GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Biomedical Engineering

Course / Subject Code : BE04003051

Course / Subject Name : Control System and Analysis

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

Prerequisite:	Fourier Transform, Differentiation, Basic Electronics, Mathematics
Rationale:	This course will provide knowledge about fundamentals of the control system, various methods to find the transfer function, analysis of the control system with use of time domain and frequency domain techniques and stability of the control system.

Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Gain an understanding of the types and concepts of control systems.	R,U
02	Determine the transfer function or mathematical representation for various systems.	R,U,A
03	Understand steady-state errors and their derivation for standard test signals by analyzing the responses of first and second-order systems.	R,U,A,N,C
04	Utilize the Root-locus technique, examine the stability criteria and optimal response of control systems	R,U,A,N,E
05	Utilize frequency domain techniques such as the Bode Plot and Polar Plot to evaluate the stability of the control system.	R,U,A,N,E

**Revised Bloom's Taxonomy (RBT)*

Teaching and Examination Scheme:

Teaching Scheme (in Hours per Semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	PR	PBL*	TH	C	ESE (E)	PA /(M)	PA (I)	PBL (I)	ESE (V)	
45	0	30	15	90	3	70	30	20	30	50	200

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

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	**Introduction of Control system**: Open and Close loop control system, LTI Control system, Basics of Laplace Transform and Inverse Laplace Transform, Concept of Impulse Response and Transfer function, standard test signals.	04	5%
2.	**Mathematical Modeling of System**: Mathematical Modeling of Electrical Elements, Mathematical Modeling of Mechanical System, Mechanical Electrical Analogy, Block Diagram Algebra, Signal Flow Graphs.	13	25%
3.	**Time Response Analysis:** Transient and steady state response, Stability and Sensitivity of a system, Disturbance Rejection, Standard Test signals and their Needs, Time response of First order system for standard test signals, Speed of Response, Unit impulse and Unit step response of second order system, Effect of Damping factor in Second Order System Performance, Time Domain Specifications, Steady State Error and Error Constants, Derivation of Steady State errors of system (type 0, type 1 type 2)	07	20%
4.	**Stability Analysis and Root Locus Technique**: Stability Criterion, Relationship between System parameters and pole locations, Hurwitz Stability Criterion, Routh Stability Criterion, Relative Stability Analysis, Root Locus method of Design, Value of Gain Margin and Phase margin from Root Locus, Effect of Addition/Cancellation of Poles and Zeros on Root Locus.	10	25%
5.	**Frequency Response Analysis**: Concept of Frequency Response, Frequency Domain Specifications. Bode plot: Sketch of the Bode plot, Calculate Gain and Phase Margin from Bode plot, Stability Analysis using Bode plot, and Transfer function from Bode plot. Polar plot: Sketch of the Polar Plot, Calculate Gain and Phase Margin from Polar plot, Stability analysis using polar plot.	11	25%
	Total	**45**	**100**

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	**U Level**	**A Level**	**N Level**	**E Level**	**C Level**
10%	**20%**	**20%**	**20%**	**25%**	**5%**

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

1. R. Anandanatarajan, P. Ramesh Babu, "Control Systems Engineering", Scitech Publications (India).
2. U. A. Bakshi, S. C. Goyal, "Feedback Control Systems", Technical Publications.
3. Smarajit Ghosh, "Control Systems: Theory and Applications", Pearson.
4. I. J. Nagrath, M. Gopal, "Control Systems Engineering", New Age International Publishers.
5. Katsuhiko Ogata, "Modern Control Engineering", Prentice Hall.

(b) Open source software and website:

1. https://archive.nptel.ac.in/courses/107/106/107106081
2. https://in.mathworks.com/videos/series/control-systems-in-practice.html

Suggested Course Practical List: If any

List of Laboratory/Learning Resources Required:

1. Study the basic concepts of control systems, including their classifications: open-loop and closed-loop control systems.
2. To study about the introduction of MATLAB/SciLab, Implementation of basic operation, signal generation and plot.
3. To study mathematical modeling of electrical systems and the analogy between mechanical and electrical systems, accompanied with examples.
4. To study the derivation of the transfer function of a control system utilizing Block Diagram Algebra techniques, along with examples.

5. To study the derivation of the transfer function of a control system utilizing Signal Flow Graph techniques, along with examples.
6. To study the time domain specifications or transient response of a second-order system using illustrative examples.
7. To Find out Impulse and Step Response of 1st and 2nd order systems in MATLAB/SciLab. Draw their Pole-zero maps and check the system stability in MATLAB/SciLab.
8. To study the steady-state response of a second-order system for various input signal types, including examples.
9. To find out Steady State Error of different types of Control system in MATLAB/SciLab.
10. To Study about the Hurwitz and Routh stability criteria for the analysis of control system stability, accompanied with examples.
11. To draw the Root Locus of the Control system transfer function in MATLAB/SciLab.
12. To draw the Bode plot of the Control system transfer function in MATLAB/SciLab.

Suggested Activities for Students: If any

- MATLAB/ SIMULINK implementation of Biomedical physiological system modeling or any transfer function or system can be given to students and ask them to analyze stability and parameters using time domain or frequency domain methods.

- **Problem Based Learning Suggested Activities:**

Sr. No	Name of the Activity	No. of Hours	Evaluation Criteria
1	Industry/Research laboratory visit	Visit: 5h Report preparation: 5h Total: 10h	Based on the 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.

Sr. No	Name of the Activity	No. of Hours	Evaluation Criteria
3	Assignment writing (Numerical-based assignment is preferable)	5 assignments × 4h each **Total: 20h**	Based on the assignments submitted.
4	Problem solving/Coding using C, C++, Python, SCILAB, MATLAB, MS-EXCEL, or any other relevant software	5 small coding-based assignments × 2h each **Total: 10h**	Based on the coding solutions submitted.
5	Self-learning online course	Minimum duration: **10h**	Examination-based assessment at the end of the course. Based on the certificate produced.
6	Complex problem solving	Maximum 2 problemsStudy and solution finding **Total: 10h/problem**	Based on the depth of the solution submitted.
7	Videos on Industrial Safety/Disaster Management aspects based on subject	Duration of video: 5hReport preparation: 5h **Total: 10h**	Based on quiz/report submitted.
8	Discussion on research paper based on relevant subject	5 research papers: **20h**	Summarize research papers and evaluate critical parameters.
9	Poster/Chart/PowerPoint 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: 8h	Based on inter-department/external evaluation.
11	Industrial exposure (2–3 days) to observe and provide tentative solutions on society/environment/health/other issues	Industrial exposure: 15h Problem identification and tentative solution: 10h **Total: 25h**	Based on evaluation of critical problems and proposed solutions.

Sr. No	Name of the Activity	No. of Hours	Evaluation Criteria
12	Group discussion on emerging/trending technical topics based on subject	Duration: **1h each**	Based on performance in group discussion, technical depth, and knowledge.
13	Real world case studies based learning	Data collection/study: 5h Report preparation: 5h **Total: 10h**	Based on in-depth study, technical depth, data collected, and fact finding.
14	Application/Software development	Duration: **10h**	Depending on the complexity of the Application/Software developed.
15	Expert lecture/session	Duration: 2h Attendance: 2h Report writing: 2h **Total: 4h**	Based on proof of attendance and report submitted.
16	Blog or Technical Article Writing	Research: 6h Writing: 4h **Total: 10h**	Based on originality, technical content, references cited, and clarity of communication.
17	Annotated Video Explanation of Concept/Problem	Preparation + Recording + Submission: **10h**	Based on accuracy of explanation, clarity, and presentation style.
18	Online Technical Quizzes/Simulations	Multiple quizzes totaling **10h**	Based on quiz scores and reflection report after each quiz.
19	Tech Blog/YouTube Channel Curation	Content curation + Analysis: **10h**	Summary report on curated content and learning outcomes.
20	Patent Search and Innovation Gap Identification	Search + Report: **10h**	Based on number of relevant patents analyzed and identification of innovation scope.
21	Maintenance or Troubleshooting Logbook	Example: lab instruments, computer hardware — **10h**	Based on documented cases, approach, and resolution.

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