ANGSTROMERS INTERNSHIP

Project Report on

PID Control Systems: Design and Implementation Across Various Dynamic Systems

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Table of Contents

1. Introduction:

Brief Summary

This project explores PID control systems applied to various dynamic systems including Cruise Control, Motor Speed, Motor Position, Suspension, Inverted Pendulum, Aircraft Pitch, and Ball & Beam. It involves designing, implementing, and evaluating PID controllers using MATLAB to meet specific performance criteria.

Goals and Objectives

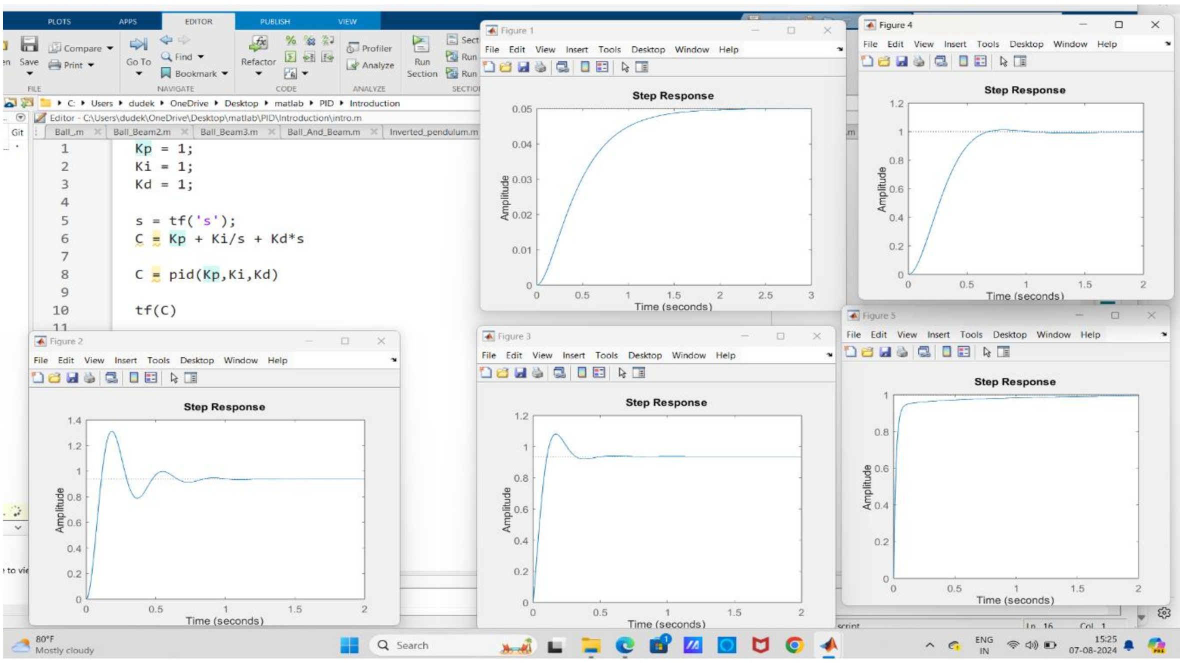
- **Design:** Develop PID controllers for diverse dynamic systems.
- **Implementation:** Simulate systems using MATLAB.
- **Evaluation:** Assess PID controller performance based on overshoot, settling time, and stability.

Boundaries and Extent

- **Scope:** Theoretical modeling and simulation.
- **Exclusions:** Physical implementation and real-time testing.

Context and Relevance

PID control is fundamental in control systems engineering. This project demonstrates its application and effectiveness in real-world scenarios.



2. Cruise Control:

Overview

Cruise control systems maintain a vehicle’s speed by adjusting the throttle based on speed error.

Objectives

- **Speed Maintenance:** Keep the vehicle's speed constant.
- **Performance Criteria:** Minimal overshoot and fast settling time.

Methods

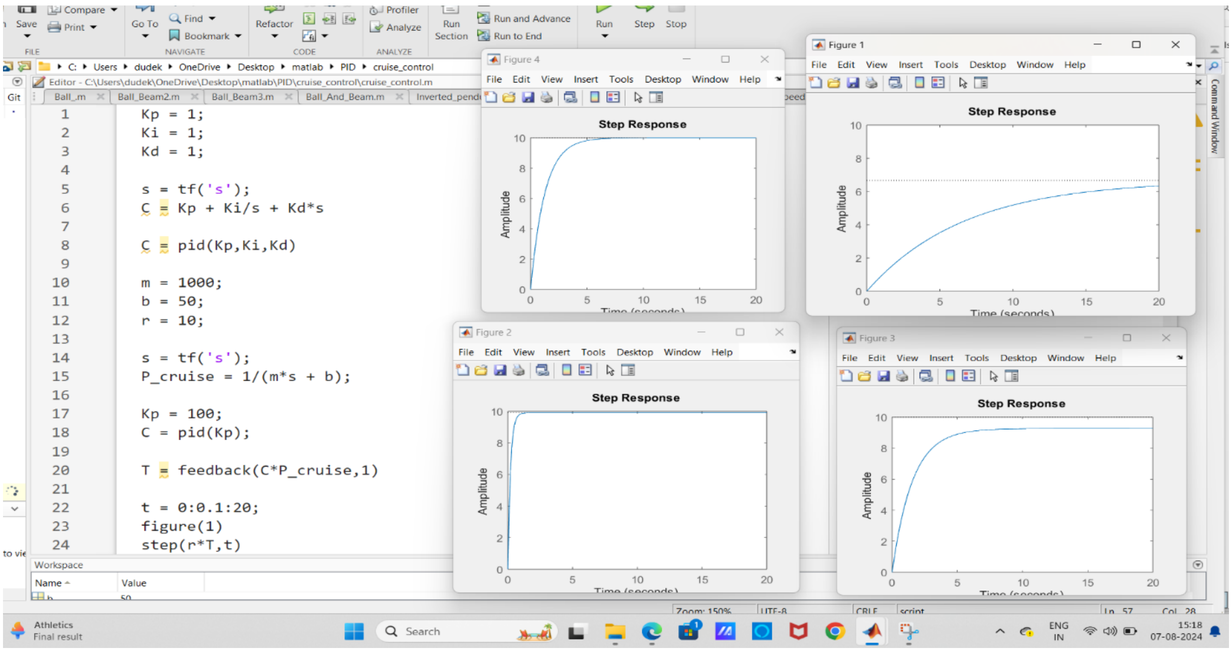
1. **Modelling:** Transfer function for speed control.
2. **PID Controller Design:** Implemented in MATLAB.
3. **Simulation:** Evaluated performance through simulations.

Results

- **Overshoot:** Minimal.
- **Settling Time:** Achieved quick stabilization.

Conclusions

PID control effectively maintained vehicle speed, meeting the performance criteria.



3. Motor Speed:

Overview

This section focuses on controlling the rotational speed of a DC motor.

Objectives

- **Speed Control:** Achieve precise speed control.
- **Error Reduction:** Minimize steady-state error.

Methods

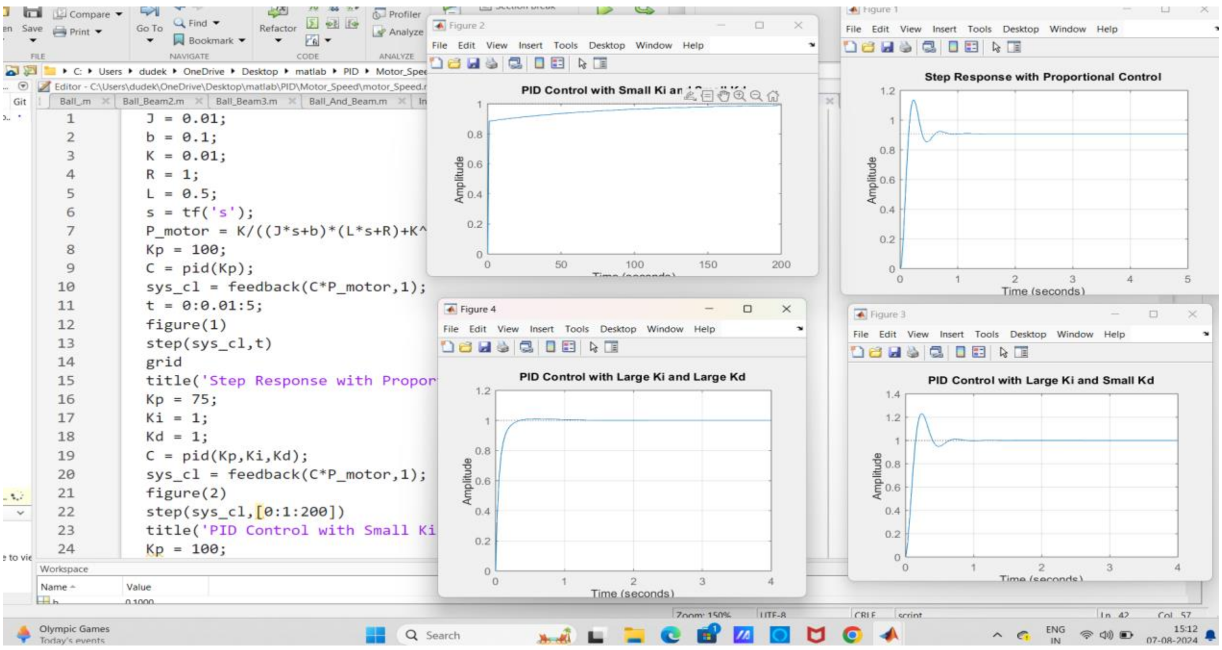
1. **Modelling:** DC motor speed model in MATLAB.
2. **PID Controller Design:** Tuning for speed control.
3. **Simulation:** Performance assessment.

Results

- **Accuracy:** Precise speed control.
- **Error:** Effective reduction in steady-state error.

Conclusions

PID control successfully managed motor speed with high accuracy and minimal error.



4. Motor Position:

Overview

Motor position control aims at accurate positioning of the motor shaft.

Objectives

- **Position Accuracy:** Exact positioning.
- **Overshoot Control:** Minimize overshoot.

Methods

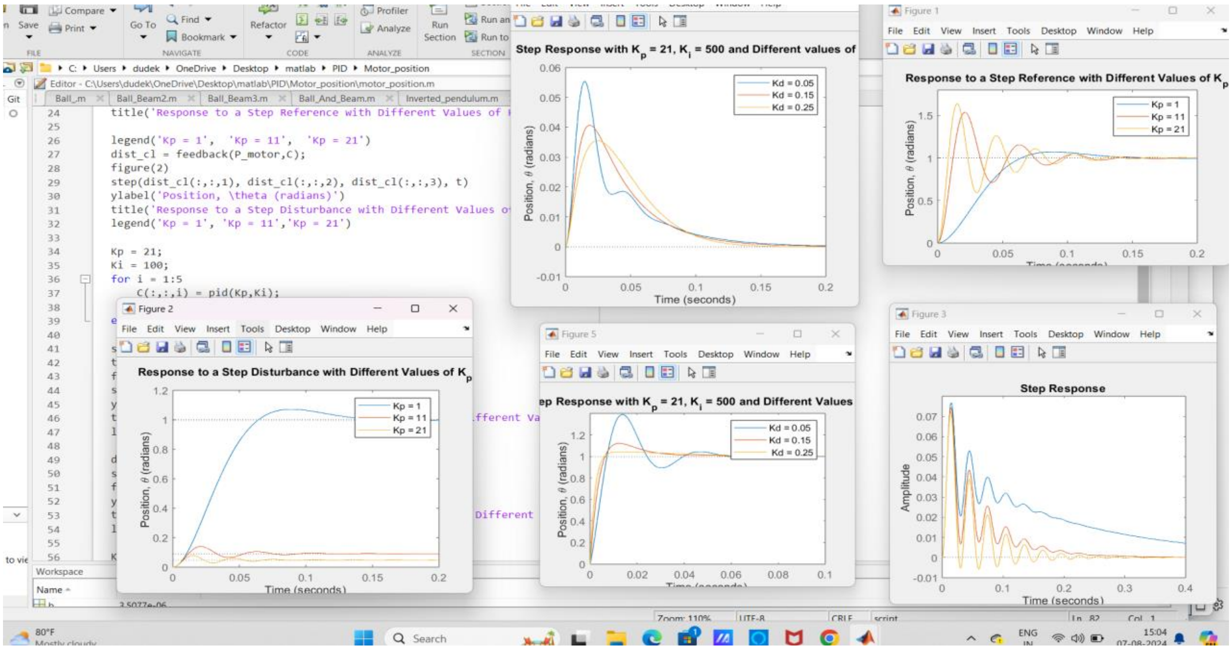
1. **Modelling:** Position control transfer function.
2. **PID Controller Design:** Applied and tuned in MATLAB.
3. **Simulation:** Analyzed system performance.

Results

- **Positioning:** Accurate control.
- **Overshoot:** Controlled to acceptable levels.

Conclusions

PID control achieved accurate motor positioning with minimal overshoot.



5. Suspension:

Overview

Suspension control improves ride comfort and vehicle handling.

Objectives

- **Ride Comfort:** Enhance vehicle ride quality.
- **Handling Improvement:** Improve vehicle handling.

Methods

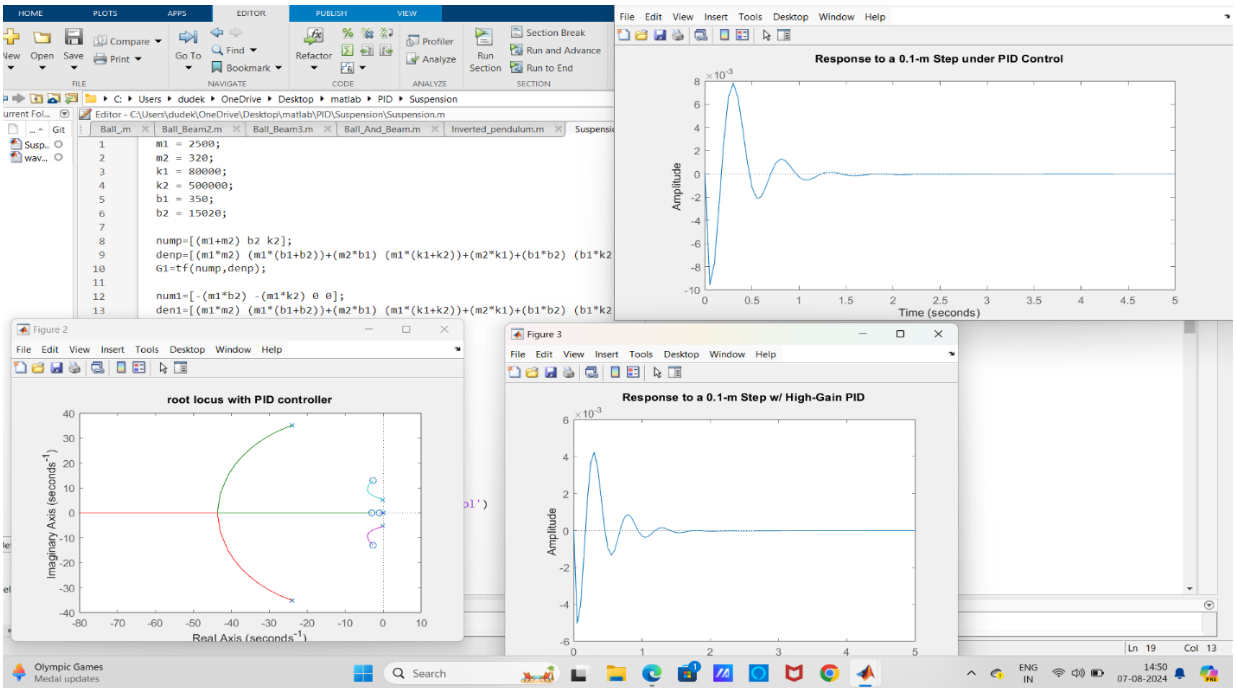
1. **Modelling:** Suspension system model.
2. **PID Controller Design:** Optimization for ride and handling.
3. **Simulation:** Performance evaluation.

Results

- **Comfort:** Enhanced.
- **Handling:** Improved.

Conclusions

PID control improved both ride comfort and handling.



6. Inverted Pendulum:

Overview

The inverted pendulum system aims to balance a pendulum upright on a cart.

Objectives

- **Stabilization:** Balance the pendulum.
- **Oscillation Minimization:** Reduce instability.

Methods

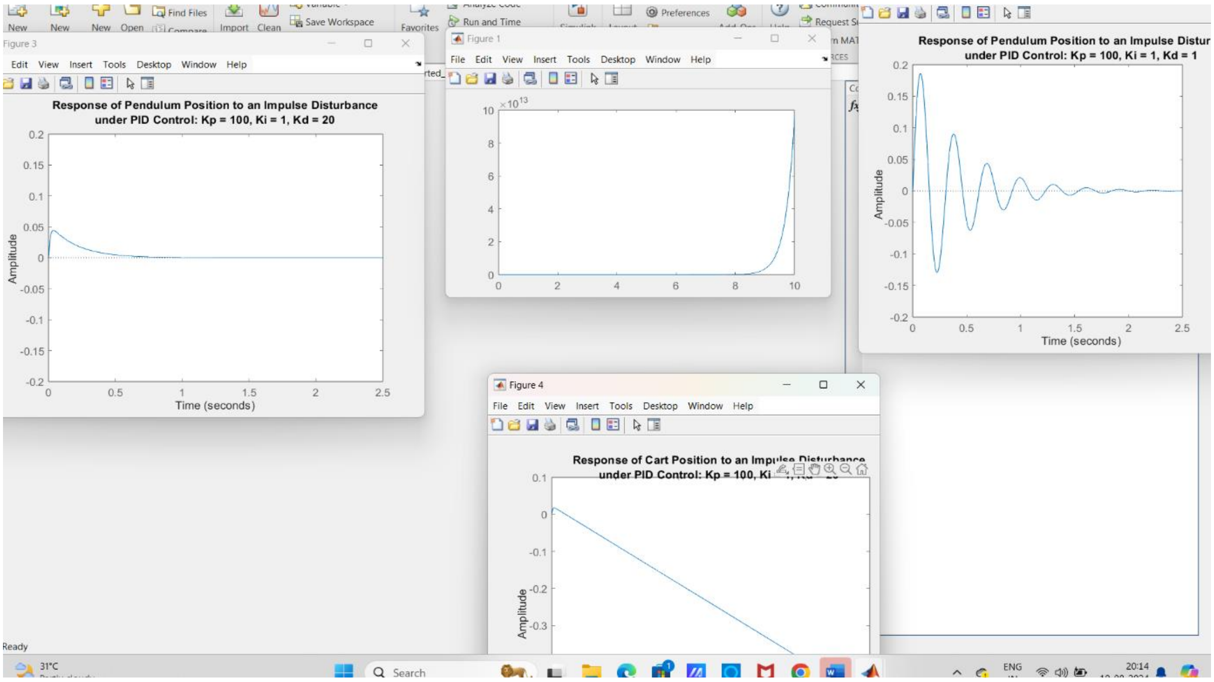
1. **Modelling:** Dynamic model in MATLAB.
2. **PID Controller Design:** Stabilization through PID.
3. **Simulation:** System performance testing.

Results

- **Stabilization:** Achieved.
- **Oscillations:** Reduced.

Conclusions

PID control successfully stabilized the inverted pendulum.



7. Aircraft Pitch:

Overview

Aircraft pitch control manages the pitch angle for stable flight.

Objectives

- **Performance Metrics:** Achieve specific metrics.
- **Stability:** Ensure pitch control stability.

Methods

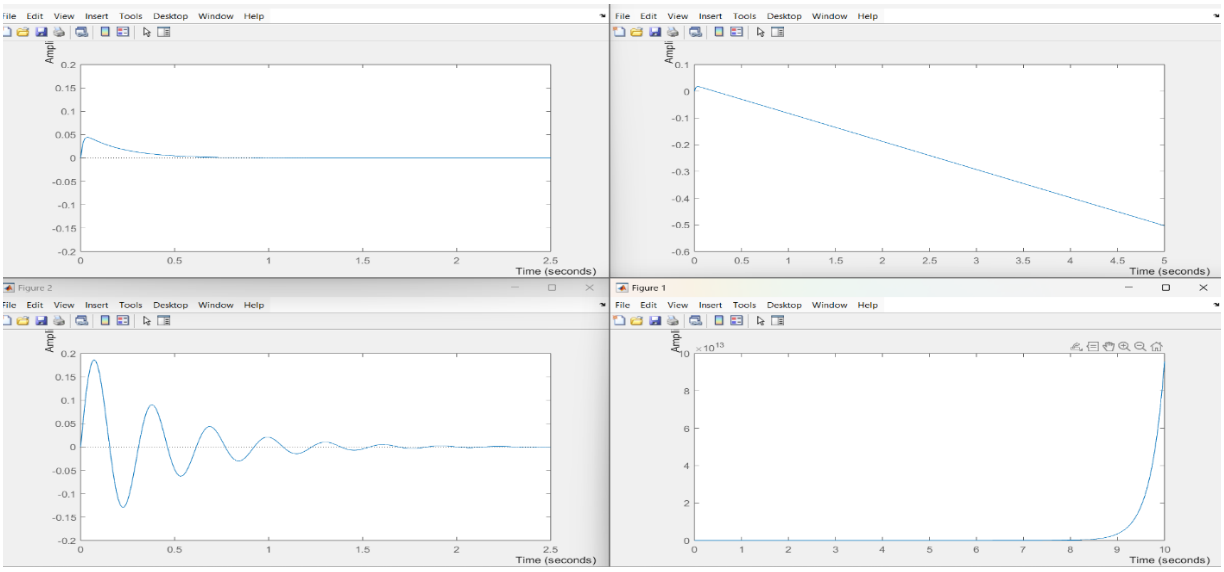
1. **Modelling:** Aircraft pitch dynamics.
2. **PID Controller Design:** Applied PID tuning.
3. **Simulation:** Performance analysis.

Results

- **Overshoot:** 7.5%
- **Rise Time:** 0.413 seconds
- **Settling Time:** 9.25 seconds
- **Steady-State Error:** 0%

Conclusions

PID control met performance metrics for aircraft pitch control.



8. Ball & Beam:

Overview

Ball & Beam control involves positioning a ball on a beam by adjusting the beam's angle.

Objectives

- **Position Control:** Precise ball positioning.
- **Performance Criteria:** Meet settling time and overshoot targets.

Methods

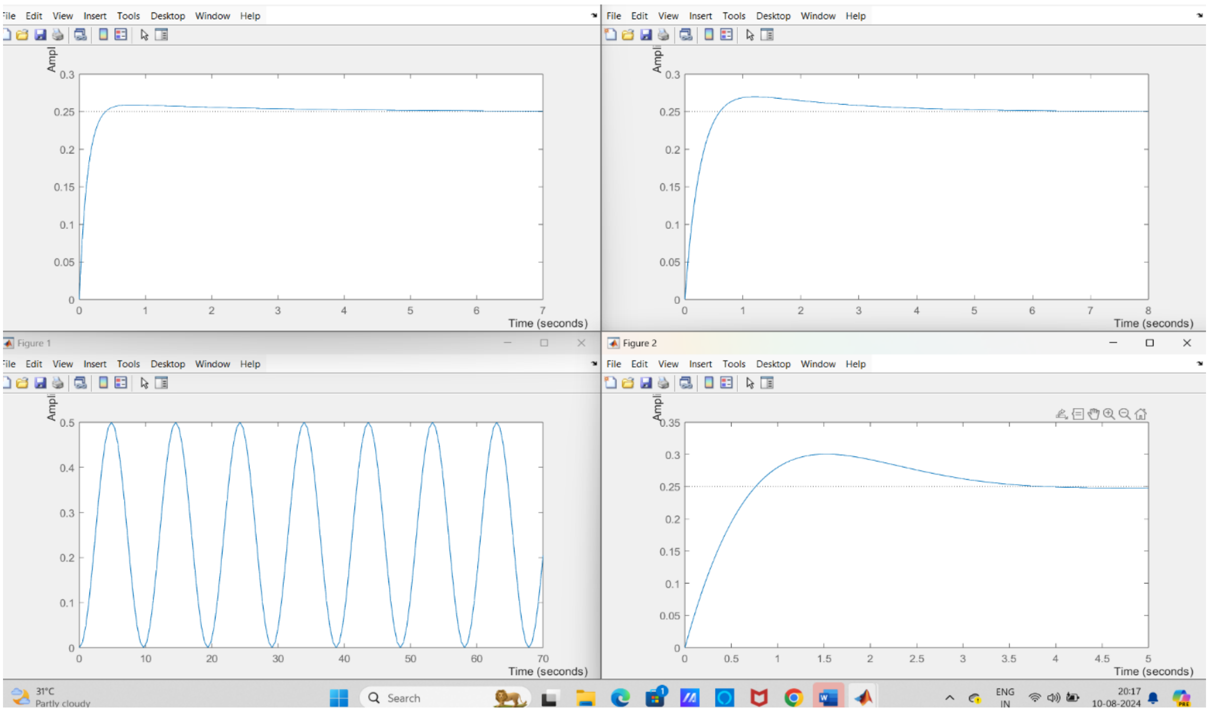
1. **Modelling:** Ball & Beam transfer function.
2. **PID Controller Design:** Proportional-Derivative control.
3. **Simulation:** Performance testing.

Results

- **Settling Time:** Less than 3 seconds.
- **Overshoot:** Less than 5%.

Conclusions

PID control achieved desired performance in ball positioning.



9. Conclusion:

Summary of Key Findings

- **Effectiveness of PID Control:** Successfully met performance criteria across systems.
- **Versatility:** Demonstrated effectiveness in diverse applications.

Implications

Highlights PID control's role in achieving desired system performance, offering insights for control systems engineering.

10. Recommendations:

Future Work

- **Further Optimization:** Explore advanced tuning techniques.
- **Real-Time Implementation:** Consider practical implementations.
- **Alternative Strategies:** Investigate other control strategies.

11. References:

1. **GitHub Repository:** MATLAB PID Control Systems