ASEN 5014 Linear Control Systems

Fall 2017 Syllabus

Lecture: ECCR 150 MWF, 1:00 – 1:50 pm
Final Exam: No Final Exam (See Course Grading)

Instructor

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Hours: TBD

Text

Required: *Modern Control Theory (3rd Ed.)*, William Brogan, Prentice-Hall, 1991.

Web Site

http://culearn.colorado.edu

All assignments and solution sets will be distributed as PDF files on the course web site.

Students are encouraged to use the Discussions thread on the course web site to ask questions and clarifications about assignments. Students should answer each other's questions when appropriate. The instructor will monitor the discussion threads daily.

Prerequisites

APPM 2380 (Ordinary Differential Equations) or equivalent, senior or graduate standing.

Overview

This course will present methods for the analysis and design of feedback control for linear dynamic systems. The course includes elements of Linear System Theory, State Space Control Theory, and State Space Control Design.

Course Grading

Homework:	15%
Exam 1:	25%
Exam 2:	25%
Project:	35%

Homework: Includes theoretical proofs, analysis, and simulation. Group work is encouraged, although individual understanding will be necessary to do well on exams.

Exams: Two take-home exams will be given during the semester (roughly 1/3 and 3/4 through the semester). Exams will require the use of a computer with matrix algebra software such as Matlab. Make up exams must be arranged at least two weeks in advance.

Projects: Analysis and control of a complex linear dynamical system using all the tools and techniques described in class.

Honor Code

Students are required to be familiar with the University of Colorado Honor Code http://www.colorado.edu/academics/honorcode/ . The honor code website contains clear explanations of what is required and gives examples of proper and improper behavior. Please review it carefully.

University Policies

Disability Services

If you qualify for accommodations because of a disability, please submit to your professor a letter from Disability Services in a timely manner (for exam accommodations provide your letter at least one week prior to the exam) so that your needs can be addressed. Disability Services determines accommodations based on documented disabilities. Contact Disability Services at 303-492-8671 or by e-mail at dsinfo@colorado.edu.

If you have a temporary medical condition or injury, see Temporary Injuries under Quick Links at Disability Services website and discuss your needs with your professor.

Religious Observances

Campus policy regarding religious observances requires that faculty make every effort to deal reasonably and fairly with all students who, because of religious obligations, have conflicts with scheduled exams, assignments or required attendance. In this class, students who, because of religious obligations, have conflicts with scheduled exams, assignments, or other required attendance, should notify faculty at least two weeks or as early as possible in advance of the conflict to request special accommodation. See full details at http://www.colorado.edu/policies/fac_relig.html

Classroom Behavior

Students and faculty each have responsibility for maintaining an appropriate learning environment. Those who fail 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 differences of race, color, culture, religion, creed, politics, veteran's status, sexual orientation, gender, gender identity and gender expression, age, disability, 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 policies at http://www.colorado.edu/policies/classbehavior.html and at http://www.colorado.edu/studentaffairs/judicialaffairs/code.html#student_code

Course Purpose and Learning Objectives

After taking this course, you should be able to

1. Construct state space models from differential equations and transfer functions.

2. Apply the concepts of linear independence, span, subspace, dimension, and basis to a vector space.

3. Test a mapping from one vector space to another for linearity, apply a change of basis, construct the matrix of a mapping.

4. Use concepts of column space, row space, right null space and left null space to characterize solutions of linear equations. Calculate least squares approximate or minimal solutions.

5. Spectrally decompose a generic linear operator using eigenspaces. Apply this to the solution of homogeneous state space equations to determine natural modes.

6. Use a modal basis to derive the general solution to state space equations using the Cayley-Hamilton theorem.

7. Characterize the Lyapunov stability properties of state space systems, relate these to eigenvalues of the state matrix.

8. Understand the tests for complete controllability and observability, apply them to find controllable and unobservable subspaces.

9. Design observers to reconstruct internal states.

10. Design state feedback controllers to achieve prescribed closed loop poles, and understand when and why complete pole assignment is possible.

11. Use linear-quadratic optimization to design control systems.

12. Understand limitations of pole placement/optimization theory due to unmodeled dynamics.

13. Use MATLAB as an aid in solving numerical problems associated with the above concepts, simulating system responses, and computing state feedback/optimal controllers.

Course Outline

Week	Monday	Wednesday	Friday	Reading (Chaps.)
8/28-9/1	No Class	No Class	Introduction	1 and 2
9/4-9/8	No Class (Labor Day)	State Space Models	State Space Models	3
9/11-9/15	Model Conversion	Vector Spaces	Dimension and Basis	4
9/18-9/22	Ortho-normalization	Subspaces	Subspaces	5.1-5.5
9/25-9/29	Linear Mappings	Linear Mappings	Mapping Subspaces	5.6-5.10
10/2-10/6	Linear Equation Solutions	Least Squares Solutions	Least Squares Solutions	6.1-6.9
10/9-10/13	Eigenspaces	Matrix Exponential	Matrix Exponential	7
10/16-10/20	Eigen-decomposition	Jordan and Modal Form	Real Modal Form	9.1-9.4
10/23-10/27	Lyapunov Stability	BIBO Stability	Stability	9.6-9.7, 9.10
10/30-11/3	Controllability	Controllability	Controllability	10.1-10.6
11/6-11/10	State Variable Feedback	State Variable Feedback	Examples	11.1-11.5, 8.4-8.5, 13.1-13.4
11/13-11/17	Observability	Observability	Observer Design	11.7, 12.1-12.5, 13.6
11/20-11/24	No Class (Fall Break)	No Class (Fall Break)	No Class (Fall Break)	
11/27-12/1	State Variable Control Design	State Variable Control Design	State Variable Control Design	13.7-13.8
12/4-12/8	Disturbance Rejection	Optimal Control	Optimal Control	14.1-14.3, 14.7
12/11-12/15	Robustness / Other Topics	Various Topics	Reading Day	