University of Colorado Boulder
ASEN 5014
Linear Control Systems
Fall 2025 Course Syllabus

General Information

Instructor: Nisar Ahmed, Associate Professor,
Smead Aerospace Engineering Sciences (`Nisar.Ahmed@colorado.edu`)

Instructor Office Hours: TBD, in person and via Zoom, details to be posted to Canvas

Lecture Time and Location: Tues & Thurs 2:30 pm - 3:45 pm, AERO 114. All lectures will be recorded and posted online via CU's Lecture Capture System and the course Canvas website. Asynchronous learning students may participate live through the Zoom meeting interface (see course website for instructions). If you use assistive technology to access the course material, please contact the instructor immediately to discuss.

Course Website: `canvas.colorado.edu` (will be used for posting all recorded lecture captures, assignments, exams, and announcements/corrections; links to Zoom lecture and office hours, Piazza, and Gradescope are also provided).

Required Textbook (for readings and assignments, e-book version available): *Modern Control Theory*, W. L. Brogan, 3rd ed. Prentice-Hall, 1991. ISBN 0-13-589763-7.

Optional text supplements (not required):

Linear Systems, P. Antsaklis and A. Michel, Birkhauser, 2006. e-ISBN 0-8176-4435-0. Available through CU library as an e-book.

A Linear Systems Primer, P. Antsaklis and A. Michel, Birkhauser, 2007. e-ISBN-13: 978-0-8176-4661-5. Available through CU library as an e-book.

Optimal Control and Estimation, R. Stengel, Dover, 1994. ISBN: 9780486682006 (good and cheap).

Course Details

Description Modeling, analysis, and design of continuous-time control systems using the state space approach. Vector spaces, linear operators, and linear equation solution theory are used to describe system solutions and their stability, controllability, and observability properties. State observers and state feedback control are developed, along with an introduction to linear-quadratic optimal control and other advanced topics.

Learning Objectives Linear systems are models for dynamical physical processes. Although physical systems are usually non-linear, linear models are simpler and often provide reasonable approximations: their dynamic behavior is very well understood theoretically. This means they can be easily manipulated to introduce desirable (or remove undesirable) behaviors, which is the whole point of control systems engineering.

This course will provide an understanding of the state space perspective of linear systems theory, with specific application toward feedback control system design. Although mathematics (especially linear algebra) is the language by which the theory is described, *this is not a math course.* The theorem-proof format is avoided in favor of an exposition of the main ideas and use of these ideas to demonstrate key theoretical results. The geometry and insight behind matrix algebra, in particular, is stressed. *However, expect to learn a little math in the process. Careful use of terminology is necessary to grasp ideas and do well on exams.*

This course is a foundation for further graduate work in various fields, particularly nonlinear dynamical systems, estimation, and autonomous uncrewed vehicle design. It introduces standard viewpoints, methods, and terminology used in applications and research literature. It also provides the basis for understanding how many computational analysis and design tools work (e.g. MATLAB's Control System Toolbox). In short, by the end of this course, you will think, work, and communicate in the language of modern linear systems and control theory.

Specific learning objectives:

1. Develop expertise with state space models for mathematically analyzing and manipulating multivariable dynamical systems described by continuous-time differential equations or discrete-time finite difference equations.

2. Discover simple yet valuable geometric insights about linear operators using key concepts from linear algebra; understand how they lead to powerful state space analysis/synthesis techniques for multivariable control systems.

3. Explain and apply ideas behind advanced methods for stability analysis and optimal control system design, which will also be glimpsed; recognize practical limitations of the theory, e.g. due to inaccuracies in system models.

Anticipated Course Schedule

Week(s)	Topic
1	Intro & overview
1-2	State space models for linear & nonlinear dynamical systems
3-7	Formal linear algebra review: vectors spaces, mappings, solution analysis, eigenspaces, etc.
7	**MIDTERM EXAM 1** (expected: out Oct 2, due Oct 9)
8-10	Linear systems theory: matrix-vector ODEs, controllability, observability, modal analysis
10-12	State space control design and analysis: full state feedback, observers, etc.
12	**MIDTERM EXAM 2** (expected: out Nov 6, due Nov 13); Start final project
12-13	Intro to optimal control and linear quadratic regulator (LQR)
14	State space stability and Lyapunov analysis; advanced topics (if time)
15	**FINALS WEEK: FINAL PROJECT REPORT DUE**

Grading, Assignments and Exams Course grades will be determined on the basis of homework (15%), online Canvas quizzes (15%), midterm 1 (20%), midterm 2 (20%), and a final project (30%).

Important things to note:

- Students will work in groups of 2 for the final project (there may be a team of 3 students, depending on enrollment parity).

- Weekly homework will be assigned, collected, and *partially graded*. Quizzes will be fully graded automatically on Canvas. Solutions for full problem and quiz sets will be posted to Canvas.

- Collaboration on homework is encouraged, but students must turn in their own homework in a timely manner (see policies below) and credit their collaborators. Students may use Piazza for online discussion (this will be loosely monitored).

- A series of weekly quizzes will be assigned and administered through Canvas. These will be posted on Thursday and be due the following Monday (off-nominal posting/due dates will come with special advance notification, as needed).
- All exams will be take home and open-book/open-note. Students will have exactly one week to complete exams and may not collaborate with each other or use generative AI on exams in any way (see policies below - CU honor code applies).
- Students will **not** require an exam proctor, but will submit all assignments and exams electronically for grading via Gradescope (see requirements on submission quality).
- Students may opt to answer optional 'Challenge Questions' on homeworks and exams for extra credit, but extra credit will only be considered if all regular homework assignment questions are also completed (zero extra credit received otherwise). Students must submit their own work for challenge questions (no group submissions). Help from instructor will be more limited on these questions, and solutions may not be posted for challenge questions.

Electronic assignment submission requirements: It is your responsibility to turn in legible and complete electronic submissions for homeworks, exams, and projects. *If your assignment is not legible for grading, you will receive one and only one warning to resubmit your assignment.* Repeated failure to comply with legibility requirements after the first warning will result in zero credit for that assignment.

Regrade policy: Requests for regrades on any assignment must be submitted **to the instructor in writing via e-mail and Gradescope within 2 weeks of the assignment being returned to the class** (no exceptions). Requests must clearly articulate the specific reasons for the regrade request, although *entire* assignment will be regraded by instructor/TA if request is granted, and thus there is no guarantee of receiving a higher grade (this includes scrutinization of time/date of original assignment submission).

Late submissions: Students are responsible for contacting and working out an alternative plan with the instructor for submitting homeworks, exams, projects, and any other assignments if these cannot be completed in time. **Penalties will be applied and strictly enforced for unpermitted late submissions and are non-negotiable after the fact for all individual and group assignments (including final project):**

- Homeworks lose 10% of total assignment grade if turned in past time deadline on due date , 10% per day late thereafter , and receive a grade of 0 points for if submitted late by 7 days or more. Penalties will be enforced for lateness, unless exceptions are explicitly granted by instructor (see above).

- Exams and projects are automatically penalized 10 points if submitted past time deadlines on due dates without permission from instructor, and will receive a grade of 0 pts thereafter if submitted after due dates without permission from the instructor.

- Late time or late date submission on any assignment (homework, exam, project, etc.) results in immediate forfeiture of any extra credit attempted for that assignment (i.e. extra credit only counts if assignment turned in on time on due dates).

Rescheduling assignment submissions: Exams must be rescheduled with the instructor **via e-mail at least 2 weeks prior**. Homework, project and other assignment extensions require **at least 48 hours e-mail notice for request to the instructor.** The rescheduling and extension policy will be strictly enforced, so plan ahead and manage your time well – **do not wait until the last minute to start assignments or ask for extensions!**
All students must adhere to the CU Honor Code (see below).

Conditional Generative AI Use: You are permitted (but not required) to conditionally use generative AI tools in this course for the following purposes only:

- partial code generation (i.e. $\leq 30\%$ as measured by total non-trivial lines of code submitted) for programming exercises on homework assignments and for the final project assignment;

- to review or study course material and topics on your own.

If you use gen AI tools for partial code generation on homeworks or the final project, you must document your usage by stating this explicitly at the top of your assignment and cite the portions (lines of code) that were generated by the specific tool you used. **Failure to properly document gen AI usage for coding assignments on homeworks and the final project will be treated as a potential CU Honor Code violation (see below).**

You **may not** use gen AI tools to produce solutions for other non-programming questions on homework or final project assignments.

You **may not** use gen AI tools for any kind of question (whether programming or non-programming) on midterm exams or on quizzes.

Work submitted for grading must conform to these rules, in order to receive full credit reflective of *your* own individual competency, learning, and understanding of the material.

CU Honor Code All students enrolled in a University of Colorado Boulder course are responsible for knowing and adhering to the Honor Code. Violations of the Honor Code may include but are not limited to: plagiarism (including use of paper writing services or technology [such as essay bots]), cheating, fabrication, lying, bribery, threat, unauthorized access to academic materials, clicker fraud, submitting the same or similar work in more than one course without permission from all course instructors involved, and aiding academic dishonesty. Understanding the course's syllabus is a vital part of adhering to the Honor Code.

All incidents of academic misconduct will be reported to Student Conduct & Conflict Resolution: StudentConduct colorado.edu. Students found responsible for violating the Honor Code will be assigned resolution outcomes from Student Conduct & Conflict Resolution and will be subject to academic sanctions from the faculty member. Visit Honor Code for more information on the academic integrity policy.

General Policies and Resources (please read carefully)

Classroom Behavior Students and faculty are responsible for maintaining an appropriate learning environment in all instructional settings, whether in person, remote, or online. Failure to adhere to such behavioral standards may be subject to discipline. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with race, color, national origin, sex, pregnancy, age, disability, creed, religion, sexual orientation, gender identity, gender expression, veteran status, marital status, political affiliation, or political philosophy.

Additional classroom behavior information:

- Student Classroom and Course-Related Behavior Policy
- Student Code of Conduct
- Office of Institutional Equity and Compliance

Accommodation for Disabilities, Temporary Medical Conditions, and Medical Isolation If you qualify for accommodations because of a disability, please submit your accommodation letter from Disability Services to your faculty member in a timely manner so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities in the academic environment. Information on requesting accommodations is located on the Disability Services website. Contact Disability Services at 303-492-8671 or dsinfo@colorado.edu for further assistance. If you have a temporary medical condition, see Temporary Medical Conditions on the Disability Services website.

If you have a temporary illness, injury or required medical isolation for which you require adjustment, please e-mail the instructor to notify them.

Preferred Student Names and Pronouns CU Boulder recognizes that students' legal information does not always align with how they identify. If you wish to have your preferred name (rather than your legal name) and/or your preferred pronouns appear on your instructors' class rosters and in Canvas, visit the Registrar's website for instructions on how to change your personal information in university systems.

Sexual Misconduct, Discrimination, Harassment and/or Related Retaliation CU Boulder is committed to fostering an inclusive and welcoming learning, working, and living environment. University policy prohibits protected-class discrimination and harassment, sexual misconduct (harassment, exploitation, and assault), intimate partner abuse (dating or domestic violence), stalking, and related retaliation by or against members of our community on- and off-campus. The Office of Institutional Equity and Compliance (OIEC) addresses these concerns, and individuals who have been subjected to misconduct can contact OIEC at 303-492-2127 or email OIEC@colorado.edu. Information about university policies, reporting options, and OIEC support resources including confidential services can be found on the OIEC website.

Please know that faculty and graduate instructors are required to inform OIEC when they are made aware of incidents related to these concerns regardless of when or where something occurred. This is to ensure the person impacted receives outreach from OIEC about resolution options and support resources. To learn more about reporting and support a variety of concerns, visit the Don't Ignore It page.

Religious Holidays Campus policy requires faculty to provide reasonable accommodations for students who, because of religious obligations, have conflicts with scheduled exams, assignments, or required attendance. Please communicate the need for a religious accommodation in a timely manner. In this class, you must notify the instructor at least 2 weeks in advance to schedule make up for completing and turning in exams and other assignments (see Course Details above). See the campus policy regarding religious observances for full details.

Mental Health and Wellness The University of Colorado Boulder is committed to the well-being of all students. If you are struggling with personal stressors, mental health or substance use concerns that are impacting academic or daily life, please contact Counseling and Psychiatric Services (CAPS), located in C4C, or call (303) 492-2277, 24/7.