CH-303
PROJECT
TWO TANK INTERACTING SYSTEM

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Thank you once more, Dr. Jayaram Valluru, for your invaluable advice and assistance that have enabled us to successfully finish this project.

ABSTRUCT

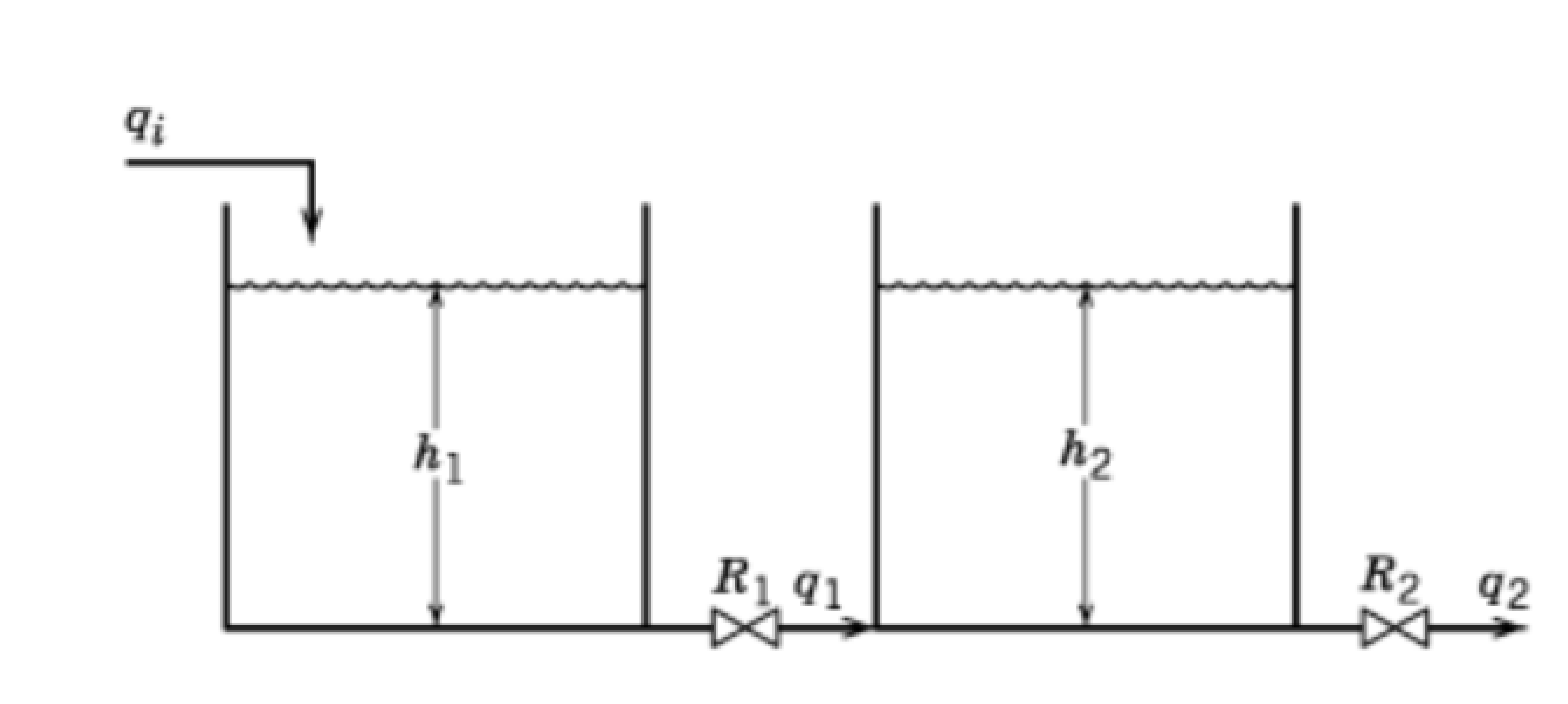
This project investigates two tank interacting systems, employing a systematic approach to linearize the equations, transform them into deviation form, and derive a Laplacee-transformed transfer function. Simulations conducted on MATLAB provide in-depth insights into the system's behaviour under dynamic conditions.

PROBLEM STATEMENT

Two tank interacting system:

Suppose that two liquid surge tanks are placed in series so that the outflow from the first tank is the inflow to the second tank, as shown in the following Fig. If the outlet flow rate from each tank is proportional to the square root of the height of the liquid in that tank, find the transfer function relating the inlet flow rate of the first tank with the height of the second tank. Note that, here we are interested in studying the dynamics of the level in tank 2 when a step change is introduced in the inlet flow rate of tank 1.

TWO TANK INTERACTING SYSTEM:



qi, q1 represents the inlet flow rate of tank 1, and q2 represents the outlet flow rate of tank 2.

DYNAMIC MODEL EQUATIONS OF THE SYSTEM

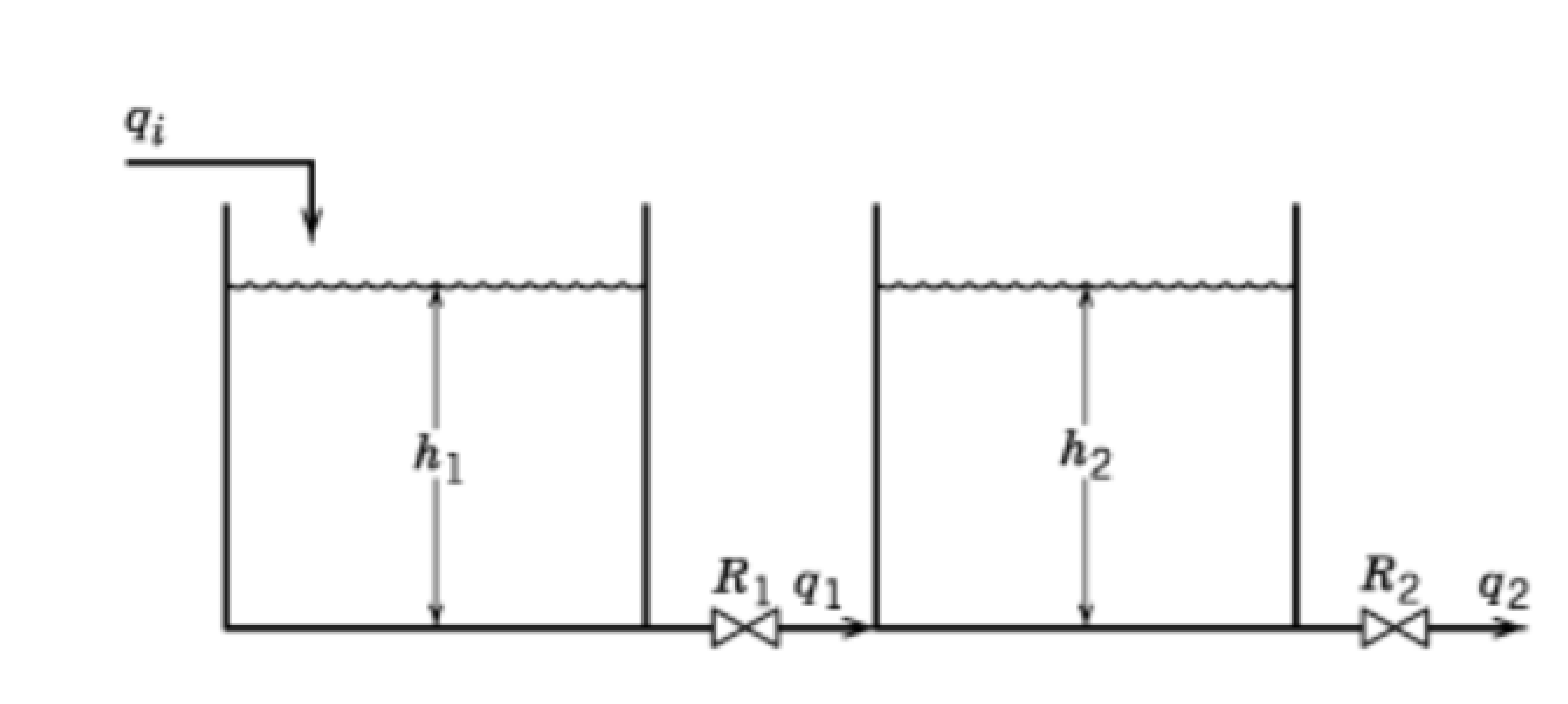
$$A_1 \frac{dh_1}{dt} = q_i - q_1$$

$$A_2 \frac{dh_2}{dt} = q_1 - q_2$$

$$q_1 = C_1\sqrt{h_1 - h_2}$$

$$q_2 = C_2\sqrt{h_2}$$

TWO TANK INTERACTING SYSTEM:



qi, q1 represents the inlet flow rate of tank 1, and q2 represents the outlet flow rate of tank 2.

INTERACTING TANK

PROJECT FLOWSHEET

System Identification

Parameters, Inputs, Disturbances, and Control Variables

Nonlinear System Steady State

- Used ODE45 Solver for Open Loop Simulation
- Obtained a Steady State Profile of Output vs. Time

Linearization of Nonlinear Model

- Linearized around Steady State
- Derived Linear Dynamic Model (Deviation Form)
- Laplace Transform for Step Change Response

Step Change Experiment

At 100th Sampling Instant:

- Applied +10%, +20% Step Changes in Input
- Recorded Output Response vs. Time

Comparison and Analysis

- Nonlinear vs. Linear Model Responses
- Observations for Different Step Change Magnitudes

System Characterization

- First-Order: Time Constant, Process Gain
- Second-Order: Damping Coefficients, System Characteristics

IDENTIFING THE PARAMETER

Parameters: A1, A2, C1, C2

Manipulated Input: qi

Controlled Variable: h2 (the level in the tank 2)

Disturbance Variable : qi

DYNAMIC MODEL EQUATIONS OF THE SYSTEM

$$A_1 \frac{dh_1}{dt} = q_i - q_1$$

$$A_2 \frac{dh_2}{dt} = q_1 - q_2$$

$$q_1 = C_1\sqrt{h_1 - h_2}$$

$$q_2 = C_2\sqrt{h_2}$$

Linearizing using Taylor series.

$$\sqrt{h_1-h_2} = \sqrt{h_{1s}-h_{2s}} + \frac{1}{2}\,\frac{1}{\sqrt{h_{1s}-h_{2s}}}\,(h_1-h_{1s}) - \frac{1}{2}\,\frac{1}{\sqrt{h_{1s}-h_{2s}}}\,(h_2-h_{2s})$$

$$\sqrt{h_2} = \sqrt{h_{2s}} + \frac{1}{2\sqrt{h_{2s}}}\,(h_2-h_{2s})$$

$$A_1\frac{dh_1}{dt} = q_i - C_1\left[\sqrt{h_{1s}-h_{2s}} + \frac{(h_1-h_{1s})}{2\sqrt{h_{1s}-h_{2s}}} - \frac{(h_2-h_{2s})}{2\sqrt{h_{1s}-h_{2s}}}\right]$$

$$A_2\frac{dh_2}{dt} = C_1\left[\sqrt{h_{1s}-h_{2s}} + \frac{1}{2}\,\frac{(h_1-h_{1s})}{\sqrt{h_{1s}-h_{2s}}} - \frac{(h_2-h_{2s})}{2\sqrt{h_{1s}-h_{2s}}}\right] - C_2\left[\sqrt{h_{2s}} + \frac{(h_2-h_{2s})}{2\sqrt{h_{2s}}}\right]$$

$$A_1 \frac{dh_1}{dt} = \bar{q}_i - \frac{C_1 \bar{h}_1}{2\sqrt{h_{1s}-h_{1s}}} + \frac{C_1 \bar{h}_2}{2\sqrt{h_{1s}-h_{1s}}}$$

$$A_2 \frac{dh_2}{dt} = \frac{C_1 \bar{h}_1}{2\sqrt{h_{1s}-h_{2s}}} - \frac{C_1 \bar{h}_2}{2\sqrt{h_{1s}-h_{2s}}} - \frac{C_2 \bar{h}_2}{2\sqrt{h_{2s}}}$$

$$T_1 = \frac{C_1}{2\sqrt{h_{1s}-h_{2s}}} \qquad T_2 = \frac{C_2}{2\sqrt{h_{2s}}}$$

$$A_1 S H_1(s) = q_1(s) - I_1 H_1(s) + I_1 H_2(s)$$

$$A_2 S H_2(s) = I_1 H_1(s) - I_1 H_2(s) - I_2 H_2(s)$$

$$H_1(s)\left[A_1 s + I_1\right] = \bar{q}_1(s) + I_1 H_2(s)$$

$$\boxed{H_1(s) = \frac{\bar{q}_1(s) + I_1 H_2(s)}{A_1 s + I_1}}$$

$$A_2 s H_2(s) = \frac{I_1\, q_i(s)}{A_1 s + I_1} + \frac{I_1^2 H_2(s)}{A_1 s + I_1} - I_1 H_2(s) - I_2 H_2(s)$$

$$H_2(s)\left[A_2 s - \frac{I_1^2}{A_1 s + I_1} + I_1 + I_2\right] = \frac{I_1}{A_1 s + I_1}\, q_i(s)$$

$$H_2(s)\left[(A_1 A_2)s^2 + s\,(I_1 A_2 + A_1 I_1 + I_2 A_1) + I_1 \cdot I_2\right] = I_1\, q_i(s)$$

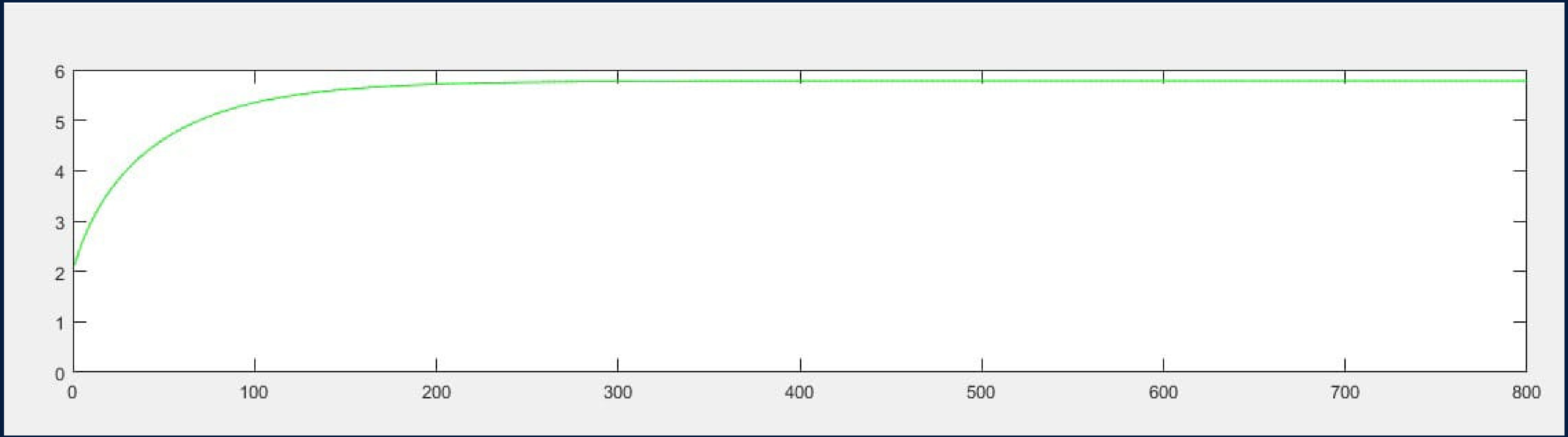
When $H_1(s) = 2$ & $H_2(s) = 1$

$$H_2(s)\left[15s^2 + 50s + 24\right] = 4\, q_i(s)$$

$$\boxed{H_2(s) = \frac{4\, q_i(s)}{15s^2 + 50s + 24}}$$

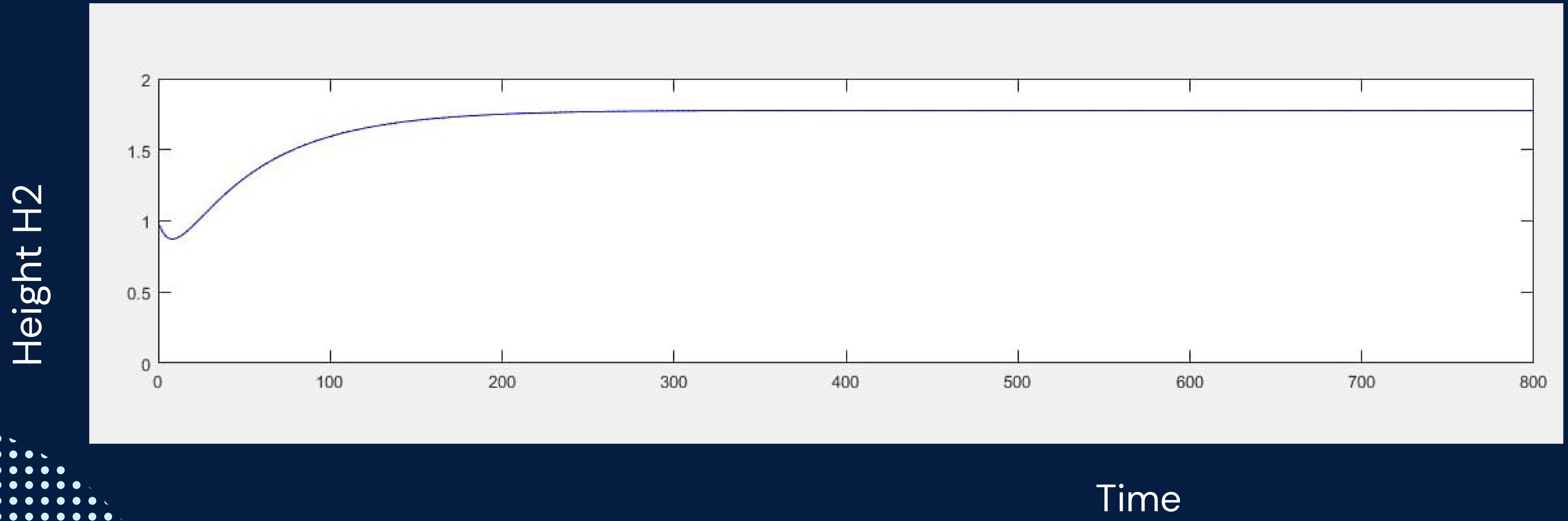
STEADY STATE PROFILE OF TANK 1

Height H1



Time

STEADY STATE PROFILE OF TANK 2

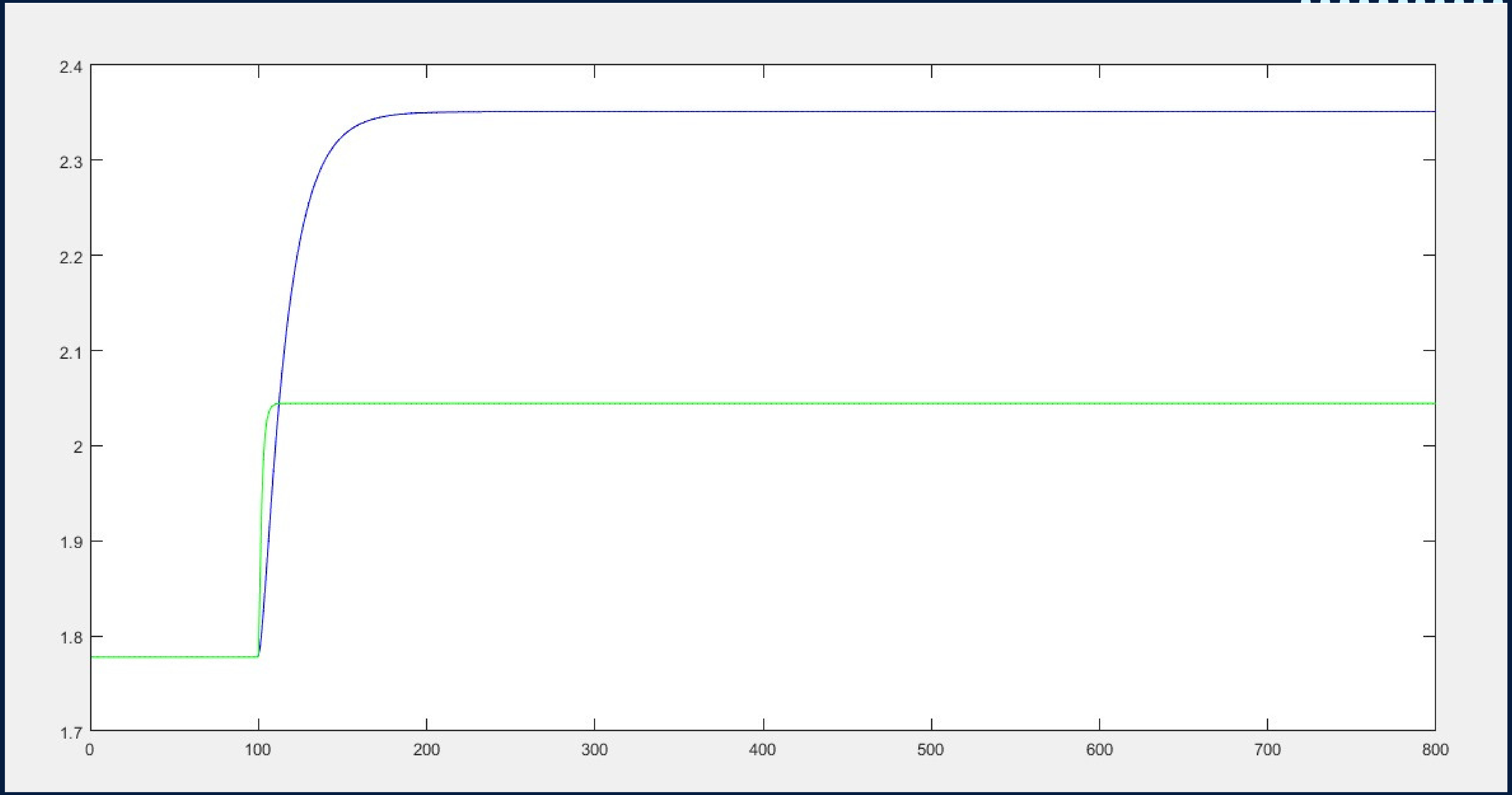


10 PERCENT CHANGE IN INPUT (Q_I)

Linear Model

Non-Linear Model

Height



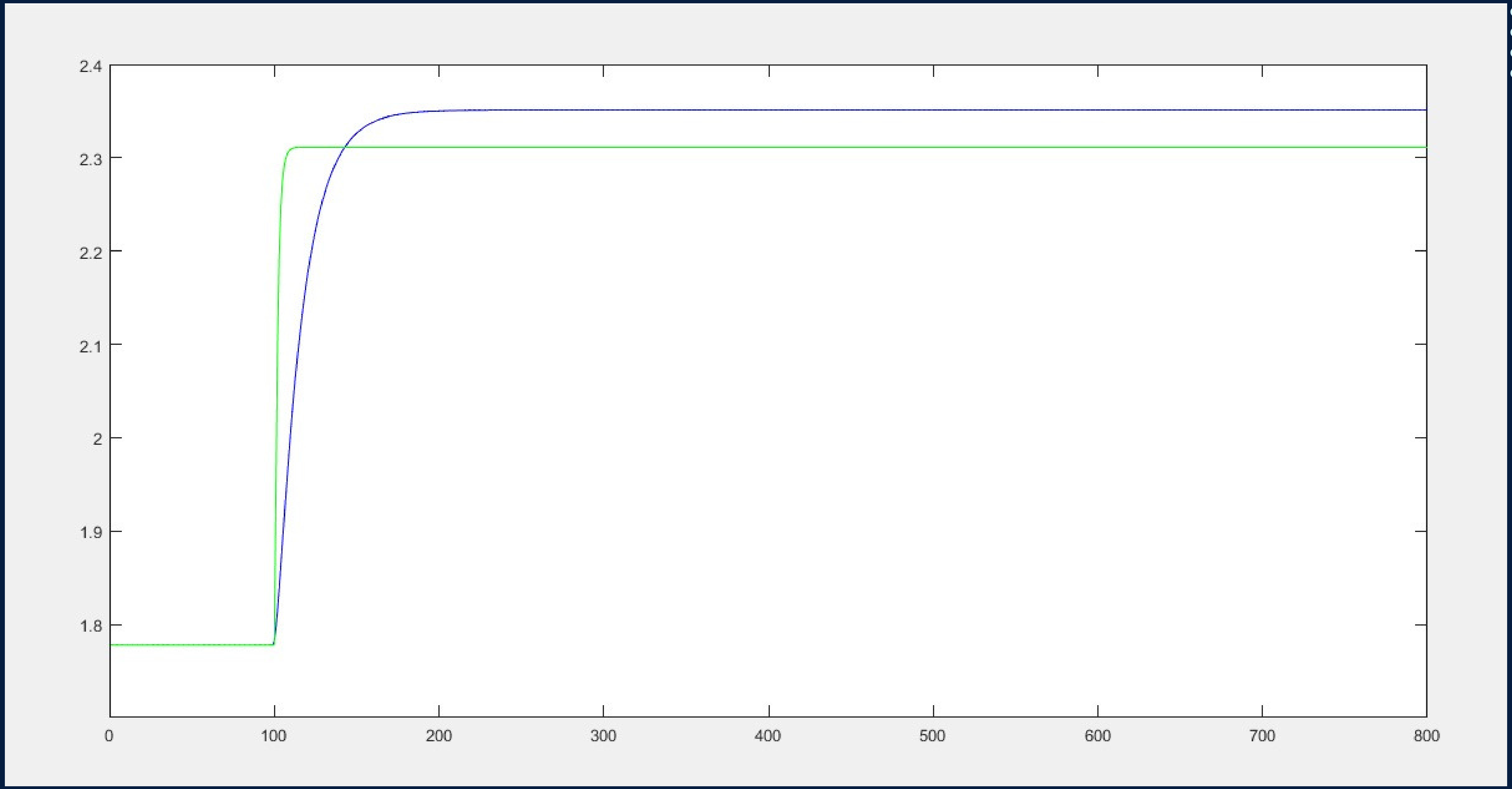
Time

20 PERCENT CHANGE IN INPUT (Q_I)

Linear Model

Non-Linear Model

Height



Time

τ ETA AND KP

From the final transfer function
Period of oscillation (tow) = 3.87
Damping Coefficient (eta) = 6.45
Process gain (Kp) = 4

NEED FOR PROJECT APART ACADEMICS :)

01 **Control Strategies:** Enhance control mechanisms for similar systems in industries.

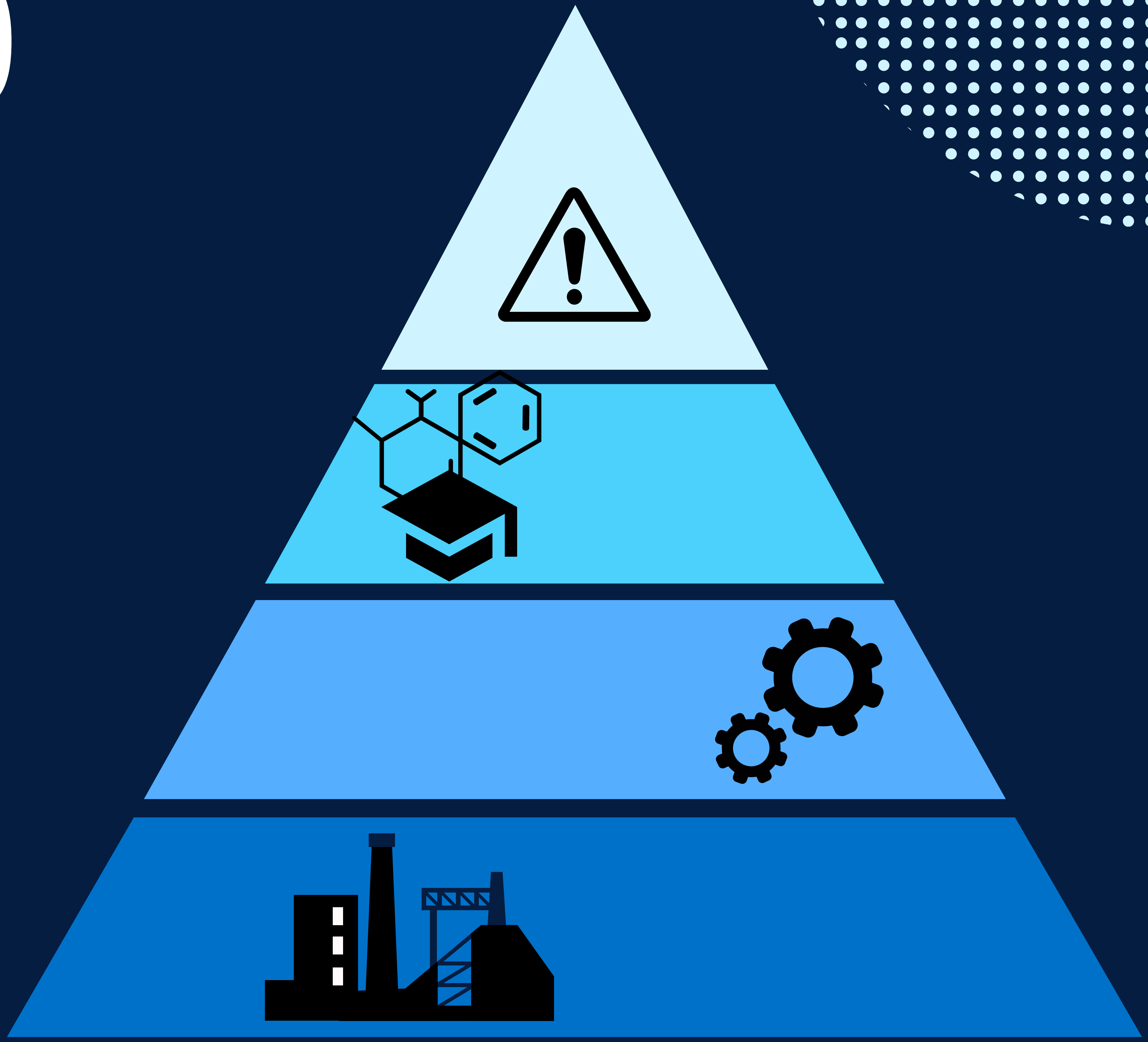
02 **Resource Management:** Optimize inventory handling and prevent overflow issues

03 **System Efficiency:** Identify bottlenecks for improved overall performance.

04 **Safety Measures:** Mitigate risks by understanding fluid flow dynamics

05 **Modeling & Simulation:** Create accurate models for scenario analysis.

06 **Education & Training:** Serve as an educational tool for learning control systems.



DIFFICULTIES FACED

1. The values of h1 and h2 were not given in the question and we took random values.
2. Tank 2 was giving an inverse response and we took time to understand the cause

CONCLUSION

In our experiment with the two-tank setup, we checked out how the liquid levels and flow rates behaved. We figured out what factors affected these levels and how they responded to changes. By doing tests and comparing different situations, we got a clear picture of how the system worked and how it reacted when we tweaked things. This helped us understand the system better, which is super important when we want to control it well and make it work more efficiently.

Thankyou