San José State University  
Charles W. Davidson College of Engineering  
Department of Mechanical Engineering

ME 190 Mechatronics System Design  
Fall 2013

Instructor:  Buff Furman
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Office Hours:  Tues 1430-1530, Thurs 1130-1230, or by appointment only
Class Days/Time:  
Lecture:  Tu-Th 1330-1420  
Lab:  Th 1430-1715
Classroom:  E135
Prerequisites:  ME 106; co-req. ME 147
Section 01 (lecture):  41191
Section 02 (lab)  42917

Accessing Course Materials and Messaging
Copies of the course materials such as the syllabus, major assignment handouts, etc. will be found on the Canvas course management website, https://sjsu.instructure.com/courses/1014438. You are responsible for regularly checking for updates and reading messages that I may send to you through MySJSU, Canvas, or other system.

Course Description
ME 190 is the capstone course for the mechatronics specialization track. Students will integrate and build upon knowledge and skills gained in previous courses to design, assemble, and analyze mechatronic systems using modern methods and tools. Lectures and laboratory experiences will include control theory, dynamic system behavior, communication protocols, pneumatics, embedded programming, and analysis in time- and frequency domains. The course concludes with an open-ended team-based multi-week design project.  
(3 units; lecture/lab)
Course Goals and Student Learning Objectives

The goals of the course are to:
- Provide a comprehensive learning experience that integrates engineering and mechatronics knowledge gained in prior courses.
- Prepare students for practice of mechatronics in industry or graduate study.

Learning Objectives

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

1) Determine a system’s transfer function through analysis of input and output data
   - Given a data set, find and plot the transfer function or state-space representation for the system
   - Identify common applications for Laplace transforms
   - Demonstrate understanding of state-space representation of a system

2) Identify system characteristics by inspection of a data plot
   - Explain system characteristics in the time domain, frequency domain, and using a Nyquist plot
   - Associate plot features with relevant mathematical expressions
   - Identify resonance frequencies

3) Extract useful data from a noisy signal
   - Given a real-world (e.g., noisy, out-of-range, etc.) signal source, acquire and extract useful data using appropriate data acquisition and signal conditioning techniques
   - Apply appropriate filtering
   - Distinguish between true outlier data points and erroneous data

4) Design and construct application-appropriate filters
   - Explain the types of filters and their characteristics for both hardware (passive and active) and software filters

5) Design and implement a hardware controller
   - Design and implement in hardware a controller for an existing system to achieve performance specifications
   - Interpret and explain circuit schematic diagrams
   - Explain the disadvantages of over-building or under-building a system
   - Identify a system that has unnecessary complexity and suggest methods to simplify the system
   - Identify a system that might have unnecessary costs and suggest methods to reduce cost
   - Describe the process of debugging a system by isolation of subsystems
   - Draw a block diagram of a physical system, noting all important inputs and outputs
- Relate a block diagram to a physical system, and identify differences between them
- Describe algorithmically an implementation of a PID controller in hardware
- Implement a hardware timer for analog-to-digital conversion
- Predict system response to a control input
- Describe at least one method for reading an incremental encoder in software
- Describe and discuss advantages, disadvantages, and limitations of a typical 8-bit microcontrollers, such as the ATmega168 and a Programmable System on Chip (PSoC) device, such as the Cypress PSoC 1
- List possible alternatives to an 8-bit microcontrollers for controlling mechatronic systems

6) Use MATLAB / Simulink for digital simulation of a real-world dynamic system
   - Use Matlab/Simulink to simulate the dynamic performance of a physical system
   - Design and optimize or analyze a control system

7) Interface assorted devices using standard communication protocols
   - List and describe common data communication protocols used in embedded systems, such as RS-232, SPI, I2C
   - Use an industry-standard communication protocol, such as I2C, SPI, or CAN to interface a controller with a sensor or other device
   - Design a simple mechatronic system using at least two of the three common data communication protocols
   - List and describe different wireless topologies
   - Explain the underlying wireless principals (FM, bandwidth, CSMC/CA, Protocol Layers)
   - Describe how addressing and packetization of data works
   - Implement addressing and packetization in a mechatronic system
   - Describe the pitfalls of wireless communication (interference, range issues, data integrity)
   - Explain how to implement fail-safe designs in a wireless system
   - Implement an ad-hoc network using microcontrollers and personal computers

8) Write and optimize code for embedded programming
   - Apply effective embedded programming approaches to optimize system performance
   - Interpret and explain circuit schematic diagrams
   - Demonstrate knowledge of good programming practices and conventions
   - Debug computer code using a runtime debugger (or simulator)
   - Describe the difference between an algorithmic bug, a syntax error, and an implementation bug
   - Diagram the operation of a program using a flow chart and/or pseudo-code
   - Diagram a program by its necessary inputs and outputs
Explain a block of code using language that a team member or manager without a strong programming background would be able to understand
Implement an interrupt-driven microcontroller program
Write the equations for finding numerically the integral and derivative of a feedback error in a discretized system

9) **Design and analyze basic pneumatic systems**
- Select, configure, and implement pneumatic components for a specific task
- Read a Piping and Instrumentation Diagram (P&ID) and describe the function of the system
- Draw a P&ID based given an actual hardware implementation in the laboratory
- Build a pneumatic circuit when given a P&ID and required components
- List the steps needed to disassemble a pneumatic system safely (depressurization verification, etc.)
- Write a checklist to verify that an pneumatic system is safe to pressurize
- Calculate the pushing and pulling force of an air cylinder given system parameters
- Describe the function of an air regulator and a backpressure regulator
- Explain the advantages and disadvantages of air cylinders as compared to other actuators
- Explain the key differences between pneumatic and hydraulic actuators
- Correctly interpret ISO symbols on a fluid power schematic diagram
- Properly draw a fluid power schematic diagram to solve a problem involving pneumatics
- Describe the basic elements of an air treatment system for obtaining usable compressed air
- Size pneumatic components (valves, tubing, regulators, etc.) for a given application
- Interface a pneumatic system with a microcontroller or programmable logic device (PLC)

**Required Materials and Readings**

**Textbook**

**Required Textbook**

**Recommended Textbooks**
Required Hardware
Arduino Microcontroller (Duemilanove, UNO R3, Mega, or Due). Sources for these boards include: NKC Electronics, Adafruit Industries, Sparkfun Electronics, Modern Device, (local sources: Jameco, Radio Shack, Fry’s Electronics), and many others. Ballpark price for the UNO R3 is $22-$30.

Required Software
Matlab Student Edition

Other equipment / material requirements
TBD

Library Liaison
Our liaison 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, 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 190 Course Schedule listed below for links to the homework and laboratory assignments.
Homework is generally due in both hardcopy and softcopy one week after it is assigned. You must turn in the hardcopy at the beginning of the lecture period and the softcopy to the corresponding Assignments folder in Canvas. You will not get credit for late assignments or for assignments which are missing the corresponding softcopy. I strongly suggest that you upload your assignments to Canvas before you print out the softcopy, so that you don’t forget this part.

Laboratory reports will be handled similarly: both a hardcopy and a softcopy must be submitted one week after the laboratory experiment was performed. Turn in the hardcopy to your lab instructor at the beginning of the lab period, and submit the softcopy to the appropriate folder in Canvas.

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 and presentations 20%, Projects 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. A final letter grade will be determined from your overall performance (percentage) using the following criteria:


The final examination for the course will be on Thursday, December 12, 2013 from 1215 – 1430 in E135.
University Policies

Academic integrity

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 http://www.sjsu.edu/senate/S07-2.htm, 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.sa.sjsu.edu/judicial_affairs/index.html.

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 your assignment or any material you have submitted, or plan to submit for another class, please note that SJSU’s Academic Policy S07-2 requires approval of instructors.

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:

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.


\(^2\) Adapted from, “Avoiding Plagiarism,” http://owl.english.purdue.edu/handouts/research/r_plagiar.html.
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.]

**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](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. 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/about/staff/](http://www.sjsu.edu/writingcenter/about/staff/).
# ME 190 Mechatronic Systems Engineering

## Fall 2013 Course Schedule (tentative)

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<th>Week</th>
<th>Date</th>
<th>Topics,</th>
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<tr>
<td>1</td>
<td>8/22</td>
<td>Course overview, mechatronic systems (open and closed loop)</td>
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<tr>
<td>2</td>
<td>8/27-29</td>
<td>Linear Time Invariant Systems (LTI), time and frequency domains, MATLAB / Simulink</td>
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<td>3</td>
<td>9/3-5</td>
<td>Modeling and transient response of dynamic systems</td>
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<td>4</td>
<td>9/10-12</td>
<td>Modeling and frequency response of dynamic systems</td>
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<tr>
<td>5</td>
<td>9/17-19</td>
<td>Automatic control system design: analog and digital control actions</td>
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<td>6</td>
<td>9/24-26</td>
<td>State-space formulation and analysis of dynamic systems</td>
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<td>7</td>
<td>10/1-3</td>
<td>Electromechanical sensors and actuators</td>
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<td>8</td>
<td>10/8-10</td>
<td>10/8: Pneumatics – part 1.</td>
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<td>10/10: Guest speaker: <strong>Darren Seawright</strong>, KLA-Tencor – Mechatronics systems in semiconductor manufacturing equipment</td>
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<tr>
<td>9</td>
<td>10/15-17</td>
<td><strong>10/15: Midterm Exam</strong></td>
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<td>10/17: Guest speaker: <strong>Bob Ricommini</strong>, Whipsaw – Mechatronic systems in consumer and industrial product design</td>
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<td>11</td>
<td>10/29-31</td>
<td>Embedded software.</td>
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<td>10/31: Guest Speaker: <strong>Jake Federico</strong>, Varian Associates – Embedded hardware and software</td>
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<td>12</td>
<td>11/5-7</td>
<td>PID control (continuous and discrete time)</td>
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<td>11/7: Guest Speaker: <strong>Brent Miller</strong>, Bloom Energy – Control system design and analysis using Python</td>
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<tr>
<td>13</td>
<td>11/12-14</td>
<td>Alternative microcontrollers for mechatronic systems</td>
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<td>14</td>
<td>11/19-21</td>
<td>Cypress Semiconductor PSoC microcontroller</td>
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<tr>
<td>15</td>
<td>11/26</td>
<td>Special topics</td>
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<td>16</td>
<td>12/3-5</td>
<td>Special topics</td>
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<td></td>
<td></td>
<td>12/5: Term Project Presentation</td>
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<tr>
<td>17</td>
<td>12/12</td>
<td><strong>Final Exam, Thursday, December 12, 2013, 1215 - 1430</strong></td>
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