

LAB 2 Report - ECSE 403

1)

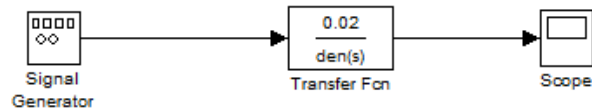


Figure 1: Diagram with transfer function derived from lab 1

2)

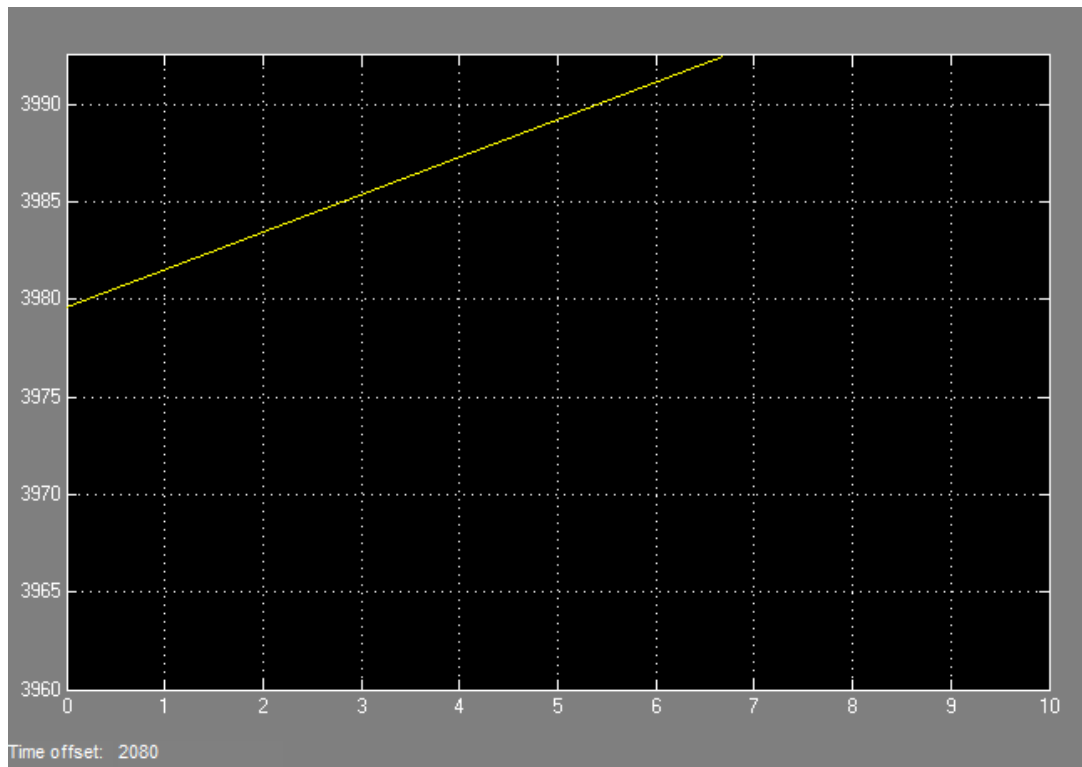


Figure 2: Response to the unit step function

We can see that the response of the system to a unit step function is an integrator. Therefore, we can conclude that there is no rise time and that the steady state response is infinite.

3) In order to obtain the necessary data to plot the magnitude Bode Diagram, we measured the amplitude for each frequency. Then, we plotted a graph with $10\log_{10}(\text{input frequency})$ as the x-axis and $20\log(\text{Amplitude})$ as y-axis.

We got:

Frequency	Amplitude
0.1	14
1	0.1985
10	$2 \cdot 10^{-3}$
100	0
1000	0

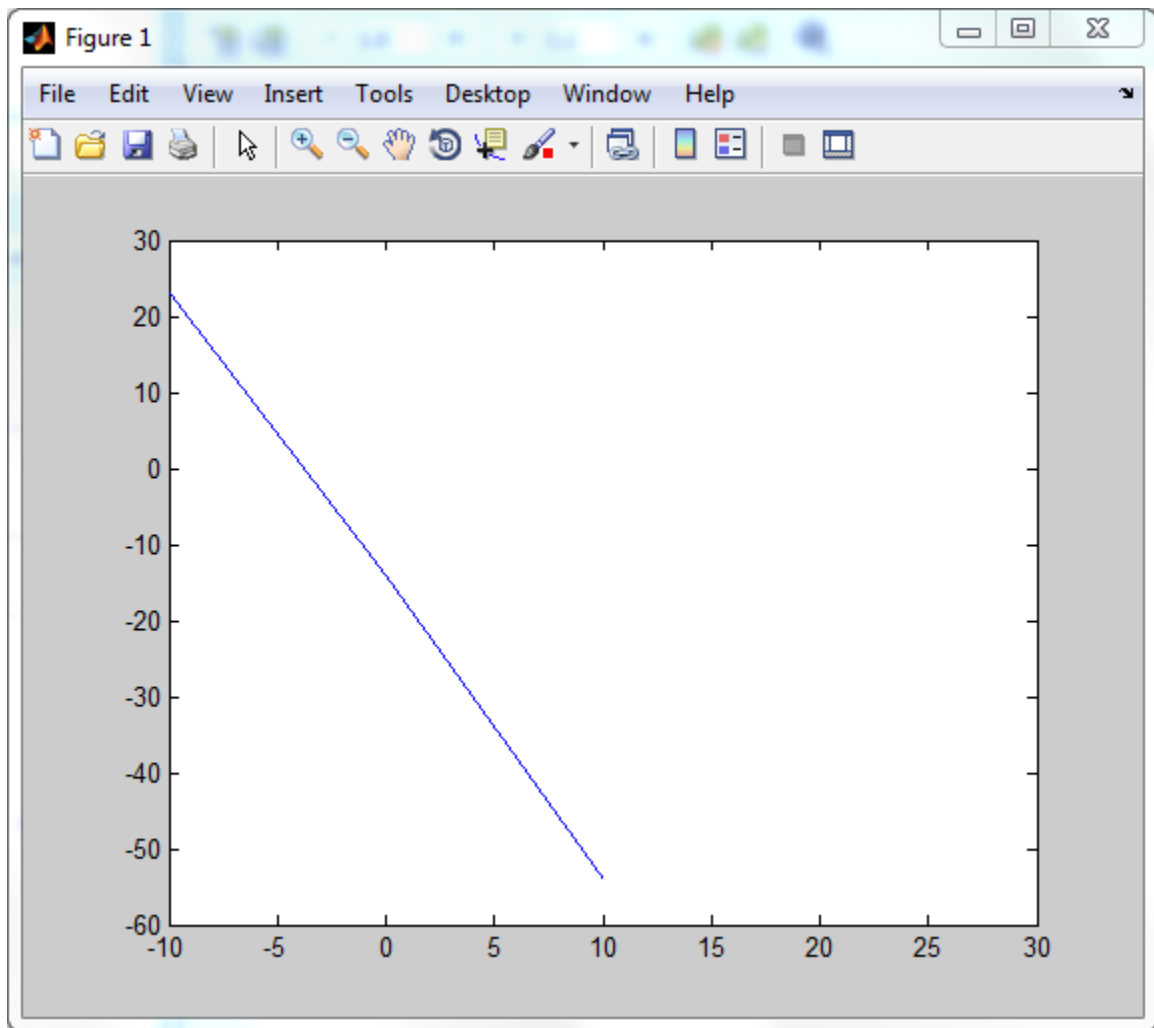


Figure 3: Experimental Bode Diagram

Then, we use the `bode(sys)` function on MATLAB to obtain the theoretical bode plot.

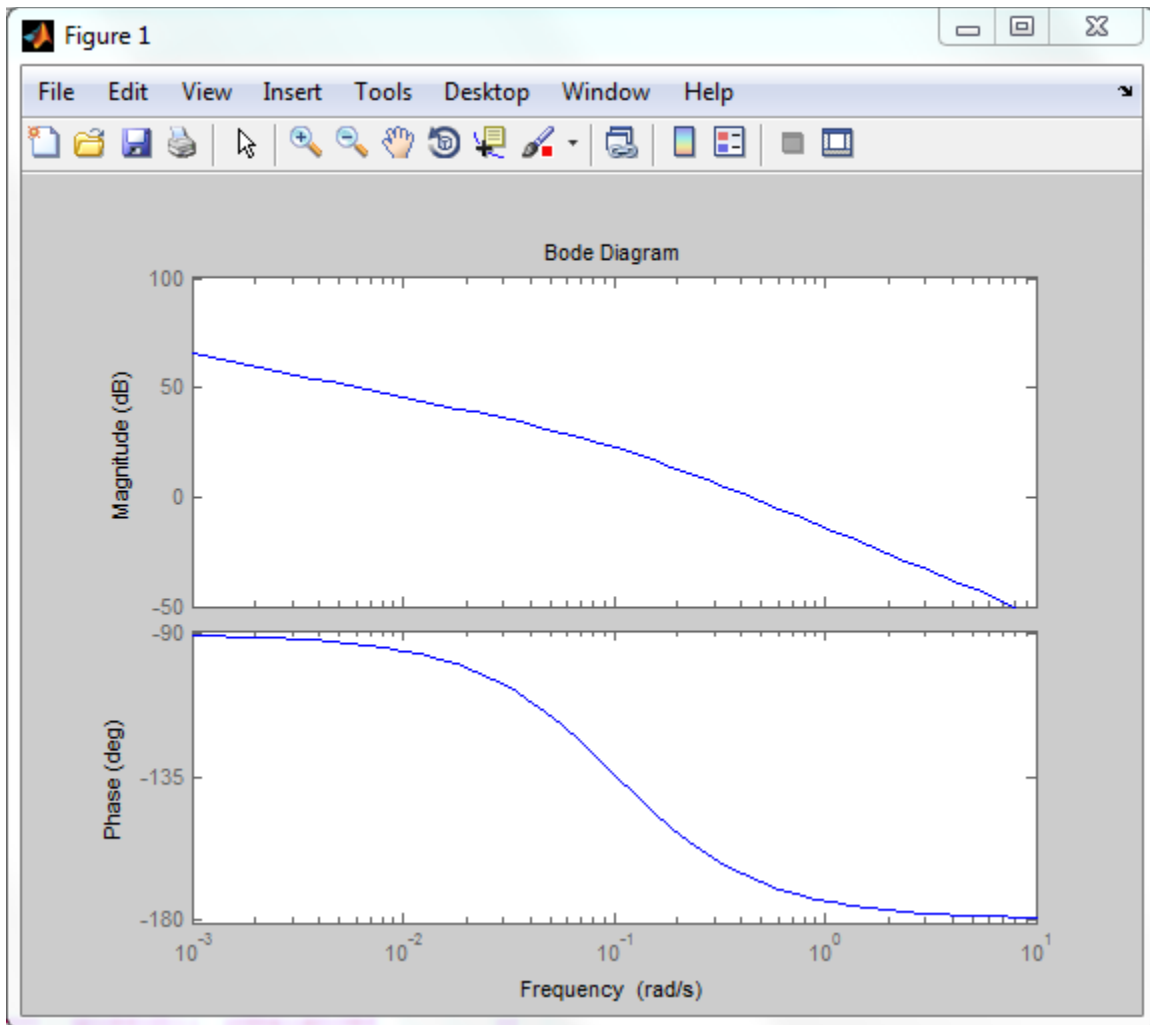


Figure 4: Theoretical Bode Diagram

```
% Q3
%% experimental bode plot
w_omega = [0.1*1*10*100*1000];
amplitude = [14*0.1985*2e-3*0*0];
%
x = 10.*log10(w_omega);
y = 20.*log10(amplitude);
plot(x,y);

%% theoretical bode plot
G = 0.02 / (0.1*s*s + 0.0104*s);
bode(G);
```

4) Following the same steps as the previous question, we obtained the following values:

Frequency	Amplitude
0.1	1.17
1	0.785
10	0.653
100	2.51
1000	0.0135

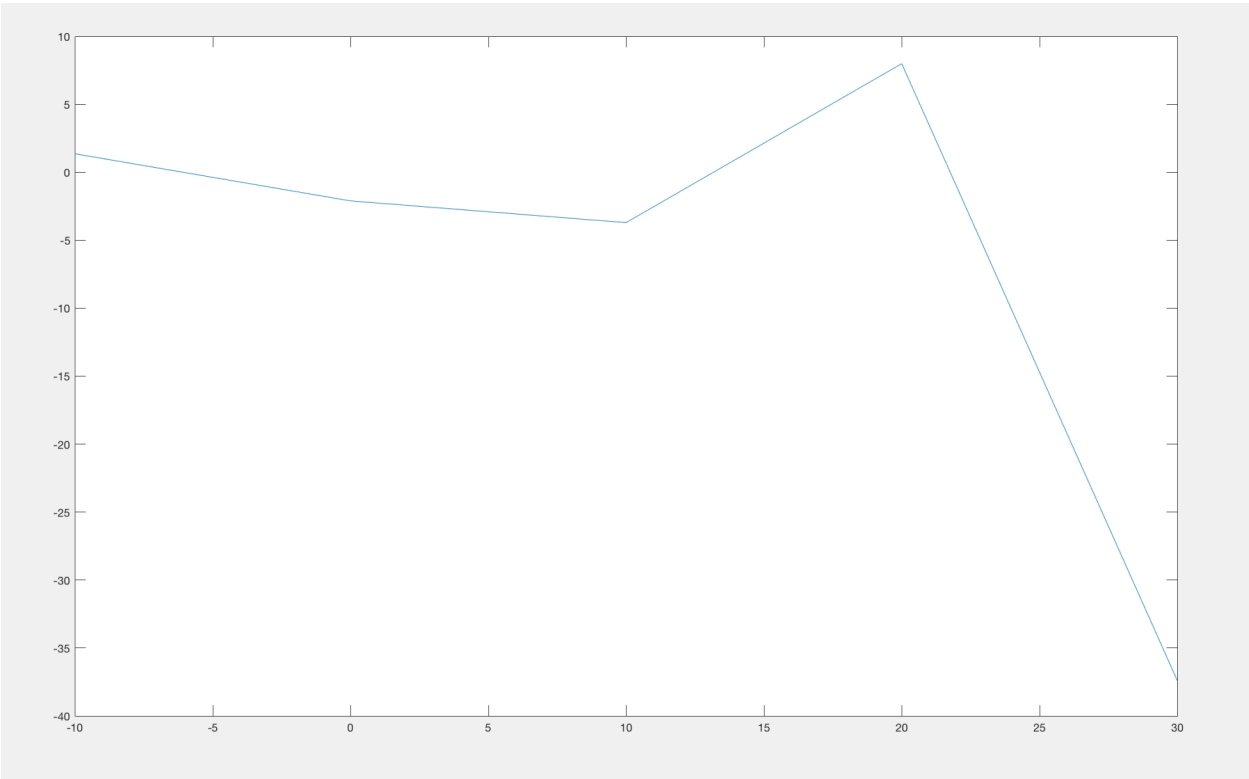


Figure 5: Experimental Bode Diagram

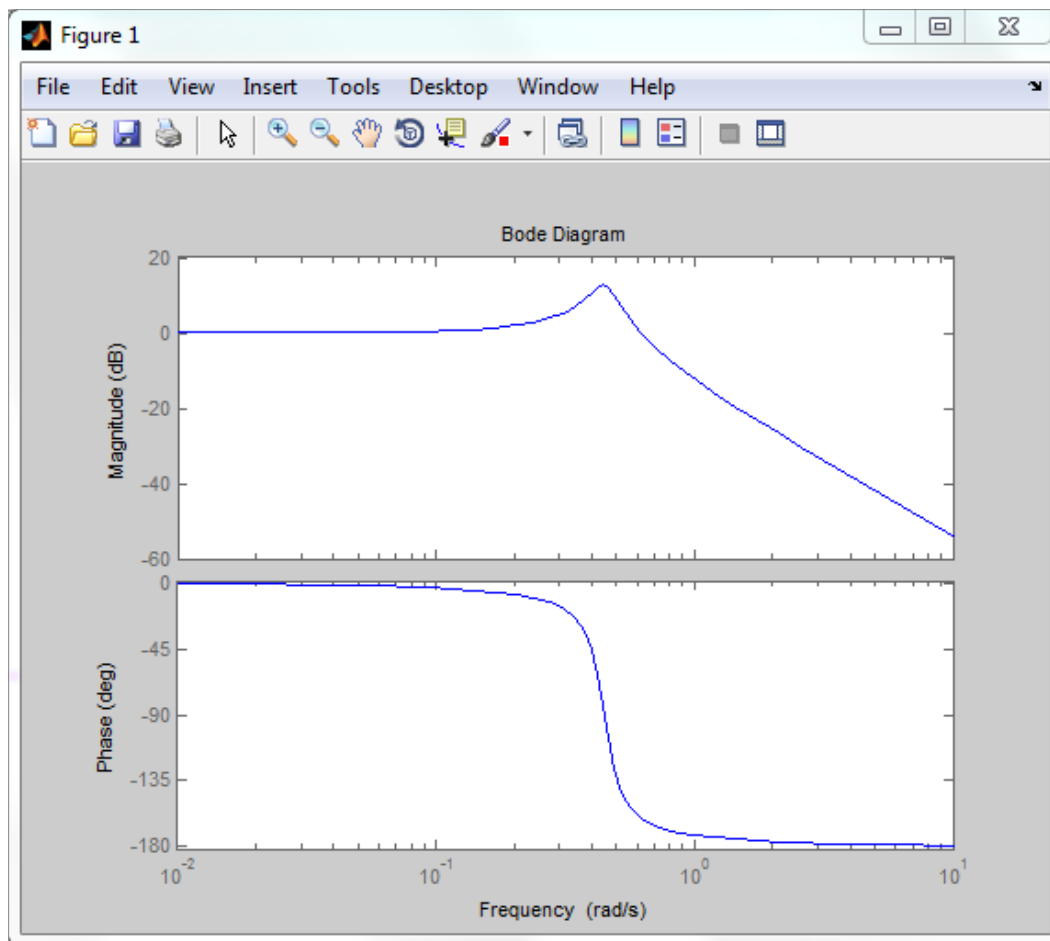


Figure 6: Theoretical Bode Diagram

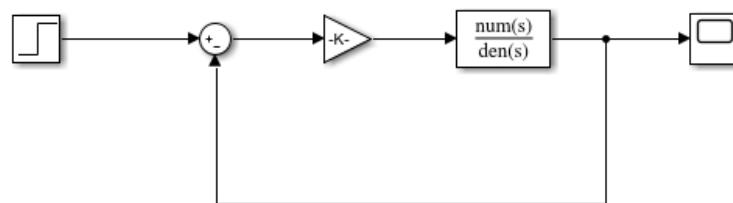


Figure 7: Simulink Model for question 4 to 6

```

% Q4
%% experimental bode plot
w_omega = [0.1*10*100*1000];
amplitude = [1.05*0.25*2.075e-3*4.1e-4*7e-3];

x = 10.*log10(w_omega);
y = 20.*log10(amplitude);
plot(x,y);

%% theoretical bode plot
G2 = 0.02 / (0.02 + (0.1*s*s + 0.0104*s))
bode(G2)

%%
stepinfo(G2);

```

5) Rise time 4 s

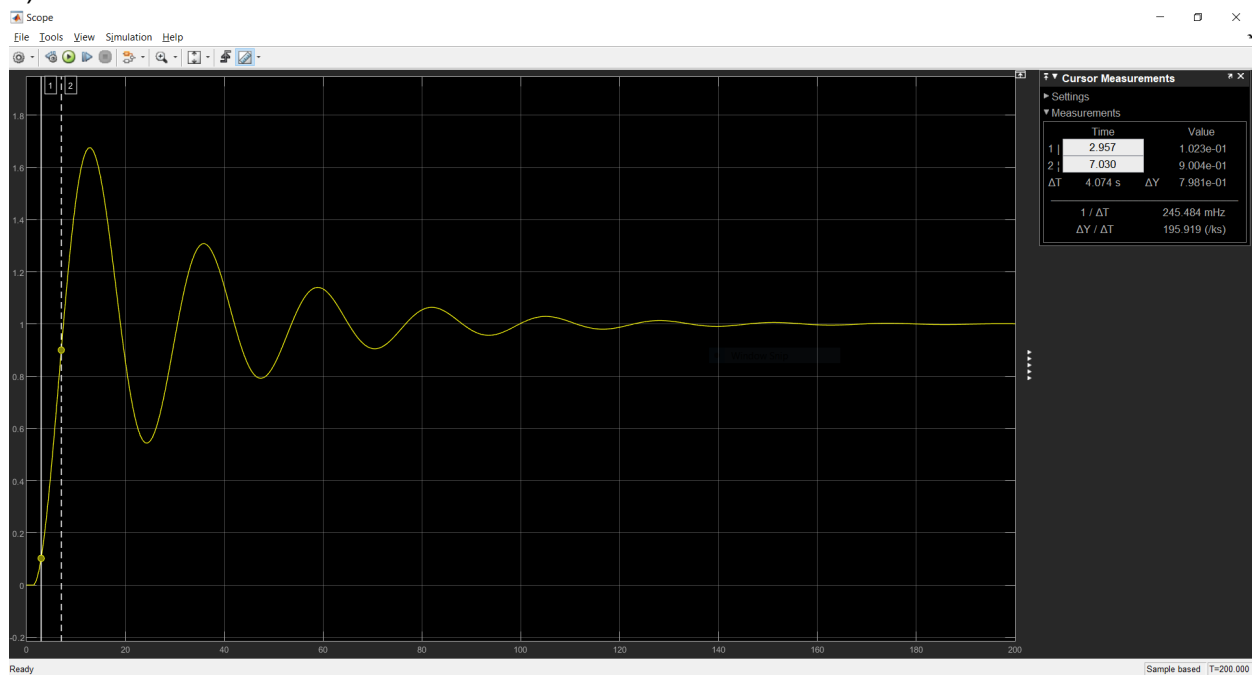


Figure 8: Scope with P controller, $K = 0.37$

Rise time is the time difference for change in system from 10% to 90% of steady-steady value. Figure 8 is for a system with gain $K = 0.37$ and unit feedback. We can see in Figure 9 that the time difference = 4 s (approximately).

6) Overshoot 20%

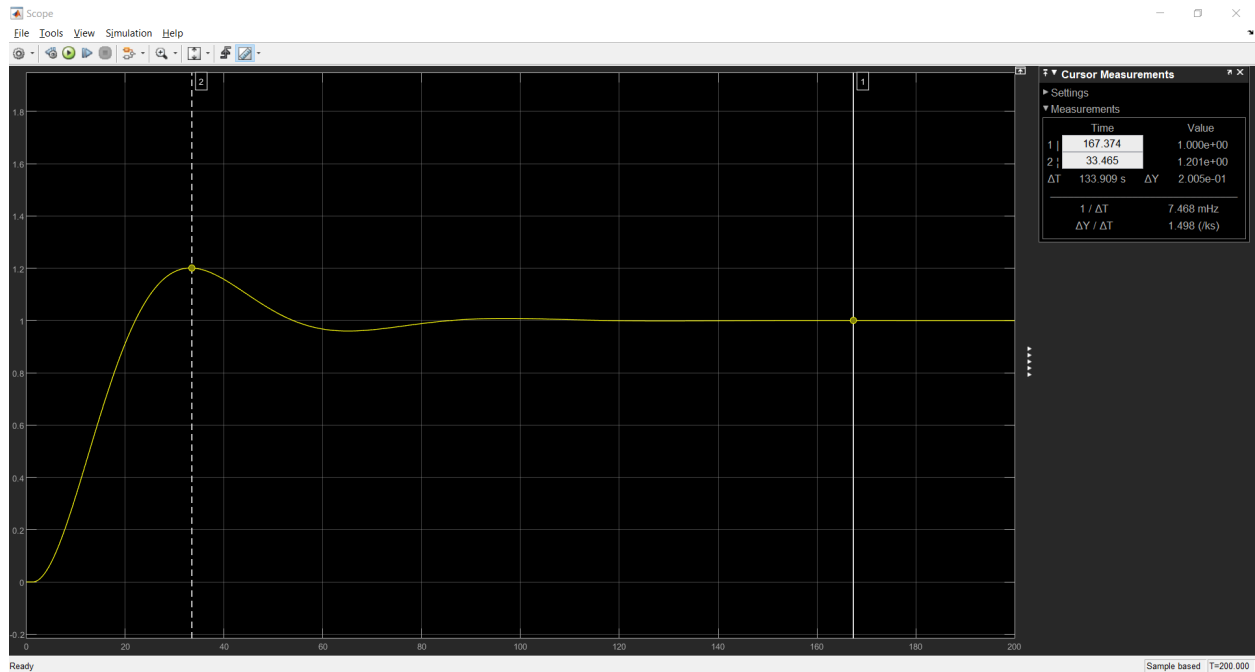


Figure 9: Scope with P controller, $K = 0.0595$

Overshoot being the maximum value of output the system gives more than steady-state, we can see from Figure 9, that for overshoot 20%, the applied gain $K = 0.0595$.

7) Effects of PID controllers

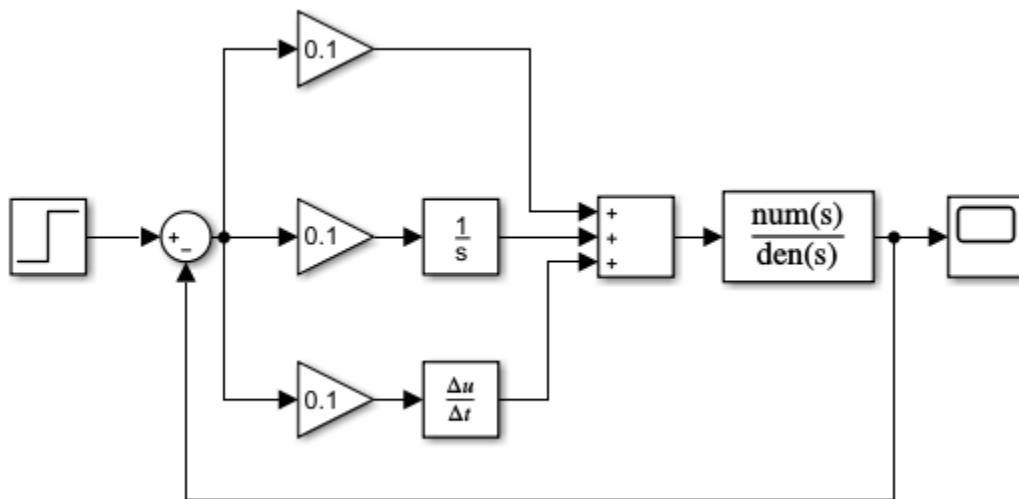


Figure 10: Model for PID controller

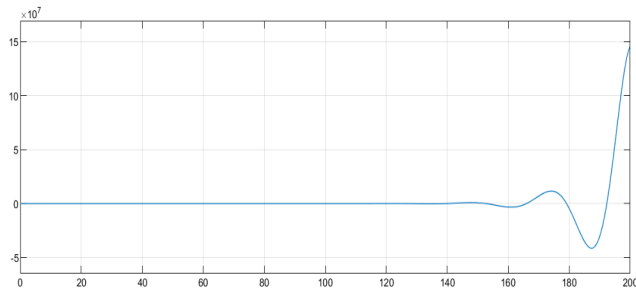


Figure 11: $K_p=0.1$ $K_i=0.1$

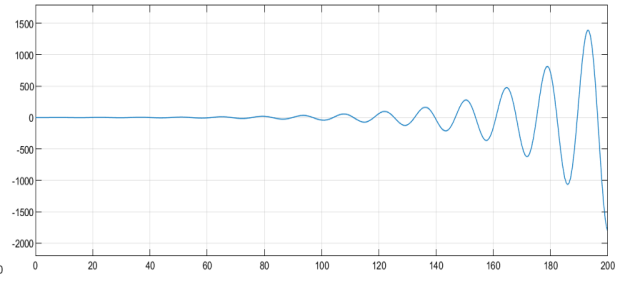


Figure 12: $K_p=1$ $K_i=0.1$

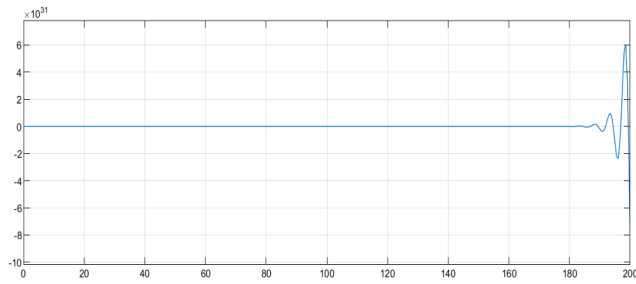


Figure 13: $K_p=10$ $K_i=0.1$

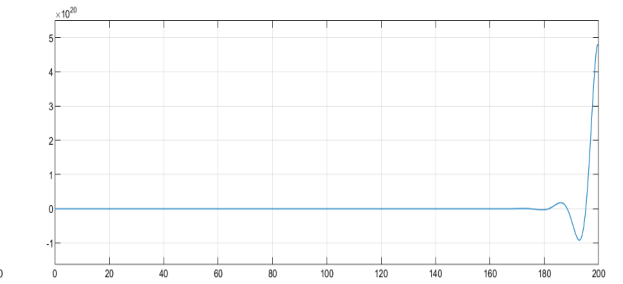


Figure 14: $K_p=0.1$ $K_i=1$

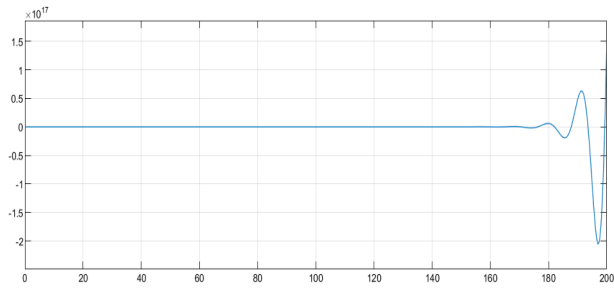


Figure 15: $K_p=1$ $K_i=1$

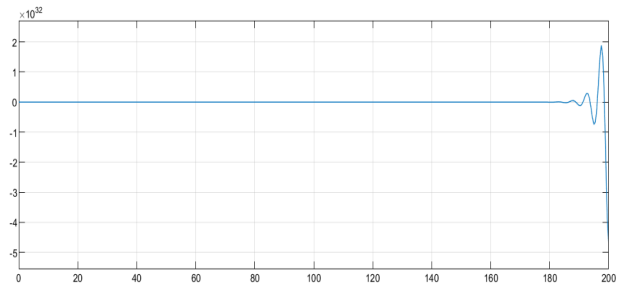


Figure 16: $K_p=10$ $K_i=1$

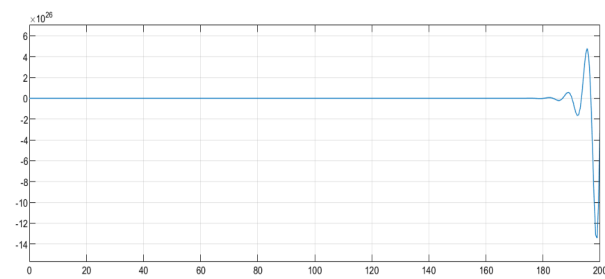


Figure 17: $K_p=0.1$ $K_i=10$

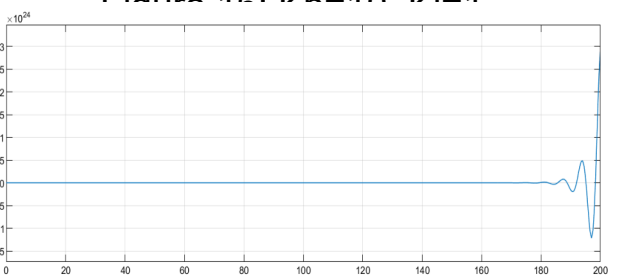


Figure 18: $K_p=1$ $K_i=10$

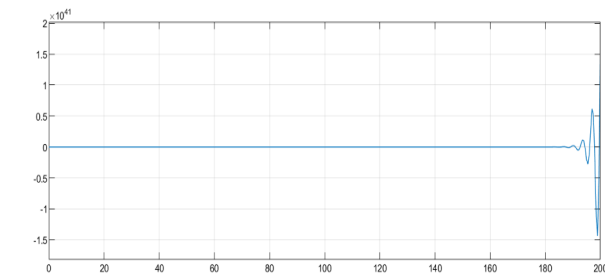


Figure 19: $K_p=10$ $K_i=10$

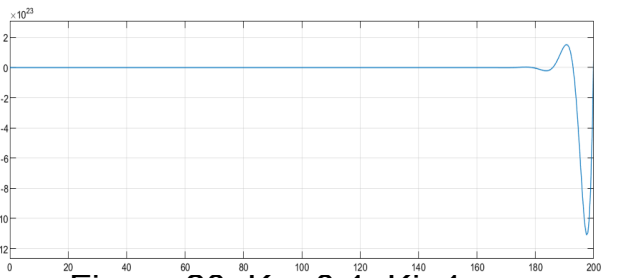


Figure 20: $K_p=0.1$ $K_i=1$

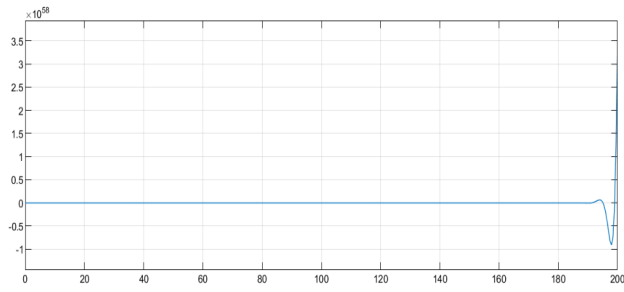


Figure 21: $K_p=0.1$ $K_i=10$

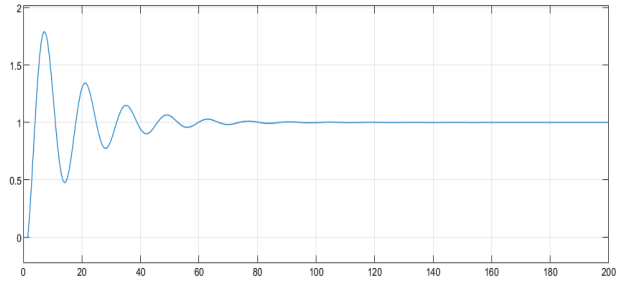


Figure 22: $K_p=1$ $K_i=0.1$

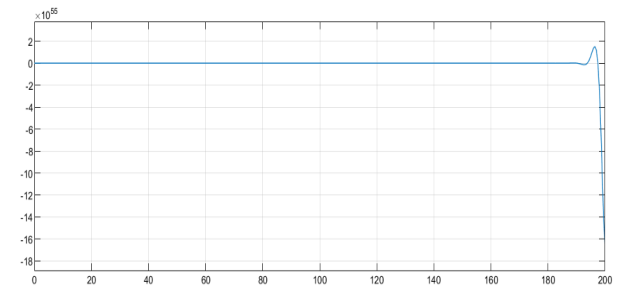


Figure 23: $K_p=1$ $K_i=10$

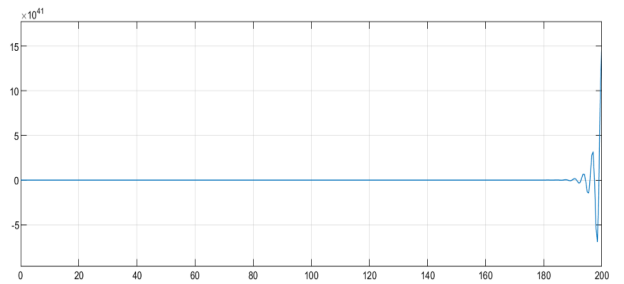


Figure 24: $K_p=10$ $K_i=0.1$

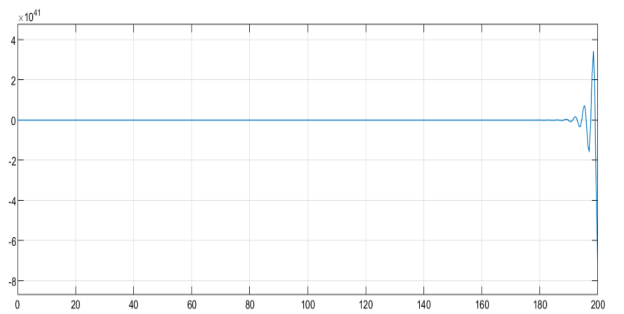


Figure 25: $K_p=10$ $K_i=1$

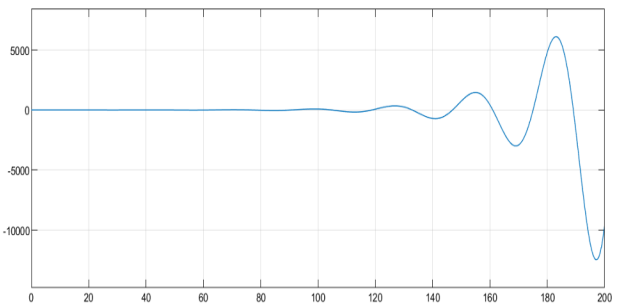


Figure 26: $K_p=0.1$ $K_i=0.1$

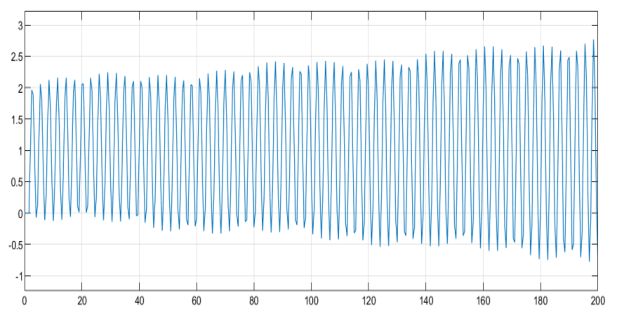


Figure 27: $K_p=0.1$ $K_i=0.1$

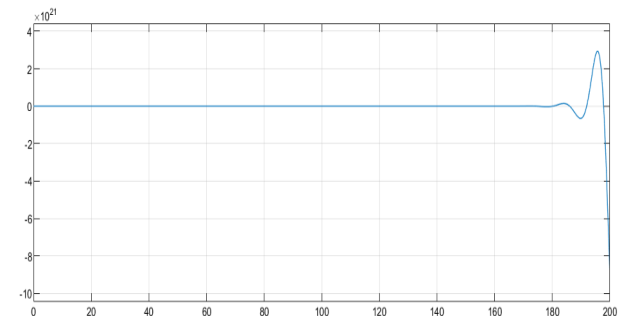


Figure 28: $K_p=1$ $K_i=1$

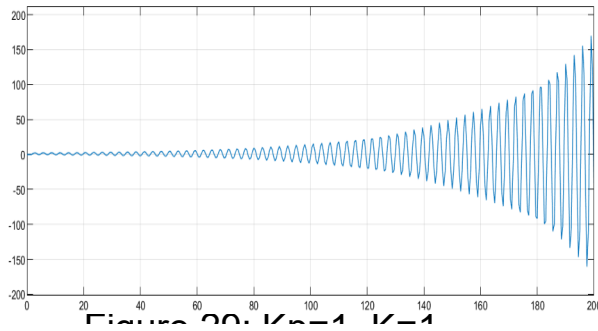


Figure 20: $K_p=1$, $K_i=1$

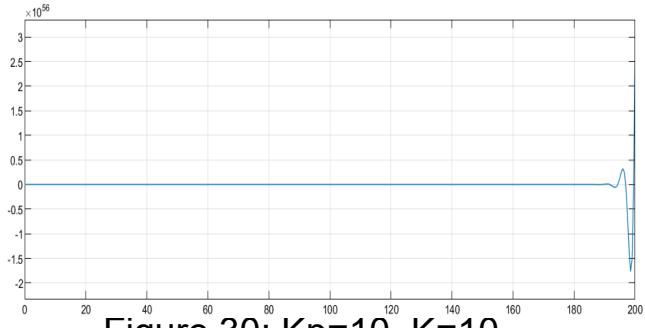


Figure 21: $K_p=10$, $K_i=10$

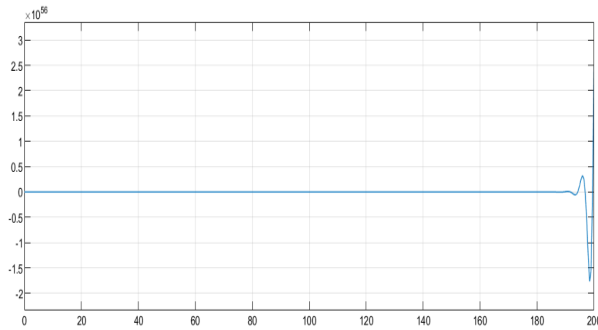


Figure 22: $K_p=10$, $K_i=10$

Keeping K_p and K_d constant, increasing K_i decreases Rise Time, Overshoot and Settling Time and also eliminates Steady-State error.

Keeping K_p and K_i constant, increasing K_d decreases Overshoot and Settling Time.

8) With Derivative Gain $K_d = 0$

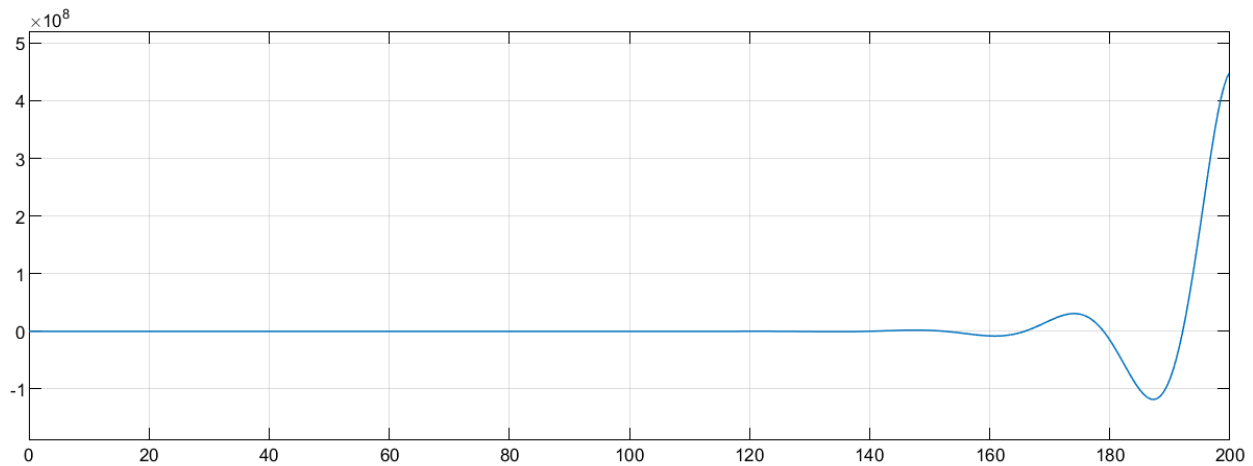


Figure 32: $K_p = 0.1$, $K_i = 0.1$, $K_d = 0$

With $K_p = 0.1$ and $K_i = 0.1$, we can see that for a $K_d = 0$, we get a very high rise time and a decrease in overshoot and settling time.

9) With Integrator Gain $K_i = 0$

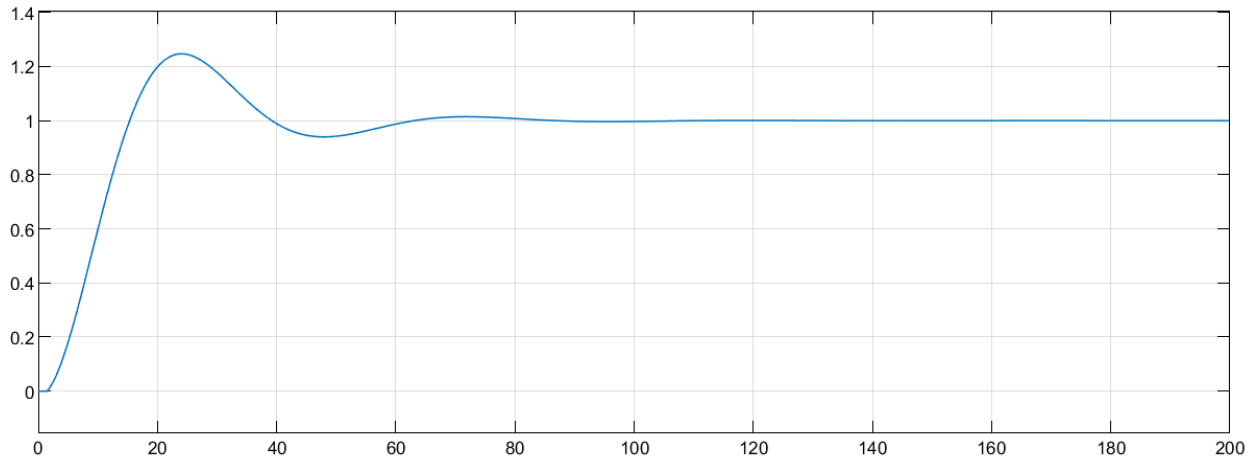


Figure 33: $K_p = 0.1$, $K_i = 0.1$, $K_d = 0$

For $K_d = 0.1$ and $K_p = 0.1$, we can see that for a $K_i = 0$, we get a low rise time and a high overshoot.

10) We followed the lab manual instructions and observed the output of the system. (Verified by the TA)

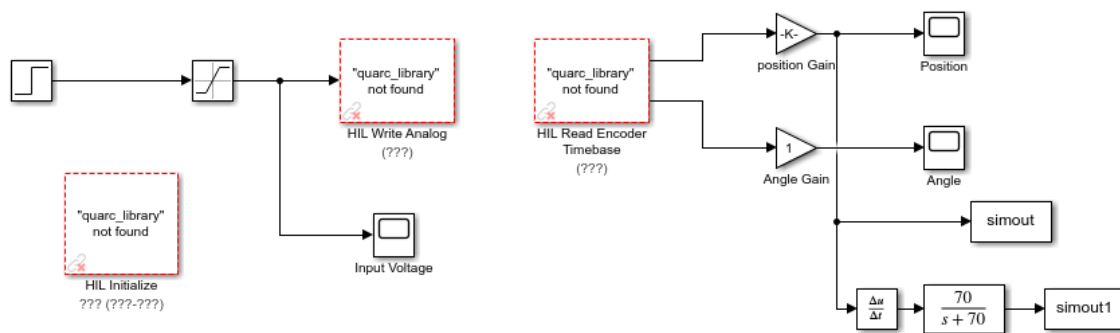


Figure 34: Simulink Model for question 10 to 14

11) The goal is to find the linear gain position such that we can observe the output in terms of centimeters. After measuring the distance traveled with a ruler for a position gain of 1, we obtain a scale of 45.5 units per centimeters travelled. Hence, dividing 1 by 45.5, we obtain the linear position gain of **0.022**.

12)

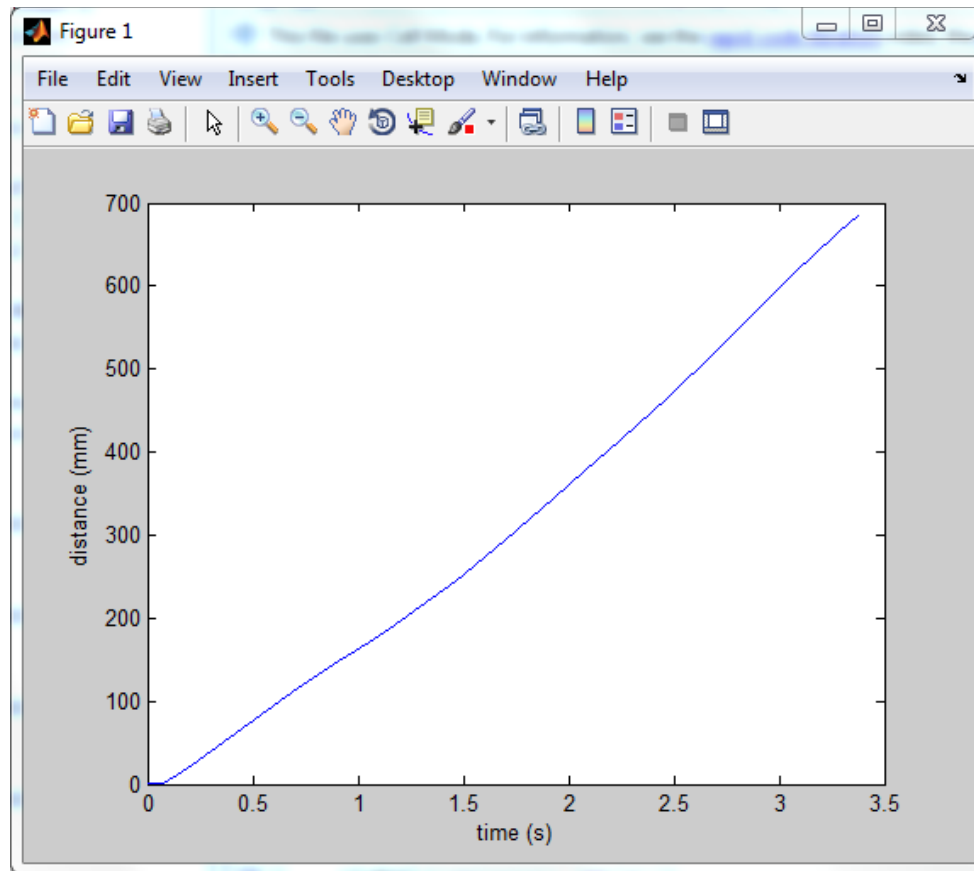


Figure 35: Step-Response of the System in terms of distance

```
%% Q12
figure(1)
plot(simout.time,simout.signals.values);
xlabel('time (s)');
ylabel('distance (mm)')
figure(2)
plot(simout.time,simout1.signals.values);
xlabel('time (s)');
ylabel('velocity (mm/s)')
```

13) We obtain the velocity as output of the system by adding a divider to the model since we had a model that had the position as output of the system.

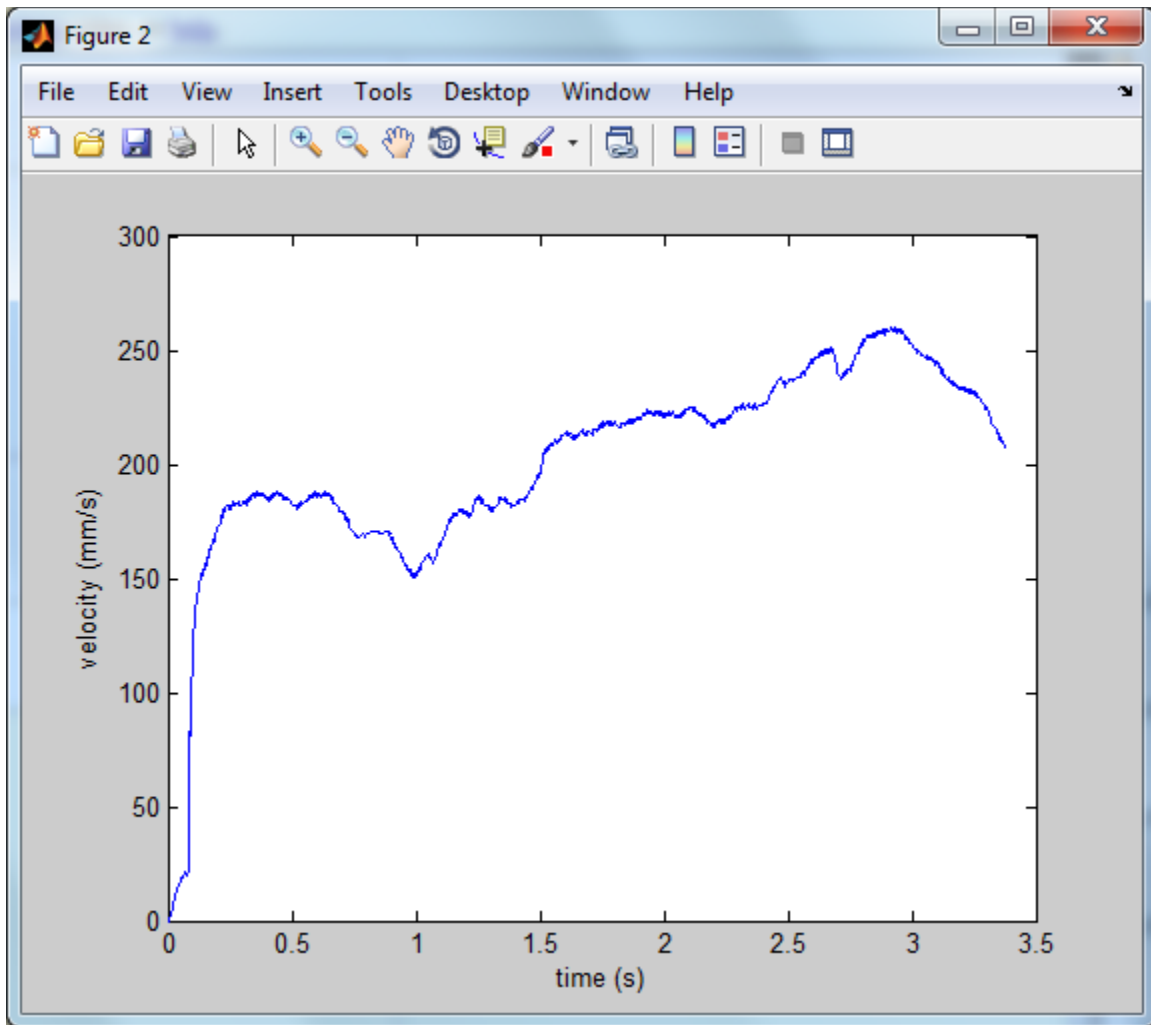


Figure 36: Step Response in terms of velocity

14) The observed velocity on the scope is noisy because we are converting digital input signals to analog signals. We can also assume that the friction of the cart can be another source of noise.