom's learning taxonomy.

CLO	Detail	Bloom's Level
CLO #1	By the end of this course, students will be able to program an Arduino microcontroller to: keep time, do basic computations, read sensors, produce data, and change the system's behavior.	Apply
CLO #2	By the end of this course, students will be able to select among common circuits and circuit components used in mechatronics and modify and/or design these circuits or layout of circuit components to meet a given purpose,	Create
CLO #3	By the end of this course, students will be able to debug broken mechatronic systems and demonstrate this skill by modifying broken systems to make them operational.	Create

CLO #4	By the end of this course, students will be able to critique and decide between common communication protocols and data representation formats to move data to/from mechatronic devices.	Evaluate
CLO #5	By the end of this course, students will be able to redesign code or mechatronic hardware to isolate functionality, improve function, modify function, or develop new functionality.	Create
CLO #6	By the end of this course, students will be able to present their mechatronic systems to others using system-level descriptions and via verbal, written, and electronic delivery of their results.	Apply
CLO #7	By the end of this course, students will be able to integrate mechatronics concepts into their daily lives by evaluating historical, cultural, and technological trends within the context of course content, and have changed their behavior to reflect their understanding of the content.	Create

Prerequisite Knowledge: Each student should remember primarily two things:

1) The basic constructs of programming in any engineering-use language (e.g., MATLAB or C language and/or Arduino programming language). On entry to the course, students should be able to correctly code an *if/then/else* statement or *for/do* loop and understand when and how to create functions. The course will review these concepts and build upon them significantly.
2) The basics of circuitry topics covered in ME 348, specifically Ohm's law, low-pass and high-pass filters (passive form), and the basic KVL and KCL methods of circuit analysis.

Most assignments will require the use of MATLAB, so knowledge of this software is beneficial but not expected. For students who are not familiar with this software, extensive tutorials are provided, and available for your personal computers (it's free as well in some cases). It is very beneficial for students to have this software installed on their own laptops or have easy access to this software for homework, labs, and quizzes.

Textbook: There is no textbook for this course; however, students are required to purchase a lab kit:

Penn State Mechanical Engineering ETM Kit:
https://www.pitsco.com/Penn-State-Mechanical-Engineering-ETM-Kit
International order support: isales@pitsco.com

Above is the link where students can order Arduino hardware kits for this class. Further instructions are included on CANVAS. The "ETM kit" should include everything students need for ME 348, 454, and sometimes 340 depending on the instructor. There is no need to purchase a new hardware kit if you still have your kit from ME 348.

Important note: Students will need to enter shipping info as part of the order form but ALL KITS will be shipped to Reber regardless of the address they enter. Pitsco will send us weekly lists of the students who have placed an order and then we can check them off as they pick them up. The ME Toolbox office in the basement will serve as the pick-up location.

After this course, the students are free to sell the kits to future students of this course, similar to textbooks, assuming the kits are in good condition.

For those that really want a textbook for a reference, the following books are suggested:

1. David G. Alciatore and Michael Histand. *Introduction to Mechatronics and Measurement Systems, 2nd Edition.* McGraw-Hill, Boston, 2003. (Good starter undergrad book, nice discussion of semiconductor electronics).
2. Robert H. Bishop. *The Mechatronics Handbook*, CRC Press, 2002.
3. Horowitz, P., Hill, W., *The Art of Electronics, 2nd ed.*, Cambridge University Press, New York, 1989. (This is the de-facto standard book on electronics, and one everyone should own if they plan to do extended work in this area)
4. D.M. Kaplan and C.G. White. *Hands-On Electronics*, Cambridge University Press, 2003
5. Takashi Kenjo and S. Nagamori. Permanent-Magnet and Brushless DC Motors (Monographs in Electrical and Electronic Engineering) (Very good book on DC motors)
6. Bolton, W., *Mechatronics: Electronic Control Systems in Mechanical Engineering*, Addison Wesley Longman, Edinburgh Gate, England, 1995.
7. Tamal Bose, *Digital Signal and Image Processing.* Wiley Interscience, 2004.
8. Charles Fraser and John Milne, *Electro-Mechanical Engineering, An Integrated Approach.* IEEE Press, New York. (This book is a general overview of mechatronics, and has a great discussion of electrical motors)
9. Ganssle, Jack. *The Art of Designing Embedded Systems, 2nd ed.* Newnes / Elsevier. Amsterdam. 2008.

Grading:

• 2 exams on lecture materials (15% each) – *Individual Effort*	30%
• 1 exam on practicum - lab materials (15%) – *Individual Effort*	15%
• 10 Labs (3.5% each) – *Team Effort*	35%
• Quizzes – *Individual Effort*	10%
• 11 Homework Assignments) – *Team Effort*	5%
• Class Participation (Top Hat) – *Team Effort*	5%

Notes: Grades in this class follow the "thirds" rule of percentages: A is 100 to 93.33, A- is 93.33 to 90. B+ is 86.67 to 90, etc. This matches how cumulative GPA is calculated. Requests for regrading must be done within one week after the graded assignment has been returned.

Lecture details:
Lectures include in person sessions on Mondays and Wednesdays. Lectures are organized into 12 modules (See course schedule) and primarily help students with homework and exam questions. Class participation will be conducted through Top Hat software which you should signup using your psu email address be able to access through an electronic device (smartphone, laptop, etc.) that you bring to class. To participate in class polls, access Top Hat through the link on the Mechatronics Canvas page. I will drop the four lowest Top Hat scores to accommodate students who need to miss class due to illness, interviews, etc.

Homework Assignments:
There is usually one homework assignment for each module, and thus approximately one assignment per week. You can work with other students on your homework, but you must submit an individual assignment unless otherwise specified. Students submit homework online through Canvas entries. *No late homework will be accepted*.

Exams:
There will be a total of three exams that will be conducted during your lab section time in 339 Reber (See the course schedule for the exam weeks). The first two exams will be based on material from the lectures, homework and any assigned reading or video lectures, with a particular focus on lecture topics. All exams will be closed-book, closed-notes.

The third exam in the class is a practical exam that covers lab content. This exam tests the student's ability to recognize and debug common Mechatronic problems – both in hardware and in code, where "common" refers to standard challenges that students face in each of the labs. So, it is best if all lab partners know how to do the labs completely, and *it is not advisable to separate lab responsibilities* into "one person codes, and the other does hardware or writing." Teams that have split work in the past have resulted in one or both students doing very poorly on the third exam. The third exam will be offered during the scheduled lab sessions in the last two weeks of class, weeks 14 and 15.

Makeup exams will only be arranged for students with valid excuses provided at least one class period before the scheduled exam. If you have a valid conflict, please let your TA know as soon as possible.

Lab Details:
There are a total of 10 labs. Please attend your scheduled lab sessions as we expect that you will be able to complete the bulk of lab activities at this time. If you wish, you can work on the labs both inside and outside the scheduled lab sessions.
NOTE: Some labs have prelabs that are due before each lab; see course schedule below.

Labs are based on team effort with each team having 2 or 3 students
Previous offerings of this course with a smaller class size indicate that students from team of 2 significantly outperform students from teams of 3 on the lab examination exam at the end of semester.

Lab Checkoffs (via videos or by TA at scheduled lab sessions), checkoff items are detailed in the lab instructions. The TA will checkoff your work to make sure, for example, that you don't fry something when you plug it in.

Lab Reports are due at 11:59 PM Monday for Tuesday lab sections and 11:59 PM on Wednesday for Thursday lab sections, the week after the lab. These should be submitted through Canvas upload, with one submission for each lab team. Canvas only allows one deadline so TAs for Thursday lab sections will remove "Late" penalties for students in those sections (if they submit before 11:49 PM on Weds).

Both partners are expected to participate in and be able to demonstrate and individually complete, if needed, all lab work. The breakdown of responsibilities is up to lab partners (see lab teaming process below), but all students will be tested on lab content in the third exam. A lab check-off is assumed to cover all students in a lab group, but each individual may be questioned on specific items by the TA or instructor. These questions, as part of the in-lab sessions, determine grades for the entire lab group.

Lab Teaming Process:
1) Self teaming: please try to find your teammates on your own and create lab groups on Canvas before 11:59 PM Wednesday (of the first week). Go to People -> Lab Section#
Name your group using the following format:
Section#_Station#_LastName1-LastName2-LastName3,
In alphabetical order by last name.

For example, Section2_Station3_Alejandro-Smith-Zhang

2) **TA-assisted teaming**: for those who need TA's assistance for the teaming, please notify the TA of your session before 11:59pm Wednesday of the first week of class. We expect to finalize all teams before Friday of first week of the semester so that lab teams are clearly established by the second week.

Teamwork process for all labs and any (rare) team-based homework assignments:
Before meeting in teams to work on the labs together, every student **must** make a significant attempt to solve every problem/tasks on their own. To confirm that this was done, **the *leader* will receive each team member's written work (prelabs) from their individual attempts and append this to the uploaded PDF, following the team's final answers**.

In accomplishing each homework or lab, each team should assign a *leader* and the rest of the team member(s) will be the *checker(s)*. These roles will rotate among team members on each lab.

Leader – The leader will make sure that all team members have their responsibilities and assign problems, tasks and solutions. The leader will also prepare the team's final answers. Once all other team members are satisfied with them, the leader will submit these as a PDF to Canvas by the due date, with a cover page. To make logistics easier for the graders, ***only the leader should upload the team's final document to Canvas.***

Checker(s) – The checker(s) will check the answers for accuracy and proper formatting before the assignments are handed in. A team with 3 students will have 2 checkers.

Every lab report will be submitted with a cover page listing all participating team members and their designated roles. If a team member does not participate, then that person's name should not appear on the cover page. Students who are not participating in team submissions will have to complete labs on their own (for example, if they are absent during the lab session).

Lab Basics:

1. The lab is open whenever Reber Building is open and the TAs are there. While each semester seems to improve our efficiency in presenting the labs, on average you will need 1 to 4 hours per week to complete the lab portions of the class. Each lab team will be assigned a lab station for the duration of the semester. Keep your lab station clean - cleaning products will always be available for this purpose. There are significant amounts of TA hours for you to attend the labs outside of your assigned lab time, but we are designing the labs with the intent that you can complete them within the allotted time.
2. NO smoking, eating or drinking in the lab. Violation of this policy will result in a 1/3 lab assignment grade reduction for each violation. One reason liquids are not allowed in the lab is that each computer station costs around $2000, plus another $500 worth of someone's time to set it up properly.
3. Wash your hands after lab. Wiring and electronics have historically been a large source for mercury and lead contamination. For mechatronics students, lead or mercury poisoning almost exclusively occurs due to students putting items in their mouth – food, tools, pens/pencils, fingers, etc. – without washing hands after handling electronics.
4. Do not remove any manuals, hardware or software from the lab without explicit permission of the TA. Electronics and hardware designated for ME 454 stock should not be carried outside the lab nor used for any outside research projects. Such activity is a violation of several financial rules that Penn State uses to fund the lab, and thus violation of this rule can result in loss of financial support for the lab equipment and project work.
5. Only students registered for ME 454 should be in the lab, due to safety/training requirements.
6. Backup all your work. We assume no responsibility for hard disk failures, lost USB drives, or viruses.
7. You are responsible for the tools, hardware and manuals at your workstation. They have been marked corresponding to stations and will be checked at the end of the semester. Please help us ensure that next semester's class has an equally well-equipped place to work. Your grade will be docked by one letter grade for each $50 worth of equipment that is missing.

Questions: Please feel free to ask questions before, during, or after class, since this saves E-mail exchanges, scheduled meetings, etc. E-mail works as well, and if the question is good, the TA or the professors will CC the entire class.

But one request: include a hypothesis. In other words, don't simply ask "What do I do here?" or "What do you mean?" or "I don't understand…". Instead, write, "I think you mean X here, is this correct?" or, "I think I should do Y, right?" A good question is one where we can reply with a yes or no answer (or a number), since this shows that students made a sincere attempt to

summarize both the material, and what type of answer you want. This question format also works well for professional work emails.

Finally, the homework is meant to challenge students, but please don't spend excessive amounts of time on minor issues, especially on a software issue. If you or your team aren't getting anywhere after a reasonable effort (20-30 minutes is a reasonable amount of time to work on a problem section), please just ask!

Policy on Cheating:
Standard (required) statement: (see https://senate.psu.edu/faculty/syllabus-statement-examples/#academicintegrity)
Academic integrity is the pursuit of scholarly activity in an open, honest and responsible manner. Academic integrity is a basic guiding principle for all academic activity at The Pennsylvania State University, and all members of the University community are expected to act in accordance with this principle. Consistent with this expectation, the University's Code of Conduct states that all students should act with personal integrity, respect other students' dignity, rights and property, and help create and maintain an environment in which all can succeed through the fruits of their efforts. Academic integrity includes a commitment by all members of the University community not to engage in or tolerate acts of falsification, misrepresentation or deception. Such acts of dishonesty violate the fundamental ethical principles of the University community and compromise the worth of work completed by others.

For this class: I want you to teach each other, but not give solutions to each other. Students are free to discuss homework problems and lab tasks within teams, but they should make sufficient individual efforts prior to discussion and teamwork. Discussions are also allowed across teams; however, each team should develop their solutions independently. When looking at solutions, the person grading can clearly tell that the work of two different teams is the same, then cheating has occurred. Where cheating is evident, all students/teams will receive a 0 for the assignment at the first warning, a letter grade deduction for the class plus a zero for the assignment on second warning, and dismissal from the class on the third warning. The second warning and third warnings will be processed as academic integrity violations per PSU policy above.

Students with Disabilities:
Standard required statement: (https://senate.psu.edu/faculty/syllabus-requirements/#disability)
Penn State welcomes students with disabilities into the University's educational programs. Every Penn State campus has an office for students with disabilities. Student Disability Resources (SDR) website provides contact information for every Penn State campus (http://equity.psu.edu/sdr/disability-coordinator). For further information, please visit Student Disability Resources website (http://equity.psu.edu/student-disability-resources/).

In order to receive consideration for reasonable accommodations, you must contact the appropriate disability services office at the campus where you are officially enrolled, participate in an intake interview, and provide documentation: See documentation guidelines (http://equity.psu.edu/sdr/guidelines). If the documentation supports your request for reasonable accommodations, your campus disability services office will provide you with an accommodation letter. Please share this letter with your instructors and discuss the

accommodations with them as early as possible. You must follow this process for every semester that you request accommodations.

For this class: Please know that my goal is to help you succeed in learning the material, however we can make this happen. Please let me know how to do this for you!

Psychological Services: (see https://senate.psu.edu/faculty/syllabus-statement-examples/#caps)
Many students at Penn State face personal challenges or have psychological needs that may interfere with their academic progress, social development, or emotional wellbeing. The university offers a variety of confidential services to help you through difficult times, including individual and group counseling, crisis intervention, consultations, online chats, and mental health screenings. These services are provided by staff who welcome all students and embrace a philosophy respectful of clients' cultural and religious backgrounds, and sensitive to differences in race, ability, gender identity and sexual orientation.

Counseling and Psychological Services at University Park (CAPS)
(http://studentaffairs.psu.edu/counseling/): 814-863-0395

Counseling and Psychological Services at Commonwealth Campuses
(https://senate.psu.edu/faculty/counseling-services-at-commonwealth-campuses/)

Penn State Crisis Line (24 hours/7 days/week): 877-229-6400
Crisis Text Line (24 hours/7 days/week): Text LIONS to 741741

Educational Equity and Bias: (see https://senate.psu.edu/faculty/syllabus-statement-examples/#reportbias)
Penn State takes great pride to foster a diverse and inclusive environment for students, faculty, and staff. Acts of intolerance, discrimination, or harassment due to age, ancestry, color, disability, gender, gender identity, national origin, race, religious belief, sexual orientation, or veteran status are not tolerated and can be reported through Educational Equity via the Report Bias webpage (http://equity.psu.edu/reportbias/).

Tentative Course Schedule:
The following course schedule includes the planned modules for lecture and lab sequences and the associated dates. This will form the basis for this semester's activity; however, modifications are always being made to the content, and so it may occur that the content in some places will drift away from this schedule, particularly for the last few lectures where new content and topics are often tested as time permits. I will update the syllabus during the semester as required.

Date		Topics and Labs	Major Assignments Due
19-Aug	Mon	Pre-ordering begins (Module 00)	
26-Aug	Mon	Module 00: Syllabus, Safety, Code Basics	
27-Aug	Tue	**Lab 00: Prelab activity - safety, grouping, grading, hardware kits and lab basics**	
28-Aug	Wed	Module 01: Time, Analog, & Digital Measurements	
2-Sep	Mon	**LABOR DAY - NO CLASS**	Prelab 01 due
3-Sep	Tue	**Lab 01: Measuring Time**	
4-Sep	Wed	Module 01: Time, Analog, & Digital Measurements	HW 01 due F
9-Sep	Mon	Module 02: Computer Logic	Lab 01 due
10-Sep	Tue	**Lab 02: Binary Addition with Logic Circuit**	
11-Sep	Wed	Module 02: Computer Logic	HW 02 due F
16-Sep	Mon	Module 03: System Interfacing	Lab 02 due
17-Sep	Tue	**Lab 03: Etch-a-Sketch - Arduino-MATLAB Interface**	
18-Sep	Wed	Module 03: System Interfacing	HW 03 due F
23-Sep	Mon	Module 04 -- Analog and Digital Actuation	Lab 03 due
24-Sep	Tue	**Lab 04: Encoders - Interrupts and Quadrature**	
25-Sep	Wed	Module 04 -- Analog and Digital Actuation	HW 04 due F
30-Sep	Mon	Module 05: Signal Filtering	Prelab 05 and Lab 04 due
1-Oct	Tue	**Lab 05: Signal Filtering - Analog Input and Digital Filters**	
2-Oct	Wed	Module 05: Signal Filtering	HW 05 due F
7-Oct	Mon	Module 06: Servos and DC Motors	
8-Oct	Tue	**EXAM 1 - No Lab**	
9-Oct	Wed	Module 06: Servos and DC Motors	HW 06 due F
14-Oct	Mon	Module 07: Brushless and Stepper Motors	Lab 05 due
15-Oct	Tue	**Lab 06: Servos - Hobby Servo Position Control**	
16-Oct	Wed	Module 07: Brushless and Stepper Motors	HW 07 due F
21-Oct	Mon	Module 08: Sensors	Lab 06 due
22-Oct	Tue	**Lab 07: DC motors - Motor Drive Electronics**	
23-Oct	Wed	Module 08: Sensors	HW 08 due F
28-Oct	Mon	No Class - MECC Conference	Lab 07 due
29-Oct	Tue	**Lab 08: RedBot - Introduction**	
30-Oct	Wed	No Class - MECC Conference	HW 09 due F
4-Nov	Mon	Module 09: PID Control	Lab 08 due
5-Nov	Tue	**Lab 09: RedBot - Emergency Braking and Parking**	
6-Nov	Wed	Module 09: PID Control	HW 09 due F
11-Nov	Mon	Module 10: Serial Communication	Lab 09 due
12-Nov	Tue	**Lab 10: RedBot - Wall Following**	
13-Nov	Wed	Module 10: Serial Communication	HW 10 due F
18-Nov	Mon	Module 11: Data Science and AI	
19-Nov	Tue	**Lab 10: RedBot - Wall Following**	
20-Nov	Wed	Module 11: Data Science and AI	HW 11 due F
11/24 - 11/30		**THANKSGIVING HOLIDAY - NO CLASSES**	
2-Dec	Mon	No Class	Lab 10 due
3-Dec	Tue	**EXAM 2 - No Lab**	Return Redbot/Lab materials
4-Dec	Wed	No Class	
9-Dec	Mon	No Class	Tech Rpt and Oral Pres due
10-Dec	Tue	**EXAM 3 - No Lab**	
11-Dec	Wed	No Class	