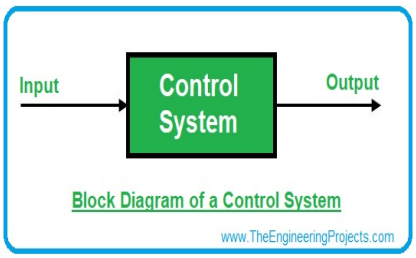
ECE 5380/6380: Linear Systems Analysis

Spring 2025



Course meeting time: MW 3:00 – 4:20 pm @ Chemistry & Computer Sci. Bldg. 1.0204
Credits: 3
Course website: MY UTEP ⟶ Blackboard
Textbook: *Linear State-Space Control Systems* by Douglas A. Lawrence and Robert L. Williams

1 Instructor

Dr. Shi'an Wang (swang14@utep.edu)
Office: Engineering Building, A-316
Office hours: M 4:30–5:30 pm; T 4:00–5:00 pm; W 4:30–5:30 pm, or by appointment

I received a PhD in 2022 and MS in 2018 from the University of Minnesota and University of Ottawa, respectively. I first started teaching at The University of Texas at El Paso in Fall 2023.

2 Course description

Welcome to ECE 5380/6380! This course focuses on the fundamental concepts of modern control theory for linear systems, using the state-space approach. In state-space representation, a mathematical model of a physical system is developed as a set of first-order differential equations. Under the appropriate conditions, this model can be represented in matrix form, allowing for efficient implementation on a computer. Course topics include the relationships with frequency-domain design, modeling of physical systems, controllability, observability, stability, the design of controllers and observers, and optimal control. By the end of the course, you will have a fundamental understanding of modern control theory for linear systems, as well as the experience and tools needed to work with control systems. This course also emphasizes the use of prerequisite mathematics and physics skills for engineering problem-solving.

3 Course format

While this course primarily follows a problem-based learning format, I will also introduce both numerical and practical control problems to you during the lecture. **The purpose is for you to**

learn problem-solving skills, in addition to solution methods. Every student is expected to participate in class discussions of problems and solutions. Active engagement with problems in-class has been shown to increase learning and retention[1].

3.1 Prerequisites

Exposure to linear algebra and differential calculus is essential for this course. An undergraduate course in frequency domain design (such as ECE 4338 Systems and Controls) is also highly beneficial. Success in ECE 5380 relies on understanding the underlying core concepts, not just the calculations involved. If it has been some time since you took linear/matrix algebra or differential equations, you may find it worthwhile to review these topics before the semester gets too busy.

3.2 Course material

The required textbook for this course is Linear State-Space Control Systems, by Douglas A. Lawrence and Robert L. Williams, which is available for borrowing at the UTEP Library. I will periodically upload my hand-written lecture notes for each chapter to Blackboard.

3.3 Communication

Please feel free to drop in during my office hours without prior notice; that is the purpose of office hours. If you cannot make office hours, feel free to email me to set up an alternative appointment time. Also feel free to ask questions via emails. I will try to respond to all emails within one business day.

4 Assessment

Grades will be determined by performance on the following items. Requests for regrading must be submitted no more than one week after grades are posted.

Category	Weight
Homework assignments	30%
Class participation	10%
Midterm exam 1	15%
Midterm exam 2	15%
Final exam	30%

The A–F grading scale will be used. At the end of the course, I may apply a curve if needed to ensure a proper grade distribution. Please feel free to contact me at any time during the semester to discuss your progress to date.

[1] Deslauriers, L., McCarty, L., Miller, K., Callaghan, K., & Kestin, G. (2019) Measuring actual learning versus feeling of learning in response to being actively engaged in the classroom. *Proceedings of the National Academy of Sciences*, 116 (39), 19251–19257.

Assignments will be posted on Blackboard and announced in class. Schedule changes will be announced on Blackboard. Late submissions will **not** be accepted. When submitting files online, students are responsible for ensuring that the submitted files are uploaded correctly. The instructor cannot give credit for corrupt or irrelevant files, and the standard late penalty will be applied when correct files are uploaded after the deadline.
Although attendance is not a component of the final grade, succeeding in this course requires full understanding of the concepts, and few students can achieve this without regular class attendance and participation. The class format (problem-based learning) is designed to encourage you to study and master the concepts during class.

4.1 Homework assignments

Homeworks will require time and effort. Do not wait until the night before to start. Understanding the engineering equations will not be sufficient to succeed on the homeworks; you must master the concepts to answer correctly. Homeworks will be assigned at the beginning of each chapter and include conceptual, analytical or computational problems. You are encouraged to work together on homeworks, but **you must write your solutions individually, in your own words.** You may use spreadsheets or other computer software on the homeworks. Email your spreadsheets and programs to me as part of the homework submission, or submit them on Blackboard.

4.2 Exams

The midterm exams will be given during class time. The final exam is **cumulative**, and will be held at the University-scheduled time (Section 5). You may bring one double-sided 8.5"$\times$11" sheet of notes to the midterm, and two double-sided sheets to the final exam. Bring a scientific or graphing calculator to both exams. Internet or communications-capable devices (laptops, smartphones, etc.) cannot be used on exams. If you have a schedule conflict with an exam, please inform me as far in advance as possible so that alternative arrangements can be made. Depending on the circumstances, these arrangements may include taking a different exam before or after the scheduled time, additional assignments, and/or adjusting a student's final grade distribution. Except for unforeseen and documented emergencies, makeup exams will not be given without prior notice.

5 Schedule

A tentative class schedule is shown below, but dates and topics may change.

MONDAY		WEDNESDAY	
1/22 Orientation; introduction to control systems	**1**	1/27 Review of linear algebra	**2**
1/29 Review of differential equations	**3**	2/3 State-space fundamentals	**4**
2/5 State-space fundamentals	**5**	2/10 State-space fundamentals	**6**
2/12 State-space fundamentals	**7**	2/17 **Midterm exam 1**	**8**
2/19 Controllability	**9**	2/24 Controllability	**10**
2/26 Controllability	**11**	3/3 Observability	**12**
3/5 Observability	**13**	3/17 Observability	**14**
3/19 Minimal realizations	**15**	3/24 Stability	**16**
3/26 Stability	**17**	3/31 Stability	**18**
4/2 Stability	**19**	4/7 **Midterm exam 2**	**20**
4/9 Linear state feedback control design	**21**	4/14 Linear state feedback control design	**22**
4/16 Linear state feedback control design	**23**	4/21 Observers	**24**
4/23 Observers	**25**	4/28 Observers	**26**
4/30 Optimal control	**27**	5/5 Optimal control	**28**
5/7 Optimal control	**29**	5/12 1:00–3:45pm, classroom **Final exam** (UTEP scheduled time)	

6 Miscellania

ABET is the external accreditation organization for all engineering programs in the United States. ABET requires documented student outcomes that prepare graduates to attain the program educational objectives. EE 4364 explicitly addresses three of these seven student outcomes.

- Criterion 1 – An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science and mathematics.
- Criterion 4 – An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
- Criterion 5 – An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.

Policy statements

- University-wide final examination schedules: Final Examination Schedules
- Administrative Policy: Policies and Regulations
- Attendance and Grading: Policies and Regulations: Attendance and Grading
- Scholastic Dishonesty: Academic Dishonesty Violations and Handbook of Operating Procedures
- Student Conduct: Student Conduct
- Board of Regents Policy: Equal Opportunity
- Student Support: Center for Accommodations and Support Services (CASS)
- Board of Regents Policy: Academic Freedom and Responsibility
- My goal is to create a learning environment that is accessible and inclusive for all students. If you anticipate any barriers related to the design of the course, e.g., format, materials, or structure, please contact me outside of class so we can explore potential options. If you have a disability and want to explore formal accommodations and/or further resources, please contact Center for Accommodations and Support Services (CASS). If you have already consulted with the CASS, please share your letter with me as soon as you can to discuss how your accommodations will be implemented in this course.