SAN JOSÉ STATE UNIVERSITY
Charles W. Davidson College of Engineering
Department of Mechanical and Aerospace Engineering

ME/EE 106 - Fundamentals of Mechatronics — Fall 2009

Instructor:	Buff Furman (http://www.engr.sjsu.edu/bjfurman/)
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Office Hours:	Tu-Th 1430 – 1600 or by appointment only
Class Meeting Information	ME 106 Seminar 01 (46996): TuTh 1330 – 1420 room E341 Lab 02 (47127): Tue 1430 – 1715 E125 First meeting on 9-01-09 Lab 03 (47128): Thr 1800 – 2045 E125 First meeting on 9-03-09 Lab 04 (47129): Fri 1430 – 1715 E125 First meeting on 9-04-09 EE 106 Seminar 01 (48967): TuTh 1330 – 1420 E341 Lab 02 (48968): Tue 1430 – 1715 E125 First meeting on 9-01-09 Lab 03 (48969): Thr 1800 – 2045 E125 First meeting on 9-03-09 Lab 04 (48970): Fri 1430 – 1715 E125 First meeting on 9-04-09
Prerequisites:	ME 30, EE 98
Course Fees:	$25

Faculty Web Page and MySJSU Messaging

Copies of the course materials such as the syllabus, major assignment handouts, etc., may be found on my website for this course: http://www.engr.sjsu.edu/bjfurman/courses/ME106/ME106courseinfo.htm. We will also use the SJSU Blackboard course management system (see http://www.sjsu.edu/ecampus/students/ for more information). You are responsible for regularly checking with the messaging system through MySJSU, Blackboard, or other communication system as indicated by the instructor, to keep on top of your assignments.

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.

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, and microcontrollers.
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 concept and characteristics of a signal source.
3. 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.

4. Explain the practical limitations of operational amplifiers and can quantitatively estimate the effects of these limitations on output voltage and current of the op-amp.
5. Design and analyze the performance of RC low-pass and high-pass filter circuits.
6. Explain the basic operation of bipolar and MOS field-effect transistors and can design with them to activate solenoids, relays, motors, etc. from signal sources.
7. Explain the input/output characteristics of digital logic devices and can design a logic circuit to accomplish a given task.
8. Explain the underlying operational principles and construction of electromagnetic actuators such as DC, AC, and stepping motors.
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 motor.
10. Explain the basic structure of a microcontroller.
11. Write a program to successfully perform digital input and output from a microcontroller port.
12. Explain the common analog-to-digital-conversion (A/D) methods.
13. Write a program to successfully do A/D conversion using a microcontroller.
14. Explain the digital-to-analog (DAC) conversion process.
15. Write a program to successfully interface analog and digital devices, such as sensors and actuators, with a microcontroller.
16. Function effectively as part of a team in carrying out laboratory experiments and an open-ended project.
17. Document a laboratory experiment and an open-ended project clearly and completely in written form.

Texts

Required Textbook

Histand, M. B., Alciatore, D. G. (2007). *Introduction to Mechatronics and Measurement Systems 3rd ed.*, WCB/McGraw-Hill, Boston. ISBN: 9780072963052. (abbreviated as HA in tentative Course Schedule below)

Library Liaison

Our liason to the University Library is Menxiong Liu <Mengxiong.Liu@sjsu.edu >, 408-808-2020. Menxiong 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/sac/policies/latedrops/ **.** 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, the term project, and a 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 is generally due one week after it is assigned. Unless otherwise specified, homework will handled electronically via the web as your instructor will explain. There will be deadlines for when your work must be submitted, after which you will be unable to submit, and therefore you will not get credit for late assignments.

Laboratory reports will also be handled via the web, generally one week after the laboratory experiment was done. Pay attention to the deadline for the lab assignment, so that you do not miss points for the report.

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

The final examination for the course will be Tuesday, December 15, 2009 from 1215 - 1430 in room E341.

Weighting of Course Components

HW 10%, Lab Reports 25%, Term Project 25%, Quizzes 10%, Final Exam 20%, Individual Performance 10%

Criteria for Assigning Letter Grades

The scores on you homework, laboratory reports, quizzes and exams, term project, final examination, and individual performance will be combined and totaled using the weighting scheme described above. 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: MAE must earn at least a grade of C- to pass the course.

University Policies

Academic Integrity

Students in this course are expected to maintain high ethical standards in ***all*** matters pertaining to the course, including, but not limited to, examinations, homework, course assignments, presentations, writing, laboratory work, team work, treatment of class members, and behavior in class. Cheating and plagiarism are violations of the SJSU Policy on Academic Integrity S07-2 and will not be tolerated in the class. Students are expected to have read the Policy, which is available at:

http://sa.sjsu.edu/download/judicial_affairs/Academic_Integrity_Policy_S07-2.pdf

Plagiarism is defined as, *the use of another person's original (not common-knowledge) work without acknowledging its source*.[1] Thus plagiarism includes, but is 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:

http://www.stanford.edu/dept/vpsa/judicialaffairs/students/plagiarism.sources.htm

I encourage students to collaborate on assignments, such as homework and lab reports, however what this means is that you can work together 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 put together your own lab reports. So 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 any material you have submitted, or plan to submit for another class, please note that SJSU's Academic Policy F06-1 requires approval of instructors.

Faculty members are required to report all infractions to the office of Student Conduct and Ethical Development. The website for Student Conduct and Ethical Development is available at:

http://www.sa.sjsu.edu/judicial_affairs/index.html

[1] Definition adapted from "Defining and Avoiding Plagiarism: The WPA Statement on Best Practices," http://www.ilstu.edu/~ddhesse/wpa/positions/WPAplagiarism.pdf; and "What is Plagiarism?," http://www.stanford.edu/dept/vpsa/judicialaffairs/students/plagiarism.sources.htm.

[2] Adapted from, "Avoiding Plagiarism," http://owl.english.purdue.edu/handouts/research/r_plagiar.html.

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 DRC (Disability Resource 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 1st floor of Clark Hall and on the 2nd floor of the Student Union. Additional computer labs are available for MAE students in E213 and E215. Computers are also available in the Martin Luther King Library (see: http://www.sjlibrary.org/services/computers/index.htm).

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

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. Our 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 Blackboard system and the ME 106 web site for the class (http://www.engr.sjsu.edu/bjfurman/courses/ME106/ME106courseinfo.htm). Keep an eye out for email from you course and laboratory instructor.
- If you are going to be absent from class, please give me a call, or send me an email prior to the class meeting to let me know that you will not be coming. Don't just not show up!
- Each reading assignment shown in the Course Schedule below 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. When you read, summarize the important points and jot down any questions that you have. Bring your questions with you to the lecture.
- 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 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, so don't slack off.
- Start working on the term 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 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.

COURSE SCHEDULE (approximate)

Wk.	Date	Subject
1	8/25-27	Enrollment, course organization, intro to mechatronics, review of basic electronics
Learning obj.		1, 2
Reading		HA (Chapters in Histand, M. B., Alciatore textbook): 1 – 2 http://www.memagazine.org/contents/current/features/whoowns/whoowns.html http://www.allaboutcircuits.com/vol_1/chpt_6/index.html http://www.allaboutcircuits.com/vol_1/chpt_10/8.html
Lab		No lab! Labs begin the week of 9/1/09
Assignment		Homework 1
Due		Questionnaire due on 8/27/09.
2	9/1-9/3	Signal sources and their limitations; RC filters
Learning obj.		2, 5
Reading		HA: 4.4 http://www.allaboutcircuits.com/vol_2/chpt_8/index.html
Lab		Introduction to the Mechatronics Laboratory (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 2
Due		Homework 1 via Blackboard Assignment upload (before the deadline!)
3	9/8-9/10	Microprocessor fundamentals, I/O ports, ATmega16 intro, Digital I/O
Learning obj.		10, 11, 15
Reading		HA: 7.1 – 7.3 http://www.freescale.com/files/microcontrollers/doc/ref_manual/M68HC05TB.pdf, ('What's a Micro?'), AVR Architecture at: http://www.avrbeginners.net/ (especially AVR Architecture and'I/O Ports, General Description') ATmega16 summary or full manual (http://www.atmel.com/dyn/resources/prod_documents/doc2466.pdf) See especially the sections on, Features, Overview, I/O Ports, and Electrical Characteristics.
Lab		Introduction to the ATmega16 (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 3
Due		Homework 2 via Blackboard Assignment upload (before the deadline!)
4	9/15-17	Programming the ATmega16
Learning obj.		10, 11, 15
Reading		HA: http://www.avrfreaks.net/index.php?name=PNphpBB2&file=viewtopic&t=22514 http://www.users.on.net/~symes/CwithAVR/IntrotoCwithAVR.htm Introduction to the ATmega16
Lab		RC Filters (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 4
Due		Homework 3 via Blackboard Assignment upload (before the deadline!)

5	9/22-24	Diodes, transistors, using transistors to switch power to loads
Learning obj.		6
Reading		HA: 3 http://www.allaboutcircuits.com/vol_3/chpt_3/index.html http://www.allaboutcircuits.com/vol_3/chpt_4/index.html
Lab		LED's and Transistors (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 5
Due		Homework 4 via Blackboard Assignment upload (before the deadline!) 9/22/09: Term Project Vital Information sheet. (use template from: http://www.engr.sjsu.edu/bjfurman/courses/ME106/ME106vital_info.zip)
6	9/29-10/1	MOSFET's and power interfacing applications
Learning obj.		6
Reading		HA: 3.5 http://www.allaboutcircuits.com/vol_3/chpt_2/10.html http://www.fairchildsemi.com/an/AN/AN-7500.pdf
Lab		Digital I/O (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 6
Due		Homework 5 via Blackboard Assignment upload (before the deadline!)
7	10/6-8	Motor action, DC motors, drive system inertia calculation
Learning obj.		8, 9
Reading		HA: 10.1 – 10.7 http://hyperphysics.phy-astr.gsu.edu/hbase/magnetic/elemot.html#c1 http://www.memagazine.org/backissues/membersonly/july99/features/blacksmith/blacksmith.html http://www.faulhaber-group.com/n390270/n.html
Lab		Interfacing RC Servos (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 7
Due		10/6/09: Term Project concept sketches (check Term Project guideline) Homework 6 via Blackboard Assignment upload (before the deadline!)
8	10/13-15	Motor sizing, stepper motors
Learning obj.		8, 9
Reading		HA: 10.1 – 10.7 http://www.compumotor.com/literature/pdf/pg223_engrg_mtrsz.pdf http://www.faulhaber-group.com/n128948/n.html (see the Motion Control Handbook, p. 16-23) http://www.cs.uiowa.edu/~jones/step/ http://www.eio.com/jasstep.htm
Lab		Interfacing a DC Motor and Encoder (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 8
Due		Homework 7 via Blackboard Assignment upload (before the deadline!)

9	10/20-22	Operational amplifiers, limitations of op-amps
Learning obj.		3, 4
Reading		HA: 5 http://www.allaboutcircuits.com/vol_3/chpt_8/index.html http://hyperphysics.phy-astr.gsu.edu/hbase/electronic/opampcon.html#c1
Lab		Printer Carriage Motion Control (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 9
Due		10/20/09: System block diagram, calculations, preliminary test results Homework 8 via Blackboard Assignment upload (before the deadline!)
10	10/27-29	Comparators, signal conditioning; A/D and D/A conversion
Learning obj.		3, 12, 13, 14
Reading		HA: 5.13, 8.1 – 8.4 http://www.allaboutcircuits.com/vol_3/chpt_8/12.html http://home.cogeco.ca/~rpaisley4/Comparators.html http://www.elecdesign.com/Files/29/6987/6987_01.pdf http://www.embedded.com/columns/technicalinsights/60403334?printable=true http://www.atmel.com/dyn/resources/prod_documents/doc6039.pdf
Lab		Electronic Scale (note: Take pre-lab quiz in CE8 prior to your session)
Assignment		Homework 10
Due		10/27/09: Evidence of first working prototype (show lab instructor during your lab period) Homework 9 via Blackboard Assignment upload (before the deadline!)
11	11/3-5	Digital electronics, basic logic functions
Learning obj.		7
Reading		HA: 6 http://www.allaboutcircuits.com/vol_4/index.html http://www.eelab.usyd.edu.au/digital_tutorial/
Lab		Open Lab for term project
Assignment		Homework 11
Due		Homework 10 via Blackboard Assignment upload (before the deadline!)
12	11/10-12	Logic gates, logic ICs
Learning obj.		7
Reading		HA: 6 http://www.allaboutcircuits.com/vol_4/index.html
Lab		Open Lab for term project
Assignment		Homework 12
Due		Homework 11 via Blackboard Assignment upload (before the deadline!)
13	11/17-19	Sensors for mechatronic devices
Learning obj.		11, 13, 15
Reading		HA: 9 http://newton.ex.ac.uk/teaching/CDHW/Sensors/
Lab		Open Lab for term project
Assignment		Homework 13
Due		Homework 12 via Blackboard Assignment upload (before the deadline!)

14	11/24	NO CLASS THIS WEEK! Furlough days plus Thanksgiving Holiday
Learning obj.		TBD
Reading		TBD
Lab		Open Lab for term project
Due		TBD
15	12/1-3	Special topics in mechatronics
Learning obj.		TBD
Reading		TBD
Lab		Open Lab for term project
Due		12/3/09: Term Project Fair. Time: 1:30 – 4:00 pm. Location: in and around E125. Bring project and poster.
16	12/8	Course review
Due		12/8: Term Project Report (hardcopy (in class) and softcopy via CE8). One report per team. Return any hardware that you borrowed. **12/15: Final Exam: Tuesday, December 15, 2009 1215 – 1430 in room E341**
17	12/15	**Final Exam: Tuesday, December 15, 2009 1215 – 1430 in room E341**
Due		Exit Evaluation

References

(In addition to these hardcopy references, check out the ME106 tutorial web pages)

Ball, S. (2003). *Analog Interfacing to Embedded Microprocessor Systems*, 2nd ed., Newnes, ISBN: 0750677236

Barnett, R., O'Cull, L., Cox, S. (2003). *Embedded C Programming and the Atmel AVR*, Delmar Learning, Clifton Park, NY.

Catsoulis, J. (2002). *Designing Embedded Hardware*, O'Reilly, ISBN: 0596003625

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

Horowitz, P., Hill, W. (1989). *The Art of Electronics*, 2nd ed., Cambridge University Press, New York.

Labrosse, J. J. (1999). *Embedded Systems Building Blocks: Complete and Ready-To-Use Modules in C*, 2nd ed., CMP Books, ISBN: 0879306041

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.

Pardue, J. (2005). *C Programming for Microcontrollers*, Smiley Micros, Knoxville, TN, www.SmileyMicros.com, ISBN: 0976682206.

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.

Scherz, P. (2006). *Practical Electronics for Inventors*, 2nd ed., McGraw-Hill/TAB Electronics, ISBN: 0071452818

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-Engineering, ISBN: 0534366422.

(Please check the Course Reserve in the MLK Library for several of the references listed above.)