GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3140313
Semester – IV
Control System & Analysis

Type of course: Core Course

Prerequisite: Mathematics, Basic Electronics.

Rationale: This subject is an introduction to control systems defined as a collection of interconnected elements whose goal is to achieve a desired response even when external disturbances are present. In this subject, various methods, such as, transfer functions, time and frequency domain analysis, impulse, step and ramp responses, open vs. closed loop response, stability, system modeling has been included.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	1	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction of Control system:** Basic Concepts of Control System**,** Types of Control system, LTI Control system, Basics of Laplace Transform and Inverse Laplace Transform, Concept of Impulse Response and Transfer function.	**04**	**10%**
2	**Mathematical Modeling of System**: Mathematical Modeling of Electrical Elements, Mathematical Modeling of Mechanical System, Mechanical-Electrical Analogy, Mathematical Modeling of a Liquid-Level System, Mathematical Modeling of Thermal System, Applications of Biomedical Control System: Simple Model of lung Mechanics (Lumped), Muscle stretch reflex model (Lumped), Block Diagram Algebra, Signal Flow Graphs.	**08**	**20%**
3	**Time Response Analysis**: Transient and steady state response, Stability and Sensitivity of a system, Disturbance Rejection, Standard Test signals and their Needs, Time response of First order system for standard test signals, Speed of Response, Unit impulse and Unit step response of second order system, Effect of Damping factor in Second Order System Performance, Time Domain Specifications, Steady State Error and Error Constants, Derivation of Steady State errors of system (type 0, type 1 type 2), Effect of Adding a zero and pole to a system, Compensation, PID Controller.	**09**	**20%**

4	**Stability Analysis and Root Locus Technique**: Stability Criterion, Relationship between System parameters and pole locations, Hurwitz Stability Criterion, Routh Stability Criterion, Relative Stability Analysis, Root Locus method of Design, Value of Gain Margin and Phase margin from Root Locus, Effect of Addition/Cancellation of Poles and Zeros on Root Locus, Inverse Root Locus.	**08**	**15%**
5	**Frequency Response Analysis:** Concept of Frequency Response, Frequency Domain Specifications. **Bode plot**: Sketch of the Bode plot, Calculate Gain and Phase Margin from Bode plot, Stability using Bode plot, Transfer function from Bode plot. **Polar Plot and Nyquist Plot:** Sketch of the Polar Plot, Calculate Gain and Phase Margin from Polar plot, Stability using polar plot, Nyquist Analysis, Nyquist Stability Plot, Nyquist stability criterion, Relative Stability using Nyquist criterion.	**09**	**25%**
6	**State Variable Analysis:** Introduction, Advantages of State Space Approach, State Model, State Space Model from Differential Equation, State Space Model from Transfer Function, Transfer Function from State Space Model.	**04**	**10%**
		42	**100%**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10%	**15%**	**15%**	**25%**	**25%**	**10%**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create 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. R. Anandanatarajan, P. Ramesh Babu, **"Control Systems Engineering"**, Scitech Publications (India).
2. U. A. Bakshi, S. C. Goyal, **"Feedback Control Systems"**, Technical Publications.
3. Smarajit Ghosh, **"Control Systems: Theory and Applications"**, Pearson.
4. I. J. Nagrath, M. Gopal, **"Control Systems Engineering"**, New Age International Publishers.
5. Michael C. K. Khoo, "**Physiological Control Systems**: Analysis, Simulation, and Estimation", John Wiley & Sons.

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Course Outcomes:

After learning this subject, students will be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the concepts of Control system and its types.	10%
CO-2	Derive the Mathematical model (transfer function) for various systems.	20%
CO-3	Analyse the response of first and second order system to understand steady state errors and its derivation for standard test signals.	20%
CO-4	Analyse stability Criteria and optimized response of Control systems using Root-locus technique.	15%
CO-5	Analyse stability of control system using frequency domain techniques such as, Bode Plot, Nyquist Plot and Polar plot.	25%
CO-6	Solve system equations for State variable models.	10%

List of Experiments:

Sr. No.	Name of Experiments	Duration (Hours)
1.	To study about the commands of Vectors, Functions, Plotting, Polynomials as Vectors, Polynomials Using the s Variable, Matrices etc. in MATLAB.	**2**
2.	To study and implement the relationship of transfer function with poles, zeros and gain using MATLAB.	**2**
3.	To determine of Impulse, Step and Ramp response for a First order unity feedback system using MATLAB.	**2**
4.	To determine of Impulse, Step and Ramp response for a Second order unity feedback system using MATLAB.	**2**
5.	To draw the Step response and Pole zero Plot of Over damped, under damped and Critically damped system for the Second order system having different value of Damping factor in MATLAB.	**2**
6.	To determine the transfer function from Natural frequency and Damping ratio. To determine the Transient characteristics of Step response of a Second order system in MATLAB.	**2**
7.	To Analyse Steady State Error of different types of Control system in MATLAB.	**2**
8.	To plot the Root locus, identify break-away points, interaction with imaginary axis and determine the stable range of gain using MATLAB.	**2**
9.	To plot Bode diagram, derive values of GM, PM and analyze stability using MATLAB.	
10.	To plot Nyquist diagram using MATLAB.	**2**

11.	To understand the relationship of Transfer function with State-model using MATLAB.	**2**
12.	To design a model of simple Lung mechanics (Lumped) and Neuromuscular Reflex (Lumped) using SIMULINK.	**2**

Major Software:

MATLAB/SIMULINK SOFTWARE

List of Open Source Software/learning website:

1. NPTEL online courses and Virtual laboratory
2. Scilab