GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3131101
Semester III
Control Systems

Type of course: Modeling, performance analysis and control with potential application to engineering systems.

Prerequisite: Knowledge of Linear algebra, Differential equations and Laplace transform.

Rationale: This course explores the fundamentals of systems and control. The course has following primary focuses:

(1) Understanding and predicting behavior of the system.
(2) Differentiate between the open loop and closed loop systems.
(3) Design and analysis of closed loop control systems.
(4) Analyze the condition for system stability.
(5) Understand different methods for finding the relative and absolute stability of the system.
(6) Evaluate the performance of the system for different excitations.

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Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE Viva (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Introduction to Control Systems: Introduction, Brief History of Automatic Control, Examples of Control Systems, Engineering Design, Mechatronic Systems, The Future Evolution of Control Systems.	**2**	**4%**
2	Mathematical Models of Systems: Differential Equations of Physical Systems, Linear Approximations of Physical Systems, The Laplace Transform, The Transfer Function of Linear Systems, Block Diagram Models, Signal-Flow Graph Models.	**5**	**12%**
3	Feedback Control System Characteristics: Error Signal Analysis, Sensitivity of Control Systems to Parameter Variations, Disturbance Signals in a Feedback Control System, Control of the Transient Response, Steady-State Error, The Cost of Feedback.	**3**	**8%**
4	The Performance of Feedback Control Systems: Test Input Signals, Performance of Second-Order Systems, Effects of a Third Pole and a Zero on the Second-Order System Response, Transient Response, The Steady-State Error of Feedback Control Systems, Performance Indices, The Simplification of Linear Systems.	**5**	**10%**
5	The Stability of Linear Feedback Systems: The Concept of Stability, relative stability analysis, Routh-Hurwitz criteria.	**2**	**10%**
6	The Root Locus Method: The Root Locus Concept. The Root Locus Procedure, Parameter Design by the Root Locus Method, Sensitivity and the Root Locus, Three-Term (PID) Controllers.	**5**	**12%**

7	Frequency Response Methods: Frequency Response Plots, Frequency Response Measurements, Performance Specifications in the Frequency Domain, Log Magnitude and Phase Diagrams.	**3**	**8%**
8	The Design of Feedback Control Systems: Approaches to System Design, Cascade Compensation Networks, Phase-Lead Design Using the Bode Diagram, Phase-Lead Design Using the Root Locus, System Design Using Integration Networks, Phase-Lag Design Using the Root Locus, Phase-Lag Design Using the Bode Diagram, Design on the Bode Diagram Using Analytical Methods.	**6**	**12%**
9	Stability in the Frequency Domain: Mapping Contours in the s-Plane, The Nyquist Criterion, Relative Stability and the Nyquist Criterion, Time-Domain Performance Criteria in the Frequency Domain, System Bandwidth, The Stability of Control Systems with Time Delays.	**5**	**12%**
10	State Variable Models: The State Variables of a Dynamic System, The State Differential Equation, Signal-Flow Graph and Block Diagram Models, Alternative Signal-Flow Graph and Block Diagram Models, The Transfer Function from the State Equation , The Time Response and the State Transition Matrix.	**6**	**12%**
	Total	**42**	**100%**

Distribution of Theory Marks for Cognitive level					
R Level	U Level	A Level	N Level	E Level	C Level
20	**15**	**15**	**20**	**20**	**10**

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

**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 from above table*

Reference Books:

1. Control Systems Engineering by Nagrath and Gopal New Age Publication
2. Modern Control Engineering by Katsuhiko Ogata, 4th Edition, Prentice Hall of India.
3. Modern Control System by Richarc C. Drof and Robert H. Bishop,11th Edition Person Int.
4. Automatic Control Systems by Benjamin C.Kuo, 8th Edition, Farid Golnaraghi, John Wiley & Sons.
5. Feedback and Control Systems by Joseph J Distefano 2nd Edition TMH

Course Outcomes:
After learning the course the students should be able to:

Sr. No.	**CO statement**	**Marks % weightage**
CO-1	analyze and Evaluate system behavior in time and frequency domains based on the mathematical model of the system.	25
CO-2	apply control theory to linear system for system modeling using differential equations and transfer function realizations.	20

CO-3	analyze and apply all the stability techniques for closed loop system performance parameters.	25
CO-4	comprehend the need of different types of controllers and compensators to obtain the required dynamic response of the system.	15
CO-5	synthesis system equations for state space models of linear systems.	15

List of suggested Experiments:

1. Simulation of DC motor working
2. Simulation of synchros
3. Generating standard test signals i.e. step, ramp, unit impulse on a simulator
4. Analysis of time response of second order system.
5. Effect of P, PD, PI, PID Controller on a second order systems.
6. Plotting root locus of a given transfer function using a simulator.
7. Temperature control using PID.
8. Plotting phase magnitude plot of a given transfer function with a simulator.
9. Obtaining frequency response of a common emitter amplifier and plotting on a Bode plot.
10. Simulation of a given transfer function using OPAMPs.
11. Stability Analysis (Root locus, Bode, Nyquist) of Linear Time Invariant System.
12. Study of a PLL as a closed loop control system on a simulator.

Use SCILAB/MATLAB or other equivalent software as a simulator.

Lab Work: SCILAB/ MATLAB based assignments and simulations covering design, analysis and modelling of control systems relevant to curriculum.

List of Open Source Software/learning website:

Ng-spice/MATLAB, www.nptel.com