

**ECE 461 - Automatic Control Systems**  
 Old Dominion University  
 Department of Electrical & Computer Engineering

**COURSE INFORMATION**

Fall 2019

- Instructor:** Oscar R. Gonzalez, ogonzale@odu.edu  
 Kaufman Rm. 231O, Phone: 757-683-4966, ECE Dept: 757-683-3741
- Office Hours:** MW 3:00 PM – 4:00 PM, after class, and by appointment. (Also, see Piazza.)
- Lectures:** MW 4:20 PM – 5:35 PM  
 Building: BAL 1013B
- Blackboard (Bb):** Log in to ODU’s ECE 461/561 Bb web site, using your ODU’s e-mail username and password for course materials and grades.
- Piazza:** <https://piazza.com/odu/fall2019/ece461561/home> Bulletin board for all ECE 461/561 public and private discussions.  
 Bb will be used to post course content, announcements, and grades. Whenever content is posted, a Bb announcement is sent via e-mail. Piazza is a forum for questions and answers pertaining to any topic relevant to ECE 461/561. Please use Piazza for all communication with the instructor instead of using e-mail. You may post private questions to instructors and also anonymous ones in Piazza.
- Teaching Assistant:** Tahsin, Sadiya <stahs001@odu.edu>
- Textbook:** *Control Systems Engineering*. Norman S. Nise, John Wiley & Sons, Inc., 7<sup>th</sup>. Ed, 2015.
- Software:** Matlab ® with Control Systems Toolbox and Simulink. It is available in labs and at <https://move.odu.edu/>, and can be downloaded from <https://www.odu.edu/ts/software-services/matlab> It is expected that it be downloaded and installed in your personal computer.
- Prerequisites:** To begin this course you should have taken ECE 302 or equivalent and should be proficient in the following areas:
1. Laplace transform operations.
  2. Solution of linear ordinary differential equations.
  3. Matrix algebra operations.
  4. Circuit analysis and derivation of transfer functions.
  5. Sketching and interpreting Bode plots.
- Grading Policy:** The final course grades will be determined from the students’ performance on the examinations, course project, and problem sets, according to the following percentages:
- |                |     |  |
|----------------|-----|--|
| Problem Sets   | 15% |  |
| Course Project | 15% |  |
| Exam 1         | 20% | Wednesday, September 25, 2019                  |
| Exam 2         | 20% | Wednesday, October 30, 2019                    |
| Final Exam     | 30% | Monday, December 9, 2019 3:45 p.m. – 6:45 p.m. |

**Catalog:**

Analysis and design of control systems via frequency and time domain techniques. Root locus, Bode and Nyquist techniques. Stability, sensitivity, and performance specifications. Cascade and feedback compensation. Computer-aided analysis and design. Pole placement through state variable feedback. Prerequisite: ECE 302.

**Course Objectives:**

To develop an understanding and practice in the analysis and design of linear time-invariant continuous-time control systems using frequency and time-domain techniques. Computer-aided simulation, analysis, and design techniques will be used extensively.

1. **Modeling in the Frequency Domain.** Review the representation of electrical circuits using transfer function models. Understand the limitations of mathematical models.
2. **Modeling in the Time Domain.** Derive differential equation and state-space models of systems. Derive linearized models of nonlinear electro-mechanical systems.
3. **Reduction of Interconnected Systems.** Perform operations on an interconnection of systems represented by block diagrams using graphical and/or algebraic techniques. Relate signal flow graphs to block diagrams. Determine input/output transfer functions of interconnected systems represented by block diagrams using Mason's rule. Determine a state-space representation of an interconnection of systems.
4. **Time Domain Analysis.** Determine time response characteristics from the locations of the poles and zeros. Qualitatively and quantitatively analyze first and second order systems. Approximate higher order systems by a dominant first or second order subsystem, if possible. Understand the effect of additional poles and zeros.
5. **Stability.** Analyze Bounded-Input, Bounded-Output (BIBO) and asymptotic stability of open and closed-loop systems. Analyze BIBO stability using the Routh-Hurwitz Criterion.
6. **Steady-state Performance – Analysis and Design.**  
Analysis: Learn the definition and learn to calculate the steady-state error of a system. Derive and use general relations to compute the steady-state error of a unity feedback system. Define and learn to use the system type and static error constants. Derive and learn to use efficient relations to compute steady-state errors for unity feedback systems. Learn to calculate the steady-state error for a non-unity feedback system.  
Design: Determine the range of values of the design parameters that meet the steady-state error specification.
7. **Root Locus Analysis.** Explain the motivation for the root locus plot. Define a root locus. Derive the root locus equation. Derive the fundamental root locus property. Derive the fundamental root locus conditions. Draw, explain and use root locus diagrams. Determine controller parameters using the root locus plot.
8. **Root Locus Design.** Learn and use the control system design guidelines. Use root locus to design cascade PD and lead compensators to stabilize the closed-loop system and to improve transient response. Use root locus to design cascade PI and lag compensators to improve the steady-state response. Use root locus to design cascade PID and lead-lag compensators.

9. **Frequency Domain Analysis and Design.** Analyze open and closed-loop systems using frequency response techniques. Sketch the Nyquist frequency response plot. Use the Nyquist plot in stability analysis. Learn to calculate and interpret classical gain and phase robust stability margins. Determine desirable Bode plot magnitude shapes for control. Learn to design controllers that meet both time and frequency domain specifications.
10. **State Space Design.** Perform pole placement design using linear state variable feedback controllers with full state feedback and with estimated states.

**Honor System:**

The Honor System at Old Dominion University is based on individual integrity. In registering for ECE 461/561, 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."

**You must follow the Honor System principles in all the work you turn in, that is, the work you turn in must be yours. It is permitted to work together the problem set solutions, but you must turn in your own work. Experience in problem solving can only be gained by attempting most problems completely on your own. This experience is the best preparation for the course examinations and for future engineering problem solving. However, it is useful to seek help after an honest attempt has been made. Come prepared with your questions to the office hours or post questions in Piazza. Everyone is encouraged to actively participate in Piazza. Acknowledge the people that helped you. Absolutely no collaboration is allowed in any other assessed work other than problem sets.**

**Course Project:**

Some parts of the project may require work in the Signals & Systems workbench in the Systems Research Laboratory (KH Rm. 233).

**Course Policies:**

1. Late problem sets will not be graded. One problem set grade will be dropped. It is encouraged that students work together. Since not all the homework problems may be graded, you are responsible to verify that your answers are correct by comparing them to the posted solutions. Some assignments may require work in the Signals & Systems workbench in the Systems Research Laboratory (KH Rm. 233).
2. Examinations must be taken at the scheduled times. Only valid excuses such as illness requiring a physician's care, death in the family, or court appearance will be accepted. Always notify me or the ECE department secretary at 683-3741 before the exam.
3. All parts of the course project, must be completed in order to pass this course.
4. Blackboard will be the primary online resource to make available course handouts such as problem sets, solutions, and course project. Every posting of new material is broadcasted with an e-mail announcement.
5. Piazza is the primary communications tool for public and private postings related to any course topic and questions. Everyone is encouraged to post and reply or edit other people's postings. Credit will be assigned for active and pertinent participation.
6. The use of Matlab, a computer-aided control system design package (CACSD) is required. It will be used in problem sets and in the project. The examinations and final may include data and plots generated by MATLAB. MATLAB will be used to analyze, design, and simulate control systems. You will not be tested on the syntax of MATLAB commands, but you need to know how to use it, since you will get to use MATLAB during some of the examinations and final exam. A full version of MATLAB, including SIMULINK and the Signal and Control Toolboxes can be downloaded from <https://www.odu.edu/ts/software-services/matlab> It is also available in KH Rms. 228-229-230 and online in the Monarch Virtual Environment (MOVE): <https://move.odu.edu/> It is better to use the VMware Horizon View Client.
7. Reasonable accommodations are provided for students with disabilities. Students should present a letter from the Office of Educational Accessibility as soon as possible.
8. Matlab's online pdf manuals and html help files are the best resource of information. In addition, the textbook's Appendices B, C, E, and F introduce Matlab and provide many examples. More examples will be introduced in the course, and in the solutions to assigned problems. In general, when you encounter a new Matlab command, learn about it by running `help commandname` or `doc commandname`.
9. Opportunities to earn bonus points will be announced throughout the semester.

**Academic Expectations:**

1. Regular attendance is essential.
2. Reading assignments must be completed prior to lectures.
3. Seek help if any topic in the lectures or reading assignment or graded work is not completely understood.

**Outline and Reading Assignments:**

<b>Module</b>	<b>Reading Assignment</b>
I. Introduction	Chapter 1 Appendices B.1, C.1, and C.2
II. Modeling in the Frequency Domain	Chapter 2, Sections 2.1-2.4 Appendix B.2-Chapter 2
III. Modeling in the Time Domain	Chapter 3 Appendix B.2-Chapter 3
IV. Operations with Interconnected Systems	Chapter 5, Section 5.2, 5.4 - 5.5 Appendix B.2-Chapter 5 (Skip <i>Solution via Append &amp; Connect Commands</i> )
V. Time Domain Analysis	Study Sections 4.1 - 4.8 Appendix B.2-Chapter 4, Appendices E.1 – E.4
VI. Stability	Study Sections 6.1 - 6.2 Appendix B.2-Chapter 6
VII. Steady State Errors	Chapter 7, Sections 7.1 - 7.6 Appendix B.2-Chapter 7
IX. Root Locus Analysis	Chapter 8, Sections 8.1 - 8.4, 8.7 - 8.9 Appendix B.2-Chapter 8, Appendices E.5-E.8
X. Root Locus Design	Chapter 9, Sections 9.1-9.4 Appendix B.2-Chapter 9
XI. Frequency Response Analysis and Design	Chapter 10, Sections 10.1-10-11 & 10.13, Chapter 11 Appendix B.2-Chapters 10-11
X. State Space Design	Chapter 12 Appendix B.2-Chapter 12