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WATER TANK SYSTEM

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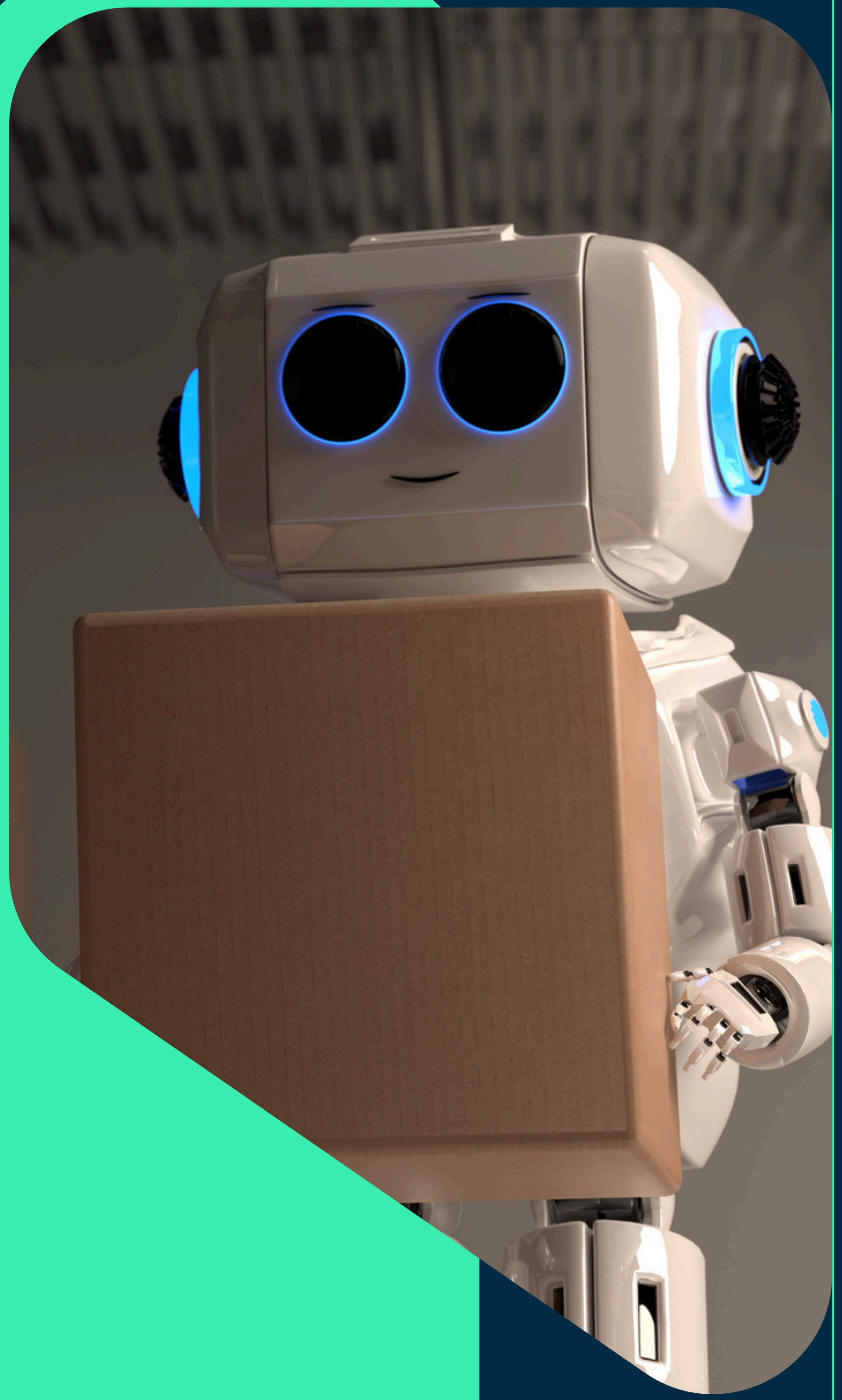
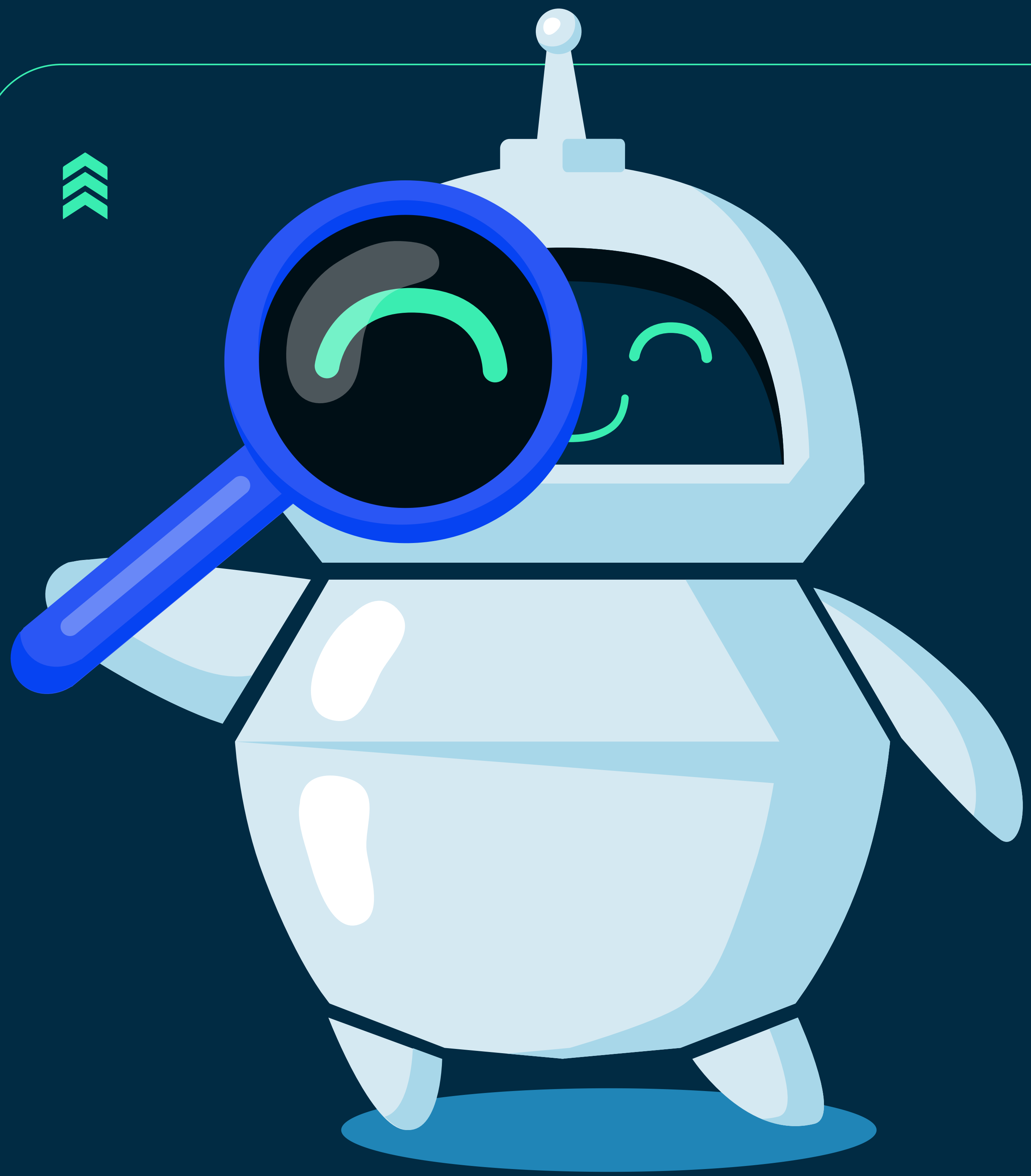
MCTA 4362- Machine Learning

PROBLEM STATEMENT

Efficient water management is a critical issue across various industries, but traditional water control systems are often inefficient, manual, and rigid.



- Water Wastage: Many systems rely on fixed schedules or manual adjustments, leading to overuse or shortages of water
- High Operational Costs: The lack of automation leads to unnecessary energy consumption and labor costs
- Environmental Impact: Inefficient water management contributes to water wastage, especially in regions facing water scarcity.



INTRODUCTION

→ This system utilizes Reinforcement Learning (DDPG) to automate and optimize water level control in real-time. By continuously adjusting water inflows based on dynamic conditions such as demand, weather, and water levels, the system ensures efficient water usage. It reduces manual intervention, minimizes water wastage, and cuts operational costs, making it ideal for industries, agriculture, and municipal water management.

METHODOLOGY

1. System Setup

- Environment: Simulate a water tank system where water inflows are dynamically controlled based on the water level.
- Inputs: Real-time data such as water level, demand, and weather conditions (can be simulated or gathered from sensors).

2. Reinforcement Learning (DDPG):

Actor-Critic Model:

- The actor network suggests optimal actions (inflow rates) based on the current state (water level).
- The critic network evaluates the action by estimating future rewards (water balance and system efficiency).

3. Training Process

The system learns through interactions with the environment, improving its ability to adjust water levels by receiving feedback (rewards) from maintaining optimal levels.

4. Real-time Adaptation

The system adapts to changing conditions and continuously refines its water control policy to optimize resource usage.

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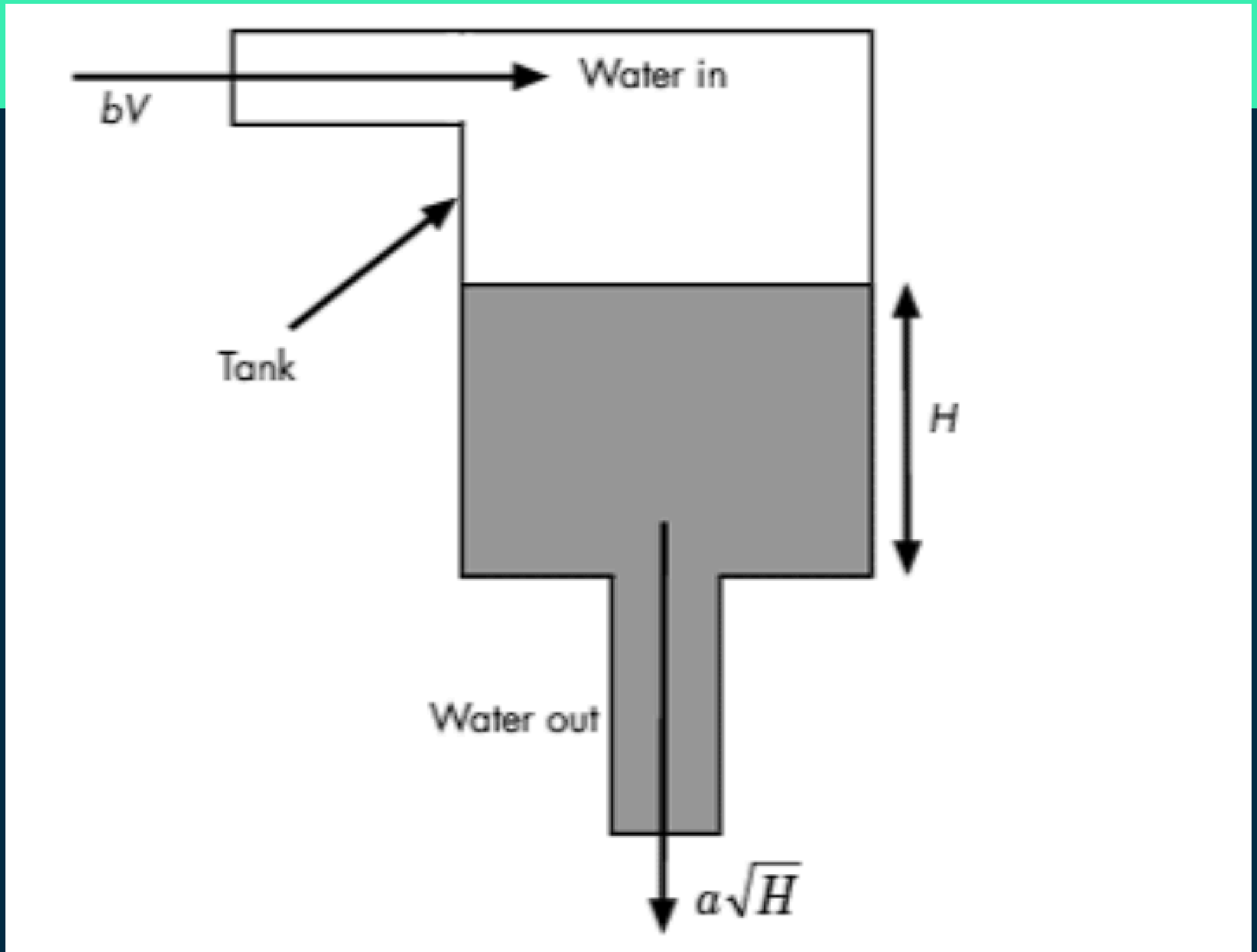
WATER TANK SYSTEM



VARIABLES:

- H is the height of water in the tank.
- Vol is the volume of water in the tank.
- V is the voltage applied to the pump.

PARAMETERS:

- A is the cross-sectional area of the tank.
- b is a constant related to the flow rate into the tank.
- a is a constant related to the flow rate out of the tank.

$$Flowrate = bV - a\sqrt{H}$$

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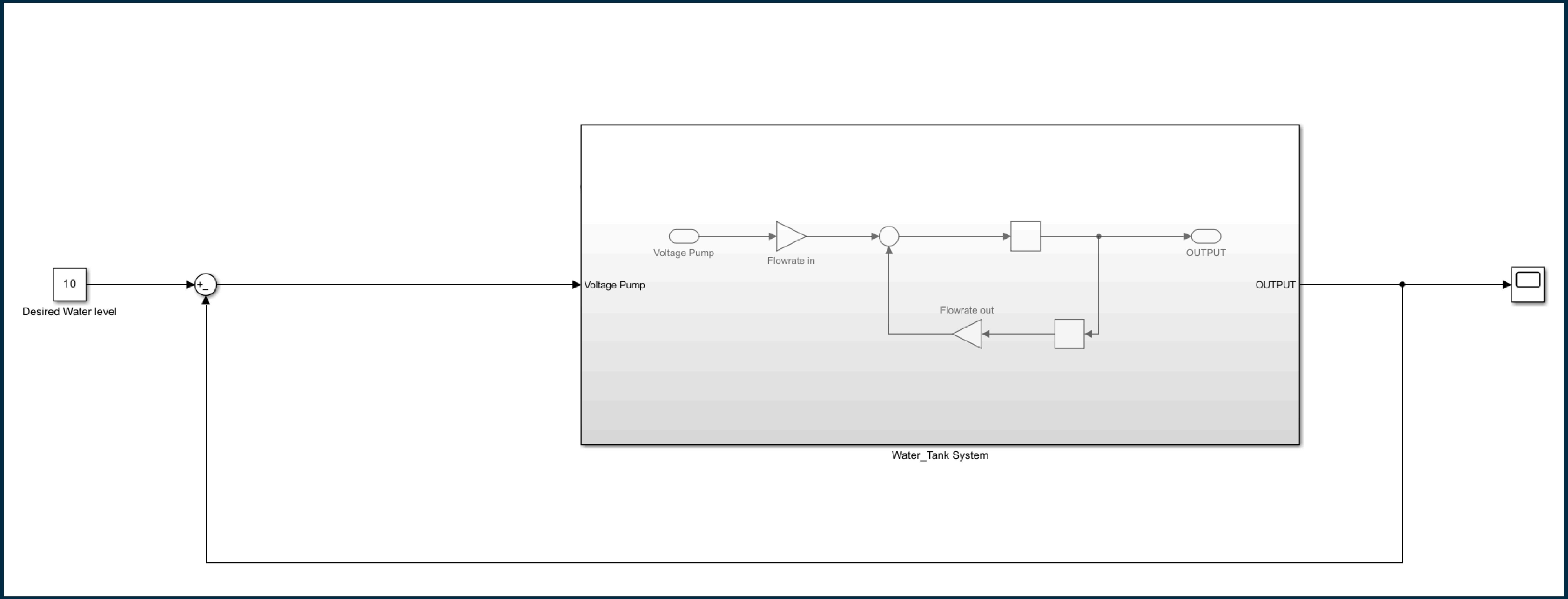
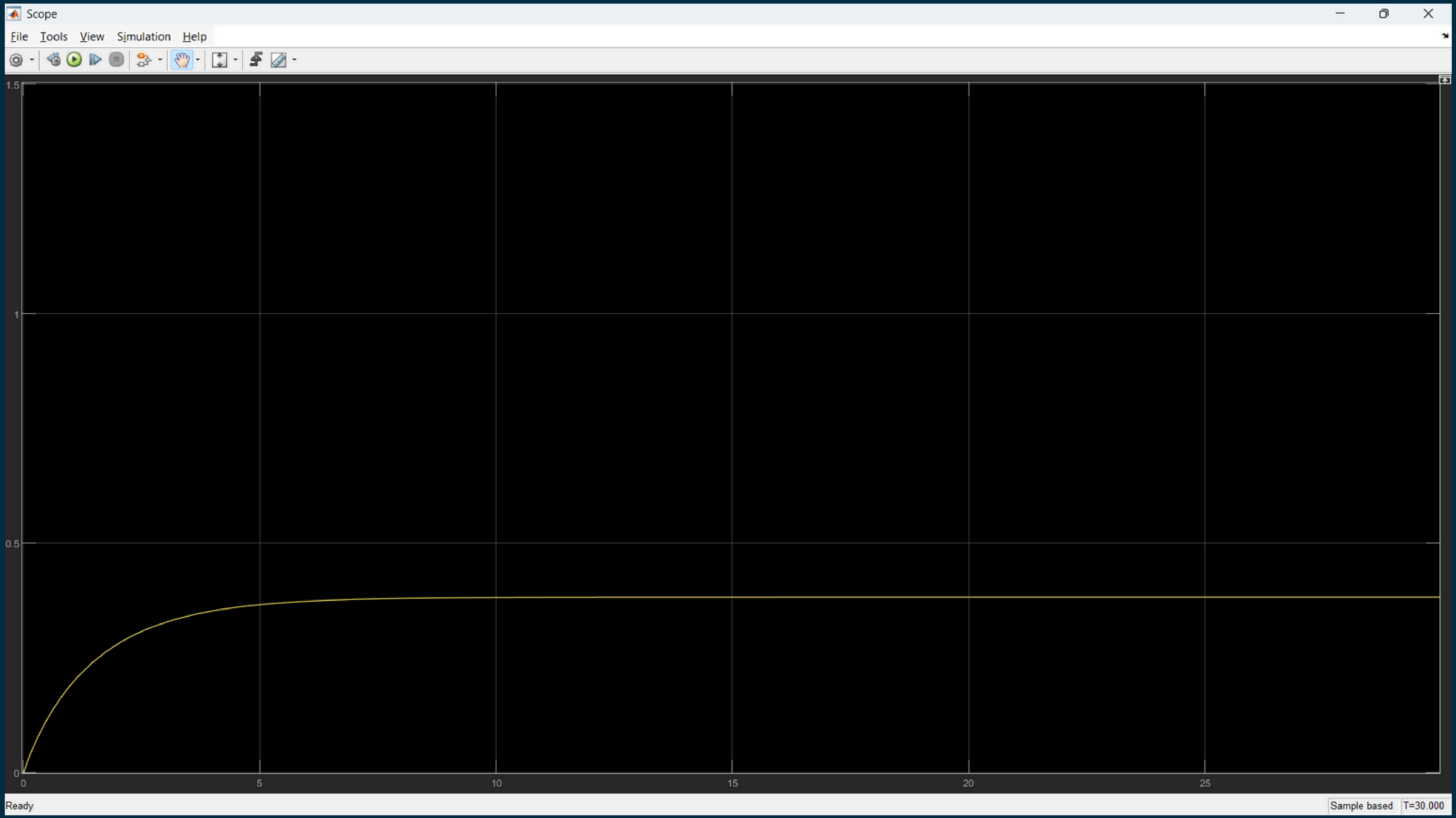
SIMULATION WITHOUT PI CONTROLLER OR RL AGENT



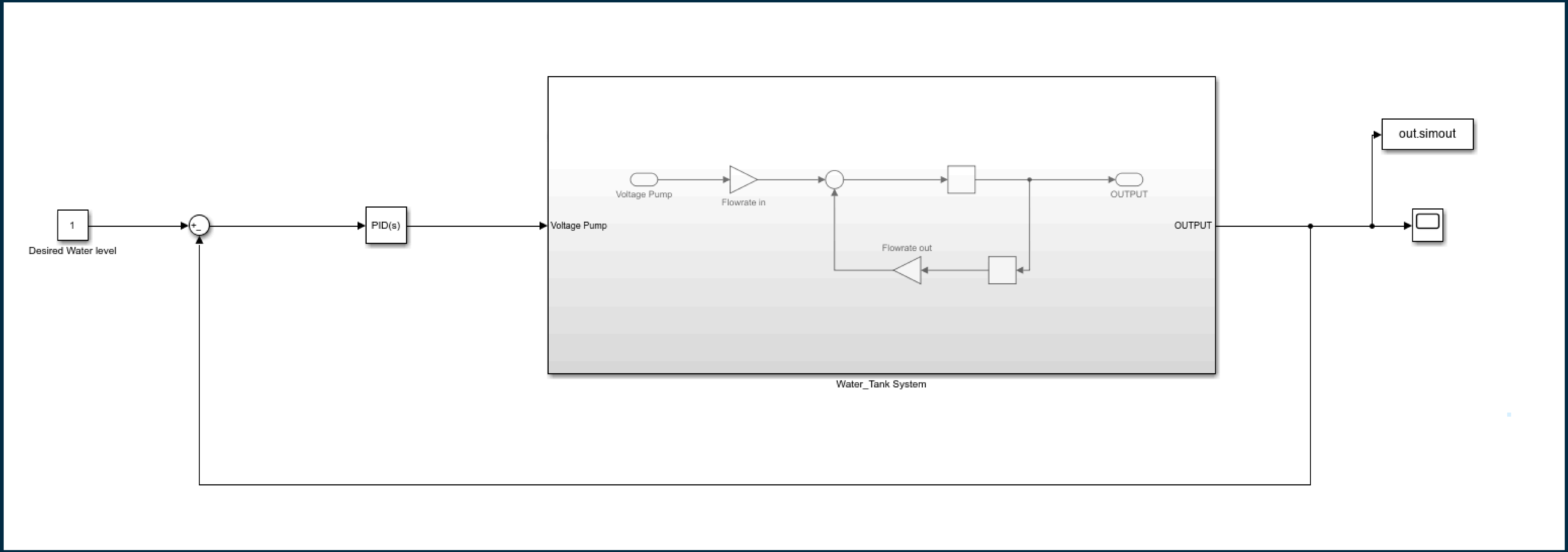
RESULTS



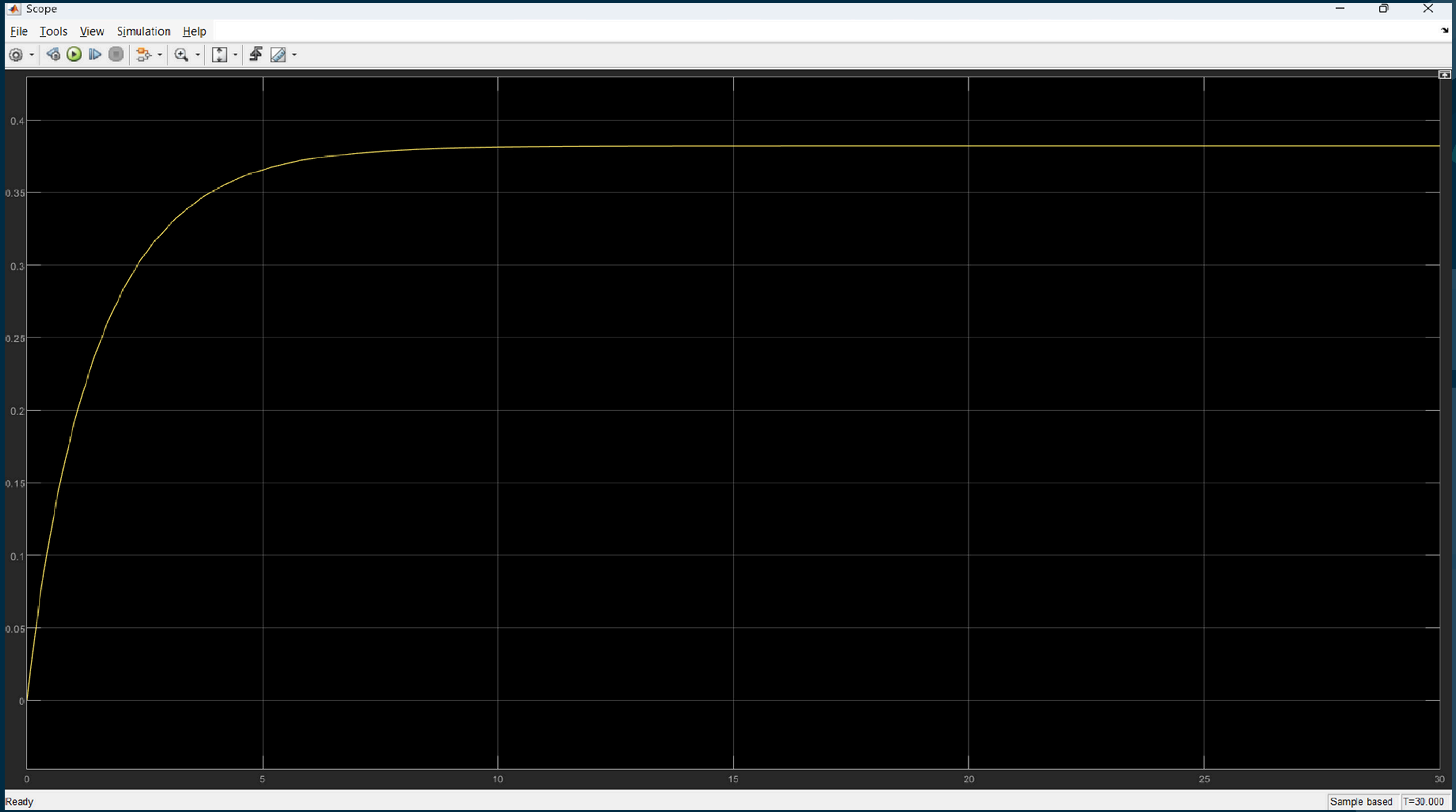
- T = 30S,
- P = 0,
- I = 0,

```
      RiseTime: 3.4625
 TransientTime: 6.2675
  SettlingTime: 6.2675
   SettlingMin: 0.3457
   SettlingMax: 0.3820
     Overshoot: 0
    Undershoot: 0
          Peak: 0.3820
      PeakTime: 30
```

SIMULATION WITH PI CONTROLLER



RESULTS



- T = 30S,
- P = 1,
- I = 0,

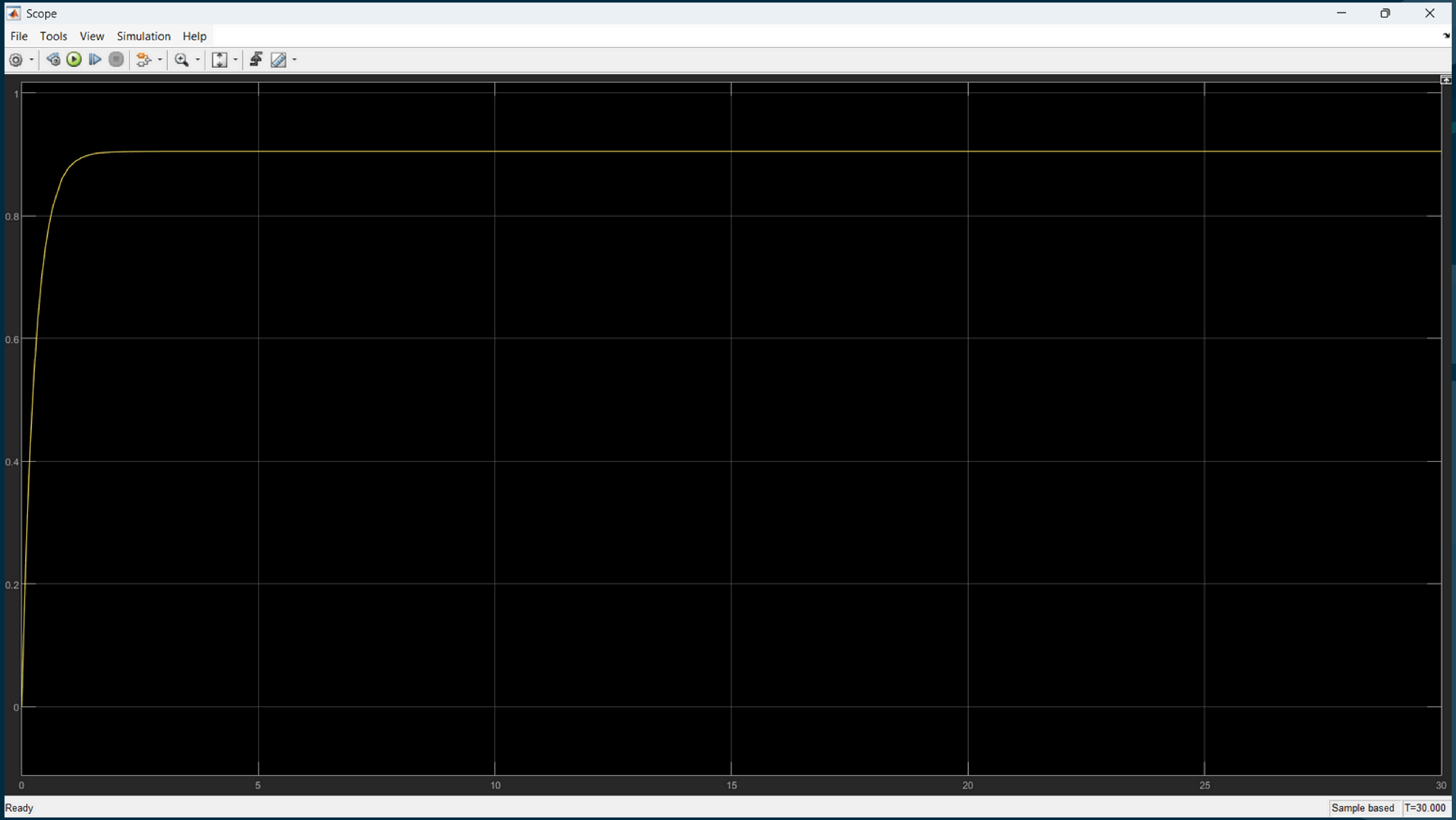
```
   RiseTime: 3.4625
TransientTime: 6.2675
SettlingTime: 6.2675
 SettlingMin: 0.3457
 SettlingMax: 0.3820
   Overshoot: 0
  Undershoot: 0
        Peak: 0.3820
    PeakTime: 30
```

RESULTS

- T = 30S,
- P = 5,
- I = 0,

```
     RiseTime: 1.1819
TransientTime: 2.1061
 SettlingTime: 2.1061
  SettlingMin: 0.7556
  SettlingMax: 0.8190
    Overshoot: 0.0040
   Undershoot: 0
         Peak: 0.8190
     PeakTime: 6.1594
```

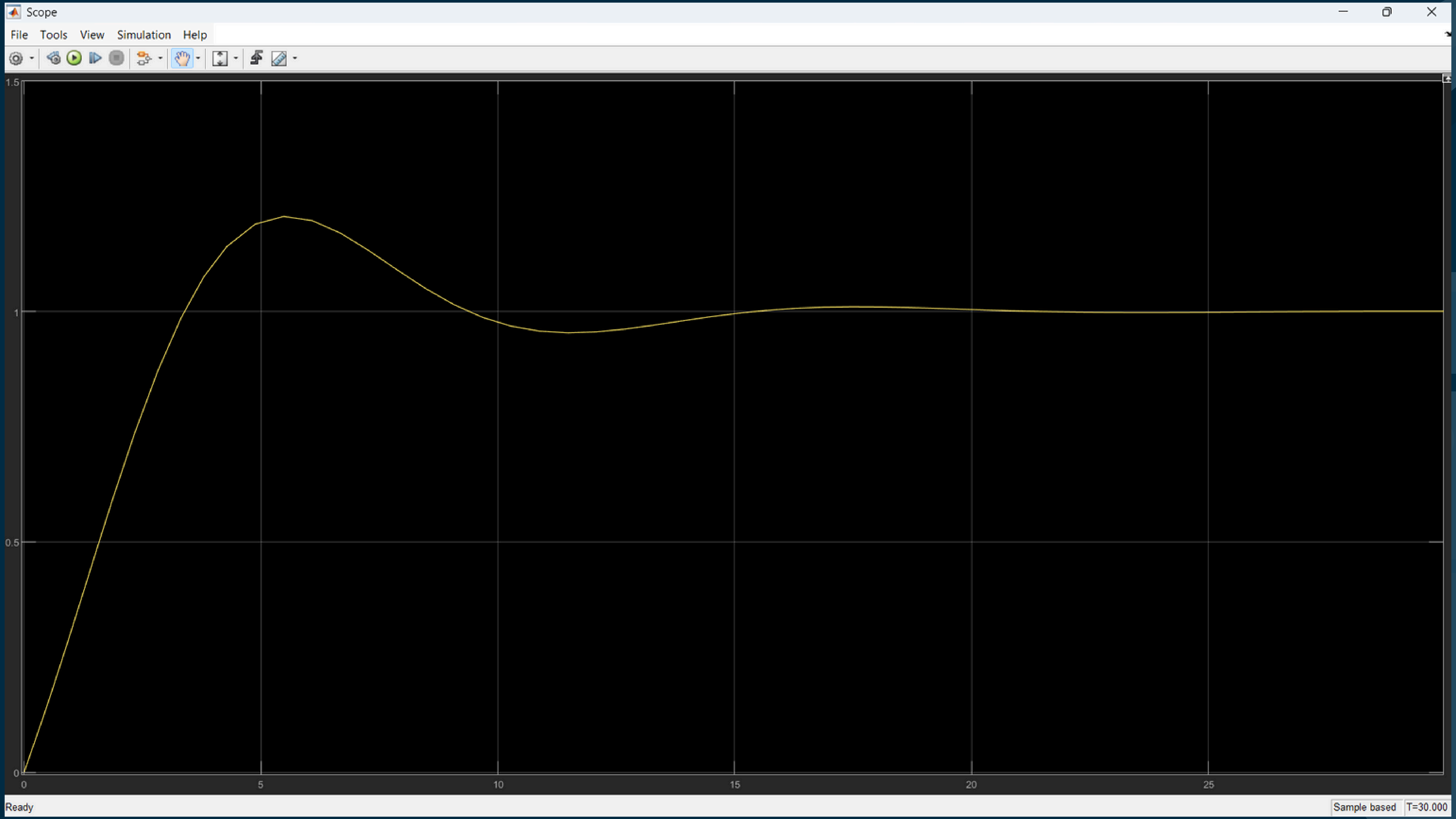
RESULTS



- T = 30S,
- P = 10,
- I = 0,

```
     RiseTime: 0.6248
TransientTime: 1.1049
 SettlingTime: 1.1049
  SettlingMin: 0.8153
  SettlingMax: 0.9049
    Overshoot: 0.0030
   Undershoot: 0
         Peak: 0.9049
     PeakTime: 3.5521
```

RESULTS



- T = 30S,
- P = 1,
- I = 1,

RiseTime:	2.6093
TransientTime:	13.9442
SettlingTime:	13.9442
SettlingMin:	0.9537
SettlingMax:	1.2063
Overshoot:	20.5705
Undershoot:	0
Peak:	1.2063
PeakTime:	5.4750

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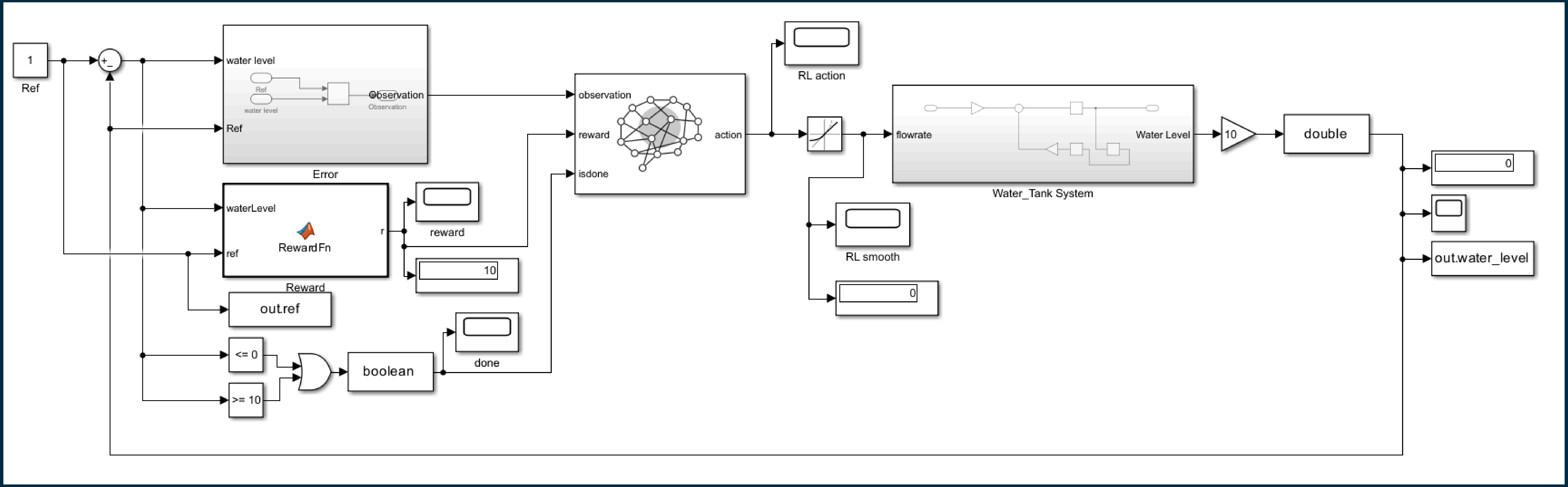
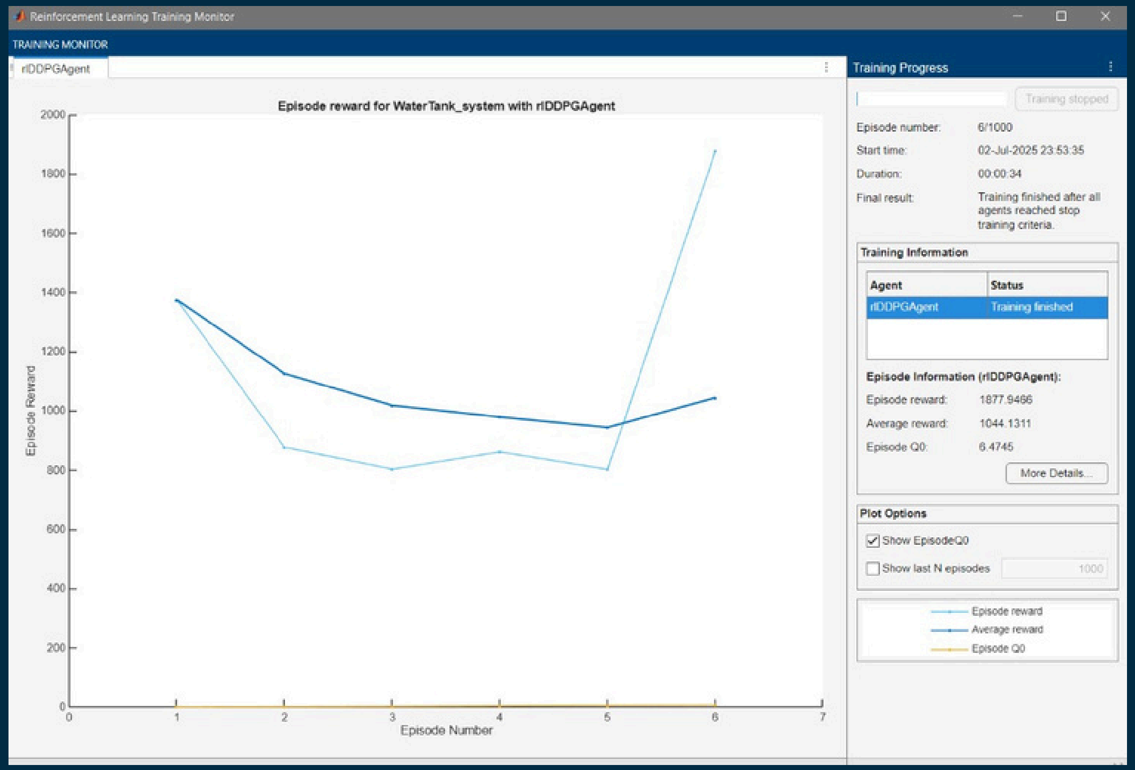
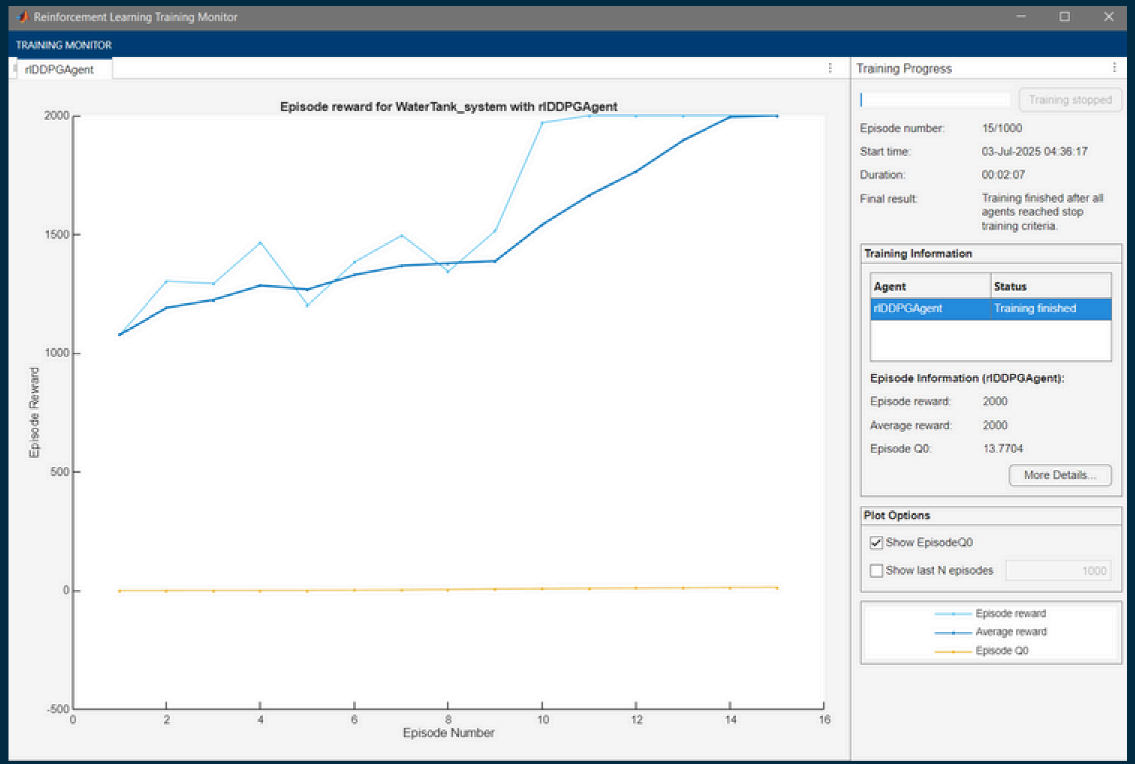
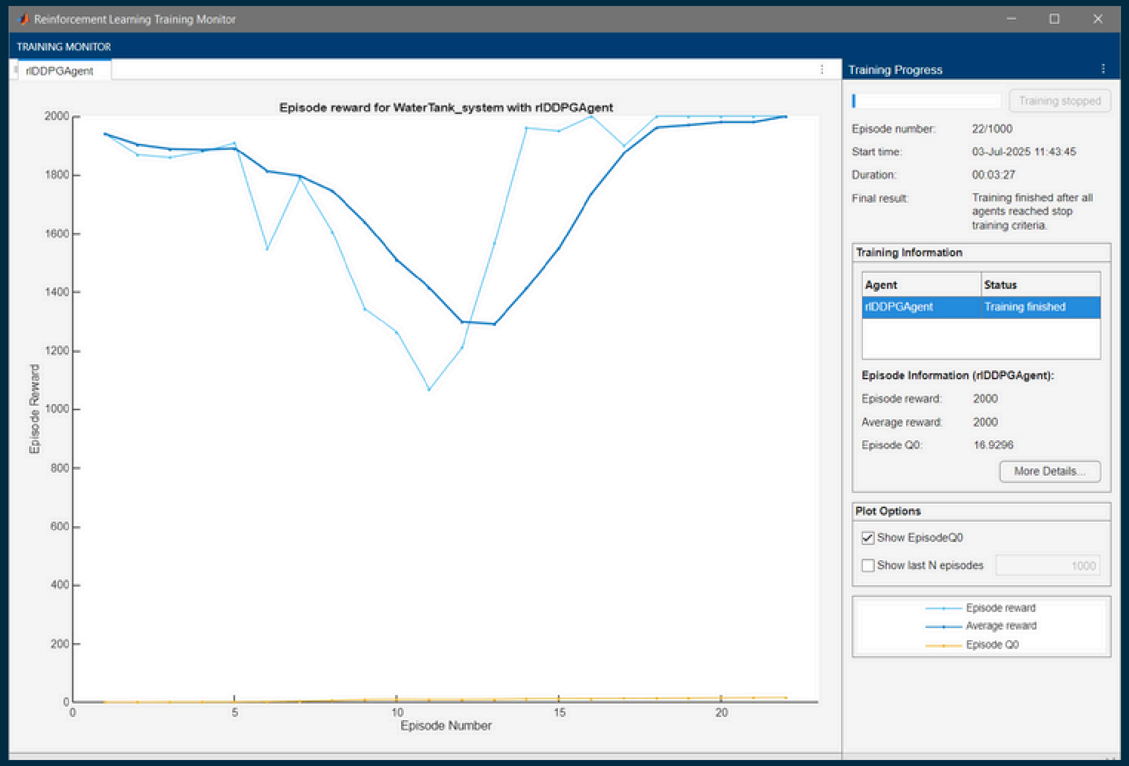
SIMULATION WITH RL DDPG

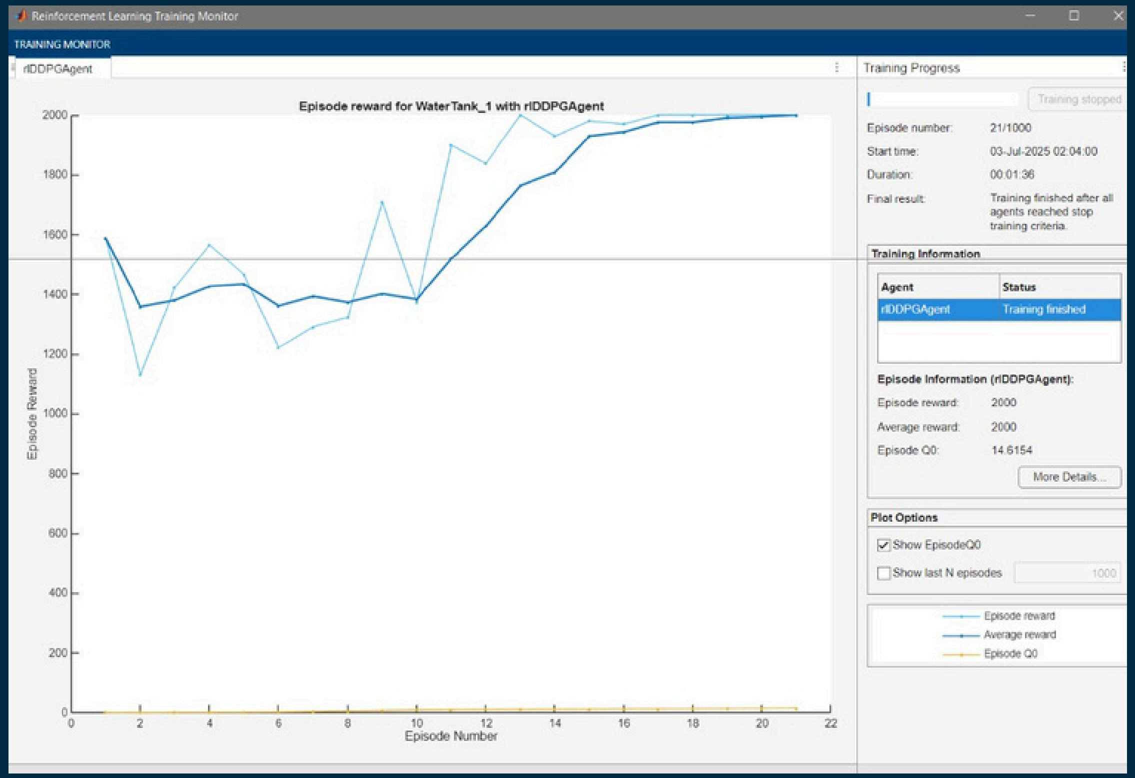


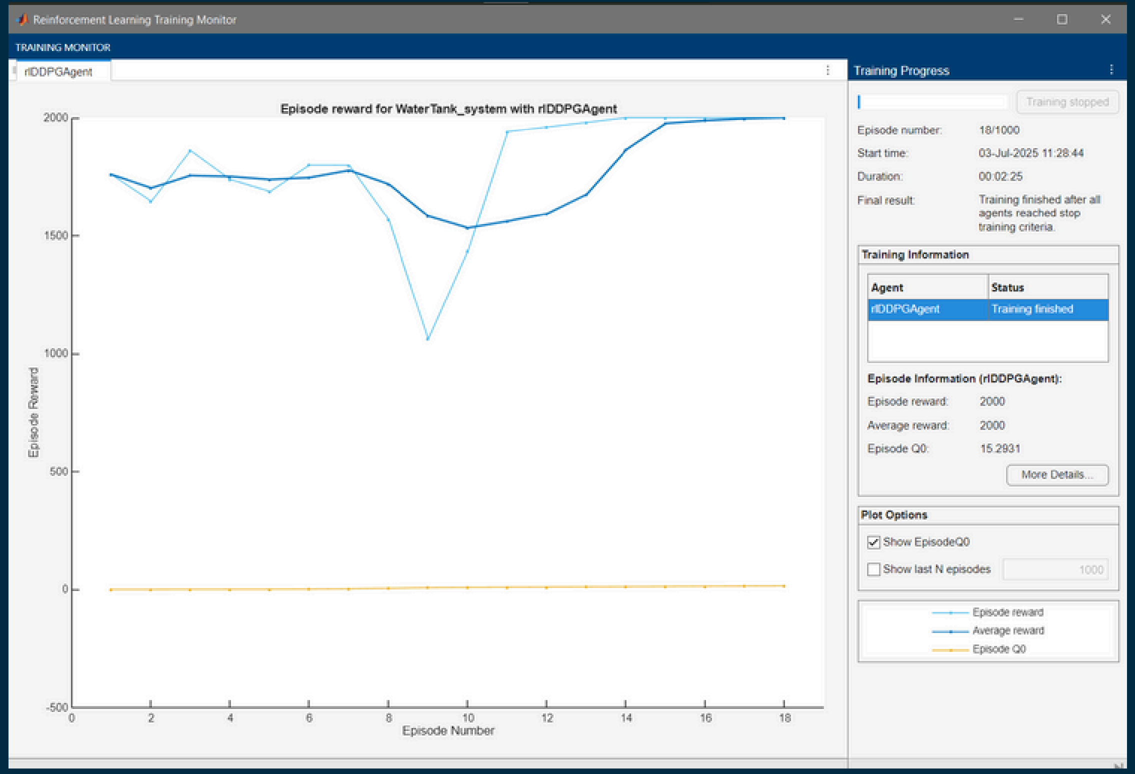
TRAINING SIMULATIONS

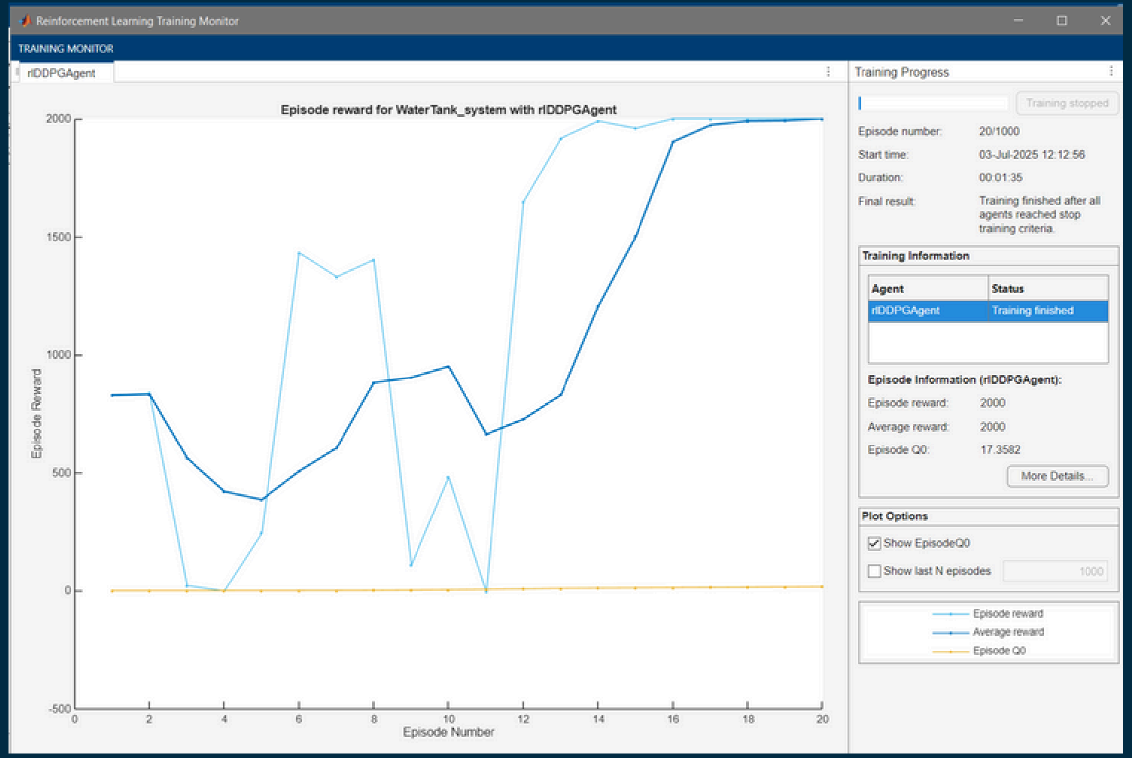




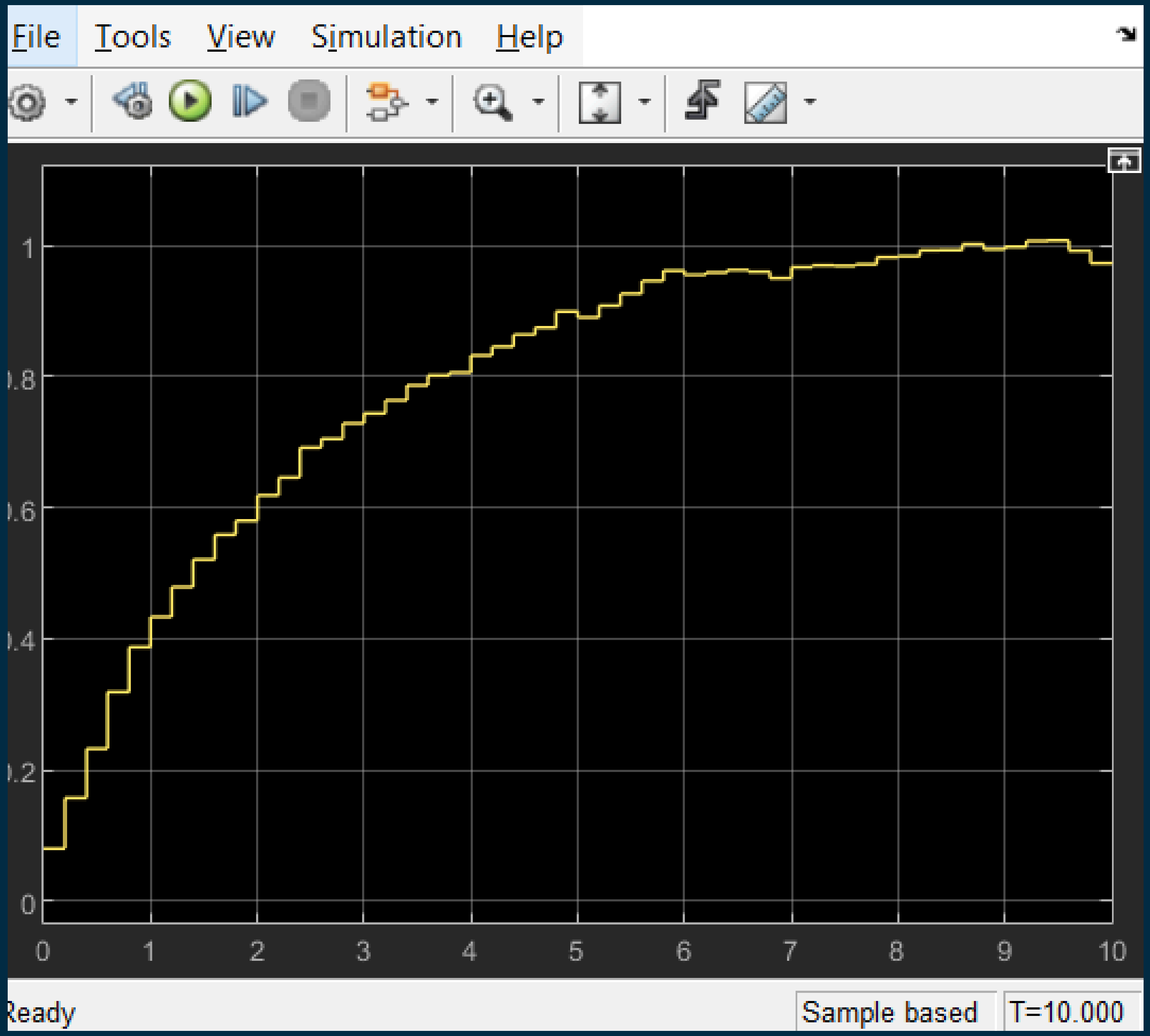








RESULTS




```
Overshoot: 0.75%
Rise Time: 5.00s
Settling Time: 10.00s
Steady-State Error: 0.0252
>>
```

CONCLUSION

PI CONTROLLER VS RL AGENT

1. Rise Time:
   - The PID controller responded slightly faster in reaching the target level.
   - However, the RL agent had a smoother approach, which helped reduce overshoot.

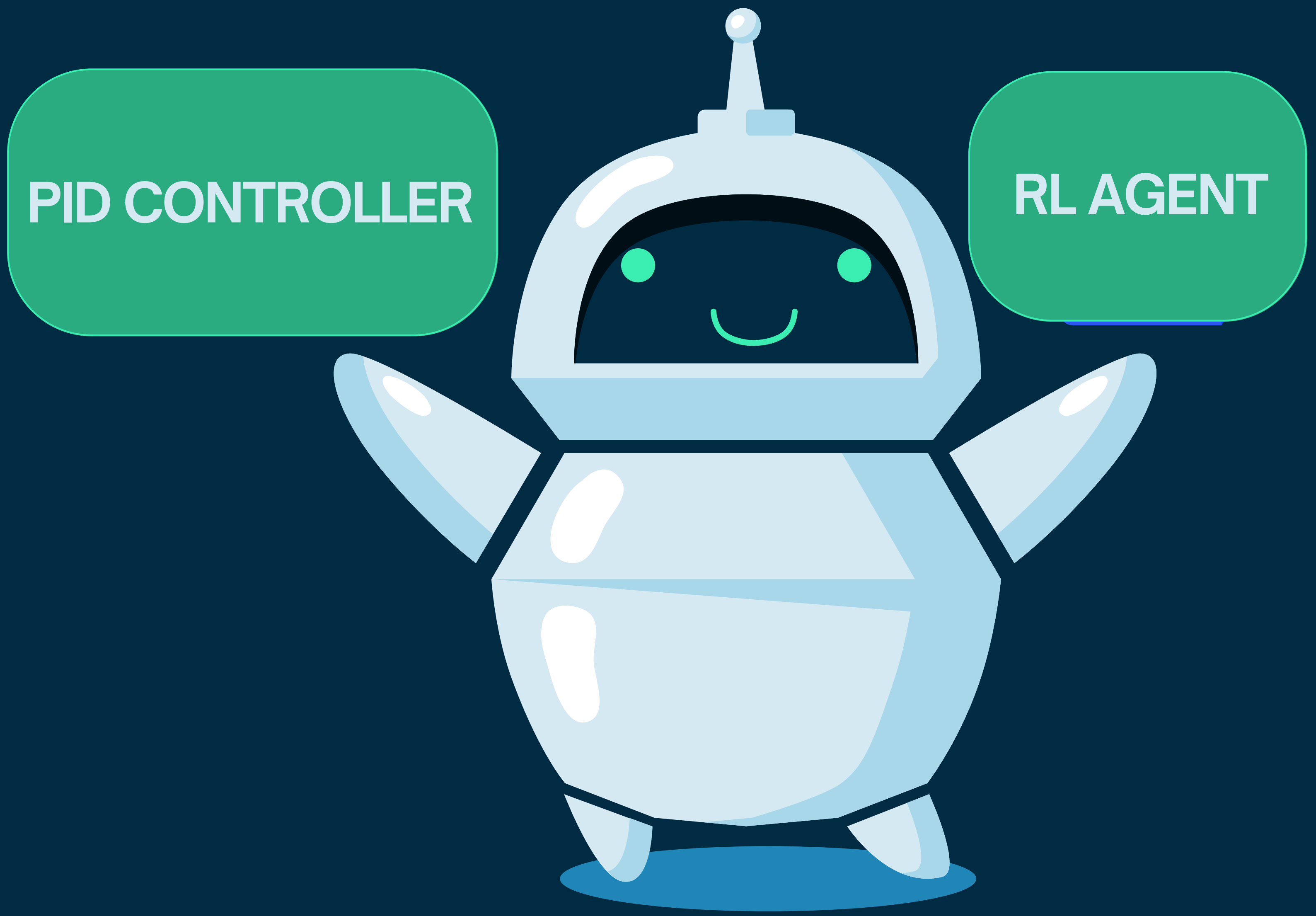
2. Overshoot:
   - The RL agent had significantly lower overshoot, demonstrating better damping and control.
   - PID showed a sharper initial rise, which caused it to overshoot more.

3. Settling Time:
   - The RL agent settled quicker overall, indicating better long-term stability in the presence of small fluctuations.

4. Steady-State Error:
   - Both controllers had minimal steady-state error, but the RL agent consistently converged closer to the reference value.

5. MSE:
   - The RL agent outperformed the PID controller in terms of overall tracking accuracy, as shown by its lower mean squared error.

FINAL CONCLUSION



PID offers quick and reliable performance with simple tuning. But the RL agent demonstrated superior long-term performance in terms of overshoot, settling time, and accuracy

The RL-based approach is also more adaptive to changing system dynamics or disturbances, making it a promising alternative for complex or nonlinear systems.

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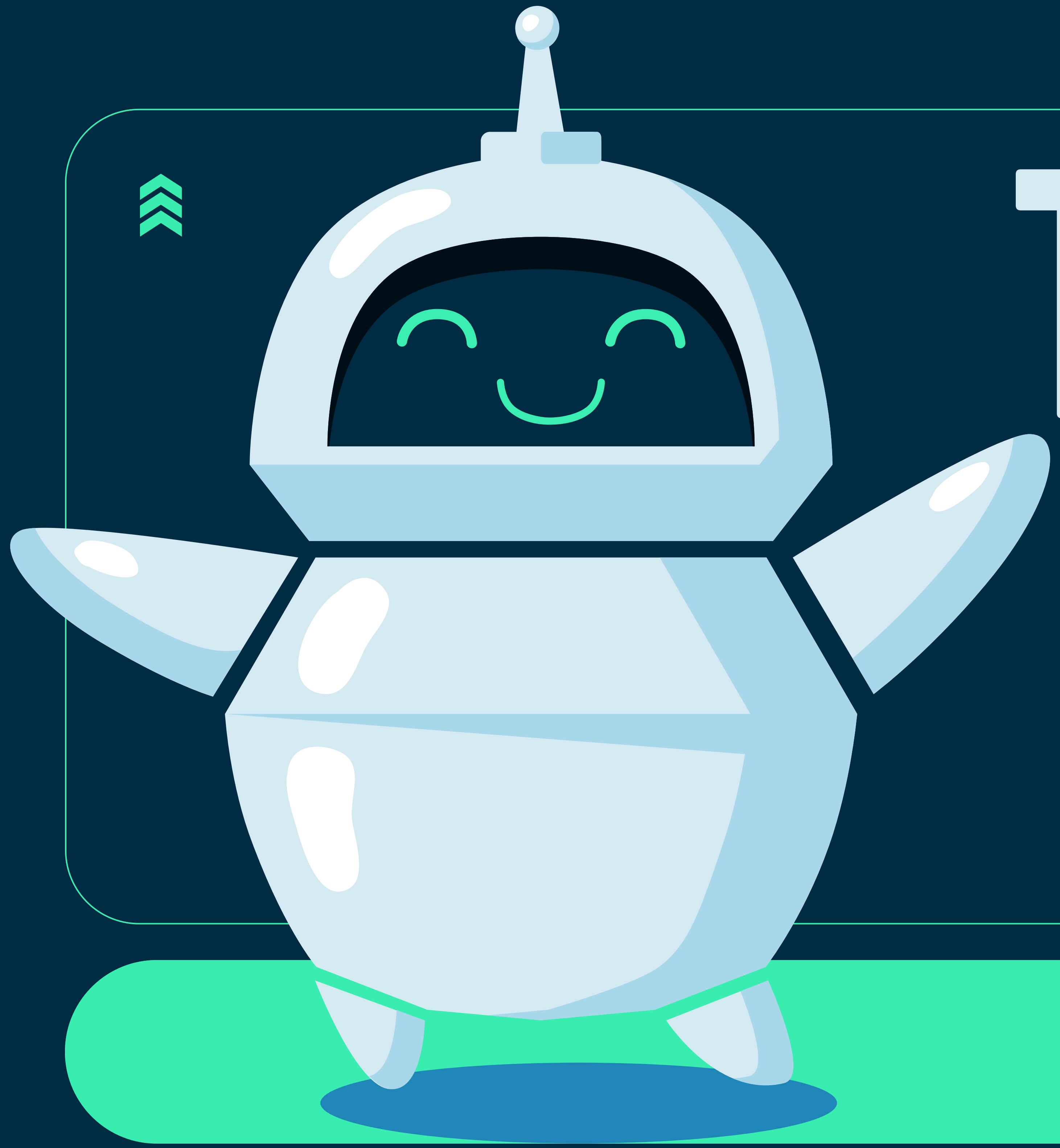

THANK YOU

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