GUJARAT TECHNOLOGICAL UNIVERSITY

INSTRUMENTATION & CONTROL ENGINEERING (17)
Bachelor of Engineering
Subject Code: 3141708
Semester – IV
Subject Name: Control Theory

Type of course: Professional Core Course

Prerequisite:
1. Calculus
2. Ordinary differential equations
3. Complex variables
4. Linear system concepts
5. Laplace transforms.

Rationale: To prepare students for Basics of Control Engineering

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)	
4	0	2	5	70	30	30	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE- End Semester Examination; PA- Progressive Assessment

Content:

Sr. No.	Content	Total Hrs
1	**Introduction to Control Systems** Introduction Brief History of Automatic Control Examples of Control Systems Engineering Design Control System Design Mechatronic Systems Green Engineering The Future Evolution of Control Systems Design Examples Sequential Design Example*	**4**
2	**Mathematical Models of Systems** Introduction Differential Equations of Physical Systems Linear Approximations of Physical Systems The Laplace Transform The Transfer Function of Linear Systems Block Diagram Models	**6**

	Signal-Flow Graph Models Design Examples The Simulation of Systems Using Control Design Software Sequential Design Example*	
3	**State Variable Models** Introduction The State Variables of a Dynamic System The State Differential Equation Signal-Flow Graph and Block Diagram Models Alternative Signal-Flow Graph and Block Diagram Models The Transfer Function from the State Equation The Time Response and the State Transition Matrix Design Examples Analysis of State Variable Models Using Control Design Software Sequential Design Example*	**6**
4	**Feedback Control System Characteristics** Introduction Error Signal Analysis Sensitivity of Control Systems to Parameter Variations Disturbance Signals in a Feedback Control System Control of the Transient Response Steady-State Error The Cost of Feedback Design Examples Control System Characteristics Using Control Design Software Sequential Design Example*	**6**
5	**The Performance of Feedback Control Systems** Introduction Test Input Signals Performance of Second-Order Systems Effects of a Third Pole and a Zero on the Second-Order System Response The S-Plane Root Location and the Transient Response The Steady-State Error of Feedback Control Systems Performance Indices The Simplification of Linear Systems Design Examples System Performance Using Control Design Software Sequential Design Example*	**6**
6	**The Stability of Linear Feedback Systems** The Concept of Stability The Routh-Hurwitz Stability Criterion The Relative Stability of Feedback Control Systems The Stability of State Variable Systems Design Examples	**6**

	System Stability Using Control Design Software Sequential Design Example*	
7	**The Root Locus Method** Introduction The Root Locus Concept The Root Locus Procedure Parameter Design by the Root Locus Method Sensitivity and the Root Locus PID Controllers Negative Gain Root Locus Design Examples The Root Locus Using Control Design Software Sequential Design Example*	**6**
8	**Frequency Response Methods** Introduction Frequency Response Plots Frequency Response Measurements Performance Specifications in the Frequency Domain Log Magnitude and Phase Diagrams Design Examples Frequency Response Methods Using Control Design Software Sequential Design Example*	**6**
9	**Stability in the Frequency Domain** Introduction Mapping Contours in the s-Plane The Nyquist Criterion Relative Stability and the Nyquist Criterion Time-Domain Performance Criteria in the Frequency Domain System Bandwidth The Stability of Control Systems with Time Delays Design Examples PID Controllers in the Frequency Domain Stability in the Frequency Domain Using Control Design Software Sequential Design Example*	**6**

Note: Sequential Design Example* (Tutor/Instructor/Teacher has to select one case study and carry forward same to teach all the topics of syllabus.)

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
21	**21**	**14**	**7**	**7**	**-**

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. Richard C. Dorf & Robert H. Bishop : Modern Control Systems, 13th Edition, Pearson, 2017
2. Norman S. Nise, Control Systems Engineering, Wiley India, Student Edition (Fifth), 2009
3. NAGRATH & GOPAL : Control system engineering, New age International Publication (1996)
4. B.C. KUO : Automatic control systems, Prentice Hall of India Ltd, 1995
5. OGATA KATSUHIKO : Modern Control Engineering, PHI, 1996

Course Outcomes:

Sr. No.	CO statement	Marks % weightage
CO-1	Explain modeling of electrical, mechanical and electromechanical, process systems	30
CO-2	Analysis of properties of control systems, such as sensitivity, stability, tracking, in time and frequency domains	40
CO-3	Apply differential equations, transfer functions, block diagrams, and state variables in control system design.	30

List of Experiments:

1. The Simulation of Systems and models Using Control Design Software.
2. Analysis of State Variable Models Using Control Design Software
3. Analysis of Control System Characteristics Using Control Design Software
4. Identification of System Performance Using Control Design Software
5. System Stability analysis Using Control Design Software
6. The Root Locus plots and analysis study Using Control Design Software
7. Frequency Response Methods analysis study Using Control Design Software
8. Stability analysis in the Frequency Domain Using Control Design Software
9. Find Unit step, ramp, and impulse response of first and second order system using Control Design Software.
10. Derive the open loop and closed loop poles and zeros for varieties of the systems. Draw their Pole-zero map and check the system stability.

11. Draw the step response of over damped, under damped and critically damped system for the second order system having different value of damping factor.
12. Find out time domain specification of second order system using Control Design Software.

Major Equipment:

MATLAB/SCILAB Control Design Software

List of Open Source Software/learning website:

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