Control Systems Lab:

Control Systems Lab in Electrical Engineering Department, IIT(BHU) has been established to contribute to the development of various area of control theory. Control System Lab exposes students & industry professional to study the fundamentals of Control System. Studies include how one device can be used to manage, command, direct, or regulate the behaviour of a System Open Loop & Close Loop Control. The feedback automatic control systems are an essential feature of numerous industrial processes, scientific instruments. A thorough understanding of the elementary principles of this all-embracing technology is of great relevance for all engineers and scientists. This laboratory course gives hands-on experience to the feedback automatic control concepts covered in the theory course.

The Control System lab encompasses the undergraduate and post graduate teaching lab and lab for the M. Tech. and Ph. D. research work. The activities and facilities in the control system lab involve the following:

Facilities:

Simulation Software:

- MATLAB: Release 2017a
- NI LabVIEW 2013

Hardware:

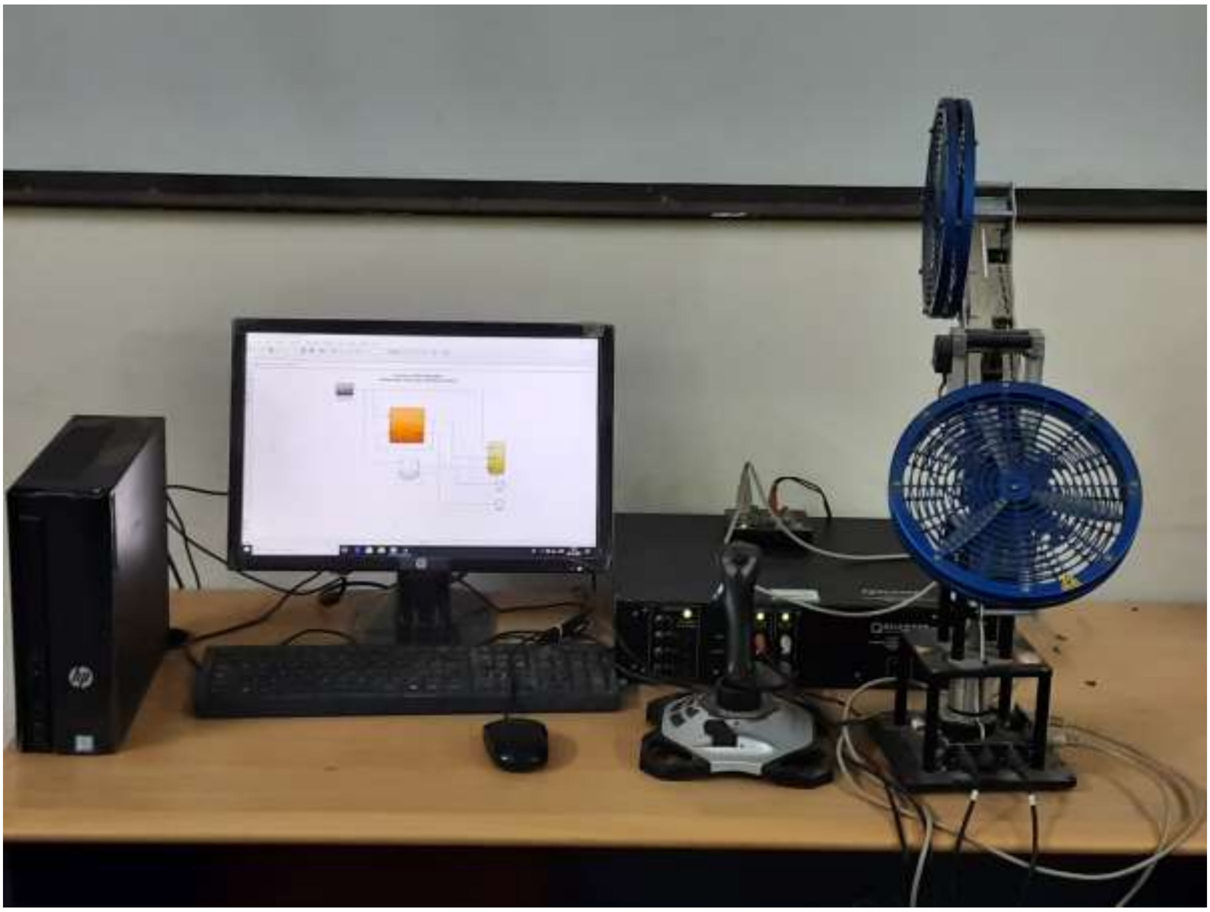
1. **Undergraduate and Postgraduate course lab:** The lab facilitates the set-up of equipment and other associated devices for experiments in the syllabus for second, third and fourth year of B.Tech. students, second, third, fourth and fifth year of IDD students and first year of master's students. The following experimental set-ups are there for UG and PG courses.

    1) PID Controller Trainer.
    2) Potentiometric error detector.
    3) Linear System Simulator.
    4) AC Servo Motor Control.
    5) Study of Synchro Devices.
    6) Transfer Function model of DC Motor.
    7) Relay Control System Trainer.
    8) Stepper Motor Control.
    9) DC Motor Speed Control.
    10) DC Motor Position Control.
    11) Digital Control System Trainer.
    12) Compensating Device Trainer.

2. **Thrust Research Areas:** In the power electronics lab, the following are the prominent ongoing research areas.
    1) Model Order Reduction and its application

2) Robust nonlinear and adaptive control theory
3) Event based controller design techniques
4) DFIG Controller design for WECS
5) Decentralized Control
6) Time-delay systems
7) Network control systems
8) Lyapunov based non-smooth controller design and its applications
9) Fractional order systems
10) Sliding mode control (continuous and discrete)
11) Contraction analysis
12) Mathematical Biology

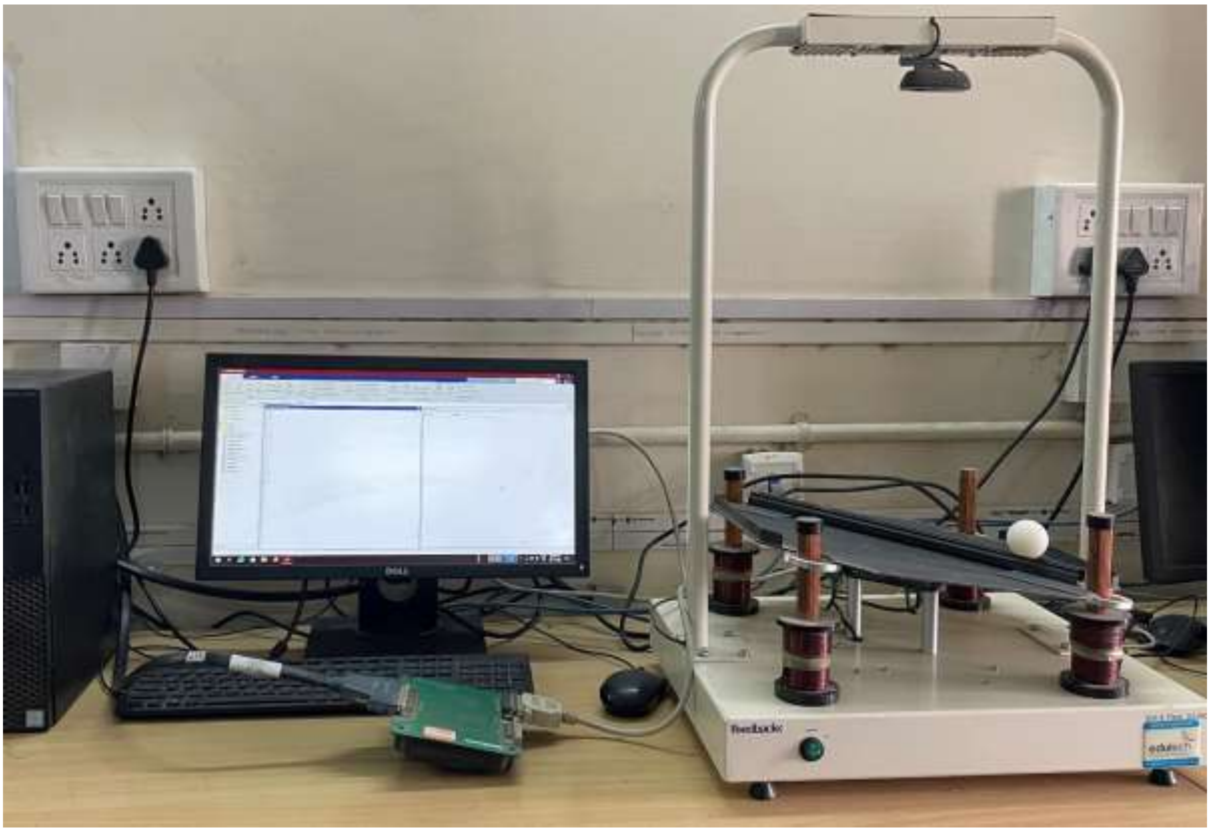
2 DOF Helicopter



The 2 DOF Helicopter experiment provides an economical testbed to understand and develop control laws for vehicles with dynamics representative of a tethered rigid body helicopter, spacecraft or underwater vehicle. The 2 DOF Helicopter experiment consists of a helicopter model mounted on a fixed base with two propellers that are driven by DC motors. The front propeller controls the elevation of the helicopter nose about the pitch axis, and the back propeller controls the side-to-side motions of the helicopter about the yaw axis. The pitch and yaw angles are measured using high-resolution encoders. The pitch encoder and motor signals are transmitted via a slip ring. This eliminates

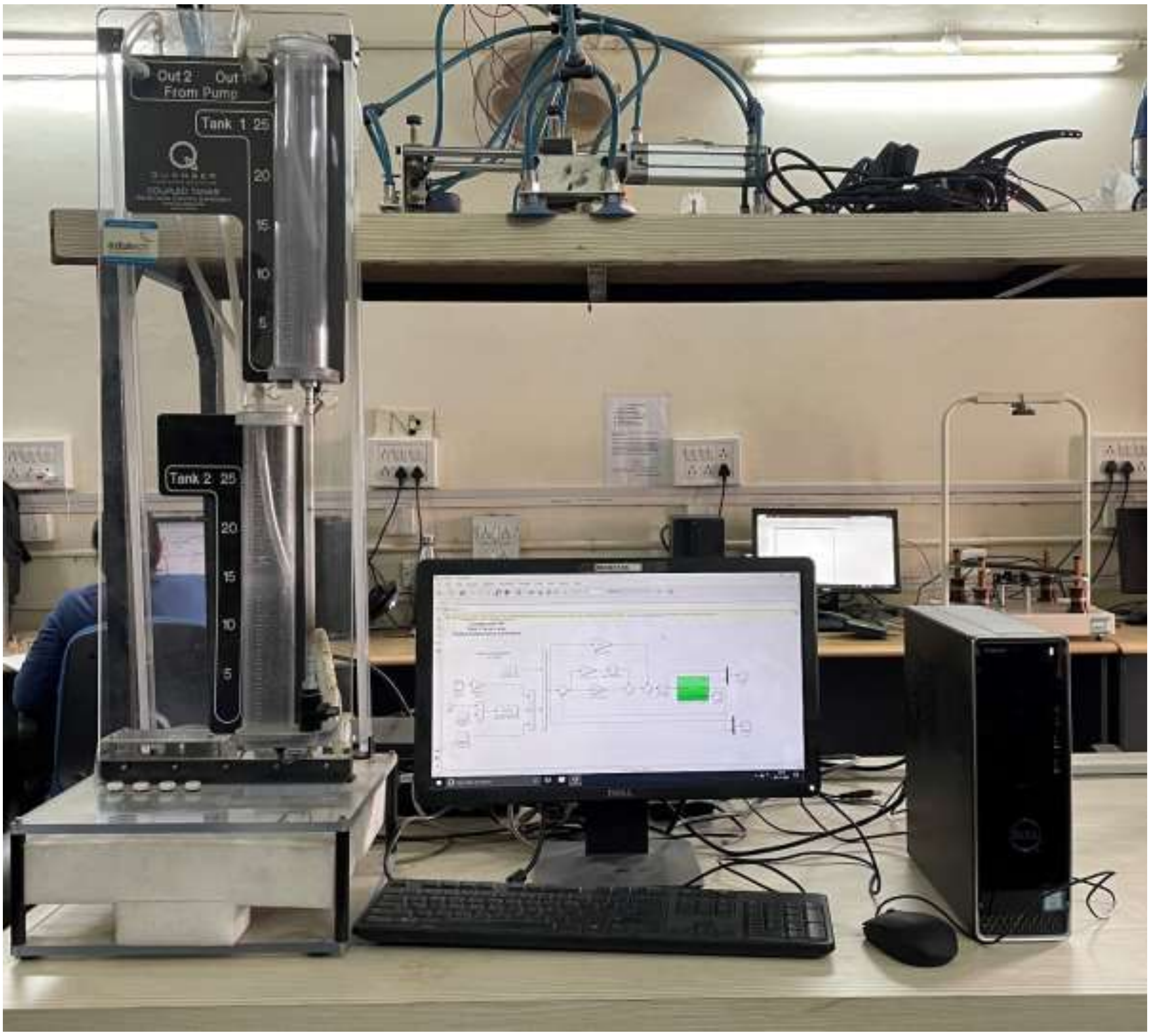
the possibility of wires tangling on the yaw axis and allows the yaw angle to rotate freely about 360 degrees. A state-feedback controller is designed to regulate the elevation and travel angles of the 2 DOF Helicopter to desired positions. The feed-forward control compensates for the gravitational torque that forces the pitch angle down.

Ball and Beam System



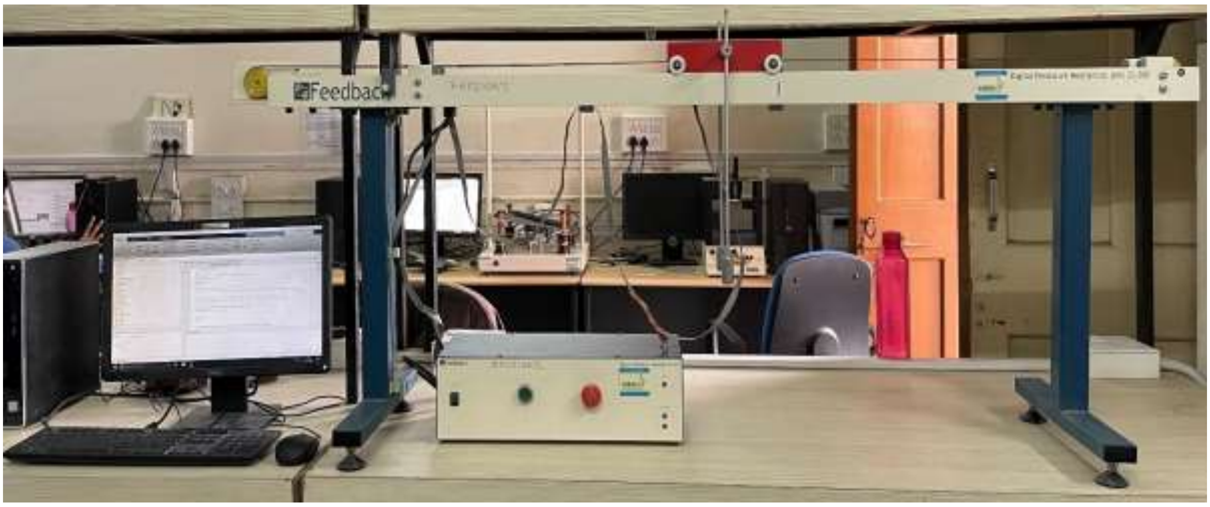
The ball and beam system is a classic dynamic system used to illustrate control. It is inherently non-linear and unstable. Despite its simple nature, the cascaded dynamics of the system (with 3/4 integrators and interconnection between rotational and translation subsystems) are very similar to planar control of rockets. A ball is placed on a beam, where it is allowed to roll with 1 degree of freedom along the length of the beam. A lever arm is attached to the beam at one end and a servo gear at the other. As the servo gear turns by an angle, the lever changes the angle of the beam. When the angle is changed from the horizontal position, gravity causes the ball to roll along the beam. A controller will be designed for this system so that the ball's position can be manipulated. Even if the beam is restricted to be very nearly horizontal, without active feedback, it will swing to one side or the other, and the ball will roll off the end of the beam. To stabilize the ball, a control system that measures the position of the ball and adjusts the beam accordingly must be used.

Coupled Tank System



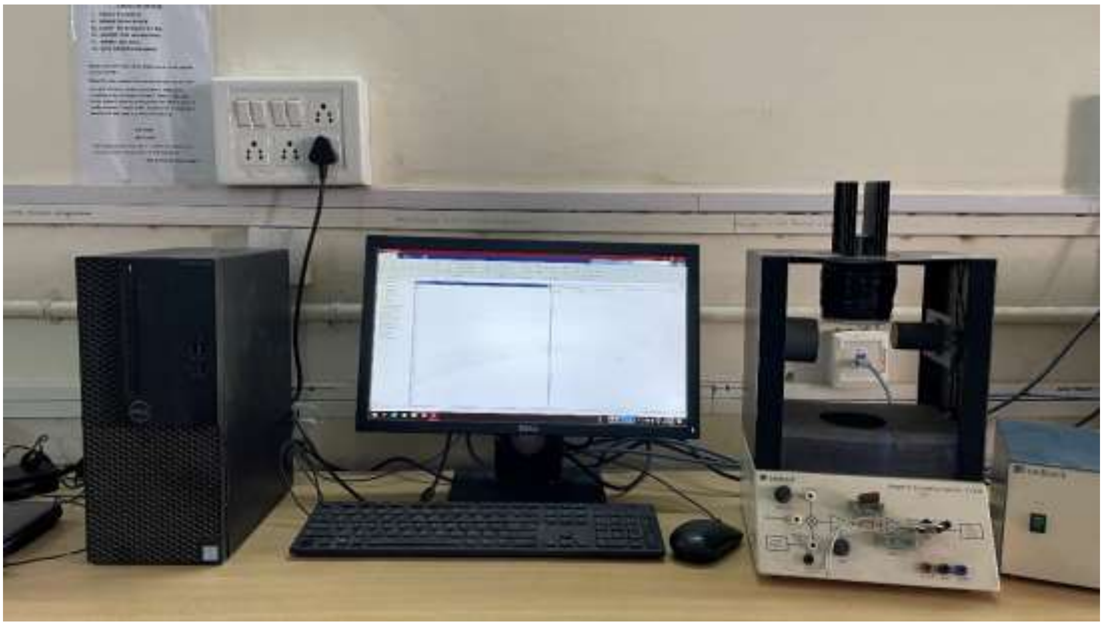
The Coupled Tanks plant is a "Two-Tank" module consisting of a pump with a water basin and two tanks. The two tanks are mounted on the front plate such that flow from the first (i.e., upper) tank can flow through an outlet orifice located at the bottom of the tank into the second (i.e., lower) tank. Flow from the second tank flows into the main water reservoir. In the present laboratory, the Coupled-Tank system is used in two different configurations, namely configuration one and configuration 2. In configuration 1, the objective is to control the water level in the top tank, i.e., tank 1, using the outflow from the pump. In configuration 2, the challenge is to maintain the water level in the bottom tank, i.e., tank 2, from the water flow coming out of the top tank. Configuration 2 is an example of state coupled system. This experimental setup helps to apply the developed control theory in real-time.

Inverted Pendulum on Cart



The Inverted Pendulum system setup provides a platform to test the developed control laws in real-time. The cart is equipped with a rotary metal shaft to which a free-turning pendulum can be attached. The Linear Servo Base Unit system has two encoders: one used to measure the cart's position and the other used to sense the position of the pendulum shaft.
A real-world example that relates directly to this inverted pendulum system is the attitude control of a booster rocket at take-off. The dynamics of the Segway self-balancing electric vehicle are also like the classic control problem of the inverted pendulum.

Magnetic levitation System

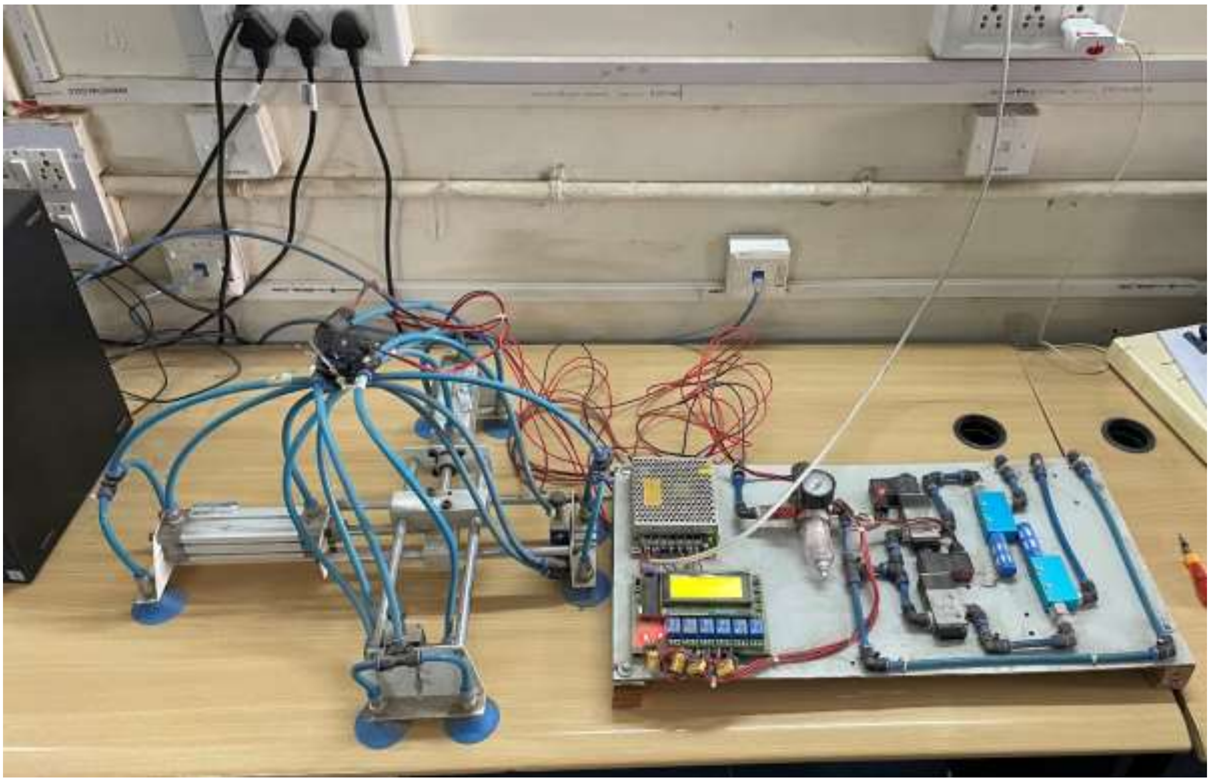


The Magnetic levitation system is used to experiment on the concept of maglev. It is a method by which an object (metal ball in our case) is suspended with no support other than magnetic force fields. The idea behind the application is to provide contactless levitation to reduce the effect of wear and tear, hence increasing the life and efficiency of the system. The magnetic levitation system is non-linear and unstable. Thus, the various linear and non-linear control strategies are used to perform the stable operation.

Rob master set up

The Rob master set up with four Mecanum wheels allows the robot to move in all directions. Connected motors provide wheel motions as well as free sliding motion by 12 rollers on the wheel. This model is used as a testbench to apply different developed control strategies. Experimental applications are vision-based control, path tracking, obstacle avoidance, picking and placing objects with colour detection.

Wall Climbing Robot



In this project, a prototype of a wall-climbing robot is developed. The user has to enter the dimension in terms of the X-axis and Y-axis. They are considering the fence as a two-dimensional Cartesian coordinate system (shown on 20*4 LCD). After entering the dimension, once the user presses the start button robot will begin its journey towards the destination. The robot will first climb in the direction of the Y-axis, then for the X-axis. The current position of the robot is also displayed on LCD simultaneously as the robot is moving. After reaching the destination, the robot will perform the required task.