ECE 4550 – Control System Design

Syllabus and Policy – Fall 2026

1 Description

- **Catalog Listing:** Design of control algorithms using state-space methods, microcontroller implementation of control algorithms, and laboratory projects emphasizing motion control applications.
- **Curriculum Thread:** Required for Robotics and Autonomous Systems Thread (EE and CmpE)
- **Prerequisites:** (ECE 2031 or ECE 20X2) and (ECE 3084 or ECE 3085 or ECE 3550)
- **Attributes:** 4 credit hours (3 for lecture section, 1 for lab section), scheduled/supervised lab
- **Unique Content/Concept:** This course has been developed so that students learn the rigorous analysis and design concepts of control engineering in the context of practical real-world applications. This course combines the teaching of feedback control and embedded design, and includes exposure to microcontrollers, power electronics, electric machines and motion systems through lab projects. This course involves a unique mix of physics, math, programming, technology and hands-on experimentation—a great combination!

2 Instructor and Assistants

- **Instructor:** Professor David Taylor, `david.taylor@gatech.edu`
  - Class sessions in VL E283: Tuesdays/Thursdays 9:30 AM - 10:45 AM
  - Office hours in VL E474: posted on the Canvas site home page
- **Assistants:**
  - to be determined
    - L01 lab sessions in VL E263: Tuesdays 12:30 PM - 3:15 PM
    - L03 lab sessions in VL E263: Thursdays 12:30 PM - 3:15 PM
    - Office hours in VL E263: posted on the Canvas site home page
  - to be determined
    - L02 lab sessions in VL E263: Tuesdays 3:30 PM - 6:15 PM
    - L04 lab sessions in VL E263: Thursdays 3:30 PM - 6:15 PM
    - Office hours in VL E263: posted on the Canvas site home page

3 Evaluation of Performance

- **Exams, 60%**
  - 3 equally-weighted exams, each covering one-third of course (last exam is 2 hours total)
  - old exam solutions posted to assist learning and preparation
- **Homework, 15%**
  - students submit legible pdf file for grading
- **Labs, 25%**
  - students submit pre-lab (10%) and task (90%) documentation for grading
  - labs are not optional, no lab effort will result in course grade of F

- **Letter Grades**
  - A: [90,100] %, B: [80,90) %, C: [70,80) %, D: [60,70) %, F: [0,60) %
  - cutoffs might be adjusted (only downward, resulting in higher letter grades)

4 Textbook

- Franklin, Powell and Emami-Naeini, Feedback Control of Dynamic Systems, 8/e, Prentice Hall, 2019.
- The textbook listed above is optional. Customized lecture notes and problem sets will be provided.

5 Topical Outline

- State-Space Methods for Analysis and Design (not all topics will be covered)
  - Physics of Electrical, Mechanical, and Electromechanical Systems
  - Approximation of Nonlinear System Dynamics by Linear Models
  - System Models, Responses, and Stability
  - Numerical Simulation Techniques
  - Objectives and Specifications in Control Applications
  - State Regulation, Controllability, Actuator Selection
  - State Estimation, Observability, Sensor Selection
  - Integral Control, Command Following, Disturbance Rejection
  - Inversion of Plant Model, Motion Planning, Tracking Control
  - Controller Discretization, Indirect Continuous-Time Design
  - Plant Discretization, Direct Discrete-Time Design
  - Parameter Identification Methods
  - Time-Scale Separation, Reduced-Order Design Models
  - Optimization-Based Design and Stability Robustness
- Microcontrollers and Control Applications (not all topics will be covered)
  - Computer Representation of Numbers
  - Interrupt-Based Program Flow
  - Clocks and Timers
  - General Purpose Inputs and Outputs
  - Serial Communication, Chip-to-Chip, System-to-System
  - Digital-to-Analog Conversion, Analog-to-Digital Conversion
  - Pulse-Width Actuation, Pulse-Width Sensing
  - Encoders, Accelerometers, Gyroscopes
  - DC Motors, AC Motors, Drive Circuits
  - Two-Machine Motoring/Generating Dynamometers
  - Switched-Mode DC-to-DC Power Converters
  - Electromechanical Motion Systems, Mobile Robots
  - Under-Actuated Motion Systems, Crane, Rocket
  - Multi-Input Multi-Output Motion Systems, Aerial Vehicles

6 Course Educational Outcomes

Upon successful completion of this course, students should be able to:

- Apply the laws of physics to obtain mathematical models describing the dynamic behavior of several types of physical systems.
- Approximate the constant coefficients parameterizing the dynamic model of a given physical system by utilizing measured input-output data.
- Develop a state-space model for a given physical system and use it to analyze the system's response and to characterize the system's stability.
- Perform controllability and observability analyses to guide the selection of suitable actuators and sensors for a given physical system.
- Design a digital control algorithm incorporating state estimation, state regulation and error integration to impose command following.
- Program a computer to simulate a digital control system, accounting for the influence of disturbances, noise, quantization, sampling and saturation.
- Program a microcontroller to implement a digital control algorithm, using interrupt-based timing and on-chip peripherals for interfacing.
- Develop microcontroller code for motion control systems incorporating various types of electric motors and associated switched-mode drive circuits.
- Evaluate the performance of motion control system implementations by analyzing and interpreting experimental data obtained from measurement.
- Prepare documentation describing control system designs and associated laboratory measurements, conforming to appropriate technical standards.

7 Course Rules and Policy

7.1 Timing of Graded Activities

- Exams are to be taken according to schedule. Exceptions require prior approval from the instructor and will be granted only under special circumstances with documentation.
- Homework and lab deliverables must be submitted on time to receive full credit.
  - **Homework:** 0.5% per hour late penalty, no credit if submitted more than 24 hours late.
  - **Lab Tasks:** 0.5% per hour late penalty (checkoffs and code).
  - **Pre-Labs:** no credit if submitted late.

  The late penalty on homework submissions is time-limited in order to allow for occasional lateness, while also ensuring that late submissions do not significantly delay the posting of homework solutions.

7.2 Academic Integrity

- It is permissible to discuss homework and lab assignments with your peers, but the work that you submit for grading *must be your own*; homework assignments and pre-lab assignments always require *individual* responses, whereas lab tasks may be completed with a partner (if applicable).
- If a discussion with others influences your solution, you are still responsible for producing a submission that demonstrates how you have worked through the details on your own. Multiple students must not submit practically indistinguishable work because only one name may appear on each submission.

- Examples of academic misconduct
  - Copying MATLAB code (in part or in full)
  - Copying C code (in part or in full)
  - Copying problem solutions (in part or in full)
  - Using resources such as Chegg to request or receive problem solutions
- Representing the work of others as if it were your own work (on homework, labs or exams) is completely unethical and a serious violation of the Georgia Tech Honor Code.
- Instances of academic misconduct will be fully documented and forwarded to the Office of Student Integrity for appropriate resolution. For further information, see `http://osi.gatech.edu/`.

7.3 Time Commitment

This course awards 3 credit hours for the lecture section and 1 credit hour for the lab section. As defined at `https://catalog.gatech.edu/rules/2/`, this means that the lecture section corresponds to 3 scheduled contact hours plus 6 non-scheduled contact hours, whereas the lab section corresponds to 3 scheduled contact hours, for a total of 12 contact hours per week. Note that 1 contact hour corresponds to 50 minutes and lab sessions include a 15-minute break. The table below summarizes the time commitment per week, assuming the standard 15-week fall and spring semesters; 5 in-seat hours and 5 at-home hours each week, where the at-home hours are for reading notes, doing homework, preparing for labs, and preparing for exams.

(4 Credits, 15 Weeks)	Contact Hours per Week	Actual Hours per Week
In Lecture	3	2.5
In Lab	3	2.5
At Home	6	5
Total	12	10

7.4 Lab Policy

- **Lab Teams:** Each lab section is limited to a maximum enrollment of 12 students and, since there are six lab stations, a full lab section will result in six groups of two. If a lab section is not full, groups of one may be desired or necessary. If presented with the option of working alone or with a partner, consider your background: if you have some prior experience with microcontrollers, then you may prefer to work alone; otherwise, you should probably be working with a partner. If you are working with a partner, you and your partner are expected to put forth comparable levels of effort; if the observed levels of active participation within a group do not meet expectations, then distinct lab grades will be assigned to the group members to reflect that observation.
- **Supervised Lab Sessions:** In this course, the lab sessions are scheduled for a particular day and time so that students receive the benefits of supervision such as one-on-one guidance and assistance as needed. Consequently, students are expected to attend their scheduled lab sessions. To maximize productivity during scheduled lab sessions, students are expected to study the lab assignments and perform preliminary tasks prior to their scheduled lab session. If the lab assignments are appropriately designed (an instructor responsibility) and if appropriate pre-lab preparations are made (a student responsibility), then there will generally be no need for student lab access aside from the scheduled and supervised lab sessions.
- **Unsupervised Lab Access:** The lab portion of this course has two primary learning objectives:
  - learn how to program microcontrollers for use in embedded control systems;
  - learn about embedded control system applications, e.g. electromechanical motion systems.

Regarding the first of these objectives, in each lab project students are asked to complete a programming task that solidifies understanding of key concepts. Students require differing amounts of time to successfully complete these assignments. Although the assignments are defined with the expectation that all well-prepared students should be able to complete them during the scheduled and supervised lab time, some students may occasionally require extra time in the lab. If extra time in the lab is needed, the best solution would be for the students to attend GTA office hours in the lab to get expert assistance. Unfortunately, the GTA cannot always be available at times that are convenient for the students who need the extra assistance. For this reason, students will be granted Buzz Card access to the lab space. This access is provided as a flexible way to accommodate the occasional need for extra unsupervised time with the lab equipment. There is no intent to imply that you must do work outside of scheduled and supervised lab sessions in order to succeed in this course; in fact, use of the lab space should typically be limited to the scheduled and supervised lab sessions or to GTA office hours, as discussed above.

- **Lab Rules:** Every student must abide by the following set of rules:
  - All students must attend their scheduled lab sessions. This is when announcements are made, when students may ask for assistance, and when instructor verification sheets are signed.
  - All members of a team must be present; working alone is not permitted. This will provide a margin of safety and will encourage all team members to make appropriate contributions.
  - If there is a shortage of available lab stations during GTA office hours or during unsupervised lab hours, teams are expected to limit their use of their lab station to one-hour intervals.
  - The lab space may be used only by students who have enrolled in this course, and only for the purpose of working on lab projects assigned in this course.
  - None of the equipment may be removed from the lab space, even temporarily, for any reason. Teams should only use the equipment located at their own station.
  - For the safety of both persons and equipment, always be cautious when working in the lab. If you have concerns about a procedure, seek assistance before continuing.
  - Never leave the door open when the lab space is unattended. The card reader and surveillance camera are used to assign responsibility to students using the lab without supervision.
  - The Georgia Tech Honor Code forbids unauthorized collaboration on assignments. Although lab teams may discuss problems of implementation, copying of code is expressly forbidden.

7.5 Honor Code

Uphold the ideals of honor and integrity by refusing to betray the trust bestowed upon Georgia Tech students; see `https://policylibrary.gatech.edu/student-life/academic-honor-code`.

7.6 Student-Faculty Expectations

To foster an appropriate environment, see `https://catalog.gatech.edu/rules/21/` for expectations.

7.7 Office of Disability Services

Students with disabilities may seek accommodations via `https://disabilityservices.gatech.edu`.

7.8 Copyrighted Course Material

Students are not permitted to distribute any of the course materials made available through Canvas. Note that unacceptable distribution would include (but is not limited to) contributing to test or homework banks, CourseHero, Chegg, or similar websites. As creator of the course materials, Prof. Taylor possesses exclusive intellectual property rights limiting the use and distribution of these materials through copyright law.