Lab: Practical Demonstration of P, I, and PI Controllers

Objective:
To comprehend and compare the functionalities of P-Controller, I-Controller, and PI-Controller through MATLAB and Simulink simulations using a second-order system.

Equipment:
- MATLAB software with Simulink
- Computer with adequate processing capabilities

System Description:
Utilize a second-order system, such as a mass-spring-damper system, represented by a transfer function G(s) = 1/(s^2 + 2s + 1). This system mimics physical elements like a mass (inertia), spring (elasticity), and damper (damping). The system provides an appropriate platform to analyze the controller behaviors.

Setup:

Part 1: P-Controller
1. **Modeling:**
   - Construct a Simulink model integrating the second-order system with a P-Controller.
   - Apply a step input signal to the system.
   - Adjust the proportional gain (Kp) in the P-Controller.

2. **Simulation:**
   - Run simulations with varying Kp values.
   - Observe the system's response in terms of overshoot, settling time, and steady-state error.

3. **Observation:**
   - Analyze the impact of different Kp values on system response.
   - Note the trade-offs between overshoot reduction and steady-state error.

Part 2: I-Controller
1. **Modeling:**
   - Modify the Simulink model by including an integrator to create an I-Controller setup.

2. **Simulation:**
   - Apply the same step input signal to the system.
   - Experiment with different integral gain (Ki) values.
   - Run simulations and observe the system's response.

3. **Observation:**
   - Analyze the reduction in steady-state error with varying Ki values.
   - Note the impact on response time and any trade-offs observed.

Part 3: PI-Controller
1. **Modeling:**
   - Combine the P-Controller and I-Controller configurations to form a PI-Controller setup.

2. **Simulation:**
   - Utilize various combinations of Kp and Ki values.
   - Run simulations and observe the combined effects of proportional and integral actions.

3. **Observation:**
   - Analyze how the PI-Controller mitigates steady-state errors and response time trade-offs observed with the P and I-Controllers.

Conclusion:
- Summarize the distinct roles of proportional and integral actions in the P, I, and PI-Controllers.
- Discuss the combined effect of proportional and integral actions in addressing system responses and minimizing steady-state errors, based on the second-order system's behavior.