EE 585: Linear Systems Theory

Units: 4
Fall 2021—Tue Thu—0900-1050

Location: OHE 100B & DEN

Instructor: Dr. Ketan Savla
Office: KAP 254A
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Course Description

The intent of this course is to provide the students with the basic tools of modern linear systems theory. We will establish a balance between state-space methods for analysis/synthesis of linear dynamical systems and frequency domain methods for studying input-output properties of multivariable linear systems. The course content will be motivated by examples from different application domains and it will be presented in such a way to make it of interest to students with background in control and dynamical systems, communications, signal and image processing, computer science and engineering, optimization, robotics, civil infrastructure systems, systems biology, and financial engineering.

Learning Objectives

The course objective is to equip students with the working knowledge of modern linear systems theory.

Prerequisite(s): *EE 441 or EE 510*
Corequisite(s): None
Concurrent Enrollment: None
Recommended Preparation: The students would benefit from a solid background in linear algebra (EE 441 or an equivalent course). Those interested should contact the instructor.

Course Notes

Lecture notes and other relevant class information will be posted on the Desire2Learn system.

Technological Proficiency and Hardware/Software Required

Homework sets will make use of Matlab.

Required Readings and Supplementary Materials

[DDV] Mohammed Dahleh, Munther Dahleh, and George Verghese, "Lectures on Dynamic Systems and Control"

[H] Joao Hespanha, "Linear Systems Theory", 2nd edition, Princeton University Press, ISBN-13: 9780691179575 (hardcover), 9781400890088 (E-book)

Please refer to https://viterbi-web.usc.edu/~mihailo/courses/ee585/f17/resources.html for additional resources and supplementary materials.

Description and Assessment of Assignments

Moderate collaboration with classmates is encouraged. However, you will not be able to learn the material unless you invest enough time alone to understand each homework problem, and independently write the solutions that you turn in. Homework will be generally handed out every other Thursday, and it will be due at the beginning of the class two weeks later. Late homework will not be accepted.

Grading Timeline

One week after submission.

Additional Policies

Attendance of the lectures is expected.

Grading Breakdown

Homework assignments	40 %
Midterm exam	30 %
Final exam	30 %

Course Schedule: A Weekly Breakdown

	Topics/Daily Activities	Readings and Homework	Deliverable/ Due Dates
Week 1	Course mechanics; What is the course about? Basic system properties; State-space models	Homework 1 assigned	
Week 2	Equilibrium points; Linearization; Solution to discrete time systems; State transition matrix; Z transform; Resolvent		
Weeks 3-4	Transfer function; Impulse and frequency responses of DT LTI systems; State transition matrix of CT systems; Variation of constants formula; Numerical computation of the state transition matrix	Homework 2 assigned	Homework 1 due
Week 5	Matrix exponential; Laplace transform; Impulse response and transfer function of CT LTI systems; Eigenvalue decomposition		
Week 6	Diagonalization of a matrix; Jordan canonical form; Modal decomposition of LTI systems; Normal vs. non-normal matrices	Homework 3 assigned	Homework 2 due
Week 7	Modal conditions for stability of LTI system; Stability of equilibrium points of nonlinear systems; Stability via linearization		
Week 8 (mid term)	Lyapunov functions for LTI systems; Algebraic Lyapunov Equation	Homework 4 assigned	Homework 3 due
Week 9	Signal norms; Frequency		

	responses of LTI systems		
Week 10	Singular Value Decomposition; System norms; Reachability of discrete-time systems; Kalman rank test	Homework 5 assigned	Homework 4 due
Weeks 11-12	Reachability gramian; Minimum energy state transfer; Canonical form of unreachable systems		
Week 13	Modal tests for reachability; Controllability of continuous-time systems; Observability	Homework 6 assigned	Homework 5 due
Week 14	Pole placement; State estimation; Kalman filter; Observer-based controller		
Week 15	Linear Quadratic Regulator		Homework 6 due
FINAL	Final Exam		For the date and time of the final exam please consult the USC Schedule of Classes at classes.usc.edu. Tentatively 11am-1pm on Dec 9 2021.

Statement on Academic Conduct and Support Systems

Academic Conduct:
Plagiarism – presenting someone else's ideas as your own, either verbatim or recast in your own words – is a serious academic offense with serious consequences. Please familiarize yourself with the discussion of plagiarism in SCampus in Part B, Section 11, "Behavior Violating University Standards" policy.usc.edu/scampus-part-b. In the case of suspicion of academic dishonesty, students are referred to the Office of Student Judicial Affairs and Community Standards (SJACS) for further review. Information about the SJACS review process can be found at: https://sjacs.usc.edu/students/academic-integrity/. The SJACS website provides additional resources that you may find helpful, so see their website: https://sjacs.usc.edu/students/

Support Systems:
Student Health Counseling Services - (213) 740-7711 – 24/7 on call
engemannshc.usc.edu/counseling

National Suicide Prevention Lifeline - 1 (800) 273-8255 – 24/7 on call
suicidepreventionlifeline.org

Relationship and Sexual Violence Prevention Services (RSVP) - (213) 740-4900 – 24/7 on call
https://studenthealth.usc.edu/sexual-assault/

Office of Equity and Diversity (OED) | Title IX - (213) 740-5086
equity.usc.edu, titleix.usc.edu
Information about how to get help or help a survivor of harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

Bias Assessment Response and Support - (213) 740-2421
studentaffairs.usc.edu/bias-assessment-response-support

Office of Student Accessibility Services (OSAS) - (213) 740-0776
https://osas.usc.edu/
Support and accommodations for students with disabilities. Services include assistance in providing readers/notetakers/interpreters, special accommodations for test taking needs, assistance with architectural barriers, assistive technology, and support for individual needs.

USC Support and Advocacy - (213) 821-4710
https://campussupport.usc.edu/students/
Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

USC Emergency - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call
dps.usc.edu, emergency.usc.edu
Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

USC Department of Public Safety - UPC: (213) 740-6000, HSC: (323) 442-120 – 24/7 on call
dps.usc.edu
Non-emergency assistance or information.