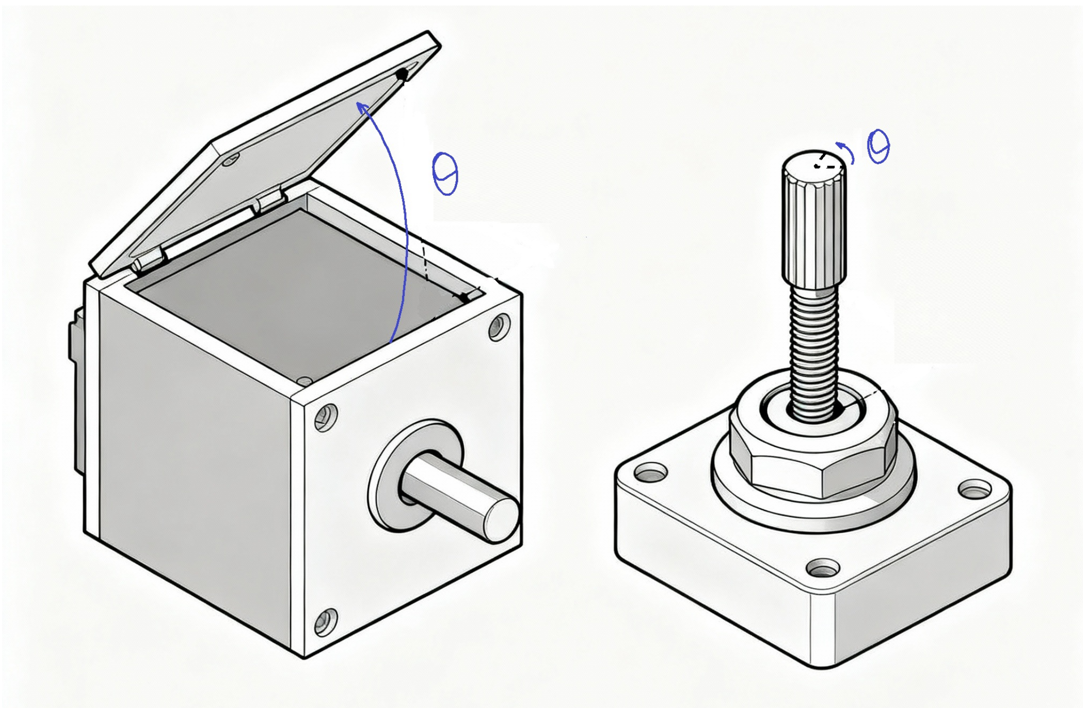
Module-04:
Position Control of a DC Motor Using PID Controller

In this module, we redesign the dustbin system introduced in Module 02. The new design incorporates a DC motor to open and close the lid, controlled by a potentiometer that sets the lid's angle of opening. The objectives of this module are as follows:

Objectives:

Design and implement a dustbin system integrating:

- A potentiometer to set and control the opening and closing angle of the dustbin lid.
- A DC motor, driven via a motor driver (e.g., L293D), to actuate the lid's movement.
- Define θ as the angular displacement of the lid, i.e., the angle by which the lid opens. The angle of opening of the lid and the angle of rotation of the potentiometer must be same.
- Add a reset switch that closes the lid.



Report Guidelines:

1. State the experimental objectives clearly.
2. Provide neatly drawn circuit and block diagrams illustrating all connections and signal flows.
3. Include a flowchart or pseudocode describing the implemented control algorithm.
4. Present key observations and clearly labeled screenshots or plots, including:
   - Serial monitor/plotter outputs demonstrating the effects of varying controller gains:
     - Effect of K_P with $K_I = K_D = 0$.
     - Effect of K_I with $K_P = K_D = 0$.
     - Effect of K_D with $K_P = K_I = 0$.
     - Performance of the final tuned system with all gains (include settling bands if possible).
   - Raw and filtered encoder signal data with corresponding plots.
5. Provide comprehensive answers to the following technical questions:

Report Guidelines:

1. Experimental objectives
2. Neatly drawn circuit and block diagrams showing all connections and signal flow
3. Flowchart or pseudo code for the implemented control algorithm
4. Key observations and screenshots/plots clearly labeled, including:
   - Serial monitor/plotter outputs for various controller settings:
     - Impact of K_P ($K_I = K_D = 0$)
     - Impact of K_I ($K_P = K_D = 0$)
     - Impact of K_D ($K_P = K_I = 0$)
     - Final tuned system performance with all gains (`show settling bands if possible`)
   - Raw and filtered encoder signals (with plots)
5. Clear answers to the following technical questions

Answer the following:

1. Draw and explain the block diagram of your closed-loop control system. Identify the setpoint and explain how feedback is incorporated.

2. Why is closed-loop (feedback) control necessary in this application? Why would open-loop PWM control be insufficient?

3. How is the angular position of the DC motor controlled in this system?

4. What is the relationship between the DC motor shaft's angle of rotation and the lid's angle of opening?

5. Based on the DC motor discussion in EE250, what is the expected order of the motor's transfer function? Sketch an approximate root locus for the motor.

6. Describe the analytical PID tuning approach employed—whether closed-loop Ziegler-Nichols or trial-and-error—and justify your choice.

7. Explain the effect of increasing each PID gain individually (K_P, K_I, K_D) using time-domain results as well as control theory concepts.

OBSERVATION SHEET - MODULE 4

`This sheet must be attached to the report (print on both sides).`

1. Demonstrate the system operation using the analytically designed PID controller.

TA Signature with Date:

2. Demonstrate the system operation using the PID controller designed via the MATLAB PID Tuner.

TA Signature with Date:

3. Show output plots for different values of K_P, keeping $K_I = K_D = 0$. Confirm screenshots were taken (Attach with report).

TA Signature with Date:

4. Show output plots for increasing K_I with $K_P = K_D = 0$ (Attach with report).

TA Signature with Date:

5. Show output plots for increasing K_D with $K_P = K_I = 0$ (Attach with report).

TA Signature with Date: