



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Subject Code : BE04000121

Subject Name : Control Theory

WEF Academic Year:	2025-2026
Semester:	4
Category of the Course:	Professional Core

Prerequisite:	1. Calculus 2. Ordinary differential equations 3. Complex variables 4. Linear system concepts 5. Laplace transforms.
Rationale:	Control Theory is a core pillar of Instrumentation and Control Engineering, providing the foundational principles for analyzing and designing control systems.

Course Outcome:

After Completion of the Course, Student will be able to:

No	Course Outcomes	RBT Level*
01	Demonstrate an understanding of the fundamentals of (feedback) control systems.	RM/UN/AP
02	Develop and use models (such as transfer function & state space models) of physical systems in forms suitable for use in the analysis and design of control systems.	AP/AN
03	Investigate and analyze the transient and steady-state responses of feedback control systems to standard test input signals.	AP/AN
04	Apply time domain techniques (such as R-H criteria and root locus) to determine and analyze the stability of a closed-loop control system.	AP/AN
05	Apply frequency domain techniques (such as Bode plot and Nyquist plot) to determine and analyze the stability of a closed-loop control system.	AP/AN

*RM: Remember, UN: Understand, AP: Apply, AN: Analyze, EL: Evaluate, CR: Create

Teaching and Examination Scheme:

Teaching-Learning Scheme (in Hours per Semester)					Total Credits = TH/30	Assessment Pattern and Marks					Total Marks
L	T	P	TW/SL	TH		Theory		Tutorial/Practical			
						ESE (E)	PA (M)	PA/ (I)	TW/ SL (I)	ESE (V)	
60	0	30	30	120	04	70	30	20	30	50	200



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- Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, PA = Progressive Assessment, ESE = End-Semester Examination

Course Content:

Sr. No.	Course Content	No. of Hours	% of Weightage
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	3	5
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 Signal-Flow Graph Models Design Examples The Simulation of Systems Using Control Design Software Sequential Design Example	9	15
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	6	10



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	Analysis of State Variable Models Using Control Design Software Sequential Design Example		
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	4	7
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	8	14
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 System Stability Using Control Design Software Sequential Design Example	5	8
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 Negative Gain Root Locus	10	16



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	Design Examples The Root Locus Using Control Design Software Sequential Design Example		
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	7	12
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 Stability in the Frequency Domain Using Control Design Software Sequential Design Example*	8	13
	Total	60	100

Reference Book:

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

Suggested Course Practical List:

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



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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 Polezero 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.

List of Laboratory/Learning Resources Required:

- 1) DTE Common Lab manual
- 2) Virtual Laboratory (vlab.co.in)
- 3) NPTEL/ MOOC Swayam Portal

Activities suggested under Problem Based Learning:

Sr. No.	Name of the activity	No. of hours per activity	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit=5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations Based on industry/lab data.
2.	Technical Video based learning related to the subject	Duration of video = 5h Report preparation=5h Total= 10h	Report/presentation based on the video learning outcomes.
3.	Assignment writing. Numerical Based assignment is preferable.	5 assignments of 2h each. Total= 10h	Based on the assignment submitted.
4.	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB,MS-EXCEL or any Other relevant software	5 small coding-based assignment of 2h each. Total = 10h	Based on the coding solution submitted.
5.	Self-learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment At the end of course. Based on the certificate produced.
6.	Complex problem solving	Maximum 2problem. Study of the problem and	Based on the depth of the Solution submitted.



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		solution finding, Total= 10h	
7	Videos on Industrial safety aspects based on subject	Duration of video = 5h Report preparation =5h Total= 10h	Based on quiz/report submitted
8	Discussion on research paper Based on relevant subject	5 research paper =20 h	Summarize research paper and Evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration=6h	Based on poster/chart Preparation and presentation skills
10	Working/non-working model on technical topics	Working=12h Non-working=8 h	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/any other issue	Duration=15hfor industrial exposure Problem identification and tentative solution = 10 h Total = 20 h	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration=1h each	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation=5h Total= 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
14.	Application/Software development	Duration=10h	Depending on the complexity of the Application/Software
15	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
16	Patent Search and Innovation Gap Identification	10h(Search + Report)	Based on number of relevant patents analyzed and Identification of innovation scope.

Note:

- All the suggested activity should be related to the subject.
- Subject coordinator shall identify activities from above list as per the subject needs, they also declare list of activities wise hours, evaluation scheme and rubrics to students at the start of semester.



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- The number of hours is suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
 - All records pertaining to the evaluation and assessment of self-learning activities must be properly maintained and preserved at the institute level. These records should be made available to the university upon request.
 - Institutes are encouraged to utilize digital platforms, such as Microsoft Teams, for effective record-keeping and to ensure transparency in the evaluation and assessment of self-learning activities.

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