Gyanmanjari Innovative University

Course Syllabus
Gyanmanjari Institute of Technology
Semester-6

Subject: Control System Theory -BETEE16322

Type of course: Professional Core

Prerequisite: Knowledge of mathematics and basic signals and systems.

Rationale: The course provides students with analytical and design skills for modern automation and regulation systems. It focuses on modeling, analysis, and controller design using classical and state-space methods. Students learn to represent physical systems mathematically and evaluate their stability and performance. The course emphasizes the role of feedback in achieving accuracy and system stability.
It bridges theoretical understanding with practical implementation using simulation tools.
Students gain the ability to design efficient and reliable controllers for real-world problems.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
CI	T	P	C	Theory Marks		Practical Marks		CA	
				ESE	MSE	V	P	ALA	
4	0	2	5	60	30	10	20	30	150

Legends: CI-Classroom Instructions; T – Tutorial; P - Practical; C – Credit; ESE - End Semester Examination; MSE- Mid Semester Examination; V – Viva; CA - Continuous Assessment; ALA- Active Learning Activities.

Course Content:

Unit No.	Course content	Hrs	% Weight age
1	**Introduction:** Concept of control system. Classification of control systems - Open loop and closed loop control systems, Differences, Examples of open loop and closed loop control systems, Feedback, Types of feedback, Effects of feedback.	10	15%

	Mathematical Modeling: Differential equation model, Transfer function model, Translational and rotational mechanical, electrical Analogies of Mechanical systems: Force voltage and force current analogy **Transfer Function Representation:** Transfer function concept,Block diagram Reduction Techniques, Transfer function from Block Diagrams, Signal flow graphs (SFG) - Mason's gain formula		
2	**Time Response Analysis:** Transient Response,Steady State Response,Standard test signals,First order System :Step, Ramp, Impulse and Parabolic Response.Second order System:Characteristic Equation.step Response.Impulse Response, Time domain specifications, Steady state response, Steady state errors and error constants.Proportional Derivative(PD).Proportional Integral(PI),PID controller .	12	20%
3	**Stability Analysis in S-Domain:** The concept of stability – Routh-Hurwitz's stability criterion – Absolutely,Conditionally and Marginally stability. Limitations of Routh-Hurwitz's stability. **Root Locus Technique:** Concept of root locus - Construction of root locus, Effects of adding poles and zeros to G(s) H(s) on the root loci.	12	20%
4	**Frequency Response Analysis:** Introduction, Frequency domain specifications, Bode plot diagrams-Determination of Phase margin and Gain margin, Stability analysis from Bode plots, Polar plots, Nyquist Plot and Stability Criteria.	12	20%
5	**State Space Analysis of Continuous Systems:** Concepts of state, state variables, and state model, State Space Model from Differential Equation,State Space Model from Transfer Function,Transfer Function from State Space Model,Concepts of Controllability and Observability.	14	25%

Continuous Assessment:

Sr. No	Active Learning Activities	Marks
1	**Simulation-Based Learning:** Students shall identify one real-time application each of open-loop and closed-loop control systems, draw and explain the function of all blocks (controller, actuator, process, sensor, and feedback), and discuss the effect of feedback on system performance in terms of stability, accuracy, and error reduction. The completed report should be uploaded to the GMIU Web Portal.	10
2	**Technical Presentation:** Each student/group will study a real-world control system such as cruise control, robotic arm, or automatic temperature control. They will identify control strategies, sensors/actuators used, and stability criteria applied.	10

	Upload the PPT to the GMIU Web portal.	
3	**Mini Project:** Students will design and simulate a small control project (e.g., DC motor speed control) using MATLAB/Simulink or a hardware setup in a group of 3. They will prepare a report and explain the results and controller design approach. Upload the report to the GMIU Web portal.	10
	Total	30

Suggested Specification table with Marks (Theory):60

Distribution of Theory Marks (Revised Bloom's Taxonomy)						
Level	Remembrance (R)	Understanding (U)	Application (A)	Analyze (N)	Evaluate (E)	Create (C)
Weightage	20%	30%	15%	10%	20%	05%

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 the above table.

Course Outcome:

After learning the course, the students should be able to:	
CO1	Understand control systems, model them mathematically, apply mechanical-electrical analogies, and analyze systems using block diagrams and signal flow graphs.
CO2	Analyze time response and steady-state errors using PID controllers.
CO3	Determine system stability using Routh-Hurwitz and Root Locus techniques.
CO4	Evaluate frequency response and stability using Bode and Nyquist plots.
CO5	Develop and analyze state-space models for control systems.

List of Practical:

Sr. No.	Description	Unit No.	Hrs
1	Implement the block diagram reduction technique to obtain the transfer function of a control system.	1	2
2	Implement a signal flow graph to obtain the transfer function of a control system.	1	2
3	Simulation of poles and zeros of a transfer function.	1	2
4	Implement the time response specification of a second-order underdamped system for different damping factors.	2	2

5	Implement PI and PD controllers.	2	2
6	Implement a PID controller and realize an error detector.	2	2
7	Demonstrate the effect of PI, PD, and PID controllers on the system response	2	2
8	Analyse the stability of the given system using the Routh stability criterion.	3	2
9	Analyse the stability of the given system using root locus.	3	2
10	Analyse the stability of the given system using Bode plots.	4	2
11	Analyse the stability of the given system using the Nyquist plot.	4	2
12	Implement the frequency response of a second-order system.	4	2
13	Implement the frequency response of a lead-lag compensator.	4	2
14	Obtain the time response from the state model of a system.	5	4
	Total		30

Instructional Method:

The course delivery method will depend on the content requirements and the students' needs. The teacher, in addition to conventional teaching methods using the blackboard, may also use various tools such as demonstrations, role-playing, Quizzes, brainstorming, and MOOCs.

From the content, 10% topics are suggested for flipped mode instruction.

Students will use supplementary resources such as online videos, NPTEL/SWAYAM videos, e-courses, and Virtual Laboratory

The internal evaluation will be done based on the Active Learning Assignment.

Practical/Viva examination will be conducted at the end of the semester for the evaluation of the performance of students in the laboratory.

Reference Books:

[1] Control Systems Engineering - I. J. Nagrath and M. Gopal, New Age International (P) Limited
[2] K. Ogata, Modern Control Engineering. New Delhi, India: PHI Learning.
[3] B. C. Kuo, Automatic Control Systems. New Delhi, India: Wiley India Pvt. Ltd.
[4] Control Systems Theory and Applications - S. K. Bhattacharya, Pearson.
[5] Control Systems Engineering - S. Palani, TMH.
[6] Control Systems - N. K. Sinha, New Age International (P) Limited Publishers.
[7] Control Systems by S.Hasan Saeed, KATSON BOOKS.