GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Subject Code: BE04000211
Subject Name: Control Theory

w.e.f. Academic Year:	2024-25
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	Zeal to learn the subject
Rationale:	The subject deals with mathematical modelling and control of different types of dynamic systems, which play a significant role in Mechatronics engineering.

Course Out comes: At the end of the course, students will be able to:

Sr. No.	CO statement	Marks% weightage
CO-1	Interpret linear time invariant system modeling using differential equations and transfer function realizations.	**25**
CO-2	Analyze LTI system behavior in time and frequency domains based on the mathematical model of the system.	**25**
CO-3	Evaluate closed loop LTI system in Time and Frequency Domain for stability check.	**20**
CO-4	Make use of Compensators for dynamic systems.	**20**
CO-5	Demonstrate State-Space Analysis of linear systems	**10**

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/CA (I)	TW/ SL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

Content:

Sr.No.	Content	Total Hrs
1	**Introduction and Overview of Control Systems:** Basic blocks of Control Systems; Understanding the terms reference input, control input, disturbance input and controlled output; Tracking and the disturbance rejection problems; History of Control Systems, Manual vs. automatic control; Feedback and feed forward control, Analysis and Design Objectives.	03
2	**System Modelling**: LTI systems, Review of Laplace Transform Review. **Modelling in Frequency Domain**: Transfer function, Electrical Network Transfer Functions, Transfer Functions of Mechanical Translational System, Rotational System, and Electromechanical System, Case Study. **Modelling in Time Domain**: Concept of states; State-space modelling of general systems; Operating points and linearization about the same; State-space to transfer function transformation and the reverse (i.e., realization) problem for LTI systems; controllability and observability, pole placement. Block-diagram (and Signal-flow-graph) representation of systems and their reduction to get Transfer Function; Mason's Gain Formula; Case Studies.	08
3	**Feedback Control System Characteristics and Performance**: Test Input Signals, pole-zero and order of control system, Significance of poles and eigenvalues, Transient and steady-state response, Cost of feedback, Performance of various test signals on first and second order Systems, Effects of a Pole and a Zero on the System Response, The Steady-State Error of Feedback Control Systems, Performance Indices, Case Studies.	06
4	**Stability of Linear Feedback Systems**: The Concept of Stability, Asymptotic and BIBO stability, Absolute and relative stability, Routh-Hurwitz criteria, Stability in State Space, Case Studies.	04
5	**Stability in the Time Domain:** Concept of Root Locus, Root Locus Design Techniques, Parameter Design by the Root Locus Method, Sensitivity, and the Root Locus, Case Studies.	08
6	**Stability in the Frequency Domain:** Frequency Response Plots, Performance Specifications in the Frequency Domain, Magnitude and Phase Diagrams (Bode Plots), Design via Bode plots, Nyquist Criterion, Relative Stability via Bode plots and Nyquist Criterion, Nichols chart, Systems with Transportation Delay, Case Studies.	08
7	**Compensation Design Techniques:** Performance goals - Steady state, transient and robustness specifications; Phase-lag, Phase-lead, Phase Lag-lead, and PID Compensators, Time domain vs. Frequency-domain design approaches; Example Study.	08
	TOTAL	45

Suggested Specification table with Marks(Theory):(For B.E. only)

Distribution of Theory Marks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
--	35%	20%	25%	20%	

R: Remembrance; U: Understanding; A: Application; N: Analyze;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	Control Systems: Principles and Design, M. Gopal, 4th Edition, TMH Publication.
2	Control Systems Engineering, Norman Nise, 7th Edition, Wiley.
3	Modern Control Engineering, Katsuhiko Ogata, 4th Edition, Prentice Hall of India.
4	Control systems Engineering, I. J. Nagrath and M. Gopal, 5th Edition, New Age International Publisher.
5	Automatic Control Systems, Benjamin C. Kuo and Farid Golnaraghi, 8th Edition, John Wiley & Sons.

List of Experiments:

1	Experiment on potentiometer characteristics and its use as error detector.
2	Experiment on the Synchro characteristics and its use as error detector.
3	The torque-speed characteristics of D.C Motor and determine its transfer function.
4	The performance characteristics of a DC Motor speed control system.
5	The performance characteristics of a DC Motor angular position control system.
6	Characteristics of a small AC servomotor and determine its transfer function.
7	Experiment on responses of Type – 0, Type – 1 and Type – 2 systems.
8	Introduction to MATLAB/SCILAB/Python: MATLAB: Control System Toolbox and Simulink, Basics of Control Systems Commands, Poles, Zeros, Type and Order of Control Systems.
9	MATLAB/SCILAB/Python simulation experiments – Time Response Analysis, Bode Plot, Root Locus, Nyquist Plot, State-Space Analysis.
10	Experiment on Phase-lead and Phase-lag network using discrete components.
11	MATLAB simulation experiments – Phase-lead and Phase-lag network.

List of Open Source Software / learning website:

1	**NPTEL Resources**

- **List of suggested activities for Problem Based Learning:**

Sl. No.	Name of the activity	No. of hours	Evaluation Criteria
1.	Industry/Research laboratory visit	Visit = 5hrs., Report preparation = 5hrs. Total = 10hrs.	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 = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Report /presentation based on the video learning outcomes.
3.	Assignment writing. Numericals based assignment is preferable.	5 assignments of 4hrs. each. Total = 20hrs.	Based on the correctness of submittedassignment.
4.	Problem solving/Coding using C, C++, MATLAB, Python, SCILAB,modeling and Analysis software or any other software	5 small coding-based assignment of 2hrs. each. Total = 10hrs.	Based on the coding solution submitted.
5.	Self-learning online course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
6.	Identification and solution of Complex problem	Maximum 2 problems. Study of the problem and solution finding, Total = 10hrs.	Based on the depth of the solution submitted.
7	Videos on Industrial safety/Disaster Management aspects based on subject	Duration of video = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on quiz/report submitted
8	Technical paper reading and summarization of research papers based on relevant subject	5 research papers = 20 hrs.	Summarize research paper and evaluation critical parameters
9.	Poster/chart/power point preparation on technical topics	Duration = 6 hrs.	Based on poster/chart preparation and presentation skills
10	Working/non-working model on technical topics	Working = 12 hrs. Non- working = 8 hrs.	Based on inter department/external evaluation
11	Industrial exposure for 2-3 days to observe and provide tentative solutions on society/environment/health/ sustainability/any other issue	Duration = 15 hrs. for industrial exposure Problem identification and tentative solution = 10 hrs. Total = 20 hrs.	Based on evaluation of critical problems and solutions
12	Group Discussion on emerging/trending technical topics based on subject	Duration = Min. 1 hr.per subject. Max. 3 hrs. per subject	Based on performance in group discussion, technical depth, knowledge etc.
13.	Real world case studies-based learning	Duration of data collection/study = 5hrs. Report preparation = 5hrs. Total = 10hrs.	Based on in-depth study, technical depth, data collected, fact finding, etc.

14.	Application/Software development	Duration = 10 hrs.	Depending on the complexity of the Application/Software
15.	Research paper publication	Duration = 10 hrs.	Based on submission of proof of publication
16.	Upgradation/Reverse engineering studies of existing equipment of the laboratory	Duration 10 hrs.	Based on the performance of the equipment
17.	Expert lecture/session	Duration 3 hrs. For attending the lecture/session– 2 hrs. and for report writing 1 hr.	Based on the proof of attendance and report submitted
18.	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
19.	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:
1. All the suggested activity should be related to the subject.
2. The number of hours are suggestive. Faculty can sub-divide the number of hours based on the activity. However, total number of hours is fixed.
3. Rubrics for the evaluation can be prepared by the faculty.
4. Subject teacher can add the relevant activities other than those listed above, with the consent of head of the department and DQAC.

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