GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Instrumentation & Control Engineering / Automation and Robotics Engineering

Subject Code: DI03000181

Course/Subject Name: Control Instrumentation System

w. e. f. Academic Year:	2024-25
Semester:	3rd
Category of the Course:	PCC

Prerequisite:	Basic knowledge of mathematics and fundamentals of electrical and mechanical systems.
Rationale:	This course helps students understand the basic concepts of control systems and their importance in instrumentation and automation. It enables students to model systems mathematically, analyze their behavior, and evaluate their stability and performance. The knowledge gained will help in designing and maintaining control systems used in industrial applications.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
CO-1	Understand the basic concepts, components, and classification of control systems	U
CO-2	Develop mathematical models using transfer functions and analyze systems using block diagrams and signal flow graphs.	U A
CO-3	Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions	U A
CO-4	Analyze the stability of control systems using the Routh-Hurwitz method and interpret the concept of root locus and apply basic rules to sketch root locus diagrams.	U A
CO-5	Interpret the frequency response of control systems using Bode plots to determine gain margin, phase margin, and assess the overall stability of the system.	U A

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
				Theory		Tutorial / Practical		
L	T	PR	C	ESE (E)	PA (M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	**Introduction to Control System**	6	12
	1.1 Background **1.2** Important Term Definition System, Control System, Plant, Controller, Input, Output, Disturbance, Controlled variable, Manipulated Variable **1.3** Classification of Control System **1.4** Open Loop Control System • Definition & Block Diagram • Advantages • Disadvantages • Real time Examples **1.5** Closed Loop Control System • Definition & Block Diagram • Advantages • Disadvantages • Real time Examples **1.6** Comparison of Open loop and Closed loop Control System **1.7** Requirements of an Ideal Control System.		
2	**Mathematical Modeling**	14	30

	2.1 Transfer Function • Definition • Properties of Transfer function • Advantages & Disadvantages • Poles & Zeros of transfer function • Characteristic equation • Transfer function of standard RLC series Circuit.(having only one each of R, L,C component) • Transfer function of standard RLC parallel Circuit.(having only one each of R, L,C component) • Transfer function of standard mechanical Translational system and mechanical Rotational system. **2.2** Methods of finding Transfer function • BDR & SFG **2.3** BDR • Definitions • Block Diagram • Advantages and disadvantages • Rules • Examples • Canonical form or simple form of feedback control system • T. F. of simple closed loop system **2.4** Signal flow graph(SFG) • Definitions • Advantages and disadvantages • Rules • Mason's gain formula • Steps for solving SFG using Mason's gain formula • Examples (simple system having max four individual loops.) **2.5** Comparison of BDR & SFG **2.6** System analogy • Concept • Advantages • Different system analogies: Force-Voltage & Force-Csurrent		
3	**Time Response Analysis of Control System**	**10**	**22**
	3.1 Time response. • Introduction		

	• Transient & Steady State Response **3.2** Standard test signals(Listing, Drawing, Explanation with Equation) • Step signal • Ramp Signal • Parabolic Signal • Impulse signal **3.3** Time response of first order system to step input • Order & type of system. • Characteristic equation. • Derivation of time response of first order system for step input. **3.4** Time response of second order system to step input • Damping Ratio & Natural Frequency of Oscillation • Time Response specification. 1. Rise Time 2. Delay time 3. Peak time 4. Maximum overshoot 5. Settling time **3.5** Steady state error & error constant • Static error Position constant Kp • Static error velocity constant Kv • Static error acceleration constant Ka • Steady state error for step ramp, parabolic input for type 0, 1 & 2 systems.		
4	**Concept of Stability**	**9**	**20**
	4.1 Stability • Introduction • BIBO stability • Necessary condition for stability • Fundamentals of various Systems(Stable, Unstable and Marginally Stable systems) • Location of Poles & Stability **4.2** Routh stability criteria • Statement for Routh stability criteria • Determination of stability of given characteristic equation		

	using Routh Criteria. • Difficulties in formulation of Routh table ○ Difficulty 1 ○ Difficulty 2 **4.4** Introduction to Root Locus Concept. **4.5** Rules for construction of Root Locus. **4.6** Simple examples of Root Locus • Derive root locus for given example.(max up to type 1, order 2)		
5	**Frequency Response Analysis using Bode plot**	**6**	**16**
	5.1 Introduction to Frequency Response Analysis **5.2** Concept of Bode plot in brief. **5.3** Log Scales **5.4** Standard form of GH (jw) **5.5** Bode plot of standard factors **5.6** Frequency Domain Specification • Gain Margin • Phase Margin • Gain crossover frequency • Phase crossover frequency • Bandwidth • Cut off frequency • Cut off rate • Resonance Peak • Resonant Frequency **5.7** Steps for solving bode plots **5.8** Examples of bode plot up to first order system only		
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
16	**36**	**30**	**10**	**8**	**-**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:
(a) Books:

Sr.	Title of Book	Author Name	Publication/ISBN
1	Control Systems Engineering	I. J. Nagrath M Gopal	New Age International Publisher
2	Linear Control Systems	B.S.Manke	Khanna Publishers
3	Control Systems Engineering	S.K. Bhattacharya	Pearson Education
4	Modern Control Engineering	D.Roy Choudhury	PHI Learning
5	Automatic Control Systems	S. Hasan Saeed	Katson Books
6	Modern Control Engineering	Ogata K.	Tata McGraw hill, New Delhi

(b) Open-source software and website:

No.	Resource Name	Web Address
1	Open source AICTE EBooks Platform	https://ekumbh.aicte-india.org/
3	Swayam Portal	https://swayam.gov.in/
4	Control Systems Lectures (YouTube)	https://www.youtube.com/c/ControlLectures
5	NPTEL – Control Engineering	https://nptel.ac.in/courses/108102043
6	Virtual Lab- Control Engineering	https://ce-dei.vlabs.ac.in/List%20of%20experiments.html
7	Virtual Lab-Control Instrumentation Laboratory	http://vlabs.iitkgp.ac.in/ctrl/index.html

Suggested Course Practical List: If any

Sr. No.	Practical Outcomes (PrOs)	Unit	CO	Approx. hours

		No.		required.
1	To study the simulation software for simulation of control system design.	-	-	2
2	Identify various blocks of a given open loop and closed loop system.	1	1	2
3	Convert an open loop system into a closed loop and observe the difference in output using simulation software.	1	1	2
4	To obtain a transfer function from given poles and zeros using simulation software.	2	2	2
5	To obtain zeros and poles from a given transfer function using simulation software.	2	2	2
6	Determine the transfer function for a given closed loop system in block diagram representation.	2	2	2
7	Determine and Analyze Steady State Error and Error Constants (Kp, Kv, Ka) for different types of systems.	2	2	2
8	Simulate Mechanical System Analogies (Force-Voltage, Force-Current)	2	2	2
9	Plot unit step response of given first order transfer function using simulation software.	3	3	2
10	Plot unit step response of given second order transfer function and finds delay time, rise time, peak time and peak overshoot using simulation software.	3	3	2
11	Simulate Second Order System response with varying damping ratios	3	3	2
12	Determine the time response of a given system subjected to any arbitrary inputs.	3	3	2
13	Determine stability for various system using Routh criteria	4	4	2
14	Plot the root locus for a given transfer function using simulation software.	4	4	2
15	Plot bode plot for given transfer function and also determine relative stability using gain margin & phase margin using simulation software.	5	5	2
16	Observe the effect of increasing and decreasing gain margin and phase margin for a given system using simulation software.	5	5	2
17	Compare various parameters of time response and frequency response for given system using simulation software.	5	5	2
Minimum 10 to 12 Practical to be performed(Total 30 Hours)				

List of Laboratory/Learning Resources Required:

1. CRO
2. Function Generator
3. Workbench
4. Control Simulator Kit
5. Simulation Softwares
6. Computer System

Suggested Project List:

The projects serve as practical learning experiences for students in the field of Instrumentation and Control Engineering. These projects integrate theoretical knowledge with hands-on application, fostering competency development across various Course Outcomes (COs). Below are guidelines for designing and executing micro-projects:

1. Models of control system.
2. Chart / Model Preparation
3. Prepare Presentation
4. Build/Test various opamp based controllers for a given control loop.
5. Prepare report on market survey for different controller availability

Suggested Activities for Students: If any

In addition to classroom and laboratory learning, students are encouraged to engage in co-curricular activities that enhance their understanding and practical skills. These activities can be conducted in groups and should be documented in 5-page reports. Collecting physical evidence of their work will also contribute to their portfolio, which can be valuable during placement interviews.

1. Do analysis of first and second order control systems using various free control simulators.
2. Present seminar on various topics from course content.
3. Prepare Poster on various topics from course content.
4. Visit nearby engineering industries and prepare a report on different processes available and control systems used to control it.
5. Internet survey of different control systems.
6. Group Discussions & Problem-Solving Sessions.
7. Online Courses & Certifications

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