GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: POWER ELECTRONICS (24)
SUBJECT NAME: Advanced Control Systems
Subject Code: 2172412
BE SEMESTER VII

Type of course: Engineering

Prerequisite:

1) 2110014, 2110015, 2130002 – (Engineering Mathematics of Sem. 1,2 and 3)
2) 2150909 – Control System Engineering

Rationale: The course intends to provide foundations related to control engineering to the undergraduate students. The course should enhance their ability to analyze and control multiple domain systems using techniques and tools related to control systems**.** This course provides detailed concepts of feedback control design, state-space approach, non- linear system analysis and overview of optimal control.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs.	% Weigh tage
1	Z-transform Z-transform, Z-transforms of elementary functions, Important properties and theorems, Inverse z-transform, Z-transform method of solving difference equations.	**04**	**5-10**
2	Z-Plane Analysis Of Discrete-Time Control Systems Impulse sampling and data hold, Pulse transfer function, Realization of digital controllers and digital filters, Mapping between s-plane and z-plane, Stability analysis of closed loop systems in z-plane, Transient and steady state analyses.	**07**	**15-20**
3	State Variable Analysis Introduction, Concepts of State, State Variable and State Model, Various State Models for Linear-Continuous Time systems, State Variables and Discrete-Time Systems, Eigen values and Eigen vectors, Diagonalization, Solution of State Equation, State transition matrix, Controllability, Observability, Principle of Duality.	**09**	**20-30**
4	State Variable Design Introduction, Pole-Placement, Design of Servo Systems, State Observers, Design of Regulator System with Observers, Design of Control System with Observers.	**07**	**15-25**
5	Non-Linear Systems	**08**	**15-25**

	Introduction, Common Physical Nonlinearities, The Phase Plane Method, Singular Points, Stability Of Nonlinear System, Construction of Phase Trajectories, Linearization, Describing Function Method, Derivation of Describing Function, Stability Analysis by Describing Function.		
6	Lyapunov's Stability Analysis Introduction, Lyapunov's Stability Criteria, The direct method of Lyapunov, Methods of constructing Lyapunov Function for Non-linear Systems.	**06**	**15-20**
7	Optimal Control Introduction, Optimal Control versus Conventional Control, Types of Optimal Control Problem, Basic Concepts of Calculus of Variation, Finding Minima of function, Linear Quadratic Regulator(LQR) Problem.	**07**	**15-20**

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks				
Remembrance R Level	**Understanding U Level**	**Application A Level**	**Analyze N Level**	**Evaluate E Level**
30%	**25%**	**25%**	**10%**	**10%**

Legends: R : Remembrance ; U = Understanding; A = Application 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 Control System Engineering , I. J. Nagrath and M. Gopal, New Age International Publishers

2 Modern Control Engineering , K. Ogata, EEE, PHI

3 Automatic Control Systems, High Education Press, B. C. Kuo

4 Control Systems: Principles and Design, M. Gopal, TMH

5 Digital control and state-variable methods , M. Gopal, TMH

6 Control System Engineering, Norman Nise, Wiley India Edition

Course Outcome:

After learning the course the students will be able to:

1. Understand how the state space system representation provides an internal description of the system including possible internal oscillations or instabilities.
2. Evaluate the output of a digital system for a given input.
3. Design state observers.
4. Analyze digital systems using the Z-transformation.
5. Derive the describing function for different types of non-linearities and then do the stability analysis.
6. Understand how the system design minimizes or maximizes the selected performance index.
7. Design digital controllers for Power Electronic Systems.

List of Experiments:

Directions for Laboratory work:
- The list of experiments is given as a sample.
- Minimum 10 experiments should be carried out.

1. Introduction to MATLAB for various matrix operations.
2. Use of Simulink for various state space models.
3. Design and simulation of Pole placement control.
4. Study of controllability and observability through simulation.
5. Design and simulation of observer.
6. Study of Lyapunov method.
7. Study of phase trajectories.
8. Study of LQR problem.
9. Study, design and simulation of Phase-Lead Controller.
10. Study, design and simulation Phase -Lag Controller.
11. Study of effect of Non-linearity in stable Control Systems.
12. Phase-plane trajectory for Non-linear control systems.
13. To study stability of Discrete-time Control Systems.
14. State-Space Analysis study with respect to Transfer function method for Stable Control Systems

Design based Problems (DP)/Open Ended Problem:
Students may carry out analysis of specific application based intelligent control system with its mathematical analysis and feedback control system. Control system analysis may be of a linear, nonlinear or discrete category and can be carried out using any simulation software.

Major Equipment:

1. All these experimental study with Software Tool: MATLAB.
2. MATLAB contains Control Systems Toolbox, Digital Signal Processing Toolbox, Fuzzy Toolbox, Neural Toolbox.
3. Control Experiment Equipment: PID Control, Non-linear Control Systems, Discrete-time Control Systems

List of Open Source Software/learning website:

- Demo versions of MATLAB and other control theory related soft wares are available free of cost for limited periods.
- Octave software -- https://www.gnu.org/software/**octave**/
- Scilab -- www.scilab.org/
- CONTROL SYSTEM TUTORIALS by University of Michigan

ACTIVE LEARNING ASSIGNMENTS: Preparation of presentation which include slides, 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 presentation 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.