

ASEN 5014 LINEAR CONTROL DESIGN

Course 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. Robustness to model uncertainty is addressed.

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Prerequisites: Undergraduate course in signals, systems, or controls (e.g. ASEN 2003, ASEN3128, ASEN3200 or equivalent).

Textbook: *Modern Control Theory*, W. L. Brogan, 3rd ed., Prentice-Hall, 1991.

Class Web Page: www.colorado.edu/ASEN/asen5014

Syllabus Outline

<u>Topics</u>	<u>Weeks</u>
Introduction: 6 Fundamental Questions	1
State Space Model Construction	1
Linear Spaces, Mappings, Equations	5
Midterm Exam 1	
State Space System Solutions	3
Lyapunov Stability	1
Midterm Exam 2	
Controllability and Observability	2
State Observation and Feedback Control	2
Optimization and Robustness	1
Project (in lieu of final exam)	

Course Policies and Grading

Grading: 2 exams and one project—30% ea., homework—10%.

Homework: Group work is encouraged, although individual understanding will be necessary to do well on exams and the project. Homework will be partially graded, and we will discuss solutions in class. Full solutions will be posted.

Exams: Take home, involving both analysis and computation. Honor system applies. Make up exams must be arranged in advance (at least two weeks).

Office hours: Regular times (to be arranged) held by instructor. Other times are available by appointment.

Course Purpose and Learning Objectives

Linear systems are models for physical processes having dynamics. Although physical systems are usually non-linear, linear models are simpler, and can often provide reasonable approximations. They have the added benefit of a very complete theoretical understanding of their behavior and of how control can change behavior.

The purpose of this course is to provide an understanding of the theory of linear systems from the state space perspective, with specific application toward feedback control design. Although mathematics (particularly linear algebra) is the language by which the theory is described, this is not a mathematics course. The theorem/proof format is avoided in favor of an exposition of useful “truths” and a demonstration of the underlying reasons. The geometry and insight behind matrix algebra, in particular, is stressed. However, expect to learn a little math in the process.

The understanding sought in this course is a foundation for further graduate work in various fields, particularly nonlinear dynamical systems, data analysis, advanced control systems, etc. It introduces standard viewpoints, methods, and terminology used in the applied and research literature. It also provides the basis for understanding how many computational analysis and design tools work.

The main learning objectives of Linear Control Design are

- Develop some expertise with the state space modeling/analysis/design approach, learning to see dynamical systems in a new way with new concepts, vocabulary, tools, and insights.
- See linear algebra in a new light, where matrices are representations of linear operators, and these operators have simple geometry and corresponding insights.
- Glimpse how optimization can be used to design control systems “automatically”.
- Understand how applications of this theory can be limited by inaccuracy in system models.

General Policies

1. If you qualify for accommodations because of a disability, please submit to me a letter from Disability Services in a timely manner so that your needs may be addressed. Disability Services determines accommodations based on documented disabilities. Contact: 303-492-8671, Willard 322, and

www.Colorado.EDU/disabilityservices

2. Campus policy regarding religious observances requires that faculty make every effort to reasonably and fairly deal with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. Please contact me in advance if you have a conflict. See full details at

http://www.colorado.edu/policies/fac_relig.html

3. Students and faculty each have responsibility for maintaining an appropriate learning environment. Students who fail to adhere to such behavioral standards may be subject to discipline. Faculty have the professional responsibility to treat all students with understanding, dignity and respect, to guide classroom discussion and to set reasonable limits on the manner in which they and their students express opinions. Professional courtesy and sensitivity are especially important with respect to individuals and topics dealing with differences of race, culture, religion, politics, sexual orientation, gender variance, and nationalities. Class rosters are provided to the instructor with the student's legal name. I will gladly honor your request to address you by an alternate name or gender pronoun. Please advise me of this preference early in the semester so that I may make appropriate changes to my records. See polices at

<http://www.colorado.edu/policies/classbehavior.html>

and at

http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

4. All students of the University of Colorado at Boulder are responsible for knowing and adhering to the academic integrity policy of this institution. Violations of this policy may include: cheating, plagiarism, aid of academic dishonesty, fabrication, lying, bribery, and threatening behavior. All incidents of academic misconduct shall be reported to the Honor Code Council (honor@colorado.edu; 303-725-2273). Students who are found to be in violation of the academic integrity policy will be subject to both academic sanctions from the faculty member and non-academic sanctions (including but not limited to university probation, suspension, or expulsion). Other information on the Honor Code can be found at

<http://www.colorado.edu/policies/honor.html>

and at

<http://www.colorado.edu/academics/honorcode/>

5. The University of Colorado at Boulder policy on Discrimination and Harassment

<http://www.colorado.edu/policies/discrimination.html>

the University of Colorado policy on Sexual Harassment and the University of Colorado policy on Amorous Relationships applies to all students, staff and faculty. Any student, staff or faculty member who believes s/he has been the subject of discrimination or harassment based upon race, color, national origin, sex, age, disability, religion, sexual orientation, or veteran status should contact the Office of Discrimination and Harassment (ODH) at 303-492-2127 or the Office of Judicial Affairs at 303-492-5550. Information about the ODH and the campus resources available to assist individuals regarding discrimination or harassment can be obtained at

<http://www.colorado.edu/odh>