San José State University
Mechanical Engineering

ME/EE 106 Fundamentals of Mechatronics Section 01, Fall 2022

Course and Contact Information

Instructor:	Dr. Mojtaba Sharifi (https://sites.google.com/ualberta.ca/mojtabasharifi)
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Office Hours:	Prof. Sharifi: Tuesday 14:30-16:30; by Zoom: https://sjsu.zoom.us/j/5172898001
Class Days/Time:	Tues and Thurs 10:30 – 11:45 (at Boccardo Business Center, Room 004. See Canvas for Zoom link)
Classroom:	See Canvas course web site: https://sjsu.instructure.com/courses/1490552
Prerequisites:	EE 098 and ME 030 (or CS 49C OR CMPE 30 OR CMPE 46) or their equivalents (with a grade of 'C-' or better in each). For IT majors: TECH 060, MATH 071, CMPE 046 (with a grade of 'C-' or better in each).

Course Description

Introduction to mechatronics with emphasis on analog electronics, digital electronics, sensors and transducers, actuators, and microcontrollers. Lectures are intended to provide the student with foundational concepts in mechatronics and practical familiarity with common elements making up mechatronic systems. Laboratory experiments are designed to give the student hands-on experience with components and measurement equipment used in the design of mechatronic products. (4 units; lecture/lab)

Course Format

The course will be conducted in an in-person format where lectures will be at Boccardo Business Center, Room 004. Laboratory sections will meet in-person in the E125 Mechatronics Engineering Laboratory. Students will be given a Raspberry Pi Pico microcontroller (https://www.raspberrypi.org/products/raspberry-pi-pico/), which will be used throughout the semester. Emphasis will be on programming the Pico using Micropython (https://micropython.org/) and the Thonny IDE (https://thonny.org/). Assignments will be given through Canvas (https://sjsu.instructure.com/courses/1490552).

Course Goals

The *goals* of this course are to help you:

1. Develop an understanding of the basic elements underlying mechatronic systems: analog electronics, digital electronics, sensors, actuators, microcontrollers, and embedded software.
2. Understand how to interface electromechanical systems to microcontrollers.
3. Gain hands-on experience with commonly used electronic test and measurement instrumentation.
4. Improve written communication skills through laboratory and project reports.
5. Gain practical experience in applying knowledge gained in the course through a hands-on project.

Course Learning Outcomes (CLO)

Upon successful completion of this course, students will be able to:

1. Articulate in a few sentences, with a few examples, what mechatronics is, so that a non-technical person would understand it.

2. Explain using analogies that an elementary school student would understand, the concepts of:
    a. Voltage
    b. Current
    c. Resistance/resistor
    d. Capacitance/capacitor
    e. Inductance/inductor
3. Calculate the effect of voltage division arising from the output impedance of one circuit and the input impedance of another circuit when the two circuits are connected.
4. Design RC low-pass and high-pass filter circuits to meet specified performance criteria and analyze the frequency response of an RC filter.
5. Explain the basic structure of a microcontroller, the nature of IO ports, and the common peripheral subsystems found in most microcontrollers.
6. Write embedded software to successfully interact with sensors, power interfaces, analog and digital IO ports, and other peripheral elements in the control of a mechatronic system.
7. Explain the basic operation of bipolar and MOS field-effect transistors using analogies that a sixth grader would understand.
8. Design a circuit with a bipolar junction transistor (BJT) and a MOS field-effect transistor (MOSFET) that will enable a microcontroller to control a device that requires more power than can be supplied from a pin of a microcontroller.
9. Determine the torque and speed requirements for a given motion control application considering system inertia, external forces or torques, and motion profiles, and select an appropriate permanent magnet DC (PMDC) or stepper motor for a desired application.
10. Select and configure operational amplifier circuits to achieve desired interfacing requirements between a signal source and a downstream device such as a microcontroller or data acquisition system.
11. Function effectively as part of a team in carrying out laboratory experiments and open-ended projects.
12. Document a laboratory experiment and open-ended projects clearly and completely in written form.

Required Material

Textbook

Carryer, J. E., Ohline, M., Kenny, T. (2011). *Introduction to Mechatronic Design*, Prentice Hall, New Jersey. ISBN: 978-0-13-143356-4. [Available in the Spartan Bookstore and in the MLK Jr. Library course reserve for ME 106.]

Hardware

Students will be given a Raspberry Pi Pico microcontroller (https://www.raspberrypi.org/products/raspberry-pi-pico/), which will be used throughout the semester. Some other components will be loaned to you and must be returned at the end of the semester. Students will need a computer to program the Pico and to access course materials by Canvas. See Student Computing Services to borrow a computer if needed. See: https://sjsuequipment.getconnect2.com/

Recommended Material

Recommended Reference on Electronics

Scherz, P., Monk, S. (2016). *Practical Electronics for Inventors 4th ed.*, McGraw-Hill, New York. ISBN: 978-1259587542 (https://www.amazon.com/Practical-Electronics-Inventors-Fourth-Scherz/dp/1259587541/). Some errors are noted here: http://tinyurl.com/yay232mv. If you get an earlier edition of this book, also consult the errata at: http://www.eg.bucknell.edu/physics/ph235/errata.pdf)

Recommended Hand Tools for working outside of the E125 lab

Digital Multimeter (DMM)
Example: https://www.amazon.com/KAIWEETS-Autoranging-Multimeter-Resistance-Continuity/dp/B07SKNN6VV/
Precision screwdriver set
Example: https://www.harborfreight.com/33-piece-precision-screwdriver-set-93916.html
Wire stripper
Example: https://www.harborfreight.com/5-inch-wire-stripper-36901.html
Flush cut pliers
Example: https://www.amazon.com/dp/B077RTNXVP/

Needle-nose pliers
Example: https://www.harborfreight.com/8-in-needle-nose-pliers-63824.html

Other technology requirements / equipment / material

We will use Zoom or other web conferencing for synchronous class sessions to record lectures and stream them online for the ones with special circumstances, so you will need a device that will enable you to see the online/recorded sessions.

Course Requirements and Assignments

The course has a weekly laboratory session that is extremely important. As you will learn, mechatronics is fundamentally about the integration of hardware (mechanics), electronics (sensors, circuits), and software. The laboratory experiments are designed for you to get hands-on exposure and experience with all the elements of mechatronic systems. You will be responsible for writing and submitting a report describing your results for each lab experiment.

The course has a term project that will give you an opportunity to apply mechatronics in the solution of an open-ended design problem. Your solution must be physically implemented and demonstrated near the end of the semester. You may work on the project in a team of two or three, subject to approval by the course instructor. The Term Project Assignment in Canvas will give more information about the project and its requirements.

Homework is to be submitted by upload to Canvas approximately one week after it is assigned. Late submissions will be handled under the token economy for the class. All submissions must be clear and legible. If the grader cannot read what you have submitted, you will not receive credit for it.

Laboratory reports will handled similarly. Unless stated otherwise by your lab instructor, softcopy of your lab report must be uploaded to the Canvas assignment one week after the laboratory experiment was performed.

Token Economy

To handle things like late assignment passes and revisions/resubmissions, we will use a 'token economy'. Everyone will be granted an initial balance of tokens that can be used for these purposes. In order to use a token, you must contact the grader (for HWs) or the corresponding lab TAs (for lab reports).

Grading Information

The course will be conducted under a *mastery framework*. Most courses typically assign a point value to assignments and assessments and then determine your final grade by the total number of points you earn by the end of the course. In this course, a passing grade (C-) will depend on you demonstrating that you have mastered the learning objectives. Higher grades will depend on the overall quality of your reports and term project; your individual performance on your term project team, and evidence from the final exam that you retained what you learned during the semester. Opportunities to demonstrate mastery will be given periodically, and it is your responsibility to keep up with the flow of the course and master the learning objectives in a timely way.

> Your course grade will be determined according to the table at the end of this document. The last column in the Canvas Gradebook is *not* used for determining your course grade, so do not rely on it! Your course grade is determined as explained on the last page of the syllabus.

Final Examination

The final examination for the course is on Tuesday, December 13, 2022 from 9:45 am – 12:00 pm.

Classroom Protocol

Since the lectures will be conducted in person, we all need to work hard to make our time together to be as socially rich as possible. If you are not able to attend in person due to any circumstances, you can attend the Zoom meeting and keep your microphone on mute until you are ready to speak, as that will help reduce background noise. The richness of your educational experience at SJSU is strongly correlated with the personal connections you make.

University Policies

See the University's Syllabus Information Page for more detail about University policies (https://www.sjsu.edu/curriculum/courses/syllabus-info.php). Several important policies are highlighted below.

Academic Integrity (This section is important, so make sure you read it! You will be held accountable to its stipulations.) Your commitment as a student to learning is evidenced by your enrollment at San José State University. The University's Academic Integrity policy, located at https://www.sjsu.edu/studentconduct/docs/SJSU-Academic-Integrity-Policy-F15-7.pdf, requires you to be honest in all your academic course work. Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The Student Conduct and Ethical Development website is available at http://www.sjsu.edu/studentconduct/.

Instances of academic dishonesty will not be tolerated. Cheating on exams or plagiarism will result in a failing grade and sanctions by the University. For this class, all assignments are to be completed *by the individual student* unless otherwise specified. If you would like to include in your assignment materials that were previously graded in another course, or you are planning to submit work simultaneously for ME 106 and another class, please note that SJSU's Academic Policy S07-2 requires prior approval by the instructor.

Plagiarism is defined as, the use of another person's original (not common-knowledge) work without acknowledging its source.[1] Examples of plagiarism include, but are not limited to[2]:

- copying in whole or in part, a picture, diagram, graph, figure, program code, algorithm, etc. and using it in your work without citing its source
- using exact words or unique phrases from somewhere without acknowledgement
- putting your name on a report, homework, or other assignment that was done by someone else

Students are expected to familiarize themselves with how to avoid plagiarism. Several helpful resources can be found at: https://communitystandards.stanford.edu/student-conduct-process/honor-code-and-fundamental-standard/additional-resources/what-plagiarism

Note: I encourage students to collaborate on assignments, such as homework and lab reports, however what this means is that you can work together to decide on solution *strategies*, discuss what should be included in reports and how they should be organized, etc., but you ***may not*** copy answers in whole or in part (this includes program code), and you must write your own lab reports. Unless otherwise specified, all assignments are to be completed by each student *individually*.
SJSU Senate Policy S12-3 - Federal Regulation of the definition of the credit hour:

Success in this course is based on the expectation that a student will spend, for each unit of credit, a *minimum* of 45 hours over the length of the course (normally three hours per unit per week with one of the hours used for lecture) for instruction or preparation/studying or course related activities including but not limited to internships, labs, clinical practica, etc. Other course structures will have equivalent workload expectations as described in the syllabus. [Thus, for this class, it is expected that you will spend *at least* seven hours outside of class working on homework, lab work, project work, test preparation, etc. If you put in less time than this, you may not pass the course and you will not learn all that you could :(] See: http://www.sjsu.edu/senate/docs/S12-3.pdf for more information.
Campus Policy in Compliance with the American Disabilities Act

If you need course adaptations or accommodations because of a disability, or if you need to make special arrangements in case the building must be evacuated, please make an appointment with me as soon as possible, or see me during office hours. Presidential Directive 97-03 requires that students with disabilities requesting accommodations must register with the AEC (Accessible Education Center) to establish a record of their disability.

Additional Information

☐ We will make extensive use of the Canvas course management system (https://sjsu.instructure.com/courses/1490552). Make sure that you adjust your settings in Canvas, so that you will get notifications in a way that you check frequently.

[1] Definition adapted from "Defining and Avoiding Plagiarism: The WPA Statement on Best Practices," http://wpacouncil.org/positions/WPAplagiarism.pdf; and "What is Plagiarism?" https://communitystandards.stanford.edu/student-conduct-process/honor-code-and-fundamental-standard/additional-resources/what-plagiarism.
[2] Adapted from: https://owl.purdue.edu/owl/research_and_citation/using_research/avoiding_plagiarism/is_it_plagiarism.html

- ☐ If you cannot attend a class session, please let one of your instructors know as soon as you know that you will not be able to attend. Don't just not show up!
- ☐ Reading assignments in Canvas should be completed ***prior to*** the lecture for the week in which the assignment is listed. In other words, read the assigned chapters before the next lecture! Doing so will help prepare you for lecture and will help you maximize your learning efficiency. It will also help you score well on any in-class quizzes on the readings. When you read, summarize the important points and jot down any questions that you have. Bring your questions with you to the lecture.
- ☐ See Canvas for auxiliary materials that we will use in lecture and that you would do well to bring with you to the lecture session. You can access the materials along with the lecture slides in the Modules area of the course shell in Canvas.
- ☐ Following each lecture, I highly recommend that you ***review*** any notes you took in lecture along with the notes that you took from reading. Read your notes, and fill in any gaps that you may have missed or that became clearer from the lecture. Write down any questions you have in the margins of your notes. Be sure to come to office hours or ask about your questions in class.
- ☐ Please make it a point to ask questions in class, on any of the class discussion platforms, or in office hours whenever you don't understand something! If you don't, then you are essentially paying tuition for nothing! The pace of this class is relatively fast, especially if you have little prior experience with electronics or computer programming, so don't slack off.
- ☐ Start working on the project as soon as possible. The most common lament heard from students who fare poorly in the class is, "We should have started earlier on the term project..."
- ☐ Laboratory reports are to be written ***individually***. It is acceptable to work *collaboratively* with your lab partner or other students in the class on lab reports, but it is **NOT** acceptable to copy someone else's report, in whole or in part. Examples of collaboration are: reviewing the data you gathered for consistency, jointly developing an outline of the key points to be included in the report, deciding together on the format and content of figures, etc. Examples of plagiarism are: copying and inserting sentences, paragraphs, or other text into your report that a classmate or someone else wrote; copying figures or tables that your lab partner or someone else put together, etc. Software listings must be in machine readable form (not as an image) and must contain comments that explain how the code works.

References (ME 106 Course Reserves. In addition to these hardcopy references, check out the ME106 tutorial web pages)

For MicroPython and Thonny:

- https://projects.raspberrypi.org/en/projects/getting-started-with-the-pico
- https://docs.micropython.org/en/latest/index.html
- https://thonny.org/

For learning Python:

- https://www.linkedin.com/learning/python-for-non-programmers (You can access LinkedIn Learning courses for *free* as an SJSU student. Go to the Spartan App Portal and look for the LinkedIn Learning app)
- https://ehmatthes.github.io/pcc/cheatsheets/README.html
- https://www.openbookproject.net/thinkcs/python/english2e/
- Automate the Boring Stuff With Python
- A Primer on Scientific Programming With Python
- Python Data Science Handbook

Mechatronics in general:

- Ball, S. (2003). Analog Interfacing to Embedded Microprocessor Systems, 2nd ed., Newnes, ISBN: 0750677236
- Catsoulis, J. (2002). *Designing Embedded Hardware*, O'Reilly, ISBN: 0596003625
- de Silva, C. W. (2010). Mechatronics: A Foundation Course, Taylor & Francis/CRC Press, Boca Raton, FL. ISBN: 978-1420082111.
- Jones, J. L. & Flynn, A. M. (1998). *Mobile Robots: Inspiration to Implementation*, 2nd ed., A. K. Peters, Wellesley, Mass.
- Ganssle, J. (1999). *The Art of Designing Embedded Systems*, Newnes, ISBN: 0750698691
- Histand, M. B., Alciatore, D. G. (2007). Introduction to Mechatronics and Measurement Systems 3rd ed., WCB/McGraw-Hill, Boston. ISBN: 9780072963052.
- Horowitz, P., Hill, W. (1989). *The Art of Electronics*, 2nd ed., Cambridge University Press, New York.

- McComb, G. (1987). The Robot Builder's Bonanza: 99 Inexpensive Robotics Projects, Tab Books, Blue Ridge Summit, PA.
- Mims, Forrest M. III. (1983). *Getting Started in Electronics* (Radio Shack cat. no. 62-5004), and his *Engineer's Mini-Notebook* series (particularly: Schematic Symbols, Device Packages, Design and Testing; Sensor Projects; 555 Timer Circuits; Optoelectronic Circuits), Radio Shack, Tandy Corp., Fort Worth, TX.
- Pont, M. J. (2001). Patterns for Time-Triggered Embedded Systems: Building Reliable Applications with the 8051 Family of Microcontrollers, Addison-Wesley, Harlow, England, ISBN: 0201331381.
- Simon, D. E. (1999). *An Embedded Software Primer*, Addison-Wesley Professional, ISBN: 020161569X
- Smaili, A. & Mrad, F. (2008). *Applied Mechatronics*, Oxford University Press, New York. ISBN: 978-0-19-530702-3
- Stiffler, A. K. (1992). Design with Microprocessors for Mechanical Engineers, McGraw-Hill, New York.
- Valvano, J. W. (2000). *Embedded Microcomputer Systems: Real Time Interfacing*, Thomson-Engin., ISBN: 0534366422.

Course Schedule

(Subject to change! Check Canvas for up-to-date information)

Week	**Date**	**Topics** (see Canvas for Assignments)
1a	8/23	**Learning objectives: 1, 2, 3, 4** Enrollment, course organization, intro to mechatronics, review of basic electronics – pt 1. Prep for Lab 1 soldering the headers on the Pico [Labs begin this week]
1b	8/25	RC filters.
2a	8/30	RC filter frequency response
2b	9/1	**Learning objectives: 5, 6** Microcontroller fundamentals, I/O ports, Raspberry Pi Pico
3a	9/6	Digital I/O, programming the Pico – pt 1
3b	9/8	Programming the Pico – pt 2, Discussion of term project.
4a	9/13	**Learning Objective: 7, 8** Diodes, the BJT transistor
4b	9/15	Using transistors to switch power to loads
5a	9/20	MOSFET's and power interfacing applications
5b	9/22	Power interfacing examples
6a	9/27	**Learning Objective: 9** Actuators for mechatronic applications – Part 1
6b	9/29	Actuators for mechatronic applications – Part 2
7a	10/4	Actuators for mechatronic applications – Part 3
7b	10/6	Stepper motors
8a	10/11	Motor sizing – Part 1
8b	10/13	Motor sizing – Part 2
9a	10/18	State machines and Events and Services – Part 1

Week	Date	**Topics** (see Canvas for Assignments)
9b	10/20	State machines and Events and Services – Part 2
10a	10/25	Midcourse review
10b	10/27	**Learning Objective: 10** Operational amplifiers, amplifier types
11a	11/1	Limitations of op-amps
11b	11/3	**Learning Objective: 5** Comparators, signal conditioning; A/D and D/A conversion
12a	11/8	Digital electronics, basic logic functions, logic gates, logic ICs – Part 1
12b	11/10	Digital electronics, basic logic functions, logic gates, logic ICs – Part 2
13a	11/15	Serial communication: I2C and SPI
13b	11/17	Biomedical robotics and applications 1
14a	11/22	Biomedical robotics and applications 2
14b	11/29	**Term Project Exhibition** (1030 – 1230 in and around E125. No lecture.)
15a	12/1	**Term Project Exhibition** (1030 – 1230 in and around E125. No lecture.)
15b	12/6	**Learning Objectives: Everything!** Course Review
Final Exam	12/13	**Final Exam: Tuesday, December 13, 2022 from 9:45 am – 12:00 pm**

Course Grading Scheme

All requirements for a grade level must be met in order to obtain a grade in that level.

Level	Final Grade	Weighted Overall Avg.	Learning Objectives 20%	Lab Reports 15%	Homework 10%	Term Project 20%	Individual Performance 15%	Final Exam 20%
Basic (C minus to C plus)	C-	67% - 69.9%	**All mastered** (80% or higher)	From lab report rubric Reports for all labs submitted (Basic Level; 60% minimum)	Overall percentage for HWs All HWs submitted (Basic Level; 60% minimum)	From Term Project Rubric All specs met (Basic Level; 60% minimum)	From group assessment rubric (Basic Level; 75% minimum)	Final Exam score (Basic Level; 60% minimum)
	C	70% - 72.9%						
	C+	73% - 76.9%						
Intermediate (B minus to B plus)	B-	77% - 79.9%	**All mastered** (80% or higher)	From lab report rubric Reports for all labs submitted (Intermediate level; 75% minimum)	Overall percentage for HWs All HWs submitted (Basic Level; 75% minimum)	From Term Project Rubric All specs met (Intermediate level; 75% minimum)	From group assessment rubric (Intermediate level; 80% minimum)	Final Exam score (Intermediate level; 70% minimum)
	B	80% - 82.9%						
	B+	83% - 86.9%						
Advanced (A minus to A plus)	A-	87% - 89.9%	**All mastered** (80% or higher)	From lab report rubric Reports for all labs submitted (Intermediate level; 85% minimum)	Overall percentage for HWs All HWs submitted (Basic Level; 85% minimum)	From Term Project Rubric All specs met (Advanced Level; 85% minimum)	From group assessment rubric (Advanced Level; 90% minimum)	Final Exam score (Advanced Level; 80% minimum)
	A	90% - 94.9%						
	A+	95% - 100%						