GUJARAT TECHNOLOGICAL UNIVERSITY

BIOMEDICAL ENGINEERING (03)

CONTROL SYSTEM AND ANALYSIS

SUBJECT CODE: 2140307

B.E. 4th SEMESTER

Type of course: Core

Prerequisite: Calculus, Ordinary differential equations, Complex variables, Linear system concepts, Laplace transform.

Rationale: To prepare students Basics of Control System & Stability Analysis in both time & frequency domain. Also introduce them to basics of modeling of physiological systems & their stability analysis using the above methods

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	**BASIC CONCEPTS OF SYSTEMS AND CONTROL LOOPS:** -Types of systems, continuous, discrete, Linear Time Variant, Linear Time Invariant, Lumped and Distributed parameter systems, Linear vs. non-linear systems, Systems with delay, Open loop control system with examples, Close loop control system With examples and its merits over open loop system Effect of both on stability, gain And Speed response of system.	**2**	5
2	**LAPLACE TRANSFORMATION AND INVERSE LAPLACE TRANSFORMATION:** A brief overview of Laplace Transforms and understanding of Laplace Transfer Functions with problems associated with it.	**4**	10
3	**MATHEMATICAL MODELING** Introduction to MATLAB, Mathematical Modeling of some real world systems: Electrical-Mechanical Analogy, Electro-thermal modeling, Fluidic and Electrical system analogy, Thermal Systems, Block Diagrams and Signal Flow Graph Analysis. Block diagram reduction techniques, Biological modeling: Generalized system properties, Linear Models of physiological system: respiratory and muscle mechanics, Modeling of simple lung mechanics, Human body thermoregulatory system.	**14**	20
4	**INTRODUCTION TO MODELING USING STATE SPACE** State variable descriptions: Introduction, The concept of state, State equations for dynamic systems and related problems, Time-variance & Linearity, Non-uniqueness of state model, State diagram	**5**	10
5	**TRANSIENT AND STEADY STATE RESPONSE:**	**12**	20

	Introduction: Type and Order of The Systems, Transient Response Analysis, First and second order systems, Unity Feedback Systems, Stability Criteria, BIBO Stability, relative and absolute stability, Routh-Hurwitz Criteria for Stability, Applications of Routh stability criterion, Steady State Errors, Impulse and Step, Ramp, Responses of first and second order systems, Analysis of Transient Response Specifications: peak overshoot, settling time, rise time, peak time etc., mathematical analysis and problems.		
6	**ROOT LOCUS TECHNIQUES**: Plot LOCIs of root from transfer function, Stability criteria and system response study from root locus, related problems	**5**	10
7	**FREQUENCY RESPONSE TECHNIQUES** : **Nyquist Plot:** Method of Plotting, Nyquist contour, Nyquist stability criteria and related problems, gain margin, phase margin, linearized lung mechanics model **Bode Plot**: Method of Plotting, Effect of gain margin, phase margin on system parameters, Asymptotic approximation, Bandwidth, linearized lung mechanics model. **Polar Plot:** Method of Plotting, stability criteria, understanding systems with delay and their analysis in frequency domain, Understanding linearized lung mechanics model	**12**	25

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
R Level	U Level	A Level	N Level	E Level
25%	20%	20%	15%	20%

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. NAGRATH & GOPAL : Control system engineering, New age International Publication (1996)
2. B.C. KUO : Automatic control systems, Prentice Hall of India Ltd, 1995
3. OGATA KATSUHIKO : Modern Control Engineering, PHI,1996
4. MICHAEL C.K. KHOO: Physiological Control Systems: Analysis, Simulation, and Estimation
5. BARNEY K. HUANG: Computer Simulation Analysis of Biological and Agricultural Systems, CRC Press.
6. CONTROL ENGINEERING THEORY & PRACTICE: M. N. BANDYOPADHYAY

Course Outcomes:

After learning the course the students should be able to do:

1. Control system modeling: modeling of electric, mechanical and electromechanical systems, using differential equations, transfer functions, block diagrams, and state variables and diagrams;

2. Control system analysis: analysis of properties of control systems, such as sensitivity, stability, tracking, in time and frequency domains

List of Experiments:

1. To find Unit step, ramp, impulse response of first and second order system using MATLABS/scilab.
2. To derive the open loop and closed loop poles and zeros for varieties of the systems. Draw their Pole-zero maps and check the system stability.
3. To derive system output of following transfer functions using MATLAB.
4. To draw the step response of over damped, under damped and critically damped system for the second order system having different value of damping factor.
5. To find out time domain specification of second order system using MATLAB/Scilab.
6. To study state space presentation of a system. And to convert from TF to State Space.
7. To draw Bode plot for a given transfer function using MATLAB/Scilab. Derive GM, PM and stability from the plot.
8. To draw Nyquist plot for a given transfer function using MATLAB/Scilab.
9. To draw Polar plot for a given transfer function using MATLAB/Scilab.
10. To solve the state equation for a given system using MATLAB/Scilab.

Design based Problems (DP)/Open Ended Problem: as per topics

Major Equipment: MATLAB/SCILAB software

List of Open Source Software/learning website:

http://nptel.ac.in/video.php?subjectId=108102043
http://en.wikibooks.org/wiki/Control_Systems/Root_Locus
http://en.wikibooks.org/wiki/Control_Systems/Bode_Plots
http://en.wikipedia.org/wiki/Nyquist_stability_criterion

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.