GUJARAT TECHNOLOGICAL UNIVERSITY

MECHATRONICS ENGINEERING (20)
CONTROL THEORY
SUBJECT CODE: 2142003
B.E. 4th Semester

Type of course: Engineering Science

Prerequisite: NA

Rationale: The subject deals with mathematical modelling and control of different types of dynamic systems, which play a significant role in Mechatronics engineering.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Introduction to Control Systems: Examples of Control Systems, Closed-loop Control versus Open-Loop Control.	5	10
2	Mathematical Modeling of Dynamic Systems: Introduction, Transfer Function and Impulse-Response Function, Automatic Control Systems, Modeling in state Space, State-Space Representation of Dynamic Systems, Transformation of Mathematical Models with MATLAB, Mechanical Systems, Electrical and Electronic Systems, Signal Flow Graphs, Concept of Linearization of Nonlinear Mathematical Models.	10	20
3	Mathematical Modeling of Fluid Systems and Thermal systems: Introduction, Liquid-Level Systems, Thermal Systems.	6	12
4	Transient and Steady-State Response Analyses: Introduction, First-Order Systems, Second-Order Systems, Higher-Order Systems, Transient-Response Analysis with MATLAB, Routh's Stability Criterion, Effects of Integral and Derivative Control Actions on System Performance, Steady-State Errors in Unity-Feedback Control Systems.	10	20
5	Root-Locus Analysis: Introduction, Root-Locus Plots, General Rules for Constructing Root Loci, Root-Locus Plots with MATLAB, Positive Feedback Systems, Conditionally Stable Systems, Root Loci for Systems with Transport Lag.	10	20

6	Frequency-Response Analysis: Introduction, Bode Diagrams, Plotting Bode Diagrams with MATLAB, Polar Plots, Drawing Nyquist Plots with MATLAB, Log-Magnitude-versus-Phase Plots, Nyquist Stability Criterion, Stability Analysis, Relative Stability, Closed-Loop Frequency Response of Unity-Feedback Systems	9	18

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
30	40	15	10	5

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table

Reference Books:

1. **Modern Control Engineering by Katsuhiko Ogata, 4th Edition, Prentice Hall of India.**
2. **Automatic Control Systems by Benjamin C.Kuo, 8th Edition, FaridGolnaraghi, John Wiley & Sons.**
3. **Control systems Engineering, I.J.Nagrath and M.Gopal, New Age International publisher**

Course Outcomes:

After learning the course the students should be able to

1. Understand the basic fundamentals ofsystem responses and modelling of systems.
2. Learn the response of systems to various different inputs.
3. Analyse the output of different systems to various different inputs.
4. Utilise transforms and plots to better understand system responses.

List of Practical:

1. (a)To study the potentiometer characteristics.
   (b) To study the potentiometer as an error detector.
2. (a)To study the Synchro characteristics.
   (b) To study the Synchro as an error detector.
3. To study the torque speed characteristics of DC Motor and determine its transfer function.
4. To study the performance characteristics of a DC Motor speed control system.
5. To study the performance characteristics of a DC Motor angular position control system.
6. To study the characteristics of a small AC servomotor and determine its transfer function.
7. To study about the Type and order of control system.
8. Introduction to MATLAB: Control System Toolbox , Simulink
9. MATLAB simulation experiments : Root Locus
10. MATLAB simulation experiments : Bode plot
11. MATLAB simulation experiments : Nyquist plot ,state-space analysis

Design based/open ended problem

Student may be given a task to express the knowledge of close loop and open loop system, mathematical modeling of dynamic system and its performance, frequency response analysis, etc.

Major Equipments:

1. Working model of potentiometer
2. Synchros
3. DC motor / DC servo motor
4. AC motor / AC servo motor
5. Techo generator
6. MATLAB or equivalent software.

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.