Syllabus
CSC409/509, ECE409/509, MAE409/509
Control Systems for Robotics

Department of Computer Science
NC State University
Fall 2026

Instructor:
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Office hours: <TBD>

Preferred Method of Communication: To make an appointment, ask a question, or clarify something my preferred method of communication is email. I try to respond within at least 2 business days, typically much faster (depending on what's going on). I would like to ask that if I email you directly, you also try to respond within 2 business days.

Email Guidelines: Include a descriptive, specific but concise subject. Include adequate context for your question in order to ensure full understanding of your email.

1 Course Overview

Introduction to dynamics and control for robotic systems tailored for computer scientists. Concepts including ordinary differential equations, kinematics, and dynamics for common air and ground robotic systems will be introduced. Systems concepts such as step, impulse responses, Laplace Transform will be introduced. Feedback control via classical PID, and modern state-space and observer-based design will be explored. Emphasis on implementation, and simulation on an aerial multicopter robot will help students visualize and evaluate learning and control design performance.

1.1 Learning Outcomes

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

- Develop mathematical models for simple robotic systems
- Design controllers meeting performance specifications for robotic systems
- Simulate and evaluate controllers for robotic systems
- Design and evaluate Linear Quadratic Regulator Control strategy (graduate only)

2 Class Details

Class: <TBD>

2.1 Course Requirements

Prerequisites: PY 208, MA 242, MA 305 or MA405
Text: Beard, R. W., T. W. McLain, C. Peterson, and M. Killpack. "Introduction to feedback control using design studies." Independently published (2017). (This book is available free of charge on the course Moodle.

Additionally, here is a list of resources you may find valuable for helping shed light on the course topics:

- Daniel W, Baker, and Haynes William. "Engineering Statics: Open and Interactive." (2024). (This book is available free of charge here
- Control theory books (I have several that include)
  - Hespanha, Joao P. *Linear systems theory*. Princeton university press, 2009.
  - Åström, Karl J., and Björn Wittenmark. *Computer-controlled systems: theory and design*. Courier Corporation, 2013.
  - Franklin, Gene F., J. David Powell, and Michael L. Workman. *Digital control of dynamic systems*. Vol. 3. Menlo Park: Addison-wesley, 1998.

Computer: A laptop computer is recommended for students taking this course. NC State's Office of Information Technology provides recommendations for your computer at NC State
Software and digitally-hosted course components: Python will be used to design, simulate, and analyze dynamical models and controllers. I recommend VSCode, but PyCharm, or really any Python IDE can be used.

3 Website, Communication, and Other Logistics

This course is **synchronous**, delivered through real-time, face-to-face class sessions. Additional materials and activities are delivered through Moodle. The course will be run lecture style, but will also occasionally include coding activities and in-class quizzes and exercises.

3.1 Moodle

We will use Moodle to disseminate materials, host the class schedule, maintain all links, etc. A weekly format will be used to help maintain clarity but will be supplemented with specific pages with the schedule, resources, and this syllabus.

3.2 Structure

The course is roughly divided into 4 main parts: 1) background material on systems theory, ODEs; 2) kinetic energy, potential energy, and dynamics; 3) design models using transfer functions and state space; 4) classical PID control design; and 5) modern observer-based control design. Homework assignments will consist of regular readings, 2-3 main design studies, as well as a simulation lab case study.

3.3 Minimum Technical and Digital Information Literacy Skills

- Familiarity with, or ability to quickly learn Python
- Navigate and use Moodle, NC State's Learning Management System.
- Use Gmail, including attaching files to email messages
- Create and submit files in commonly used word processing program formats (MS Word, text editors, Google Docs, LaTeX).
- Download and upload attachments
- Use spreadsheets, presentations, graphics programs, and other applications in digital environments
- Perform online research using various search engines and library databases. Visit Distance Learning Services at NC State Libraries for more information.
- Use computer networks to locate and store files or data.
- Use online search tools for specific academic purposes, including the use of search criteria, keywords and filters
- Analyze digital information for credibility, currency, and bias (e.g... disinformation, misinformation)
- Properly cite information sources
- Familiarity with programming and code development in Python

3.4 Communication Guidelines

The NC State Code of Student Conduct outlines expectations for behavior in the classroom (whether virtual or physical) and the consequences for students who violate these expectations. Any behavior that impacts other students' ability to learn and succeed will be addressed, but expressing diverse viewpoints and interpretations of course content is welcome.

Community guidelines for this course include:

- Use a respectful tone in all forms of communication (email, written, oral, visual)
- Maintain professionalism (avoid slang, poor grammar, etc.) in your written communication.
- Respect regional dialects and culturally embedded ways of oral communication.
- Stay home or in your dorm room if you are exhibiting symptoms of a contagious illness (fever, chills, etc.).
- Enter our virtual and/or physical classroom community respectfully by refraining from lewd or indecent speech or behavior, helping to maintain a safe physical environment, not using your cell phone for voice or text communication except when explicitly given leave to do so, and not attending class under the influence of any substance.
- Treat each community member with respect by not recording others without their consent or engaging in any form of hazing, harassment, intimidation, or abuse.
- Respect cultural differences that may influence communication styles and needs.

Plan for interaction between instructors and students: I will host office hours at the times indicated at the beginning of this document where I can answer questions and offer help. Please come prepared with specific questions. I can also be reached via email and we can setup additional meetings if you need additional help.

4 Grading and Feedback

The course will consist of written homework assignments that may have a programming/simulation component, lab assignment, and a final exam. The grade breakdown will be:

- Homework - 40%
  - Homework assignments - 35%
    - Graduate students will have additional homework problems related to LQR control
  - Reading Quizzes - 5%
- Lab assignments - 40%
- Final exam - 20%

4.1 Homework

Homework assignments will be listed in Moodle and will be due on the day indicated on the schedule. Homework will be **self graded** in two steps. First you will give yourself an initial score when you turn in the homework on the due date based on your effort to complete it. You **must** turn something in by the due date or you will a 0 for the whole assignment. Then a solution will be posted and you are required to grade your homework based on the solution and re-submit it within 1 week for a final score, which is also self graded based on how well you now understand the material and were able to finish the assignment. The idea with this paradigm is to ensure you learn the material, but also that you give each homework a solid effort prior to receiving the solutions.

4.1.1 Reading Quizzes The book we are using is very well written and reading it will help improve your learning of the material. To incentivize this, reading quizzes will be given that simply ask you whether or not you have done the reading.

4.2 Labs

Labs are done in Python using the simulator and environment provided. For these assignments you will submit the files you modified for your lab which will be run against a clean copy of the simulator for grading. Please ensure your code performs as you intend against a clean copy of the simulator before submission.

4.3 Grade Assignment

Grades will be assigned using the following table:

Grade	Percent
A+	[98-100+]
A	[93-98)
A-	[90-93)
B+	[88-90)
B	[83-88)
B-	[80-83)
C+	[78-80)
C	[73-78)
C-	[70-73)
D+	[68-70)
D	[63-68)
D-	[60-63)
F	[0-60)

5 Course Schedule

This schedule is tentative and may change:

Week	
1	Intro, syllabus, systems
2	Laplace, ODEs
3	***Labor Day***
4	Energy, Euler-Lagrange
5	Euler-Lagrange, linearization
6	Models
7	Models
8	PID Control
9	***Fall Break***
10	PID Control
11	PID Control
12	PID Control
13	Observer-based Control
14	Observer-based Control
15	Observer-based Control
16	Observer-based Control
17	Finals

6 Policies

6.1 Class Policies

1. Attendance is not mandatory, but you are responsible for anything that transpires during class. **Please** be on time to class! If you're consistently late and/or disruptive in class I reserve the right to dock you points on an assignment.
2. Put your name, course, and section on everything you turn in. Sometimes I print things out for grading. Also, this is generally just good practice.
3. Late work will **NOT** be accepted. I *will* make exceptions for NCSU-approved reasons. I *may* make exceptions for other reasons **if** you discuss it with me before the deadline. **Explanation**: I have tried several variations on accepting late work. My anecdotal evidence suggests the rate of students turning things in is about the same. Not accepting late work is simplest and encourages students to get started on assignments earlier.

4. Students have one week from time of grade posting to challenge a grade.
5. Information on incomplete grades can be found at REG 02.50.03 – Grades and Grade Point Average. If you encounter a serious disruption to your work not caused by you and you would have otherwise successfully completed the course, contact your instructor as soon as you can to discuss the possibility of earning an incomplete in the course for the semester, including an agreement on when the remaining work must be done in order to change the grade to the appropriate letter grade.
6. I'm particularly concerned with the mental and emotional distress of students. Don't hesitate to reach out and let me know how things are going. I can help direct you to resources.

6.1.1 Policy on AI/LLM Usage This course permits you to use artificial intelligence (AI) tools, such as chatbots, text generators, paraphrasers, image generators, summarizers, or solvers, to get guidance on assignments, as long as you do so in an ethical and responsible manner. Essentially, you can think of these tools as ways to help you learn but not to entirely create work for assignments, projects, papers, presentation slides, and so on. Think of AI/LLMs as an intern, someone in training who can do the job but doesn't have the subject-matter expertise that you do. Don't use the AI tools as a replacement for your independent thinking.

This means that you must:

- Not use AI tools to replace your own thinking or analysis or to avoid engaging with the course content.
- Cite or explain any AI tools you use. Provide the name of the AI tool, the date of access, the URL of the interface, and the specific prompt or query you used to generate the output.
- Be transparent and honest about how you used the AI tool and how it contributed to your assignment. Explain what you learned from the AI tool, how you verified its accuracy and reliability, how you integrated its output with your own work, and how you acknowledged its limitations and biases.

You are accountable for any mistakes or errors made by the AI tool. Always check and edit the output before submitting your work. If you discover any inaccuracies or inconsistencies in the output after submission, notify the instructor immediately and correct them as soon as possible.

Using AI tools in an unethical or irresponsible manner, such as copying or paraphrasing the output without citation or transparency, using the output as your own work without verification or integration, or using the output to misrepresent your knowledge or skills, is considered a form of academic dishonesty and will result in a zero grade for the assignment and possible disciplinary action. If you have any questions about what constitutes ethical and responsible use of AI tools, please consult with me before submitting your work.

6.2 NCSU Policies

6.2.1 Course Evaluation Information Students will receive an email message directing them to a website where they can login using their Unity ID and complete evaluations. All evaluations are confidential; instructors will not know how any one student responded to any question, and students will not know the ratings for any instructors.

Evaluation website: `http://go.ncsu.edu/cesurvey` Login Required
Help desk: classeval@ncsu.edu

6.2.2 Academic Integrity statement Exchange of ideas and techniques is **highly** encouraged but **your work must be your own**. If someone (or AI) helps you, please give them credit in your assignments and project. Also, because we are preparing you to be serious researchers you need to cite and acknowledge sources and contributions where appropriate. This includes AI (see policy here). I will follow up with suspicions of academic dishonesty, violations of the Code of Student Conduct, or the Pack Pledge in accordance with department and university policy.

Violations of academic integrity will be handled in accordance with the Student Discipline Procedures (NCSU REG 11.35.02).

6.2.3 Statement for Students with Disabilities Reasonable accommodations will be made for students with verifiable disabilities. In order to take advantage of available accommodations, students must register

with the Disability Resource Office at Holmes Hall, Suite 304, 2751 Cates Avenue, Campus Box 7509, 919-515-7653. For more information on NC State's policy on working with students with disabilities, please see the Academic Accommodations for Students with Disabilities Regulation (NCSU REG 02.20.01).

6.2.4 Digital Course Components Students may be required to disclose personally identifiable information to other students in the course, via digital tools, such as email or web-postings, where relevant to the course. Examples include online discussions of class topics, and posting of student coursework. All students are expected to respect the privacy of each other by not sharing or using such information outside the course.

6.2.5 Additional NC State Rules and Regulations Students are responsible for reviewing the NC State University Policies, Rules, and Regulations (PRRs) which pertain to their course rights and responsibilities, including those referenced both below and above in this syllabus:

- Equal Opportunity and Non-Discrimination Policy Statement `https://policies.ncsu.edu/policy/pol-04-25-05` with additional references at `https://oied.ncsu.edu/divweb/policies/`.
- Code of Student Conduct `https://policies.ncsu.edu/policy/pol-11-35-01`.