COLLEGE OF ENGINEERING
LAMAR UNIVERSITY

Syllabus

Lamar University, a Member of The Texas State University System, is accredited by the Commission on Colleges of the Southern Association of Colleges and Schools to award Associate, Baccalaureate, Masters, and Doctorate degrees (for more information go to http://www.lamar.edu).

Contact Information:	
Course Title:	**Control Engineering**
Course Number:	**ELEN 4351**
Course Section:	**48F**
Department:	**Philip M. Drayer Department of Electrical Engineering**
Professor:	**Hassan Zargarzadeh, PhD**
Class Time	**R 11:10^{am} - 12:30^{pm}**
Office/Virtual Hours:	**Office hours: M-F, 1:00pm-1:30pm or by appointment.**
Contact Information:	**LU email: h.zargar@lamar.edu** **Office: Cherry 2207** **Phone: 409-880-7007**
Grading Assistant Info	**Please contact *Mahdi Naddaf*, in case of questions regarding gradings.** **Email: mnaddafsharg@lamar.edu**

Personal Introduction

Welcome to Lamar University. My name is **Hassan Zargarzadeh (Call me Dr. Z)**, and I will be your instructor of record for **Control Engineering**. By way of a very brief introduction, I earned my baccalaureate, master's, and PhD all in Electrical Engineering. My area of expertise is Advanced Control Systems with applications to Robotics, Power Electronics, Unmanned Vehicles, and renewable energies. I joined the faculty at Lamar in August 2015 and I am currently an Assistant Professor for the Department of Electrical Engineering in the College of Engineering**.**

Course Description

This course introduces important concepts in the analysis and design of control systems. Control theories commonly used today are classical control theory (also called conventional control theory), modern control theory, and robust control theory. This course presents comprehensive treatments of the analysis and design of control systems based on the classical control theory and modern control theory. Control engineering is essential in any field of engineering and science. It is an important and integral part of space-vehicle systems, robotic systems, modern manufacturing systems, and any industrial operations involving control of temperature, pressure, humidity, flow, etc. It is desirable that any engineer and scientist be familiar with the theory and designing processes of automatic control systems. This undergraduate course is intended to be an introductory to control engineering at the senior level.

Course-Level Objectives

This course covers the concept of block diagrams, transfer functions, characteristics of closed loop systems in steady states and transient modes, sensitivity, stability, performance criteria for first and second order systems, root locus-based controller design, frequency response-based controller design, proportional integral derivative (PID) controller design, and simulation tools such as MATLAB and Simulink.

ABET Student Learning Outcomes

Students who successfully complete this course will be able to:

1. Derive the dynamic models of simple mechanical, electrical and electromechanical systems. (a)
2. Obtain the transfer function of dynamic systems. (a)
3. Obtain the response of dynamic systems using Laplace transforms. (a)
4. Use MATLAB and SIMULINK to simulate linear time-invariant (LTI) systems. (k)
5. Recognize the effect of pole-zero locations on system response. (a,e)
6. Determine the stability of LTI systems. (e)
7. Find steady state errors to polynomial-type commands. (e)
8. Be able to explain basic feedback concepts. (e)
9. Design PID control for LTI systems. (e)
10. Draw root locus of LTI systems. (e,k)
11. Determine the desirable location of system poles, given closed-loop specifications.
12. Determine the stability of closed-loop systems from root locus. (e)
13. Design lead and lag compensators for LTI systems using root locus. (a,c,e)
14. Use MATLAB and SISO Tool for drawing root locus and for control design. (k)
15. Draw frequency response (Bode plot) of LTI systems. (e)
16. Determine closed-loop bandwidth, phase-margin and steady-state error from Bode plot. (e)
17. Determine closed-loop stability from Nyquist plot. (e)
18. Design lead and lag compensators using frequency response. (a,c,e)
19. Use MATLAB and SISO Tool for drawing Bode plot, Nyquist plot and for control design. (e,k)

Academic Prerequisites

The course prerequisite is ELEN 313 – Signals and Systems.

Online Web Conferences, Threaded Discussion

To enhance student-to-student and instructor-to-student interaction, Online Web Conferences utilizing **Blackboard Collaborate** have been scheduled for **every week** for both the hybrid and online sections. I will embed the link to these Web Conferences in the course so you will have access. I will record each Web Conference so that students who are unable to participate can access, review and respond to our group discussions. Arrangements can be made for additional conferences as needed upon request.

Students will be expected to participate in Threaded Discussion board topics, and (See Grading Polices below.) (i.e. Participation is required in the discussion threads by posting your own assignment and then posting engaging comments or questions (at least two) with other peers per week. Etc.).

Technology Prerequisites

Students are required to **be familiar with MATLAB coding** in order to be successful in the class. Additionally, they should feel confident about their ability to navigate through typical online websites and their ability to use common word processing software in order to submit written assignments.

The minimum technical skills and the system requirements for this course:

Blackboard:
Students will utilize the Lamar University's Learning Management System (LMS), Blackboard, for online courses.

System Requirements
Computer/Technology Requirements

1. Students will need regular access to Windows, MAC with a broadband Internet connection. Note: mobile devices (if you have mobile devices there are limitations)
   The minimum computer requirements are:
   - Most current version of Firefox is recommended
     - *Please note that Blackboard may not support Internet Explorer, Safari, or Chrome.*
   - 8 GB or more preferred

- Broadband connection (cable modem, DSL, or other high speed) required – some courses are video intensive
- 1024 x 768 or higher resolution
- Strongly recommended that you have a headset with microphone. You may also use webcam, and speakers
    - Example: Plantronics Audio 628 USB headset
- Current anti-virus software must be installed and kept up to date.
- Students will need some additional free software for enhanced web browsing. Be certain to download the free versions of the software.
    - Firefox (http://www.mozilla.org)
    - Adobe Reader (https://get.adobe.com/reader/)
    - Adobe Flash Player (http://get.adobe.com/flashplayer)
    - Java (http://www.java.com)
    - QuickTime (https://www.apple.com/quicktime/download/)
    - Silverlight (https://www.microsoft.com/silverlight/)
- Most home computers purchased within the last 3-4 years meet or surpass these requirements.

2. At a minimum, students must have Microsoft Office 365 (https://my.wip.lamar.edu click on MS Office 365). Microsoft Office 365 is available for all students.

Skills you need to be able to:

3. Navigate websites, including downloading and reading files from them.
4. Use e-mail, including attaching and downloading documents/files.
5. Save files in commonly used word processing formats (.doc, .docx).
6. Copy and paste text and other items in computer documents.
7. Save and retrieve documents and files on your computer.
8. Locate information on the Internet using search engines.
9. Locate information in the library using the online catalog.

Course Specific Technology Skills Requirements

NA

Software Used in This Class

The students of Electrical Engineering department are required to have access to MATLAB. For personal computers, the students will purchase their own student version of the MATLAB from http://www.mathworks.com

Response Times

The emails from students will be responded within 24 hours and during working hours (8am-5pm). The assignments and exams are graded within a week after the due date.

Course Materials

Required Text:

1) "Modern Control Systems", Richard C. Dorf and Robert H. Bishop, 12th Edition, Pearson, ISBN-13:978-0-13-602458, and
2) "Modern Control Engineering", K. Ogata, 5th Edition, Pearson, ISBN: 0136156738.

Required Electronic Course Materials: NA

Recommended: NA

Optional Material: NA

Grading Policy and Evaluation

Grading Scale: (sample 10- point scale)

A	B	C	D	F
100-88	87.99-77	76.99-66	65.99-55	54.99 - below

Grading of Assignments and Assessments:

Every assignment or exam will be graded at the 0-100% basis and then the final weighted average is determined as follows.

Items to be Graded Information:	Max. Grades
Exam 1 (Modules 1,2,3)	18%
Exam 2 (Modules 4,5,6)	18%
Exam 3 (Modules 7,8)	18%
Quizzes	6%
Participation and Attendance	4%
Homework + Lab	36%
Total:	100%

Participation Requirements

Students should log into the course each day and check. Participation is required in the discussion threads by posting your own response and then posting engaging comments or questions (at least two) with other peers per week.

Make-up Work

All the graded work listed above are due on time. Late submissions may be accepted only under certain conditions with no penalties.

Drop Dates

This course adheres to the add/drop standards for each term as stated by Lamar University. For more details, refer to the http://www.lamar.edu, search "Academic Calendar."

Course Evaluation

Instruction as well as student performance is subject to evaluation. Procedures for evaluation will be provided near the end of this course via email from the university. Please respond to each evaluation link provided.

myLamar Portal

Students are asked to obtain a Lamar Electronic Account username and password so they can log onto the myLamar website. Students may get information on how to get into the myLamar website from the University's homepage (*http://www.lamar.edu*) by clicking on the myLamar link on the left top corner of the screen. Follow the steps to secure your myLamar username and password.

University Policies and Services

Students with Disabilities

For students with disabilities, this course will comply with all accommodations prescribed by the Lamar University Disability Resource Center (DRC). **It is the responsibility of the student to ensure that the instructor has been informed of all prescribed accommodations.** Lamar University's Disability Resource Center offers a variety of services designed to provide for students with disabilities and can be contacted at (409) 880-8347 or emailed at DRC@lamar.edu.

The Disability Resource Center offers a variety of services designed to assure students with disabilities equal access to the university's activities, programs and services. Some of the services provided include academic accommodations, assistive equipment, communication access service providers, note-takers, physical access and priority registration. Documentation of a disability from a professional in the field is required to receive services.

Students with disabilities should notify the director of DRC prior to registration in any university program. The director will arrange a meeting with the student to determine reasonable academic adjustments/accommodations. The Disability Resource Center is located in room 105 of the Communication Building. Students may write to P.O. Box 10087, Beaumont, Texas 77710, call 409.880.8347, fax 409.880.2225 or e-mail DRC@lamar.edu. Additional information is available at the DRC website, http://www.lamar.edu/disability-resource-center/.

Technical Support

Technical Support can be located at http://students.lamar.edu/it-services-and-support/index.html.

Academic Support

Academic Support can be located at http://students.lamar.edu/academic-support/index.html.

Student Services

Information on Student services can be located at http://students.lamar.edu/student-services/index.html.

Academic Honesty Policy

Lamar University expects all students to engage in academic pursuits in a manner that is above reproach. Students are expected to maintain complete honesty and integrity in their academic experiences both in and out of the classroom. Any student found guilty of dishonesty in any phase of academic work will be subject to disciplinary action. Disciplinary proceedings may be initiated against a student accused of any form of academic dishonesty including, but not limited to, cheating on an examination or other academic work which is to be submitted, plagiarism, collusion, and the abuse of resource materials.

> *Plagiarism* shall mean the appropriation of another's work or idea and the unacknowledged incorporation of that work or idea into one's own work offered for credit.
> *Collusion* shall mean the unauthorized collaboration with another person in preparing work offered for credit.
> *Abuse of resource* materials shall mean the mutilation, destruction, concealment, theft or alteration of materials provided to assist students in the mastery of course materials.
> *Academic work* shall mean the preparation of an essay, report, problem, assignment, creative work or other project that the student submits as a course requirement or for a grade.

Students are specifically warned against all forms of plagiarism, which include "purchasing, or otherwise acquiring and submitting as one's own work any research paper or other writing assignment prepared by an individual or firm." Plagiarism is defined as, "the appropriation and the unacknowledged incorporation of another's work or ideas into one's own offered for credit" (82). Students seeking to avoid plagiarism should

consult either the course instructor or the most recent addition of the *MLA Handbook for Writers of Research Papers* or the most recent addition of the *APA Style Guide,* depending on your College requirements for writing research papers. The course instructor will complete a thorough and impartial investigation of any instance of academic dishonesty. A student found guilty of academic dishonesty will be notified in writing by the instructor of the violation, the penalty, and the student's right to appeal the determination of dishonesty and/or the sanction imposed. Penalties for academic dishonesty in this course will result in either a lowered letter grade or failure of the course as determined by the instructor. The penalty may vary by instructor. For complete policy: go to
https://students.lamar.edu/academic-support/academic-policies.html .

Copyright Policy Statement

Copyright is defined as the ownership and control of the intellectual property in original works of authorship which are subject to copyright law. As an institution of higher learning that values intellectual integrity, Lamar University prohibits the distribution of published materials (print or electronic) in violation of copyright law.

Netiquette (Online Etiquette) Statement

Please adhere to the same standards of behavior and professional respect online that you would follow in face-to-face communication with others, but most particularly when writing email and when taking part in collaborative and discussion board activities. Lamar provides access to network resources, including the Internet, in order to support learning and to prepare students for the 21st century world. Students, however, are expected to adhere to the *Lamar University Acceptable Use Policies when Using Networks.* More comprehensive student code of conduct can be found at https://students.lamar.edu/academic-support/code-of-conduct.html .

- **Acceptable Use**
  Students must respect the integrity and security of Lamar University computer systems and network, and the privacy and preferences of other users. Responsibility for learning about and complying with Lamar University Acceptable Use Policy ultimately rests with the individual. The network may be used to download, copy, or store any software, shareware, digital media files or freeware, as long as the use complies with copyright law licensing agreements, and campus policies, such as storage space limitations and network bandwidth restrictions. The network may not be used for any activity, or to transmit any material, that violates United States or local laws.
- **Unacceptable use**
  The network may not be used for commercial purposes. Advertising and sponsorships on Lamar University websites is restricted. In addition, students may not permit other persons to use their usernames, passwords, accounts or disk space, or disclose their usernames, passwords or account information to any third party. Students may not log on to someone else's account, internet address, or other network codes, or attempt to access another user's files. Students may not create false or dummy accounts to impersonate someone else. Students may not try to gain unauthorized access ("hacking") to the files or computer systems of any other person or organization. Students may not impersonate another person by forging e-mail, web pages or other electronic media. Students who maliciously access, alter, delete, damage or destroy any computer system, computer network, computer program, or data will be subject to disciplinary action by Lamar University, and criminal prosecution as well. Students may not disrupt or attempt to disrupt network traffic, and they may not attempt to monitor or capture network traffic in any way. Finally, students may not intentionally create, store, display, print or transmit information that violates the university's Sexual Harassment Policy.

General Guidelines to Respect All Participants

- Respect the right of each person to disagree with others.
- Treat people the same as you would face-to-face.
- Respect the time of others.

Guidelines When Communicating with Others (email, discussions, blogging, and etc.)

- Always sign your names to any contribution you choose to make.
- Be constructive in your responses to others in the class.
- Do not use all caps (Doing so may be interpreted as shouting).
- Re-read your postings before sending them.
- Always think before you write.
- Respond respectably.
- Use appropriate grammar and structure.
- Spell-check your postings.
- Use short paragraphs focused on one idea.
- Use appropriate business language at all times.

Distance Education Librarian

Distance education students and faculty have access to a dedicated distance education librarian, go to http://library.lamar.edu/services/distance-learning.html. Access to library resources is described on the Academic Partnership page, also available through the can be found at http://www.lamar.edu/library-beta/services/distance-learning.html .

Lamar University Privacy Policy Statement

Student records maintained by Lamar University comply with the Family Education Rights and Privacy Act of 1974 as amended (PL93-380). Detailed information should be accessed through this link: **https://sacs.lamar.edu/catalog/PrefMaterial/V.GenAcademicPol.htm#edurights**.

Academic Continuity Statement

In the event of an announced campus closure in excess of four days due to a hurricane or other disaster, students are expected to login to Lamar University's website's homepage (http://www.lamar.edu) for instructions about continuing courses remotely.

Emergency Procedures

Be sure to update your MyLamar Account with the most current information.

Many types of emergencies can occur on campus instructions for specific emergencies such as severe weather, active shooter, or fire can be found at http://www.lamar.edu/about-lu/administration/risk-management/index.html.

These procedures may or may not apply to you:

Severe Weather:

- Follow the directions of the instructor or emergency personnel
- Seek shelter in an interior room or hallway on the lowest floor, putting as many walls as possible between you and the outside
- If you are in a multi-story building, and you cannot get to the lowest floor, pick a hallway in the center of the building
- Stay in the center of the room, away from exterior walls, windows, and doors

Violence / Active Shooter (CADD):

- **CALL-** 9-1-1
- **AVOID-** If possible, self-evacuate to a safe area outside the building. Follow directions of police officers.
- **DENY-** Barricade the door with desk, chairs, bookcases or any items. Move to a place inside the room where you are not visible. Turn off the lights and remain quiet. Remain there until told by police it's safe.
- **DEFEND- Use chairs, desks, cell phones or whatever is immediately available to distract and/or defend yourself and others from attack.**

Outline and Goals of the Course

This course is organized into 10 chapters. Chapters 8 and 9 are tentative and may be covered if time is available. The outline of each chapter may be summarized as follows:

1) Introduction to Control Systems:

   In this chapter, we discuss open- and closed-loop feedback control systems. A control system consists of interconnected components to achieve a desired purpose. We examine examples of control systems through the course of history. These early systems incorporated many of the same ideas of feedback that are employed in modern manufacturing processes, alternative energy, complex hybrid automobiles, and sophisticated robots. A design process is presented that encompasses the establishment of goals and variables to be controlled, definition of specifications, system definition, modeling, and analysis. The iterative nature of design allows us to handle the design gap effectively while accomplishing necessary trade-offs in complexity, performance, and cost.

2) Mathematical Models of Systems:

   Dealing with mathematical modeling of control systems that are described by linear differential equations. Specifically, transfer function expressions of differential equation systems are derived. Also, state-space expressions of differential equation systems are derived. MATLAB is used to transform mathematical models from transfer functions to state-space equations and vice versa.

3) State Variable Models:

   In this chapter, we consider system modeling using time-domain methods. As before, we will consider physical systems described by an n^{th}-order ordinary differential equation. Utilizing a (nonunique) set of variables, known as state variables, we can obtain a set of first-order differential equations. We group these first-order equations using a compact matrix notation in a model known as the state variable model. The time-domain state variable model lends itself readily to computer solution and analysis. The relationship between signal-flow graph models and state variable models will be investigated.

4) Feedback Control Systems Characteristics:

   Exploring the role of error signals to characterize feedback control system performance. The error signal is used to control the process by negative feedback. Generally speaking, the goal is to minimize the error signal. We discuss the sensitivity of a system to parameter changes, since it is desirable to minimize the effects of parameter variations and uncertainties. We then describe the transient and steady-state performance of a feedback system and show how this performance can be readily improved with feedback.

5) The Performance of Feedback Control Systems:

   The ability to adjust the transient and steady-state response of a control system is a beneficial outcome of the design of control systems. In this chapter, we introduce the time-domain performance specifications and we use key input signals to test the response of the control system. The correlation between the system performance and the location of the transfer function poles and zeros is discussed.

6) The Stability of Linear Feedback Systems:

   Stability of closed-loop feedback systems is central to control system design. A stable system should exhibit a bounded output if the corresponding input is bounded. This is known as bounded-input-bounded-output stability and is one of the main topics of this chapter. The stability of a feedback system is directly related to the location of the roots of the characteristic equation of the system transfer function and to the location of the eigenvalues of the system

matrix for a system in state variable format. The Routh-Hurwitz method is introduced as a useful tool for assessing system stability. The technique allows us to compute the number of roots of the characteristic equation in the right half plane without actually computing the values of the roots.

7) The Root Locus Method:

The performance of a feedback system can be described in terms of the location of the roots of the characteristic equation in the s-plane. A graph showing how the roots of the characteristic equation move around the s-plane as a single parameter varies is known as a root locus plot. The root locus is a powerful tool for designing and analyzing feedback control systems. We will discuss practical techniques for obtaining a sketch of a root locus plot by hand. We also consider computer-generated root locus plots and illustrate their effectiveness in the design process.

Course Content Outline

Week	Topic	Assignments
1	Module 1: Introduction to Control Systems	Homework 1; Lab 1
2-3	Module 2: Mathematical Models of Control Systems	Homework 2; Lab 2
3-4	Module 3: State Variable Models	Homework 3; Lab 3
5	Test I	
6-7	Module 4: Feedback Control Systems Characteristics	Homework 4; Lab 4
7-8	Module 5: The Performance of Feedback Control Systems	Homework 5; Lab 5
8-9	Module 6: The Stability of Linear Control Systems	Homework 6; Lab 6
10	Test II	
11-12	Module 7: The Root Locus Method	Homework 7; Lab 7
12-13	Module 8: The Design of Feedback Control Systems	Homework 8; Lab 8
14	Test III	