ME 6705 / AE 6705 – Introduction to Mechatronics

Course Syllabus

Fall Semester 2021

1. CLASS SCHEDULE

Lecture: 12:30 – 1:45pm Tuesday Thursday, Van Leer C456

2. INSTRUCTORS

Dr. Jonathan Rogers, Associate Professor, School of Aerospace Engineering
Office: Montgomery Knight 421B
Office Hours: Wednesday 11:00am – 11:30am, Friday 11:00am - 12:00pm
Email: jonathan.rogers@ae.gatech.edu

TA: Sixu Zhou
Office Hours: TBD
Lab Demo Hours: Tuesday 9:00am – 10:30pm
Email: szhou928@gatech.edu

TA: Zhigen Zhao
Office Hours: TBD
Lab Demo Hours: Tuesday 10:30am – 12:00pm
Email: zhigen.zhao@gatech.edu

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. COURSE FORMAT

- The ME/AE 6705 course for the Fall 2021 semester will make use of extensive online content. All course content will be available to students via instructional videos posted

prior to lecture. No new material will be covered in lecture that is not covered in the videos and slides provided to students on Canvas. Therefore, class attendance is completely optional. The in-person lecture will consist mainly of a review and summary of instructional materials provided in online videos and slides.

- **Lecture Videos:** Instructional videos on lecture topics will be posted to the Canvas page for the course under the Media Gallery. Prior to each lecture session, students will be expected to watch between 1 and 6 videos on various lesson topics. **A list of the lecture videos to be watched prior to each lecture session is posted in the Course Admin folder under Files on the Canvas page.** Please review the list of videos for each lecture session and watch them prior to the lecture.

- **Lecture Sessions:** Students are expected to watch the videos and review the slides posted to Canvas prior to each class, as this is where new class material will be presented. During lecture sessions, the instructor will informally review the lecture material for that session, discuss questions on the course material (NOT the labs), and occasionally provide demos. **Attendance during class is completely optional.** For students who choose to attend the in-person lectures, wearing a mask is **strongly, strongly advised.**

- **Lab/Homework Assignments:** Lab assignments will be given approximately once per week. **All lab assignments are designed such that they can be completed from home**. Students are encouraged to complete the labs from home to avoid crowding in the Mechatronics lab space. Labs are to be performed individually, no groups. More information about labs will be provided in Section 5.

- The instructor will not take questions about labs or course material after class. Instead, students may attend the instructor's online office hours on Wednesday or Friday to ask questions, or may email the instructor or TAs at any time with questions. The Bluejeans link for these instructor office hours will be available on the Canvas course page, and a sign-up sheet for office hours will be provided at the beginning of the semester.

5. LABORATORY ASSIGNMENTS

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

- Lab assignments will be made available on Canvas on Tuesday of each week (starting 8/31). They must be submitted prior to 12:30pm on Tuesday of the following week.
- Each lab assignment is worth 80 points.
- All labs are designed to be completed at home, on your own time (not necessarily during the specified lab section hours). Students may also use the Mechatronics lab, CoC Building 031, as needed to complete the labs. **However, due to COVID-19 students are strongly encouraged to avoid using the lab and instead complete the assignments from home.**
- Lab assignments will be demonstrated to the TAs remotely via Bluejeans (at the Bluejeans link on the Canvas page). **Students will demonstrate their labs during**

assigned time slots on Tuesday morning, or during Monday office hours. More information about signing up for a lab demo time will be provided during the first two weeks of class.

- 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 Canvas. 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 TAs or Instructor (during Demo hours on Tuesday or during office hours) to get credit for this portion of the lab.
    - Deliverable 2: If the lab involves a report component, this should be turned in on Canvas prior to the due date (must be typed, max 4 pages).
    - Deliverable 3: If the lab involves software, your software must be submitted to Canvas. This is pass-fail, i.e., if code is not submitted the lab grade will be zero. The code itself will not be graded.

6. REQUIRED EQUIPMENT

All the components needed to complete each lab will be available for pickup at the Mechatronics lab (CoC Building 031) each week. Also, you will receive an MSP432 microcontroller to use for the course, **but it must be returned at the end of the course for use in future courses**.

Students will need to purchase some components for the final project. A list of these components, and instructions for ordering them will be provided when the project is assigned. It is expected that this purchase will cost less than $50.

7. 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.

All office hours will be held remotely at pre-scheduled times. 10-minute time slots will be provided during office hours, and students can sign up for one time slot per week. Instructions for signing up for office hours will be provided during the first two weeks of class. All office hours will be held on the Canvas Bluejeans link for the course.

Students may sign up for only one 10-minute office hour slot each week. If you need additional assistance, please wait until Monday after 2pm. If additional slots are available after that time, you may sign up for one additional slot only. Students are always welcome to email questions to the instructor or TA.

8. FINAL PROJECT

A final project will be assigned sometime in late October and will be due during the final exam period. The final project will be due in lieu of a final exam (it is an "alternative final"). There will be no final exam for the course. For the final exam, each student will build a line-following robot using specific components detailed in the project assignment. **All final projects will be completed individually**. A more detailed final project assignment will be provided later in the course.

9. PREREQUISITE COURSES

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

10. 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)

11. 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.

12. 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 Assignments	(10)	= 800 points
Final Project		= 200 points
Total		**= 1000 points**

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.

13. CLASS POLICIES

Attendance: Attendance at the in-person lecture sessions is completely optional. Students will have access to all course material, including videos of the lecture sessions, completely online via Canvas. Students who attend lecture are strongly, strongly advised to wear a mask.

Students with disabilities will receive necessary accommodations. For details, please refer to the GT Disabilities Services' "Policies and Procedures" page located at this link: http://disabilityservices.gatech.edu/content/15/policies-procedures.

14. ACADEMIC DISHONESTY

Students are expected to uphold high ethical standards including adherence to Georgia Tech Academic Honor Code (which can be found in the 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.

15. GTAE VALUES

Honesty: The School of Aerospace Engineering values honesty and integrity of all members of our community. An important element of this value is the academic honor code.

Georgia Tech Honor Challenge Statement: I commit to uphold the ideals of honor and integrity by refusing to betray the trust bestowed upon me as a member of the Georgia Tech community.

Honor Code: http://policylibrary.gatech.edu/student-affairs/academic-honor-code#Article_I:Honor_Agreement

16. HEALTH AND WELL-BEING

The School of Aerospace Engineering values the complete well-being of all members of its community, which includes professional, physical, spiritual, emotional, and social dimensions. There are numerous resources to support the mental health of all members of our community.

Campus Mental Health Resources:
Center for Assessment, Referral, and Education (CARE): https://care.gatech.edu/
Tech Ends Suicide Together: https://endsuicide.gatech.edu/
Counseling Center: https://counseling.gatech.edu/
Collegiate Recovery Program: https://counseling.gatech.edu/content/collegiate-recovery-program
Stamps Psychiatry: https://health.gatech.edu/services/psych
Vice President and Dean of Students Office and Student Referral Form: https://referral.studentlife.gatech.edu/

Georgia Tech CARE: 404.894.3498
Georgia Tech Counseling Center: 404.894.2575
Georgia Tech Police Department: 404.894.2500

Georgia Crisis and Access Line: 1.800.715.4225
National Suicide Prevention Lifeline: 1.800.273.TALK (8255)
National Hopeline Network: 1-800.784.2433

17. SOCIAL JUSTICE

The School of Aerospace Engineering values social justice for all members of the Georgia Tech community and the larger society. Social justice means that everyone's human rights are respected and protected. We stand committed in the fight against racism, discrimination, racial bias, and racial injustice. Our shared vision is one of social justice, opportunity, community, and equity. We believe that the diversity and contributions from all of our members are essential and make us who we are. We believe that our impact must reach beyond the classroom, research labs, our campus, and the technology we create, but must also improve the human condition where injustice lives. We will continue to work to understand, value, and celebrate all people and create an inclusive educational and work environment that welcomes all.

As a matter of policy, Georgia Tech is committed to equal opportunity, a culture of inclusion, and an environment free from discrimination and harassment in its educational programs and employment. Georgia Tech prohibits discrimination, including discriminatory harassment, on the basis of race, ethnicity, ancestry, color, religion, sex (including pregnancy), sexual orientation, gender identity, national origin, age, disability, genetics, or veteran status in its programs, activities, employment, and admissions.

http://policylibrary.gatech.edu/equal-opportunity-nondiscrimination-and-anti-harassment-policy