

GUJARAT TECHNOLOGICAL UNIVERSITY

MECHANICAL ENGINEERING (19)

CONTROL ENGINEERING

SUBJECT CODE: 2151908

B.E. 5th SEMESTER

Type of course: Engineering Science

Prerequisite: Zeal to learn the subject

Rationale: To develop comprehensive knowledge and understanding of classical and modern control theory, industrial automation, and systems analysis. Control engineering is a diverse and rapidly expanding discipline which has become increasingly important in a wide range of industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
		PA	ALA		ESE	OEP				
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No	Topic	Lectures	Weightage
1	Basic concepts of control system: Terminology - plant, process, system, disturbances, controlled variable, manipulated variable etc., Block diagram of basic control system, application areas with examples. Classifications of control systems, Concept of superposition for linear systems with examples.	3	10%
2	Mathematical modelling of systems: Translational and rotational mechanical, electrical, thermal, hydraulic and pneumatic systems, Force voltage and force current analogy, Position servo mechanism. Block diagram and signal flow graph representation of physical systems along with rules, properties, comparison and limitation, Mason's gain formula	11	20%
3	Time response analysis: Standard test signals along with examples of their usage, steady state errors for step, ramp and parabolic inputs, analysis of first and second order systems, Transient response specifications with numerical examples, Basic control actions and two position, proportional, PI, PID and rate feedback controllers, Limitations of time domain analysis.	7	15%
4	Frequency response analysis: Need of frequency response analysis, Sinusoidal response of linear system, methods used in frequency response, Frequency domain specifications.	4	10%
5	Stability: Concept of stability, types of stability, Routh's stability criterion, special cases with numerical examples, stability of closed loop system, concept of root locus,	6	15%

	open loop and closed loop transfer poles, step by step procedure for root loci, numerical examples		
6	Hydraulic control system: Basic elements of hydraulic circuit, Principle used in hydraulic circuit, Sources of hydraulic power, Integral, Derivative, PD & PID controller with its transfer function, Comparison between hydraulic and electrical control system.	5	10%
7	Pneumatic control system: Basic elements of pneumatic circuit, Difference between pneumatic and hydraulic control systems, Force balance and force distance type controllers, Nozzle-flapper amplifier, PD, PI and PID control system along with its transfer function.	4	10%
8	State space analysis: State space representation, state variables, state, state vector, state space, formulation of state space equations for mechanical and electrical systems, advantages over classical technique.	3	10%

Course Outcome:

On completion of this course students will:

1. Understand the methodology for modelling dynamic systems with concept of stability
2. Know the transfer function, signal flow graph representation of linear systems & their controlling actions
3. Understand concept of time, frequency response as well as concept of state-space models and their relation to frequency domain models
4. Control system of hydraulic and pneumatic system

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	10	10	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

References:

1. Modern control theory, Katsuhiko Ogata, Pearson Education International, Fifth edition.
2. Control system engineering, Norman S Nise, John Wiley & Sons, Inc., Sixth edition
3. Modern control systems, Richard C. Dorf, Robert H Bishop, Pearson Education International, Twelfth edition.
4. Automatic control systems, Farid Golnaraghi, Benjamin C Kuo, John Wiley & Sons, Inc., Ninth edition
5. J.Nagrath and M.Gopal, "Control System Engineering", New Age International Publishers, 5th Edition, 2007

List of Experiments:

1. Development of block diagram of various physical systems given by instructor ex. Toster system, watt governor etc.

2. Introduction to simulation software like MATLAB/LABVIEW
3. Modelling of physical system using simulation software
4. Simulation of linear system to different inputs
5. Given a system transfer function, plot the location of the system zeros and poles using simulation software
6. Simulation of root locus plot using simulation software
7. Performance measurement of first and second order system using simulation system as given by instructor
8. Introduction to hydraulic trainer system/software
9. Development & performance of given hydraulic circuit
10. Introduction to pneumatic trainer system/software
11. Development & performance of given pneumatic circuit
12. Introduction of programmable logic controller and ladder diagram

Design based problems (DP)/open ended problem:

1. Apply the knowledge of control systems on vibration system, fluid flow system, thermal system monitoring as an open or closed loop system.
2. Give a task to develop an open loop or closed loop control of physical system
3. Develop open or closed loop simulation program for mechanical mechanisms using software showing current position of each link with respect to specified reference.

Major Equipment:

- Hydraulic trainer
- Pneumatic trainer
- MATLAB/ LABVIEW/Simulation software for hydraulic and pneumatic systems

List of Open source software/learning website:

- <https://www.scilab.org>
- www.simscale.com

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