AE 6705 – Introduction to Mechatronics

Course Syllabus

Fall Semester 2018

**1. CLASS SCHEDULE**

Lecture: 1:30 – 2:45pm Tuesday Thursday

Love 183

Lab: 11:15am – 2:00 pm Friday (ME 6405-A)

6:00 – 8:45pm Friday (ME 6405-B)

College of Computing Building, Room 030

**2. INSTRUCTORS**

Dr. Jonathan Rogers, Associate Professor, School of Aerospace Engineering, Georgia Institute of Technology

Office: MRDC 4503

Office Hours: Tuesday, Thursday, 12:00 pm – 1:30 pm or by appointment

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TA: Jonathan Camargo Leyva

Office Hours: TBD

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TA: Siavash Farzan

Office Hours: TBD

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**3. COURSE OVERVIEW**

This course introduces students to microcontrollers and hardware control of mechanical devices. Course modules will focus on microcontroller design and programming, mechanical actuators, sensors, feedback control, and system modeling. Through these modules students will develop a strong fundamental understanding for microcontroller programming, analog-to-digital conversion, control of mechanical and thermal systems, feedback concepts, and embedded software development. Through 10 lab exercises and a final project, students will gain practical experience designing and constructing all aspects of mechatronics systems.

**4. PREREQUISITE COURSES**

Appropriate undergraduate course(s) in controls and system dynamics.

**5. COURSE TEXTBOOK**

The official textbook for this course is:

* Jouaneh, M., Fundamentals of Mechatronics, Cengage Learning, 2013 (available from Amazon.com), ISBN 978-1-111-56901-3

Note that it is not required that students purchase this book. However, it may be useful as a reference throughout the course (and is very readable).

The following supplementary references are not required but may be useful:

* Valvano, J., Introduction to the MSP432 Microcontroller, Self-Published by Jonathan Valvano, 2015 (available from Amazon.com)

**6. COURSE OBJECTIVES**

Outcome 1: Students will develop a solid understanding of the various components of the interface between mechanical and electronic systems which comprise microcontroller units (MCUs).

1.1 Students will demonstrate an understanding of integer and floating point math, and will understand the concepts of finite precision and rollover.

1.2 Students will be able to develop embedded C programs of moderate complexity capable of executing feedback control of mechanical systems using an MCU.

1.3 Students will gain experience with analog-to-digital conversion, serial communications, interrupts, timers, and volatile/non-volatile memory.

Outcome 2: To educate students about actuator devices and appropriate methods of powering and controller actuator mechanisms.

2.1 Students will demonstrate knowledge of operation of brushed and brushless DC motors.

2.2 Students will demonstrate knowledge of stepper motors and stepper motor drive circuits.

2.3 Students will be able to develop appropriate actuator control software and hardware using pulse width modulation, H-bridge circuits, and power MOSFETs.

Outcome 3: To educate students about sensor devices and appropriate methods of powering sensors, reading sensor data, and conditioning sensor data for use in control algorithms.

3.1 Students will demonstrate knowledge of sensor signal characteristics such as noise, bias, range, accuracy, sensitivity, resolution, hysteresis, and repeatability.

3.2 Students will be comfortable using various types of sensors including encoders, transducers, proximity sensors, Hall effect sensors, and others. Students will be able to required sensor specifications to produce a desired mechatronic system functionality.

3.3 Students will be able to design hardware filters and software filters for the purpose of signal conditioning.

Outcome 4: To educate students about feedback control and system modeling for the purposes of efficiently designing and implementing mechatronic systems.

4.1 Students will be able to construct an input-output system block diagram for an arbitrary mechatronic device.

4.2 Students will be able to derive equations of motion for a mechanical system, apply the Laplace transform, and generate open and closed loop transfer functions using PID control.

4.3 Students will be able to utilize simulation models for control design and understand performance differences between simulated and experimental systems.

4.4 Students will be able to design, construct, simulate, and control in a feedback manner a mechatronic device which performs some specified functions.

**7. GRADING**

Grades will be determined based on demonstrated proficiency on labs and a final project. The points associated with each graded event are shown below along with the associated letter grade. Note that this course is not graded on a curve.

Point Breakout:

Lab Assignements (10) = 600 points

Final Project = 400 points

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**Total = 1000 points**

Class participation: +, 0, -

Grading Scale:

A = 900-1000 Total Points

B = 800-899 Total Points

C = 700-799 Total Points

D = 600-699 Total Points

F = 0-599 Total Points

Occasionally, students may be offered the opportunity to obtain extra credit points. These points are added to the student's total while the total points for the course remains at 1000.

In borderline cases, the class participation score will be used to influence the final grade.

**8. LABORATORY ASSIGNMENTS**

This class will include an extremely important lab component. We will have approximately one laboratory each week. Some important items about lab assignments:

* Lab assignments will be made available on T-Square on Tuesday of each week (starting 8/28). They are due in class on Tuesday of the following week.
* Each lab assignment is worth 60 points.
* All labs are “open labs”. You can complete the lab whenever you want, at your convenience. You can use the Mechatronics lab to complete the assignment, or not if you wish. The Mechatronics lab will be accessible to all students enrolled in the class during normal business hours.
* Our lab sections are scheduled for Fridays 11:15-2pm and 6:00-8:45pm. The TA will be available in the lab during a portion of this time (TBA) to assist with the lab assignment. There is no guarantee that the TA will be accessible to help with lab assignments outside of this session (students are encouraged to make an appointment if needed).
* All students must complete each lab individually, there will be no groups. Students must write all of their own code and build their own circuits for each lab assignment. Each student must submit his or her own lab report.
* All lab reports must be typed and be no more than 4 pages unless otherwise specified. There is no formal structure for lab reports – they must simply answer the questions asked in the lab, with appropriate discussion and embedded figures.
* All students must submit their code for each lab via T-Square. Lab grades will be an automatic zero if code is not submitted.
* Deliverables for Lab Assignments:
  + Many lab assignments will involve some combination of writing software, building hardware, and answering questions on theory. Labs will vary in their mix of these three. Each lab will specify exact deliverables.
  + Deliverable 1: If the lab involves a hardware/software component, successful operation of your hardware/software must be demonstrated to me (during office hours) or the TA to get credit for this portion of the lab.
  + Deliverable 2: If the lab involves a report component, this should be turned in during class on the due date (must be typed, max 4 pages).
  + Deliverable 3: If the lab involves software, your software must be submitted to T-Square. This is pass-fail, i.e., if code is not submitted the lab grade will be zero. The code itself will not be graded.
  + Deliverable 4: Many/all of the labs will have a short multiple-choice quiz given via Canvas during the lab session.

**9. REQUIRED EQUIPMENT**

Each student will receive their own Texas Instruments MSP432P401R Launchpad microcontroller development kit during the second week of class. Replacement kits are available for purchase for $12.99 at:

<http://www.ti.com/tool/msp-exp432p401r>

**10. ADDITIONAL INSTRUCTION**

Supplemental instruction by the instructor or TA is a valuable resource available to any student having difficulty with a particular concept in the course. Get help when you have a problem! Be prepared to ask specific questions that concisely articulate unclear concepts. **Students are highly encouraged to attend office hours or make an appointment via email.**

**11. CLASS POLICIES**

**Attendance:** Class attendance is required. In previous classes there has been a strong correlation between students who received good grades and students who attended class regularly.

**Cell Phones and Electronic Devices:** Cell phones ***should not be out during class***. No exceptions.

**12. ACADEMIC DISHONESTY**

Students are expected to uphold high ethical standards including adherence to Georgia Tech Academic Honor Code (which can be found in the 2017-2018 course catalog).

You are permitted and to a great extent encouraged to seek the advice of others. However, there is an obvious difference between a constructive discussion about a lab/homework problem with a classmate and copying a classmate’s work or code. Copying is not permitted. Any help/advice you receive must be fully documented so that you do not falsely represent yourself and your work.

**If you are not sure about whether a particular action could be considered plagiarism or academic dishonesty on your part, then ask the instructor**.

**13. TENTATIVE SCHEDULE**

Note the following course topics are tentative and subject to change.

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| **Topics to be Covered** |
|  |
| Introduction |
| Electrical Components and Basic Circuits |
| MSP432 Overview |
| Integer Math |
| Floating Point Math |
| C Programming 1 |
| C Programming 2 |
| C Programming 3 |
| GPIO and FPU on the MSP432 |
| Interrupts |
| Serial Communications 1 |
| Serial Communications 2 |
| Clocks, Timers, and Flash Memory |
| Analog to Digital Conversion |
| Actuators 1 |
| Actuators 2 |
| Actuators 3 |
| Sensors 1 |
| Sensors 2 |
| Sensors 3 |
| Feedback Control and System Modeling 1 |
| Feedback Control and System Modeling 2 |
| Feedback Control and System Modeling 3 |
| Digital Control 1 |
| Digital Control 2 |