

# SIE 550 (Linear) Systems Theory: Spring 2026

## Course Instructor, Lectures and Course Website

Instructor: Dr. Roberto Furfaro, [robertof@arizona.edu](mailto:robertof@arizona.edu)

1. Campus Office: ENGR305, 520-621-2525
2. Cell: 520-312-7440 (texting is preferred)

Office Hours: Tue-Th 3pm-4pm or by appointment.

Teaching Assistant: TBD (OH: for TAs will be announced later)

Lectures: Tue-Th, 4:00pm - 5:15pm (In-person/Zoom)

Course content on D2L: [www.d2l.arizona.edu](http://www.d2l.arizona.edu)

## Course Description

This course is a core course for graduate students at the SIE department. Although the title is “Linear Systems Theory”, the course will cover both linear and non-linear systems under a unified framework. The goal of the course is to give the students a deep understanding of the behavior of dynamical systems as well as means to analyze autonomous and non-autonomous systems employing basic and advanced mathematical techniques. The material covered in this course spans from representation and analysis of dynamical systems, Lyapunov stability theory, controllability and observability of linear systems as well as design techniques for dynamical system stabilization.

## Schedule and Topics

### Week 0: Jan 15

Topic: Introduction

### Week 1: Jan 20 -22

Topic: Mathematical Background: Fundamentals of linear algebra

1. Vector spaces
2. Linear Operators
3. Eigenvalues and Eigenvectors
4. Diagonal Forms and Jordan Forms
5. Special Linear Operators: Symmetric and Normal/Orthogonal Operators

### Week 2: Jan 27-29

Topic: Linear and Non-Linear Dynamical Systems

1. General Dynamical Models
2. Examples of linear and non-linear models
3. Linear and non-linear phenomena

**Week 3: Feb 3– Feb 5**

Topic: Solutions of Linear Differential Equations

1. Solution of Systems of linear differential Equations
2. Laplace transform and the concept of transfer function
3. Duality

**Wed Feb 4 - HW#1 due**

**Week 4: Feb 10 – 12**

Topic: Stability Concepts I

1. Stability of Equilibrium Points and Linearization
2. Lyapunov Stability: General Concepts
3. Lyapunov Stability for Linear Systems

**Week 5: Feb 17-19**

Topic: Stability Concepts II

1. Lyapunov Stability for Non-linear Systems and Linearization
2. Exponential Stability and Region of Attraction
3. Converse Lyapunov Functions and Non-Autonomous Systems

**Wed Feb 18 – HW#2 Due**

**Week 6: Feb 24 – Mar 26**

Topic: Stability Concepts III

1. Perturbed Systems
2. BIBO Stability

**Week 7: Mar 3 – Mar 5**

Topic: Finite Time Stability

1. Finite Time Stability: Basic Concept and Definitions
2. Finite Time Stability Conditions for Autonomous and Non-Autonomous Systems

**Wed Mar 4 – HW#3 Due**

**Week SB (Mar 7- Mar 14): Spring Recess**

**Week 8: Mar 17 – Mar 19**

Topic: Controllability

1. General Conditions
2. Controllability Canonical Forms
3. Time Invariant Systems
4. Output and Trajectory Controllability
5. Controllability and Stability for General Systems

**Week RW (Review): Mar 24- Mar 26**

Topic: Review and Mid-Term Exam

**Tue Mar 24 - Midterm Review**

**Th Mar 26 - Midterm Exam**

**Week 9: Mar 31 – Apr 2**

Topic: Observability

1. General Conditions
2. Observability Canonical Forms
3. Time Invariant Systems

**Wed Apr 1 - HW# 4 due**

**Week 10: Apr 7 – Apr 9**

Topic: Canonical Forms

1. Controllability Canonical Forms
2. Observability Canonical Forms
3. Examples

**Week 11: Apr 14 – Apr 16**

Topic: Systems Design and Estimation I: Linear Methods

1. Stabilization: Basic Concepts and Linearization
2. Linear Systems Design: Eigenvalues placements
3. Linear Systems Observers
4. Controller Observer Separation Theorem
5. Examples

**Wed Apr 15 – HW#5 due**

**Week 12: Apr 21 – April 23**

Topic: Systems Design and Estimation II: Linear Methods

1. Design and Estimation examples via MATLAB
2. Linear Quadratic Regulator

**Week 13: Apr 28 – April 30**

Topic: Nonlinear Control Design Methods

1. Selected Nonlinear Design Methods

**Week 13: May 5**

Topic: Final Review

**Tue May 5 - Final Review**

**Wed May 6 – HW#6 due**

**Final Exam: 6-8pm, May 11, 2026**

## Grading

A regular grade (A, B, C, D, E) will assigned. The grade will be established as function of the class performance (curve). Each student will receive a numerical value according to his/her performance on the following items:

|              |     |
|--------------|-----|
| Midterm Exam | 30% |
| Final Exam   | 40% |
| Homework     | 30% |

## Course Objectives

At the end of the course, the students are expected to be able to:

1. Analyzing of Linear and Non-Linear Dynamical Systems
2. Applying of the Lyapunov Stability Theory to Dynamical Systems
3. Understanding if a System is Controllable and Observable
4. Applying a Variety of Design Methodologies to Stabilize Dynamical Systems

## Semester Assignments, Midterm and Final Examination

During the semester, students will be required to submit approximately 6 (six) homeworks with bi-weekly frequency. Homeworks will be a combination of theoretical analysis and limited computer simulation via MATLAB or Python. There will be one mid-term exam and one comprehensive final exam. Considering the pandemic instructions on both exams format will be announced later. Make-up exams for a valid excuse must be arranged at least 1 week before the scheduled exam date. Emergency situation should be communicated to the instructor as soon as possible to arrange for an alternative schedule. Without prior consent, there will be no make-up exams.

## Class Attendance, Participation and General Ethical Guidelines

The students are expected to regularly attend the lectures. If lectures are missed, the student should make sure you get up-to-date with the course material by reviewing the zoom recorded lectures and the material posted on the D2L course website. Students and faculty each have a responsibility for maintaining an appropriate learning environment. Those who fail to adhere to such behavioral standards may be subject to discipline. Active participation during classes (e.g. answering questions when asked by the instructor, show interest and motivation for the subject) is encouraged and it may be taken into account when establishing the final grade. While collaboration and discussion between students during homework is encouraged, plagiarism is not tolerated and may be subjected to disciplinary actions.

## Ethical Use of Artificial Intelligence (AI) Tools for Classwork

The use of Artificial Intelligence–based tools (e.g., large language models, code assistants, symbolic solvers) is permitted in this course as a learning aid, but not as a replacement for independent thinking, analysis, or original work.

Students **may use** AI tools to:

- Clarify concepts discussed in class or in the textbook
- Obtain alternative explanations of mathematical definitions or proofs
- Debug code or explore numerical examples for learning purposes
- Support study and review of course material

However, AI tools **may not** be used to:

- Generate complete or near-complete solutions to homework problems
- Produce derivations, proofs, or written explanations that are submitted as the student's own work
- Automatically solve assignments without full understanding and independent reconstruction
- Bypass the learning objectives of the homework

All submitted homework must reflect the student's own reasoning, derivations, and problem-solving process. If AI tools are used during learning or exploration, the student is expected to be able to fully explain and reproduce the solution independently.

Using AI to directly generate homework solutions, or submitting AI-generated content as one's own work, will be treated as a violation of academic integrity and handled according to University of Arizona policies.

When in doubt about whether a particular use of AI is appropriate, students are encouraged to ask the instructor in advance.

## Textbooks

Szidarovszky and Bahill, Linear Systems Theory, Second Edition (Systems Engineering) Hardcover – November 25, 1997 (Required).

Instructor class notes and relevant material (the instructor will make them available through the D2L course website at [d2l.arizona.edu](http://d2l.arizona.edu))

## Software

MATLAB (full version available for download to UA students) and/or Python.

## Zoom Lectures

Lectures will be delivered via zoom – access is granted via D2L portal. Here you have the zoom invitation:

**NOTE: Password: 123321**

Roberto Furfaro is inviting you to a scheduled Zoom meeting.

This meeting was created in a non-BAA environment and is not intended for the discussion of healthcare, health education, or health data research.

Topic: SIE 550 SP26 001 025 110 210

Time: Jan 20, 2026 04:00 PM Arizona

Every week on Tue, Thu, until May 5, 2026, 31 occurrence(s)

Jan 20, 2026 04:00 PM

Jan 22, 2026 04:00 PM

Jan 27, 2026 04:00 PM

Jan 29, 2026 04:00 PM

Feb 3, 2026 04:00 PM

Feb 5, 2026 04:00 PM

Feb 10, 2026 04:00 PM

Feb 12, 2026 04:00 PM

Feb 17, 2026 04:00 PM

Feb 19, 2026 04:00 PM

Feb 24, 2026 04:00 PM

Feb 26, 2026 04:00 PM

Mar 3, 2026 04:00 PM

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Mar 24, 2026 04:00 PM

Mar 26, 2026 04:00 PM

Mar 31, 2026 04:00 PM

Apr 2, 2026 04:00 PM

Apr 7, 2026 04:00 PM

Apr 9, 2026 04:00 PM

Apr 14, 2026 04:00 PM

Apr 16, 2026 04:00 PM

Apr 21, 2026 04:00 PM

Apr 23, 2026 04:00 PM

Apr 28, 2026 04:00 PM

Apr 30, 2026 04:00 PM

May 5, 2026 04:00 PM

Please download and import the following iCalendar (.ics) files to your calendar system.

Weekly:

[https://arizona.zoom.us/meeting/tZcvde2grzsrGNcbE4Tf4kDTLwTZViyHv6/ics?icsToken=DFgRtARbUPg4I34Z1wAALAAAALA894kLSerTVnA5EzZnAV1qEVTpR5kV1Yxbj0S31oiRF6pK5rRcKEOCc v2\\_VuuK1WiNMvgb\\_lt1z7W0bDAwMDAwMQ](https://arizona.zoom.us/meeting/tZcvde2grzsrGNcbE4Tf4kDTLwTZViyHv6/ics?icsToken=DFgRtARbUPg4I34Z1wAALAAAALA894kLSerTVnA5EzZnAV1qEVTpR5kV1Yxbj0S31oiRF6pK5rRcKEOCc v2_VuuK1WiNMvgb_lt1z7W0bDAwMDAwMQ)

Join Zoom Meeting

<https://arizona.zoom.us/j/83224810123>

Password: 123321

One tap mobile

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+1 346 248 7799 US (Houston)

+1 602 753 0140 US (Phoenix)

+1 669 900 6833 US (San Jose)

+1 253 215 8782 US (Tacoma)

Meeting ID: 832 2481 0123

Find your local number: <https://arizona.zoom.us/u/kmKAcrAIO>

Join by SIP

[83224810123@zoomcrc.com](mailto:83224810123@zoomcrc.com)

Join by H.323

144.195.19.161 (US West)

206.247.11.121 (US East)

115.114.131.7 (India Mumbai)

115.114.115.7 (India Hyderabad)

159.124.15.191 (Amsterdam Netherlands)

159.124.47.249 (Germany)

159.124.104.213 (Australia Sydney)

159.124.74.212 (Australia Melbourne)

170.114.180.219 (Singapore)

64.211.144.160 (Brazil)

159.124.132.243 (Mexico)

159.124.168.213 (Canada Toronto)

159.124.196.25 (Canada Vancouver)

170.114.194.163 (Japan Tokyo)

147.124.100.25 (Japan Osaka)

Meeting ID: 832 2481 0123

Password: 123321