

## ME/EE 106 - Fundamentals of Mechatronics Engineering

Spring 2020

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<b>Office Hours:</b>	M 1330 – 1430, Tu 1330 – 1430, Th 1330 – 1430, or by appointment
<b>Class Meeting Information</b>	ME 106 Seminar 01 (27103): MW 1630 – 1720 room: Engineering 189 Lab 02 (27104): Tu 1330 – 1615 E125 NOTE! First meeting on 02/04/20 Lab 03 (27105): Wed 1800 – 2045 E125 NOTE! First meeting on 02/05/20 Lab 04 (27106): Thurs 1330 – 1615 E125 NOTE! First meeting on 02/06/20 Lab 05 (27107): Thurs 1800 – 2045 E125 NOTE! First meeting on 02/06/20 Lab 06 (27108): Fri 0900 – 1145 E125 NOTE! First meeting on 02/07/20 Lab 07 (27109): Fri 1330 – 1615 E125 NOTE! First meeting on 02/07/20 Lab 08 (27110): Mon 1330 - 1615 E125 NOTE! First meeting on 02/03/20  EE 106 Seminar 01 (29435): TuTh 1630 – 1720 room: Engineering 189 Lab 02 (29436): Tu 1330 – 1615 E125 NOTE! First meeting on 02/04/20 Lab 03 (29437): Wed 1800 – 2045 E125 NOTE! First meeting on 02/05/20 Lab 04 (29438): Thurs 1330 – 1615 E125 NOTE! First meeting on 02/06/20 Lab 05 (29439): Thurs 1800 – 2045 E125 NOTE! First meeting on 02/06/20 Lab 06 (29440): Fri 0900 – 1145 E125 NOTE! First meeting on 02/07/20 Lab 07 (29441): Fri 1330 – 1615 E125 NOTE! First meeting on 02/07/20 Lab 08 (29442): Mon 1330 – 1615 E125 NOTE! First meeting on 02/03/20
<b>Prerequisites:</b>	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).

### Accessing Course Materials and Messaging

Copies of the course materials such as the syllabus, major assignment handouts, etc., may be found on the SJSU Canvas course management system: <https://sjsu.instructure.com/courses/1357828>. You are responsible for regularly checking for updates and reading messages that I may send to you through mySJSU, Canvas, [Piazza](#), or other system.

### Course Description

Introduction to mechatronics with emphasis on analog electronics, digital electronics, sensors and transducers, actuators, and microprocessors. 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. (3 units; lecture/lab)

### Course Goals and Learning Objectives

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.

### Learning Objectives

The student who successfully completes the course will be able to:

1. Articulate what the essence of mechatronics is and provide examples of mechatronic systems.
2. Explain the concepts of input and output impedance, voltage division, and circuit loading
3. Explain the concept and characteristics of a signal source.
4. Design and analyze the performance of RC low-pass and high-pass filter circuits.
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 what analog-to-digital-conversion (A/D) is and how to implement it using a microcontroller.
8. 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.
9. Explain the practical limitations of operational amplifiers and quantitatively estimate the effects of these limitations on output voltage and current of the op-amp.
10. Explain the basic operation of bipolar and MOS field-effect transistors and design with them to activate solenoids, relays, motors, etc. from signal sources.
11. Explain the input/output characteristics of digital logic devices and design a logic circuit to accomplish a given task.
12. Explain the underlying operational principles and construction of electromagnetic actuators such as DC, AC, and stepping motors.
13. 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 motor.
14. Function effectively as part of a team in carrying out laboratory experiments and open-ended projects.
15. Document a laboratory experiment and open-ended projects clearly and completely in written form.

### **Text**

#### **Required Textbook**

Carryer, J. E., Ohline, M., Kenny, T. (2011). *Introduction to Mechatronic Design*, Prentice Hall, New Jersey. ISBN: 978-0-13-143356-4.

#### **Recommended Textbooks**

Scherz, P., Monk, S. (2016). *Practical Electronics for Inventors 4th ed.*, McGraw-Hill, New York. ISBN: 978-1259587542. 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>

#### **Required Hardware**

Adafruit Feather M4 Express (<https://www.adafruit.com/product/3857>) and a USB A – micro B data cable. EduShields Inc. (Eric Wertz) will be selling the FM4E during the first and second week of class. You can save yourself time and money by buying a board from Eric that already has the headers soldered and that comes with a USB cable. If you miss the opportunity to buy from Eric, you'll need to order from Adafruit and solder your own headers. If Adafruit is out of stock, check Mouser (<https://tinyurl.com/y5x8476b>), Digikey (<https://www.digikey.com/products/en?mpart=3857&v=1528>), or Evil Mad Scientist (<https://shop.evilmadscientist.com/productsmenu/916> located in Sunnyvale). You will also need a WiFi enabled device, such as a smartphone, laptop, or tablet for in-lecture exams and quizzes. Such devices can be borrowed from Student Computing Services if you unable to obtain your own. See: <http://library.sjsu.edu/student-computing-services/equipment-loans>

### Library Liaison

Our liaison to the University Library is Rachel Silverstein <[rachel.silverstein@sjsu.edu](mailto:rachel.silverstein@sjsu.edu)>, 408-808- 2106. Rachel can help you make optimum use of information resources available to you through the University Library.

### Classroom Protocol

I expect everyone to make their best effort to attend *all* class sessions and laboratory periods. Please arrive to the classroom or laboratory *before* the session begins, so that others are not disturbed by your entry after instruction has begun. If you normally keep a cell phone activated and with you, put your cell phone on 'vibrate' *before* you enter the classroom. Having your cell phone ring during class is disruptive, and will not be tolerated.

### Dropping and Adding

Students are responsible for understanding the policies and procedures about add/drops, academic renewal, etc. Information on add/drops are available at <http://info.sjsu.edu/home/schedules.html>. Information about late drop is available at <http://www.sjsu.edu/aars/policies/latedrops/policy/>. Students should be aware of the current deadlines and penalties for adding and dropping classes.

### Assignments and Grading Policy

Assessment for the purposes of determining your course grade will consist of evaluating your performance on homework assignments, laboratory reports, quizzes and examinations, projects, and the final examination.

Quizzes may take place in lecture and/or lab and may be unannounced (so keep up on your reading and studying for this class). Check the ME 106 Course Schedule listed below for links to the homework and laboratory assignments.

Homework will be submitted by upload to Canvas approximately one week after it is assigned. Late submissions *might* receive partial credit, but this will be at the discretion of the grader (don't count on it). 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 must be uploaded to the Canvas assignment one week after the laboratory experiment was performed.

The weighting of the course components and criteria for assigning letter grades are given below.

### Weighting of Course Components for Determining the Course Grade

HW 10%, Lab Reports 20%, Project 20%, Midterm 10%, Quizzes 5%, Final Exam 20%, and Individual Performance on the Term Project 15%

### Criteria for Assigning Letter Grades

The scores on your homework, laboratory reports, quizzes and exams, term project, final examination, and individual performance will be combined and totaled using the weighting scheme described above. Note: your overall percentage shown in Canvas Grades is a *very approximate estimation* of your overall percentage. I calculate final grades offline, because Canvas is not flexible enough when it comes to making normalizing scores and making adjustments. Thus, what you see may not be what you get. A final letter grade will be determined from your overall performance (percentage) using the following criteria:

A 100 – 93%; A- 92 – 90%; B+ 89 – 87%; B 86 – 83%; B- 82 – 80%; C+ 79 – 77%; C 76 – 72%;

C- 71 – 69%; D+ 68 – 66%; D 65 – 62%; D- 61 – 59%; F <58%. Note: ME students must earn at least a grade of C- to pass the course.

**The final examination for the course will be Tuesday, May 19, 2020 from 1445 - 1700 in room E189. You may need a WiFi enabled device, (i.e., a laptop or a tablet computer) for the final exam. Such devices can be borrowed from Student Computing Services if you do not have your own. See: <http://library.sjsu.edu/student-computing-services/equipment-loans> for more information.**

### University Policies

**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](http://www.sjsu.edu/studentconduct/docs/S07-2.pdf), located at <http://www.sjsu.edu/studentconduct/docs/S07-2.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](http://www.sjsu.edu/studentconduct/) 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.*<sup>1</sup> Examples of plagiarism include, but are not limited to<sup>2</sup>:

- 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.

#### **Student Technology Resources**

Computer labs for student use are available in the Academic Success Center located on the 1<sup>st</sup> floor of Clark Hall and on the 2<sup>nd</sup> floor of the Student Union. Additional computer labs are available for ME students in E213 and E215. Computers are also available in the Martin Luther King Library (see: <http://library.sjsu.edu/student-computing-services/equipment-loans>).

A wide variety of audio-visual equipment is available for student checkout from Media Services located in IRC 112. These items include camcorders, video players, 16 mm, slide, overhead, DVD, CD, and audiotape players, sound systems, wireless microphones, projection screens and monitors.

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<sup>1</sup> 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>.

<sup>2</sup> Adapted from: [https://owl.purdue.edu/owl/research\\_and\\_citation/using\\_research/avoiding\\_plagiarism/is\\_it\\_plagiarism.html](https://owl.purdue.edu/owl/research_and_citation/using_research/avoiding_plagiarism/is_it_plagiarism.html)

**SJSU Writing Center**

The SJSU Writing Center is located in Room 126 in Clark Hall. It is staffed by professional instructors and upper-division or graduate-level writing specialists from each of the seven SJSU colleges. Their writing specialists have met a rigorous GPA requirement, and they are well trained to assist all students at all levels within all disciplines to become better writers. The Writing Center website is located at <http://www.sjsu.edu/writingcenter/>.

**Additional Notes:**

- We will make extensive use of the Canvas course management system (<https://sjsu.instructure.com/courses/1357828>) and the Piazza Q & A platform. Make sure that you adjust your settings in Canvas and Piazza, so you will get notifications in a way that you check frequently. You also may need a WiFi enabled device (smartphone, tablet, or laptop) to bring to lecture, and a laptop or tablet computer to use for exams. If you don't have one of these devices, there are resources on campus that can loan you something appropriate. See: <http://library.sjsu.edu/scs>
- You will need to have access to Adafruit Feather M4 Express (<https://www.adafruit.com/product/3857>) board and a USB A – micro B data cable for homework assignments. You can buy a FM4E board from EduShields during the first two weeks of class. If Adafruit is out of stock, check Mouser (<https://tinyurl.com/y5x8476b>), Digikey (<https://www.digikey.com/products/en?mpart=3857&v=1528>), or Evil Mad Scientist (<https://shop.evilmadscientist.com/productsmenu/916> located in Sunnyvale).
- If you are going to be absent from class or lab, please give me a call, or send me an email 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 back through 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 Piazza, 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."
- Lab experiments are intended to be performed in a group of two students. The laboratory report is to be written *individually*. It is acceptable to work *collaboratively* with your lab partner or other students in the class on the lab report, 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 with your lab partner 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 your lab partner 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).

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

For learning Python

<https://ehmatthes.github.io/pcc/cheatsheets/README.html>

[Think Python - How to Think Like a Computer Scientist 2nd Edition Version 2.2.23](#)

[A Primer on Scientific Programming With Python](#)

[Python Data Science Handbook](#)

[Automate the Boring Stuff With Python](#)

For CircuitPython

<https://learn.adafruit.com/welcome-to-circuitpython>

<https://circuitpython.readthedocs.io/en/latest/>

Mechatronics in general

Ball, S. (2003). *Analog Interfacing to Embedded Microprocessor Systems*, 2<sup>nd</sup> 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*, 2<sup>nd</sup> 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 (Approximate... **Check Canvas**)**

Wk	Date	Subject
1		No class, no labs this week, since classes begin on Thursday, 1/23/20
2	1/27 – 1/31	Learning objectives: 1, 2, 3, 4 Enrollment, course organization, intro to mechatronics, review of basic electronics. Signal sources and their limitations. RC filters. Discussion of term project. No labs this week. Check Canvas Modules and Assignments
3	2/3 – 2/7	Learning objectives: 4, 5, 6 RC filters, microcontroller fundamentals, I/O ports, Feather M4 Express intro, Digital I/O Lab 1 – <u>Introduction to the Mechatronics Engineering Laboratory</u> Check Canvas Modules and Assignments
4	2/10 – 2/14	Learning objectives: 5, 6 Programming the Feather M4 Express – Part 1 Lab 2 – <u>Introduction to the Feather M4 Express Board</u> Check Canvas Modules and Assignments
5	2/17 – 2/21	Learning objectives: 5, 6 Programming the Feather M4 Express – Part 2 Lab 3 – <u>RC Filters</u> Check Canvas Modules and Assignments

6	2/24 – 2/28	Learning objectives: 10 Diodes, transistors, using transistors to switch power to loads Lab 4 – <u>Soldering the Feather Bar Graph Board</u> Check Canvas Modules and Assignments
7	3/2 – 3/6	Learning objectives: 6, 10 MOSFET's and power interfacing applications Lab 5 – <u>Digital IO</u> Check Canvas Modules and Assignments
8	3/9 – 3/13	Learning objectives: 12, 13 Actuators for mechatronic applications Lab 6 – <u>LEDs, Photoresistors, and Transistors</u> <b><u>Term Project Phase I Progress Review</u></b> (NOTE: counts for 10% of your Term Project grade!!!!) Check Canvas Modules and Assignments
9	3/16 – 3/20	Learning objectives: 12, 13 Motor sizing, stepper motors Lab 7 – <u>Motors and Motion Control</u> Check Canvas Modules and Assignments
10	3/23 – 3/27	Learning objectives: 1-6, 10, 12, 13 Midterm review <b><u>Midterm exam on 3/27/20</u></b> Lab 8 – <u>Servo/Encoder</u> Check Canvas Modules and Assignments
11	3/30 – 4/3	Learning objectives: Get rest, have fun, but don't forget about Mechatronics :) S P R I N G B R E A K!! Check Canvas Modules and Assignments
12	4/6 – 4/10	Learning objectives: 6, 7, 8, 9 Operational amplifiers, amplifier types, limitations of op-amps Lab 9 – <u>Stepper Motor</u> <b><u>Term Project Phase 2 Progress Review</u></b> (show to your lab instructor during your lab section. NOTE: counts for 10% of your Term Project grade!!!!) Check Canvas Modules and Assignments
13	4/13 – 4/17	Learning objectives: 6, 7, 8, 9 Comparators, signal conditioning; A/D and D/A conversion Lab 10 – <u>Electronic Scale</u> Check Canvas Modules and Assignments
14	4/20 – 4/24	Learning objectives: 11 Digital electronics, basic logic functions, logic gates, logic ICs Open Lab Check Canvas Modules and Assignments
15	4/27 – 5/1	Learning objectives: 6 Serial communication: I2C and SPI Check Canvas Modules and Assignments

16	5/4 – 5/8	Learning objectives: 6 5/4/20: <b>Term Project Exhibition – Part 1</b> (beginning at 1500 and lasting until about 1800 in E125 and the hallways nearby) 5/6/20: <b>Term Project Exhibition – Part 2</b> (beginning at 1630 and lasting until about 1830 in E125 and the hallways nearby) Check Canvas Modules and Assignments
17	5/11	Learning objectives: Everything! Course review. Return any borrowed hardware. Check Canvas Modules and Assignments (Term Project Report and videos due)
18	5/19	Learning objectives: Everything! <b>Final Exam 1445 – 1700 in E189</b>