Course Syllabus
Gyanmanjari Institute of Technology
Semester-6 (B. Tech)

Subject: Simulation of Mechanical Systems-BETME16328

Type of course: Skill Based Courses

Prerequisite: Mathematics, Solid Mechanics, Solar Thermal Systems

Rationale: The course aims to develop mathematical and block diagram models of mechanical and physical systems and apply simulation tools to analyze dynamic behavior. It focuses on system stability, transient and steady-state response, while introducing automation systems such as hydraulics, pneumatics, and PLCs to build industry-relevant simulation and problem-solving skills.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks					Total Marks
				Theory Marks		Practical Marks		CA	
CI	T	P	C	ESE	MSE	V	P	ALA	
-	-	4	2	-	-	10	40	50	100

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
1	**System Modeling and Simulation** Introduction to mechanical and physical systems. Development of mathematical models and block diagrams of physical systems (e.g., toaster system, Watt governor, spring–mass–damper system). Introduction to simulation software such as MATLAB/Simulink and LABVIEW. Basics of system modeling using simulation tools.
2	**Time Response and Stability Analysis** Simulation of linear systems for standard inputs (step, ramp, impulse). Analysis of transient and steady-state response. Performance evaluation of first and second order systems. Stability analysis using pole–zero plots and root locus simulation.
3	**Mechanical System Simulation** Introduction to hydraulic trainer systems and hydraulic simulation software. Modeling and performance analysis of basic hydraulic circuits. Introduction to solar thermal systems, components, and working principles. Simulation and performance evaluation of simple solar thermal systems such as solar water heaters and solar collectors.
4	**Automation and Industrial Applications** Introduction to Programmable Logic Controllers (PLC). PLC hardware components and operating principles. Basics of ladder diagrams. Development of simple ladder logic programs for industrial and energy-related automation applications.

Continuous Assessment:

Sr. No	Active Learning Activities	Marks
1	**System Modeling** Students will model a given mechanical or physical system (such as a toaster, electric iron, ceiling fan, or water tank system) by developing its mathematical model and block diagram using MATLAB/Simulink. Students will generate simulation results and upload the model file and screenshots on the GMIU web portal.	10
2	**Time Response Simulation** Students will demonstrate the time response characteristics of a predefined system by simulating step, ramp, and impulse inputs using MATLAB. Students will generate response plots, calculate performance parameters, and upload the results on the GMIU web portal.	10
3	**Stability Analysis** Students will analyze stability for a given transfer function by plotting the pole–zero map and root locus using MATLAB. Students will interpret the stability of the system and upload the plots and observations on the GMIU web portal.	10

4	**Simulation of Solar Thermal System** Students will simulate a solar thermal system (such as a solar water heater or solar collector) by developing a basic model using MATLAB. Students will analyze system performance for given input conditions and upload the simulation results on the GMIU web portal.	10
5	**PLC Logic Representation** Students will create an automation logic for an industrial or energy-related application by developing a basic PLC ladder logic using MATLAB. Students will simulate the control sequence and upload the ladder logic model and explanation on the GMIU web portal.	10
	Total	50

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	-	-	-	-	-	-

Course Outcome:

After learning the course, the students should be able to:	
CO1	Develop mathematical and block diagram models of mechanical and physical systems using appropriate simulation tools.
CO2	Simulate and analyze time response characteristics of linear systems and evaluate system stability using modern simulation software.
CO3	Model and simulate mechanical systems including hydraulic and solar thermal systems and evaluate their performance under different operating conditions.
CO4	Apply basic automation concepts by developing simple PLC ladder logic programs for industrial and energy-related applications.

List of Practical:

Sr. No	Descriptions	Unit No	Hrs.
1	Development of mathematical model and block diagram of a given mechanical or physical system.	1	4
2	Simulation of a mechanical system model using MATLAB/Simulink or LABVIEW and verification of system behavior.	1	6
3	Time response analysis of a first-order system for standard test inputs (step, ramp, impulse) using simulation software.	2	4
4	Time response analysis of a second-order system and evaluation of performance parameters such as rise time, peak time, overshoot, and settling time.	2	6
5	Stability analysis of a given system using pole–zero plot through simulation software.	2	6
6	Root locus simulation of a linear control system and interpretation of system stability.	2	6
7	Simulation and performance analysis of a basic hydraulic circuit using hydraulic trainer or simulation software.	3	6
8	Modeling and simulation of a solar thermal system such as a solar water heater using appropriate simulation tools.	3	6
9	Performance evaluation of a solar thermal collector system under varying operating conditions using simulation.	3	6
10	Introduction to PLC hardware and identification of PLC components using PLC trainer kit or software.	4	4
11	Development of basic PLC ladder logic programs for industrial or energy-related automation applications.	4	6
		Total	60

Instructional Method:

The course delivery method will depend upon the requirement of content and need of students. The teacher in addition to conventional teaching method by black board, may also use any of tools such as demonstration, role play, Quiz, brainstorming, MOOCs etc.

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

The internal evaluation will be done on the basis of Active Learning Assignment

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

Reference Books:

[1] "Modern Control Theory" by Katsuhiko Ogata, Pearson Education International, Fifth edition.

[2] "Control System Engineering" by Norman S Nise, John Wiley & Sons, Inc., Sixth edition.

[3] "Modern Control Systems" by Richard C. Dorf, Robert H Bishop, Pearson Education International, Twelfth edition.

[4] "Automatic Control Systems" by Farid Golnaraghi, Benjamin C Kuo, John Wiley & Sons, Inc., Nineth edition.

[5] "Control System Engineering" by J.Nagrath and M.Gopal, New Age International Publishers, 5th Edition, 2007.