GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING
ADVANCED CONTROL SYSTEMS
SUBJECT CODE: 2180913
B.E. 8TH SEMESTER

Type of course: NA

Prerequisite: Control System Engineering

Rationale: This course explores the fundamentals of modern control using linear algebra and non-linear system theory. The course has two primary focuses: (1) Understanding and predicting system behavior in state space and non-linear systems, and (2) Design and analysis of closed loop control systems.

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)	
					PA	ALA	ESE	OEP		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**State Space Analysis of Control Systems :** State Variables; State-Space Representation of Electrical and Mechanical and Electromechanical Systems; State Space Representation of Nth Order Linear Differential Equation; Transformation to Phase Variable Canonical Form; Relationship Between State Equations and Transfer Functions; Characteristic Equation; Eigen Values and Eigen Vectors; Transformation to Diagonal Canonical Form; Jordan Canonical Form; Controllability Canonical Form; Observabilty Canonical Form; Decomposition of Transfer Function-Direct, Cascade and Parallel Decomposition; State Diagram; Solution of the Time-Invariant State Equation; State Transition Matrix and its Properties; Transfer Matrix; Transfer Matrix of Closed Loop Systems	**14**	30
2	**Controllability and Observability:** Concept of Controllability and Observability; Kalman's Theorems on Controllability; and Observability, Alternative Tests (Gilbert's Method) of Controllability and Observability; Principle of Duality; Relationship among Controllability, Observability and Transfer Function.	**4**	10
3	**State feedback controller**: Design of state feedback controller using pole placement technique, Ackerman's formula,	4	10

4	**Liapunov Stability Analysis :** Stability of Equilibrium State in the Sense of Liapunov; Graphical Representation of Stability; Asymptotic Stability and Instability; Sign-Definiteness of Scalar Function; Second Method of Liapunov; Stability Analysis of Linear Systems; Krasovski's Theorem; Liapunov Function Based on Variable Gradient Method	**4**	10
5	Describing Function Analysis of Nonlinear Control System : Introduction to Nonlinear Systems, Describing Functions for Common Types of Nonlinearities, Describing Function Analysis, Stability and Limit Cycles.	**10**	20
6	Phase Plane Analysis : Introduction : Analytical Methods for constructing Trajectories, Graphical Methods for constructing Trajectories; Isocline Method; Delta Method; Pell's Method; Lienard's Method; Classification of Singular Points; Limit Cycles; Phase-Place Analysis of Linear control system; Phase-plane Analysis of Non-linear control system. Minimum Time Trajectory; Optimum Switching Curve.	**6**	30

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks (%)					
R Level	U Level	A Level	N Level	E Level	C Level
12-15	**15-20**	**20-25**	**30-35**	**20-30**	**0**

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. Katsuhiko Ogata, Modern Control Engineering, Prentice-Hall of India, Second Edition, 1997.
2. B. C. Kuo. Automatic Control Systems, Prentice – Hall of India, Seventh Edition 1997.
3. L. J. Nagrath & M. Gopal, Control Systems Engineering. Wiley Eastern Limited, Second Edition, 1992.
4. M. Gopal, Control System Principles and Design Tata – McGraw Hill, 1997.
5. John E. Gibson, Non-linear Automatic Control, Mc. Graw Hill Book C.(ISE)
6. Hasan K. Khalil, Non-linear systems, Prentice-Hall of India, 2002.
7. E Slotine, Weiping Li, Applied Nonlinear Control, Prentice-Hall

Course Outcome:

After learning the course the students should be able to:

- Apply linear algebra to complex real world problems in order to obtain models that are expressed using state space equations.
- Analyize the system behavior based on the mathematical model of that system where the model may be expressed in state-space domain
- Analyze the behavior of closed loop systems using tools like Matlab
- Design controllers using the concept of state feedback and pole placement tech.
- Write a report that effectively communicates the results of an analysis or design

List of Experiments: The students may be given the simulation based experiments by the instructor for the each topic given in the syllabus.

Design based Problems (DP)/Open Ended Problem:

Students may take up the challenge for designing the controllers for:

- Space Shuttle Rocket,
- Satellite navigation Control, Roll Angle Control,
- Mars Rover Vehicle, Mars Guided Vehicle Control, Mars Rover,
- Disk Drive Read Write System, Rotating Disk Speed Control, Disk Drive Read.

Major Equipment: N.A

List of Open Source Software/learning website: Use SCILAB/MATLAB or other equivalent software as a simulator

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.