Course Type	Course Code	Name of Course	L	T	P	Credit
DP	NMEC533	Control Systems Lab	0	0	3	1.5

Course Objective

- The course aims to provide hands-on experience and a practical understanding of the principles and applications of mechanical control systems. This typically involves studying the behavior of various mechanical systems, such as motors, actuators, and sensors, and learning how to design, analyze, and control these systems using different techniques and tools.

Learning Outcomes

On successful completion of this course, students will:

- Understand the principles of mechanical control systems.
- Gain proficiency in designing and analyzing control systems for mechanical systems such as fluid power systems, and pneumatic systems.
- Learn to implement and test control algorithms using software tools and hardware setups.
- Enhance problem-solving skills related to mechanical control systems.
- Improve teamwork and communication skills through group projects and presentations.

Exp. No.	Topics to be Covered	Contact Hours	Learning Outcome
1.	To design and develop a feedback-controlled hydraulic system using a proximity switch.	3	Students will learn to design and develop a feedback-controlled hydraulic system using a proximity switch. The characteristics and responses of the feedback control will be analyzed.
2.	To design and develop a hydraulic sequential system using a pressure switch.	3	Students will learn to set up a hydraulic sequential circuit which will be controlled using pressure switches.
3.	To investigate the response and performance characteristics of a proportional valve-controlled open-loop hydraulic actuator system.	3	Students will learn to set up a proportional valve-controlled open-loop hydraulic actuator system. They will get familiarized with the techniques for analyzing the performance behaviour of a proportional valve-controlled hydraulic actuator system in an open-loop configuration.
4.	To investigate the response and performance characteristics of a PID-controlled closed-loop hydraulic actuator system.	3	Students will get to understand and analyze the behavior of a hydraulic actuator system when controlled using a PID (Proportional-Integral-Derivative) controller in a closed-loop configuration.
5.	To design a control system using an electromagnetic suspension acting on a solid one-inch steel ball to stabilize in mid-air and track the ball position to a desired trajectory.	3	Students will learn to tune controller parameters to track the ball position to a desired trajectory.
6.	To control a twin rotor multi-input-multi-output (MIMO) system with a significant cross-coupling between two rotors.	3	Students will learn a model-based study of the cross-coupling effect between the two rotors. They will be skilled in gain tuning the PID controller to track the different desired trajectories given to both rotors.

7.	Modeling and control of a rotary inverted pendulum by tuning a swing-up control system.	3	Students will get familiarized with the experimental determination of the Model Parameters, i.e., system identification. They will learn to design controllers that balance the pendulum upright by rotating or changing the angle at the base.
8.	Modeling and control of the water flow rate of a coupled tank system in both SISO and MIMO configurations.	3	Students will learn to track a specified trajectory for the water level in the top tank (i.e., tank-1) based on the applied voltage to the pump. They will also be able to track a specified trajectory for the water level in the bottom tank (i.e., tank-2) using the water flow discharged from the top tank.
9.	To control the vertical movement of a quarter-car model mimicking the vehicle wheel using an actuator placed on the suspension axis.	3	This setup offers students unique, hands-on learning relevant present automotive industry and they will get familiarized with the techniques to do the performance analysis of the active suspension of a quarter car model using PID control.
10.	To study the pneumatic and electro-pneumatic components used for industrial automation and control.	3	Students will understand the construction of pneumatic control devices. They will get familiarized with the working of various pneumatic control devices.
11.	To design a pneumatic circuit for reciprocating a double-acting cylinder.	6	Students will be acquiring skills to rig up any pneumatic control circuit. They will be able to appreciate the functioning of these circuits and the various applications that are exposed during the experiment.
12.	To design an electro-pneumatic circuit for sequential operation of two single-acting cylinders.	6	Students will be acquiring the skill to rig up an industrial automation/control circuit using pneumatic actuators, valves, and switches fitted with low-power electronic sensors and/or solenoids, i.e., electro-pneumatic components.
Total		42	

Text Books:

1. Ogata, K., & Yang, Y. (2002). Modern Control Engineering (Vol. 5). Prentice Hall (Pearson Education India).
2. Nise, N. S. (2020). Control Systems Engineering. John Wiley & Sons.

Reference Books:

1. Pinches, M. J., & Ashby, J. G. (1988). Power Hydraulics. Prentice Hall.