

**USC** Viterbi School  
of Engineering

**Course ID and Title:**

**EE 585: Linear Systems Theory**

**Units: 3**

**Term—Day—Time: Fall 2017—TuTh—9:30-10:50am**

**Location:** OHE 100B

**Instructor: Mihailo Jovanovic**

**Office:** EEB 324

**Office Hours:** Tu, 2:00-3:00pm

**Contact Info:** [mihailo@usc.edu](mailto:mihailo@usc.edu)

**Instructor Webpage:** [ee.usc.edu/mihailo/](http://ee.usc.edu/mihailo/)

**Course Webpage:** [ee.usc.edu/mihailo//courses/ee585/f17/](http://ee.usc.edu/mihailo//courses/ee585/f17/)

**Teaching Assistant:** TBA

**Office:** TBA

**Office Hours:** TBA

**Contact Info:** TBA

**IT Help:** N/A

**Hours of Service:** N/A

**Contact Info:** N/A

## 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, power 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

**Co-Requisite(s):** None

**Concurrent Enrollment:** None

**Recommended Preparation:** Even though I plan to cover everything from scratch, 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

Letter Grade. Lecture notes and other relevant class information will be posted on the course webpage.

## Technological Proficiency and Hardware/Software Required

Homework sets will make a use of Matlab.

## Required Readings and Supplementary Materials

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

Please refer to the course webpage for information about additional references and supplementary materials.

## Description and Assessment of Assignments

Homework is intended as a vehicle for learning, not as a test. Moderate collaboration with your classmates is encouraged. However, I urge you to invest enough time alone to understand each homework problem, and independently write the solutions that you turn in. Homework is generally handed out every other Thursday, and it is due at the beginning of the class a week. Late homework will not be accepted. Start early!

## Assignment Submission Policy

Please see "Description and Assessment of Assignments".

## Grading Timeline

One week after submission.

## Additional Policies

Attendance of the lectures is expected.

## Grading Breakdown

Including the above detailed assignments, how will students be graded overall? Participation should be no more than 15%, unless justified for a higher amount. All must total 100%.

Assignment	Points	% of Grade
Homework	40	40
Midterm exam	30	30
Final exam	30	30
<b>TOTAL</b>	<b>100</b>	<b>100</b>

## Course Schedule: A Weekly Breakdown

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

<b>Week 8</b>	Lyapunov functions for LTI systems; Algebraic Lyapunov Equation		Homework 4 due.
<b>Week 9</b>	Signal norms; Frequency responses of LTI systems	Homework 5 assigned.	
<b>Week 10</b>	Singular Value Decomposition; System norms; Reachability of discrete-time systems; Kalman rank test		Homework 5 assigned.
<b>Week 11</b>	Reachability gramian; Minimum energy state transfer; Reachability ellipsoid	Homework 6 assigned.	
<b>Week 12</b>	Canonical form of unreachable systems; Modal tests for reachability		Homework 6 due.
<b>Week 13</b>	Controllability of continuous-time systems; Observability	Homework 7 assigned.	
<b>Week 14</b> (Thanksgiving)	Pole placement; State estimation; Kalman filter; Observer-based controller	Homework 8 assigned.	Homework 7 due.
<b>Week 15</b>	Linear Quadratic Regulator		Homework 8 due.
<b>FINAL</b>	Final Exam		For the date and time of the final exam please consult the USC Schedule of Classes at <a href="http://classes.usc.edu">classes.usc.edu</a>

## 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” <https://policy.usc.edu/student/scampus/part-b>. Other forms of academic dishonesty are equally unacceptable. See additional information in *SCampus* and university policies on scientific misconduct, <http://policy.usc.edu/scientific-misconduct>.

Discrimination, sexual assault, intimate partner violence, stalking, and harassment are prohibited by the university. You are encouraged to report all incidents to the *Office of Equity and Diversity/Title IX Office* <http://equity.usc.edu> and/or to the *Department of Public Safety* <http://dps.usc.edu>. This is important for the health and safety of the whole USC community. Faculty and staff must report any information regarding an incident to the Title IX Coordinator who will provide outreach and information to the affected party. The sexual assault resource center webpage <http://sarc.usc.edu> fully describes reporting options. Relationship and Sexual Violence Services <https://engemannshc.usc.edu/rsvp> provides 24/7 confidential support.

### Support Systems

A number of USC’s schools provide support for students who need help with scholarly writing. Check with your advisor or program staff to find out more. Students whose primary language is not English should check with the *American Language Institute* <http://ali.usc.edu>, which sponsors courses and workshops specifically for international graduate students. *The Office of Disability Services and Programs* <http://dsp.usc.edu> provides certification for students with disabilities and helps arrange the relevant accommodations. If an officially declared emergency makes travel to campus infeasible, *USC Emergency Information* <http://emergency.usc.edu> will provide safety and other updates, including ways in which instruction will be continued by means of Blackboard, teleconferencing, and other technology.