GANPAT UNIVERSITY

FACULTY OF DIPLOMA ENGINEERING

Programme	Diploma in Electronics and Communication Engineering		
Semester	IV	Version	1.0.0.0
Effective from Academic Year	2025-26	Effective for the batch Admitted in	JULY 2025
Course code	1EC41PE02	Course Name	Control Systems

I.TEACHING-LEARNING AND ASSESSMENT SCHEME

Course Type	Course Code	Learning Scheme						Assessment Scheme										
		Actual Contact Hrs./Week			SLH	NLH	Credits	Theory				Practical				Based on SL		Total Marks
		CL	TL	LL				FA-TH	SA-TH	TOTAL		FA-PR	SA-PR	TOTAL		SLA		
								MAX	MAX	MAX	MIN	MAX	MAX	MAX	MIN	MAX	MIN	
VEC	1EC41PE02	3	-	2	1	6	3	40	60	100	40	30	20	50	20	20	8	170

Abbreviation:	**CL-** Classroom Learning	**TL -** Tutorial Learning	**LL -** Laboratory Learning
	SLH - Self Learning Hours	**NLH -** Notional Learning Hours	**SLA -** Self Learning Assessment
	FA - Formative Assessment (Term work +Mid Sem Exam +Attendance)		**SA -** Summative Assessment

II. PRE-REQUISITES

Semiconductor physics, Analog electronics, Electronic devices and circuits

III. INDUSTRY / EMPLOYER EXPECTED OUTCOMES

Ability to model, analyze, and design control systems to ensure stability, accuracy, and optimal performance of engineering systems. Competence in using modern tools (MATLAB/Simulink) to simulate, tune, and troubleshoot real-world control applications.

IV. COURSE LEARNING OUTCOMES

At the end of the course, students will be able to achieve the following course learning outcomes:

CO1: Understand basics, classification, and modeling of control systems.

CO2: Apply block diagram reduction and signal flow graph techniques.

CO3: Analyze time response and steady-state errors of control systems.

CO4: Evaluate system stability using Routh–Hurwitz and root locus methods.

CO5: Analyze frequency response using Bode, Nyquist plots and stability margins.

V. THEORY LEARNING OUTCOMES AND ALIGNED COURSE CONTENT:

Name of Unit	Theory Learning outcomes (TLO's) aligned to CO's	Learning Content mapped with Theory Learning outcomes (TLO's) & CO's	Marks	Hours
Unit-1: Introduction to Control Systems and Mathematical Modeling of System	**TLO 1.1** Understand the concept and definition of control systems. **TLO 1.2** Differentiate between open loop and closed loop control systems. **TLO 1.3** Classify control systems and identify properties of a good control system. **TLO 1.4** Understand feedback, feed-forward control systems and servomechanism. **TLO 1.5** Understand transfer function and impulse response. **TLO 1.6** Identify poles and zeros of transfer function. **TLO 1.7** Develop state variable models of systems.	**1.1** Definition of control system **1.2** Open loop and closed loop control systems **1.3** Classification of control systems, properties of a good control system **1.4** Feedback control, feed-forward control, servomechanism **1.5** Transfer function, impulse response **1.6** Poles and zeros of transfer function **1.7** State variable modeling **1.8** Mechanical system modeling, RLC network modeling, analogous systems, nodal	14	9

	TLO 1.8 Model mechanical and electrical systems.	representation, gear trains		
Unit-2: Block Diagrams and Signal Flow Graph	**TLO 2.1** Understand block diagram representation and properties. **TLO 2.2** Apply block diagram reduction techniques. **TLO 2.3** Construct signal flow graphs and apply Mason's Gain Formula.	**2.1** Block diagram fundamentals and properties **2.2** Block diagram reduction rules **2.3** Signal flow graph construction, Mason's Gain Formula	10	8
Unit-3: Time Response Analysis	**TLO 3.1** Understand transient and steady-state response of systems. **TLO 3.2** Analyze first and second order control systems. **TLO 3.3** Determine time domain specifications and steady-state error.	3.1 - Transient response, steady-state response, test signals 3.2 - First and second order system analysis, damping ratio 3.3 - Time domain specifications, steady-state error	8	6
Unit-4: Stability Analysis and Root locus	**TLO 4.1** Understand the concept of stability and pole locations. **TLO 4.2** Apply Hurwitz and Routh-Hurwitz stability criteria. **TLO 4.3** Analyze relative stability of control systems. **TLO 4.4** Understand the concept of root locus. **TLO 4.5** Construct root locus plots using rules. **TLO 4.6** Determine system stability using root locus technique.	4.1 - Concept of stability, pole location 4.2 - Hurwitz criterion, Routh-Hurwitz criterion 4.3 - Relative stability analysis, special cases of Routh's criterion 4.4 - Root locus concept 4.5 - Rules for construction of root locus 4.6 - Stability conditions using root locus	18	14
Unit-5: Frequency Response Analysis	**TLO 5.1** Understand frequency response characteristics. **TLO 5.2** Analyze systems using Bode, Polar and Nyquist plots. **TLO 5.3** Determine gain margin, phase margin and stability.	**7.1** - Correlation between time and frequency response 7**.2** - Bode plots, Polar plots, Nyquist plots 7.3 - Gain margin, phase margin, Nyquist stability criterion	10	8

VI. LABORATORY LEARNING OUTCOME AND ALIGNED PRACTICAL			
Sr. No.	**Practical/Laboratory Learning Outcome (LLO)**	**Practical Titles**	**Relevant COs**
1	LLO 1.1: Identification and comparison of open-loop and closed-loop control systems using real-life examples.	Realize open-loop and closed-loop control systems	CO1
2	LLO 2.1: Derivation of transfer function of mechanical systems (translational/rotational).	Realize transfer function of mechanical systems	CO1
3	LLO 3.1: Obtain transfer function of RLC circuits using differential equations.	Realize transfer function of RLC circuits	CO2
4	LLO 4.1: Study and verification of electrical–mechanical analogies (Force–Voltage / Force–Current).	Prove electrical–mechanical analogies	CO2

5	LLO 5.1: Reduction of complex block diagrams using algebraic reduction rules.	Prove Reduction of complex block diagrams	CO3
6	LLO 6.1: Construction of signal flow graph from given system equations and evaluation using Mason's Gain Formula.	Prove signal flow graph from given system equations and evaluation using Mason's Gain Formula.	CO4
7	LLO 7.1: Analysis of step response, time constant, rise time and steady-state value.	Prove Analysis of step response	CO3
8	LLO 8.1: Study of underdamped, critically damped and overdamped systems and effect of damping ratio.	Prove underdamped, critically damped and overdamped systems	CO2
9	LLO 9.1: Determination of steady-state error for Type-0, Type-1 systems for step, ramp inputs.	Prove steady-state error for Type-0, Type-1 systems for step, ramp inputs.	CO1
10	LLO 10.1: Testing stability and relative stability of given control systems.	Realize Testing stability and relative stability	CO2
11	LLO 11.1: Plotting and interpretation of Bode plots to find gain margin and phase margin (Simulation-based using MATLAB / Scilab or equivalent)	Realize Plotting and interpretation of Bode plots to find gain margin and phase margin	CO3

VII. SUGGESTED MICRO PROJECT / ASSIGNMENTS / ACTIVITIES FOR SELF LEARNING / SKILL DEVELOPMENT (SELF LEARNING)

A. Self-Learning Assignments / Activities

1. Prepare a **concept map** showing relationships among control system components, transfer function, stability, and response analysis.
2. Create a **comparison chart** for open-loop vs closed-loop systems with real-life applications.
3. Develop a **formula handbook** including time-domain specifications, stability criteria, and frequency-domain parameters.
4. Solve numerical problems involving **transfer functions, poles and zeros**, and interpret system behavior.
5. Practice **block diagram reduction** and validate results using signal flow graphs.
6. Analyze **step, ramp, and impulse responses** of different order systems using simulation tools.
7. Study **stability conditions** using Routh-Hurwitz criterion and root locus technique.
8. Draw and interpret **Bode, Nyquist, and Polar plots** for given control systems.
9. Prepare short notes on **gain margin, phase margin**, and their physical significance.
10. Use **MATLAB / Scilab / Python** to simulate system responses and compare analytical and simulated results.
11. Identify and study **real-world control systems** such as motor speed control, temperature control, or cruise control.
12. Perform a **case study** on failure of a control system due to instability.

B. Mini Projects

1. Modeling and Analysis of a Feedback Control System
   - Develop mathematical model
   - Perform time and frequency response analysis
   - Check stability using Routh and Root Locus
2. Speed Control of DC Motor
   - Model mechanical and electrical subsystems
   - Analyze transient and steady-state response
   - Improve performance using feedback

3. Temperature Control System Using Closed-Loop Control
   - Develop block diagram and transfer function
   - Analyze stability and steady-state error
   - Propose improvements
4. Stability Comparison Using Different Techniques
   - Analyze the same system using Routh, Root Locus, and Nyquist
   - Compare results and conclusions
5. Time vs Frequency Response Correlation Study
   - Analyze step response and Bode plot of a system
   - Study relationship between damping ratio, bandwidth, and overshoot
6. Simulation-Based Control System Analysis
   - Use MATLAB / Scilab
   - Simulate root locus, step response, and frequency response
   - Interpret results

VIII. LIST OF INSTRUMENTS / EQUIPMENT / TRAINER BOARD	
1	Instruments 1. DC regulated power supply 2. Analog/Digital multimeter 3. Cathode Ray Oscilloscope (CRO) / Digital Storage Oscilloscope (DSO) 4. Function generator / Signal generator
2	Trainer Boards / Kits 1. Control System trainer kit (basic block diagram & feedback concepts) 2. First-order system trainer board 3. Second-order system trainer board 4. Root locus trainer kit 5. Frequency response (Bode plot) trainer board 6. Stability analysis (Routh–Hurwitz) trainer kit 7. Servo motor control trainer kit 8. DC motor speed/position control trainer 9. AC servo motor trainer (if available)
3	Components & Accessories 1. Breadboard / patch cords 2. Resistors, capacitors, potentiometers 3. Operational amplifier ICs (e.g., 741) 4. Connecting leads & probes
4	Software (Optional but Recommended) 1. MATLAB / SCILAB (for simulation & analysis)

IX. LIST OF REFERENCE BOOKS

Sr.No.	Title	Author	Publication
1	Control system engineering	I. J. Nagrath & M.Gopal	New Age International Publishers
2	Linear Control Systems	B. S. Manke	Khanna Publishers
3	Feedback Control Systems	Dr. S.D. Bhide, R.A. Barapate	Tech Max Publication
4	Modern control engineering	K.Ogata	PHI

X. LINK OF LEARNING WEB RESOURCE	
1	https://www.nptelprep.in/courses/108106098/materials
2	https://www.nptelprep.in/courses/107106081/videos
3	https://www.nptelprep.in/courses/108101037/materials

4	https://onlinecourses-archive.nptel.ac.in/noc18_ph16/course

XI. SUGGESTED WEIGHTAGE TO LEARNING EFFORTS & ASSESSMENT PURPOSE

Unit	Unit Title	Aligned COs	Learning Hours	R-Level	U-Level	A-Level	Total Marks
1	Introduction to Control Systems & Mathematical Modeling	**CO1**	14	4	6	4	14
2	Block Diagrams and Signal Flow Graph	**CO2**	8	2	4	4	10
3	Time Response Analysis	**CO3**	6	2	3	3	8
4	Stability Analysis and Root Locus	**CO4**	14	4	6	8	18
5	Frequency Response Analysis	**CO5**	8	3	4	3	10
		Total	**50**	**15**	**23**	**22**	**60**

XII. COs AND POs AND PSOs MAPPING

Course outcome (Cos)	Programme Outcomes (POs)							Programme Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO1	PSO2	PSO3
CO1	3	2	0	0	0	0	1	3	0	0
CO2	2	3	2	0	0	0	0	2	1	0
CO3	2	3	0	1	0	0	0	2	2	0
CO4	2	3	2	1	0	0	0	3	2	0
CO5	2	3	2	2	0	0	0	2	3	0

Legends: - *3- High 2-Moderate/Medium 1-Slight/Low 0-None*