Revised: August 25, 2025

ECE 601 - Linear Systems

Old Dominion University
Department of Electrical and Computer Engineering

Fall Semester 2025

Instructor

W. Steven Gray
Email: `sgray@odu.edu`
Office Hours: Monday & Friday, 13:30 - 15:00 EST, Location: Zoom

Lectures

Time: Thursday, 16:30 - 19:10 EST
Location: Live via Zoom (ODU class launch pages)

Course Webpage

http://wstevengray.org/classes/ece601
Canvas is only used to archive the lecture videos.

Prerequisites

Undergraduate courses MATH 307 (ordinary differential equations) and ECE 302 (linear systems analysis) or their equivalents. This includes the following topics: linear algebra and matrix operations, Laplace transforms, system representations and transformations, signal representations and transformations, ordinary differential equations.

Textbook

Linear Systems, T. Kailath, Prentice Hall, 1980

References

1. *Linear System Theory and Design, 3rd Edition*, C. T. Chen, Oxford University Press, 1998
2. *Linear System Theory, 2nd Edition*, W. J. Rugh, Prentice Hall, 1995
3. *Modern Control Theory, 3rd Edition*, W. L. Brogan, Prentice Hall, 1991
4. *Linear Algebra and Its Applications*, G. Strang, Saunders College Publishing, 1976

Course Objectives

The main objective of the course is to provide a comprehensive introduction to the theory of linear systems from an input-output and state space point of view at the graduate level. This material is essential in continuing studies in control systems, signal processing, and communications. The main mathematical tool employed is linear algebra, which will be reviewed briefly at the beginning of the course. The use of MatLab/Simulink simulation software (or some equivalent) is directly integrated into the homework assignments.

Grading Policy

Final grades are determined using the numerical averages computed as follows:

Homework - 10 % (weekly)
Midterm Exam 1 - 25 % (week 5: September 25, 2025, Thursday, 15:45 - 19:10 EST)
Midterm Exam 2 - 25 % (week 10: October 30, 2025, Thursday, 15:45 - 19:10 EST)
Final Exam - 40 % (exam week: December 11, 2025, Thursday, 15:45 - 18:45 EST)

Course Policies

1. This course will be run exclusively online. Live interactive lectures will be broadcast via Zoom at the link given above. It is strongly advised that students attend the lectures live to get the most out of the course. Lectures will be taped and archived for later viewing.

2. The course webpage is the clearinghouse for all information concerning the course. It will be updated frequently, so check it first when you have any questions or concerns. Canvas is only used to archive the lecture videos.

3. The text is an integral part of the course. You are responsible for the material in the sections cited in the course outline below. It will not be possible to cover every important topic in detail in lecture. This is a graduate level course, so a graduate level text is used. You might have to read it more than once!

4. On average homework will be assigned once a week and collected the following week. All homework must be submitted by email to your instructor (`sgray@odu.edu`) by 16:30 EST on the due date using:

   (a) Subject line: `Last Name, First Name, ECE 601 Homwork X`

(b) File name: `LastName_FirstName_ECE601_Homwork_X`

Late homework will not be accepted since solutions will be posted on the course webpage shortly after class. See your instructor *in advance* in case of extenuating circumstances.

5. All submitted assignments should be in a single .pdf file, organized, neat, and professional in appearance. Handwritten assignments are fine. You can use either a tablet or scan your papers using what every technology you prefer. (This app works well.) Have a back-up plan just in case.

6. Online office hours are available to meet with the instructor. Come with specific questions prepared in advance for the best outcome. Other meeting times are available by appointment.

7. Matlab software will be used in some of the homework assignments. You can install this software on your laptop following the instructions here. You might consider purchasing the Student Edition of MatLab/Simulink directly from MathWorks.

Honor System

The Honor System at Old Dominion University is based on individual integrity. In registering for ECE 601, you have agreed to adhere to the following Honor Pledge:

> *"I pledge to support the Honor System at Old Dominion University. I will refrain from any form of academic dishonesty or deception, such as cheating or plagiarism. I am aware that as a member of the academic community it is my responsibility to turn in all suspected violators of the Honor Code. I will report to an Honor Council hearing if summoned."*

Additional information is available at the website:

`https://www.odu.edu/oscai`

Educational Accessibility

The Old Dominion University's educational accessibility policy is:

> *"Students are encouraged to self-disclose disabilities that have been verified by the Office of Educational Accessibility by providing Accommodation Letters to their instructors early in the semester in order to start receiving accommodations. Accommodations will not be made until the Accommodation Letters are provided to instructors each semester."*

Additional information is available at the website:

`https://www.odu.edu/accessibility`

Course Outline

1. **Introduction and Background Material - Class Notes and Kailath Appendix**
    - Motivation for the Study of Linear Systems
    - Linear Algebra Review
    - Some Facts About Square Matrices
2. **Prelude to Numerical Linear Algebra - Class Notes and Kailath Appendix**
    - Sensitivity of Linear Systems of Equations
    - Symmetric Case: Condition Numbers via Spectral Decomposition
    - General Case: Condition Numbers via Matrix Norms
    - General Case: Condition Numbers via Singular Value Decomposition
3. **State Space Descriptions - Chapters 1 and 2**
    - Some Canonical State Space Realizations
    - State Equations in the Time Domain
    - State Space (Similarity) Transformations
    - State Equations in the Frequency Domain
    - Nominal System Functions
    - State Observability and Controllability
    - Discrete-Time Systems, Controllability and Observability
    - Minimality of State Space Realizations
    - Decompositions of Nonminimal Realizations
    - The Popov-Belevitch-Hautus (PBH) Tests
    - Solving the State Equation
    - Modal Decomposition
    - Stability of Linear Systems
4. **Linear State Variable Feedback - Chapter 3 (only Sections 3.0-3.3)**
    - Overview of Feedback Structures
    - Compensation via State Variable Feedback
    - Explicit State Feedback Design Formulas
    - State Feedback for Noncontrollable Systems
5. **Asymptotic State Variable Observers - Chapter 4 (only Sections 4.0-4.3)**
    - Open-Loop Observers
    - Closed-Loop Asymptotic Observers
    - Combined Controller-Observer Compensators: The Separation Principle
    - Reduced-Order Observers