University of Hormozgan

Name of Faculty	Department of Mechanical Engineering
Teacher	Dr. Mohammad Hosseini Scan me!
Web Page	https://nasim.hormozgan.ac.ir/ostad/resualtfni?m=397121
Theory/Sessional	Theory
Reference	1- Katsuhiko Ogata - Modern Control Engineering (5th Edition)-Prentice Hal (2010)
Complementary	Modern Control Systems, TWELFTH EDITION By Richard C. Dorf & Robert H. Bishop Nagrath I J and Gopal.M., Control Systems Engineering , I edition,Wiley and sons, 1985. Benjamin C Kuo, Automatic Control System, 7th edition, Prentice Hall of India Private Ltd, New Delhi, 1993. Gajic Z., Lelic M., Modern Control System Engineering, Prentice Hall of India Private Ltd, New Delhi, 1996. Norman S. Nise, Control Systems Engineering, 6th Edition John Wiley & Sons, Inc., 2011.
Lesson Plan Duration	16 Weeks
Working method	Presencial
Pre-requirements (prior knowledge) and co-requirements (common knowledge)	Students are expected to be familiar and comfortable with: • Vector calculus: functions of several variables, multivariable calculus, scalar fields, vector fields, gradients. • Linear algebra: matrices, matrix inversion, matrix determinant, vectors, vector spaces, basis vectors, linearly independence, linear span of vectors, null/kernel spaces, characteristic equations, eigenvalues, eigenvectors, diagonalisation of a matrix, exponentiation of a matrix, Jordan canonical form. •Students should be acquainted with vector calculus and ordinary differential equations. •Students should be acquainted with Matlab software.
Study level/ semester at which this course is offered:	Second Year- Second Semester
Context and Aims	This course is an introductory course on linear control systems based on the state-space models. The main goal of the course is to provide students with basic tools in modeling, analysis and design for control and estimation. The analysis in this course includes stability, controllability, observability, realization and minimality

	of the state-space model, while the design methods are divided into pole placement for state feedback and observer design, and optimal methods such as linear quadratic regulator, Kalman filter and linear quadratic Gaussian control. Students will also learn how to apply the theory to engineering problems with MATLAB. The course will cover both continuous-time and discrete-time systems, as well as both time-invariant and time-varying systems. Simple examples from mechanical and electrical engineering will be used to show the applicability of the theory. This course will give the basic knowledge for advanced control courses, such as nonlinear control, robust control, optimal control, adaptive control, digital control, sampled-data control, hybrid control, and system identification. This course will give students an introduction to elements of modern control theory based on state space representations of dynamical systems. Over the years, modern systems and control theory has found numerous interesting applications in broad areas of automation, signal processing, communication, economics, finance, circuit analysis, mechanical and civil engineering, aeronautics, navigation and guidance etc. The purpose of this course is to expand the students' knowledge of the field of control engineering and systems and control theory by providing them with fundamental concepts and problem solutions from modern systems and control theory that are useful for the above-mentioned applications. 1. Further enhance students' understanding of simple as well as more complex continuous-time control systems. 2. Give a deeper introduction to state-space representation of continuous-time control systems, particularly for single input single output (SISO) linear systems. 3. Help students to understand the importance of the system state. 4. Familiarise students with the stability concept for linear and nonlinear systems, and controllability and observability concepts for linear systems. 5. Give students an understanding of basic analysis and synthesis tools for state space control systems, including basic design techniques for nonlinear systems. 6. Provide opportunities for students to gain practical experience in the use of computer-based state space design and analysis tools in Matlab and Simulink.
Location of teaching the course	Department of mechanical Engineering

	Designation	Weight (%)
Assessment Components	Midterm Exam	30%
	Final Exam	50%
	Exercises and Homework (Assignments)	10%
	Quiz	10%
	Class Attendance & Participation.	10% Extra

Week	**Lecture Day**	**Topic**	**Homework (Problems)**
Chapter 1: Introduction to Control Systems			
1	1	1.1 Introduction 1.2 Brief History of Automatic Control 1.3 Examples of Control Systems	

		1.4 Engineering Design 1.5 Control System Design 1.6 Mechatronic Systems 1.7 Green Engineering 1.8 The Future Evolution of Control Systems 1.9 Design Examples 1.10 Sequential Design Example: Disk Drive Read System 1.11 Summary	
Chapter 2: Mathematical Modeling of Control Systems			
2	2	2.1 Introduction 2.2 Differential Equations of Physical Systems 2.3 Linear Approximations of Physical Systems 2.4 The Laplace Transform 2.5 The Transfer Function of Linear Systems 2.6 Block Diagram Models	Dorf E2.7 E2.8 E2.9 E2.12 E2.23 E2.24 E2.27 P2.32
	3	2.7 Signal-Flow Graph Models 2.8 Design Examples 2.9 The Simulation of Systems Using Control Design Software 2.10 Sequential Design Example: Disk Drive Read System 2.11 Summary	
CHAPTER 3: State Variable Models			
3	4	3.1 Introduction 3.2 The State Variables of a Dynamic System 3.3 The State Differential Equation 3.4 Signal-Flow Graph and Block Diagram Models 3.5 Alternative Signal-Flow Graph and Block Diagram Models 3.6 The Transfer Function from the State Equation	Dorf E3.5 E3.7 E3.9 E3.10 E3.19 E3.21 P3.10 P3.17 P3.21 P3.37
4	5	3.7 The Time Response and the State Transition Matrix 3.8 Design Examples	
	6	Chapter review	
Chapter 4: Transient and Steady-State Response Analyses			
5	7	4.1 Introduction 4.2 First-Order Systems 4.3 Second-Order Systems 4.4 Higher-Order Systems 4.5 Transient-Response Analysis with MATLAB	Ogata B-5-3 B-5-5 B-5-7 B-5-11 B-5-18 B-5-23
6	8	4.6 Routh’s Stability Criterion 4.7 Effects of Integral and Derivative Control Actions on System Performance	

		4.8 Steady-State Errors in Unity-Feedback Control Systems	
	9	Example Problems and Solutions	
Chapter 5: Control Systems Analysis and Design by the Root-Locus Method			
7	10	5.1 Introduction 5.2 Root-Locus Plots 5.3 Plotting Root Loci with MATLAB	Ogata B-6-1 B-6-2 B-6-3 B-6-7 B-6-10 B-6-18 B-6-24 B-6-27
8	11	5.4 Root-Locus Plots of Positive Feedback Systems 5.5 Root-Locus Approach to Control-Systems Design 5.6 Lead Compensation 5.7 Lag Compensation 5.8 Lag–Lead Compensation 5.9 Parallel Compensation	
	12	Chapter Review: Example Problems and Solutions	
Chapter 6: Control Systems Analysis and Design by the Frequency-Response Method			
9	13	6.1 Introduction 6.2 Bode Diagrams 6.3 Polar Plots	Ogata B-7-1 B-7-7 B-7-13 B-7-14 B-7-15 B-7-16 B-7-17 B-7-20 B-7-21 B-7-29
10	14	6.4 Log-Magnitude-versus-Phase Plots 6.5 Nyquist Stability Criterion 6.6 Stability Analysis	
	15	6.7 Relative Stability Analysis 6.8 Closed-Loop Frequency Response of Unity-Feedback Systems	
11	16	6.10 Control Systems Design by Frequency-Response Approach 6.11 Lead Compensation 6.12 Lag Compensation	
12	17	6.13 Lag–Lead Compensation	
	18	Chapter Review	
Chapter 7: PID Controllers and Modified PID Controllers			
13	19	7.1 Introduction 7.2 Ziegler–Nichols Rules for Tuning PID Controllers	Ogata B-8-2 B-8-4 B-8-5 B-8-8 B-8-9 B-8-12
14	20	7.3 Design of PID Controllers with Frequency-Response Approach 7.4 Design of PID Controllers with Computational Optimization Approach	
	21	7.5 Modifications of PID Control Schemes	
15	21	7.6 Two-Degrees-of-Freedom Control 7.7 Zero-Placement Approach to Improve Response Characteristics	
CHAPTER 8: The Design of State Variable Feedback Systems			
16	22	8.1 Introduction 835 8.2 Controllability and Observability 835 8.3 Full-State Feedback Control Design	

		8.4 Observer Design 847 8.5 Integrated Full-State Feedback and Observer	
	23	Review	