Cape Peninsula University of Technology
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Built Environment & Engineering

Department of Mechanical, Mechatronics and Industrial Engineering

Laboratory Report

Practical 4

CSS260S

Control Systems

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Part One

Question 1

Code

```
% Define numerator and denominator of transfer function G
numg = 500 * poly([-2 -5 -6]); % Numerator of the original transfer function
deng = poly([0 -8 -10 -12]);   % Denominator of the original transfer function
G = tf(numg, deng);            % Transfer function

% Check stability by calculating poles of the closed-loop system
T = feedback(G, 1);            % Closed-loop transfer function
poles = pole(T)                % Display poles to check stability

% Step Input
Kp = dcgain(G);                % Proportional gain for step input
essKp = 1 / (1 + Kp);          % Steady-state error for step input
disp(['Steady-state error for step input: ', num2str(essKp)]);

% Ramp Input
num_ramp = conv([1 0], numg);  % Numerator for ramp input
den_ramp = deng;               % Denominator remains the same for ramp input
sG = tf(num_ramp, den_ramp);   % Transfer function for ramp input
sG = minreal(sG);              % Minimal realization of the transfer function
Kv = dcgain(sG);               % Velocity gain for ramp input
essKv = 1 / Kv;                % Steady-state error for ramp input
disp(['Steady-state error for ramp input: ', num2str(essKv)]);

% Parabolic Input
num_parabolic = conv([1 0 0], numg);  % Numerator for parabolic input
den_parabolic = deng;                 % Denominator remains the same for parabolic input
s2G = tf(num_parabolic, den_parabolic); % Transfer function for parabolic input
s2G = minreal(s2G);                   % Minimal realization of the transfer function
Ka = dcgain(s2G);                     % Acceleration gain for parabolic input
essKa = 1 / Ka;                       % Steady-state error for parabolic input
disp(['Steady-state error for parabolic input: ', num2str(essKa)]);

pause % Pauses the execution, press a key to resume
```

Figure 1 - The script that demonstrates the calculation of the steady state errors for the unit

```
Steady-state error for step input: 0
Steady-state error for ramp input: 0.032
Steady-state error for parabolic input: Inf
```

Figure 2 - Results from running the script

Question 2

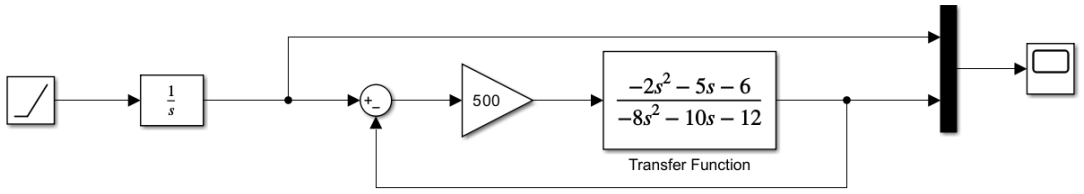

Figure 3 - A diagram of the system recieving parabolic input

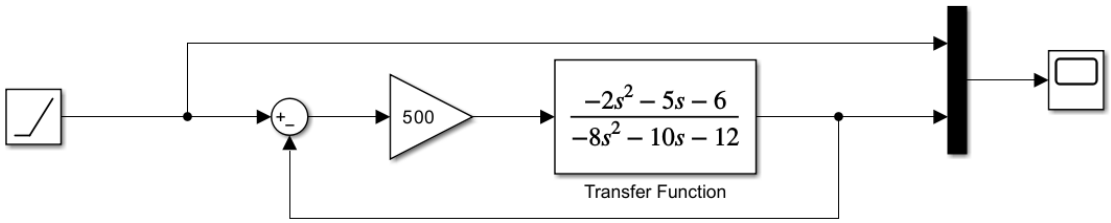

Figure 4 - A diagram of the system recieving ramp input

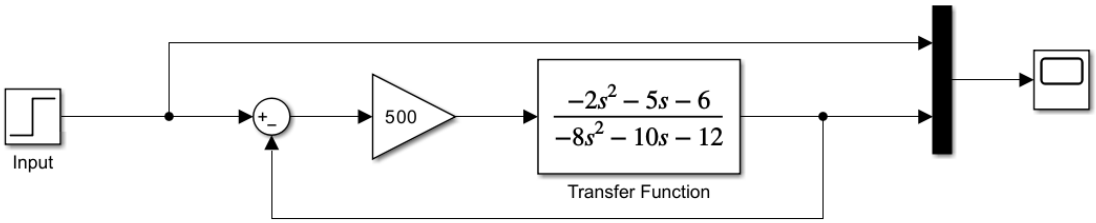

Figure 5 - A diagram of the system recieving step input

Part Two

Simulink Implementation

Simulink Diagrams

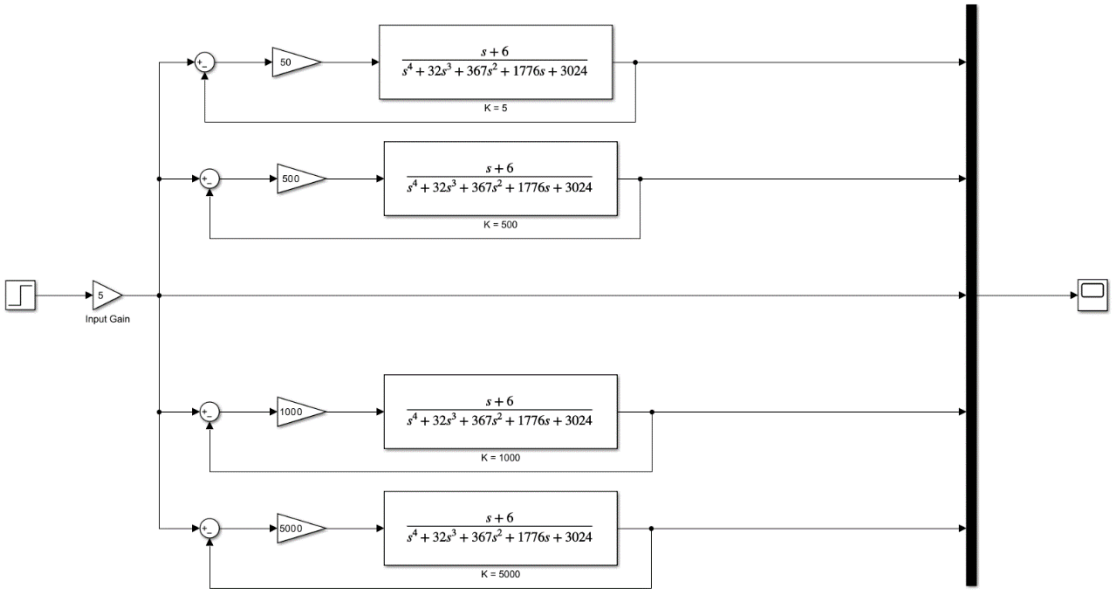

Figure 6 - A diagram of the error signal of the system for an input of 5 for (6)

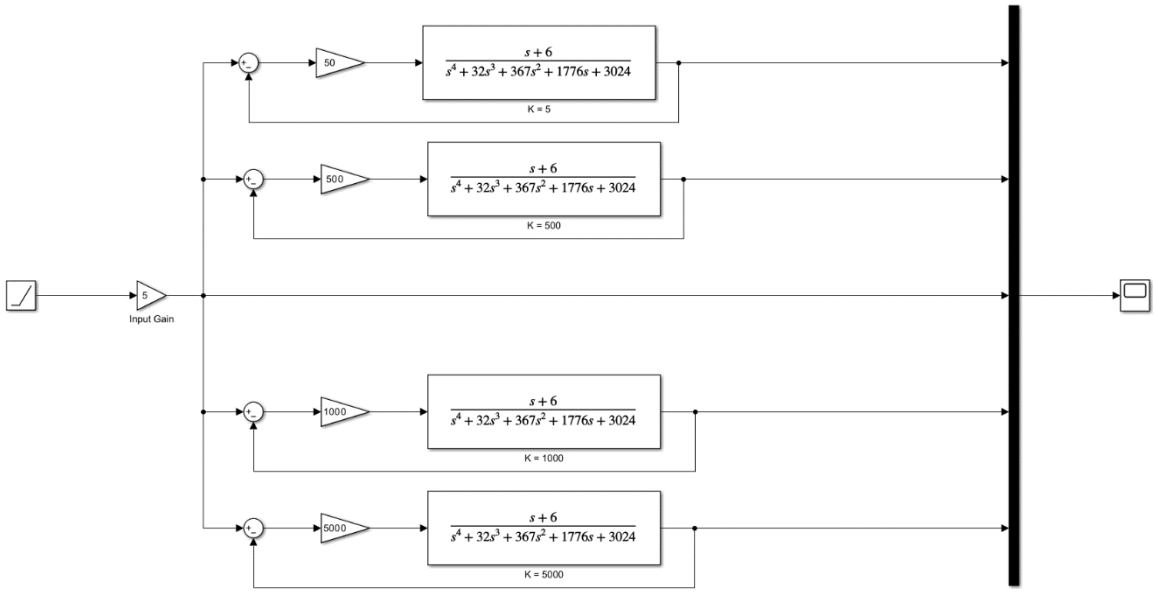

Figure 7 - A diagram of the error signal of the system for an input of 5t for (6)

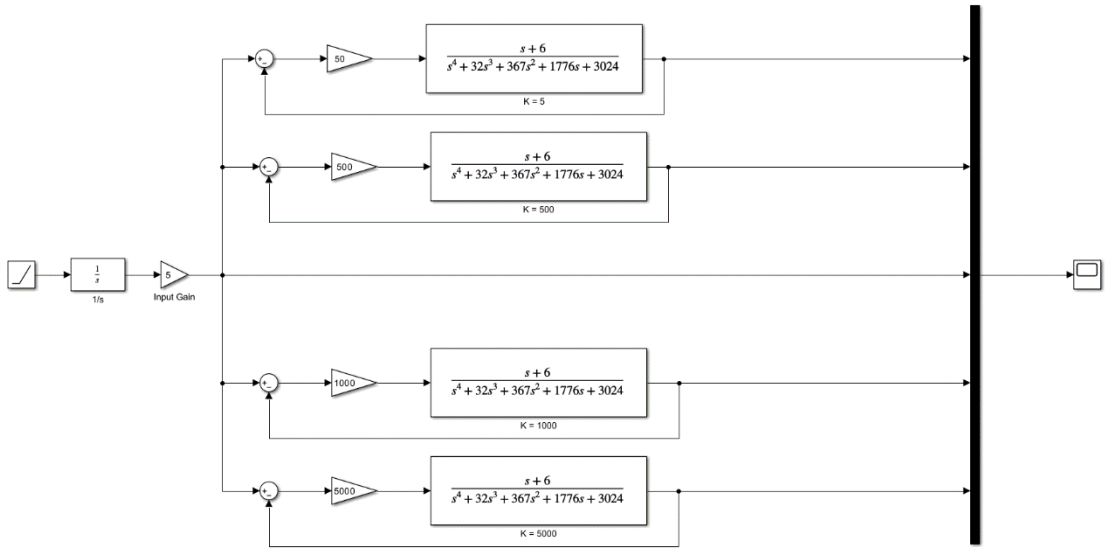

Figure 8 - A diagram of the error signal of the system for an input of 5t^2 for (6)

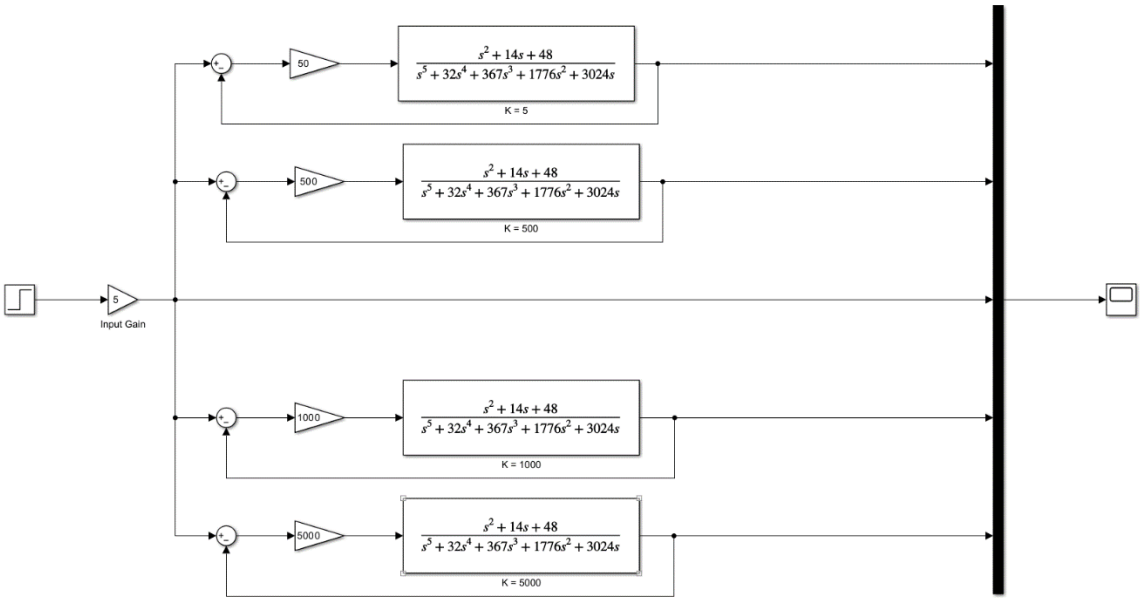

Figure 9 - A diagram of the error signal of the system for an input of 5 for (7)

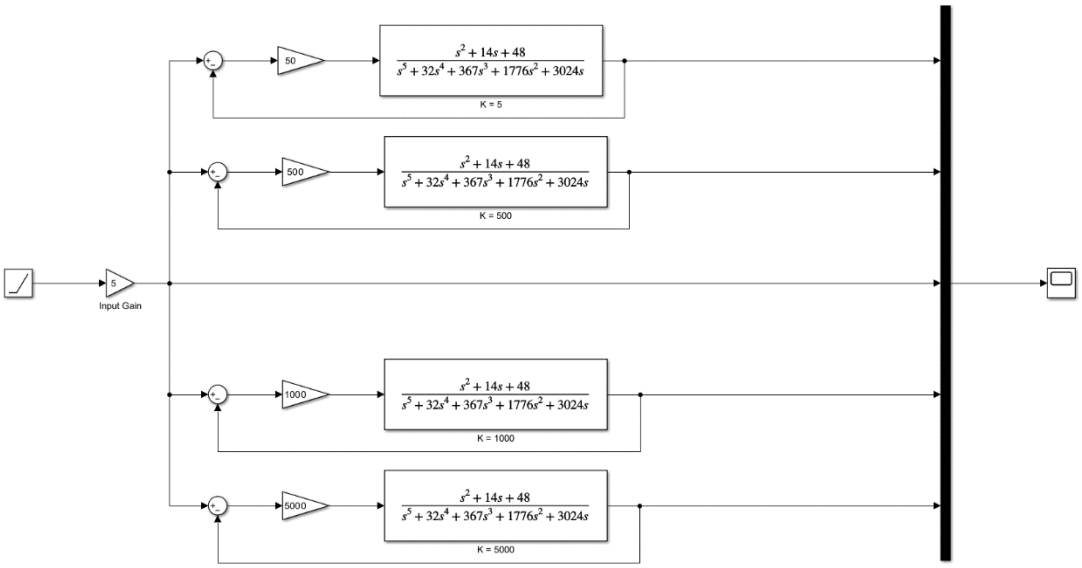

Figure 10 - A diagram of the error signal of the system for an input of 5t for (7)

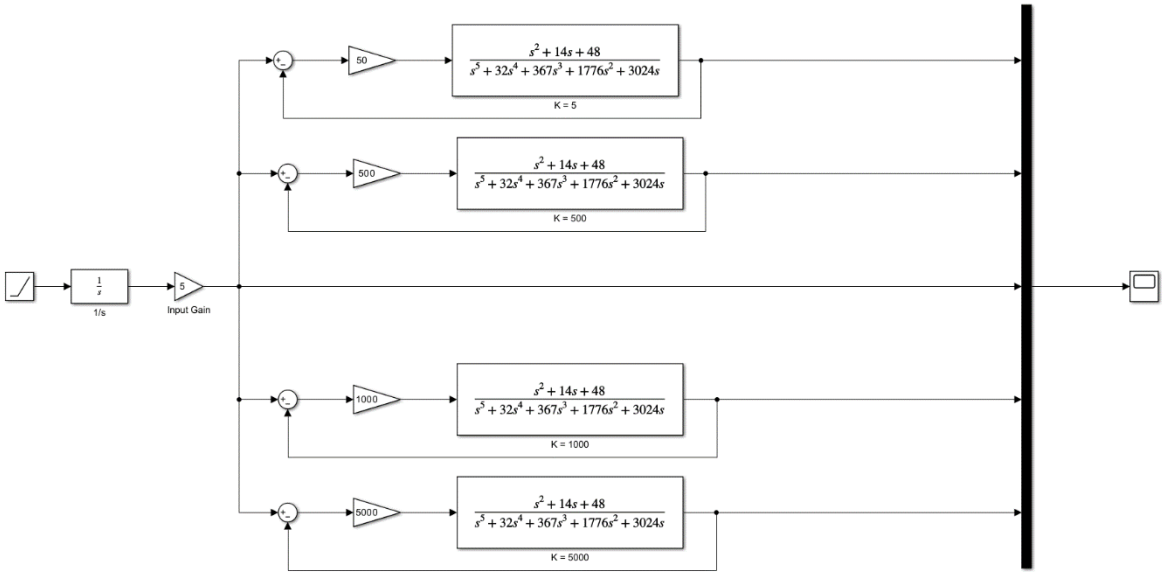

Figure 11 - A diagram of the error signal of the system for an input of 5t^2 for (7)

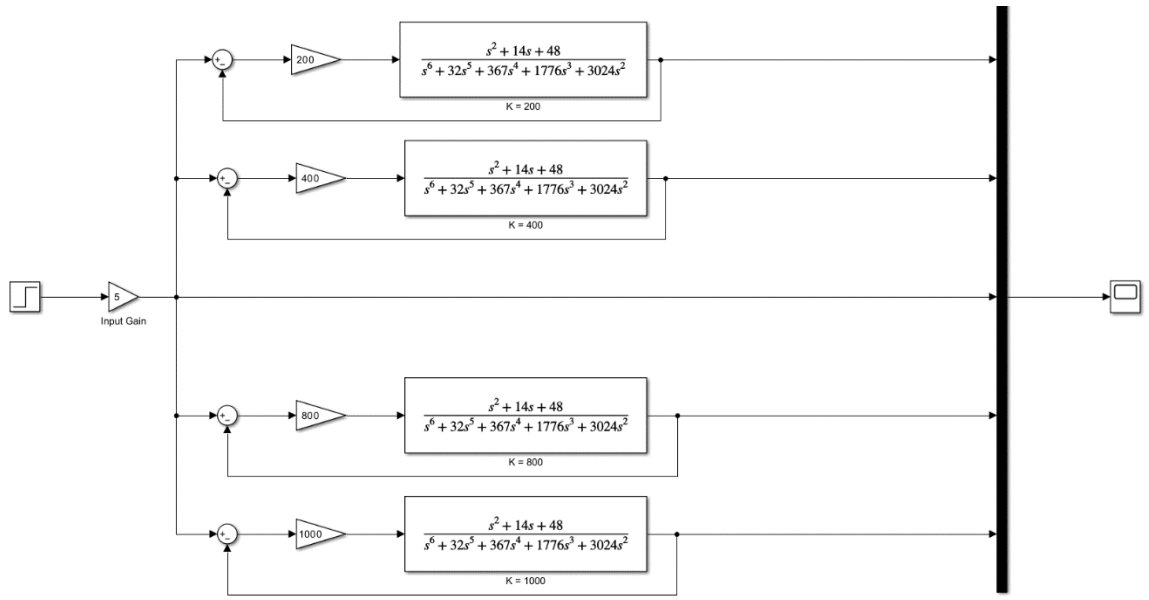

Figure 12 - A diagram of the error signal of the system for an input of 5 for (8)

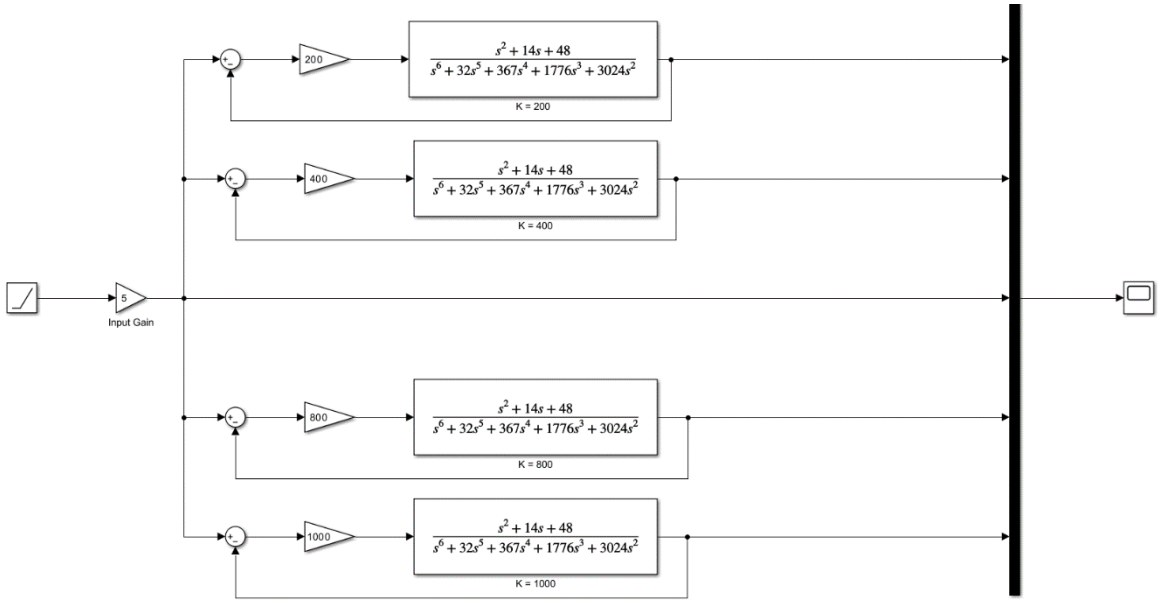

Figure 13 - A diagram of the error signal of the system for an input of 5t for (8)

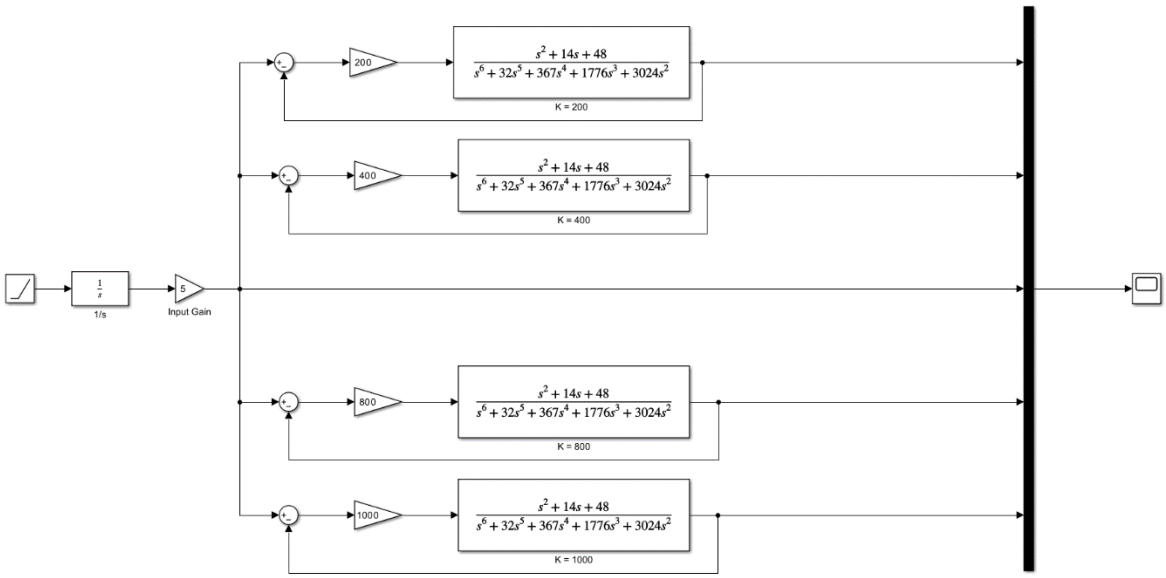

Figure 14 - A diagram of the error signal of the system for an input of 5t^2 for (8)

Simulink Graphs

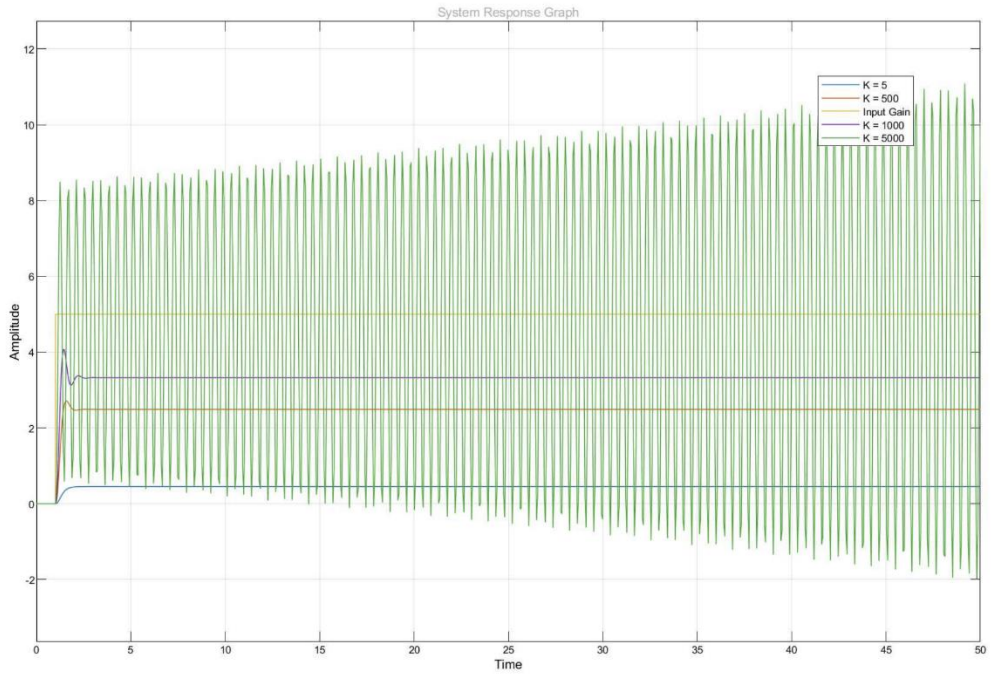

Figure 15 - A graph of the error signal of the system for an input of 5 for (6)

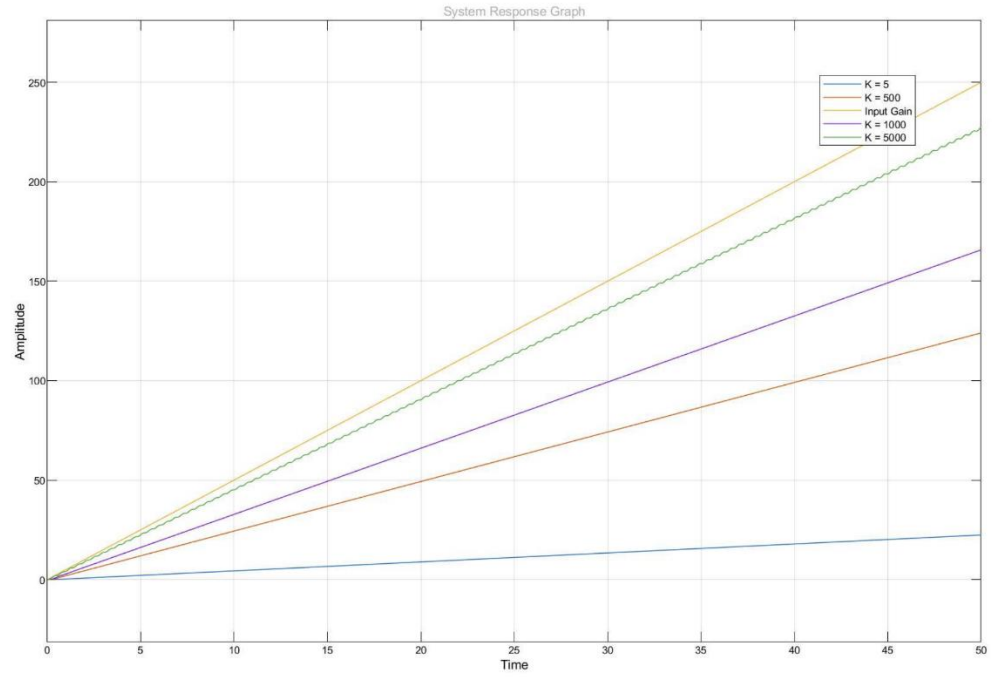

Figure 16 - A graph of the error signal of the system for an input of 5t for (6)

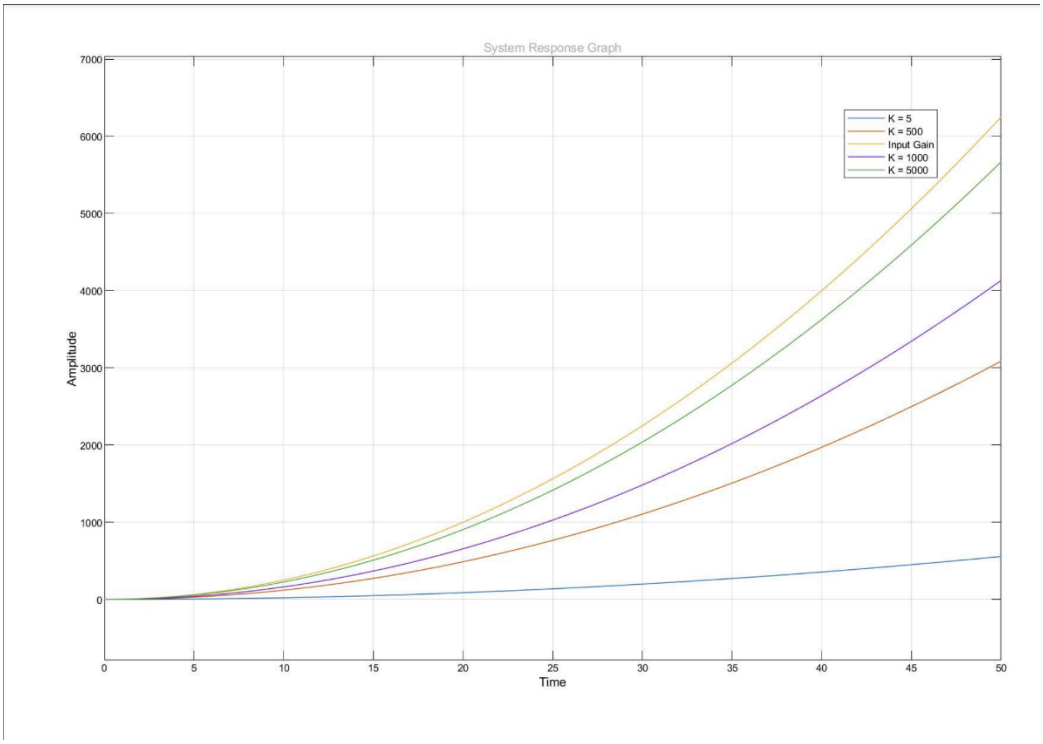

Figure 17 - A graph of the error signal of the system for an input of 5t^2 for (6)

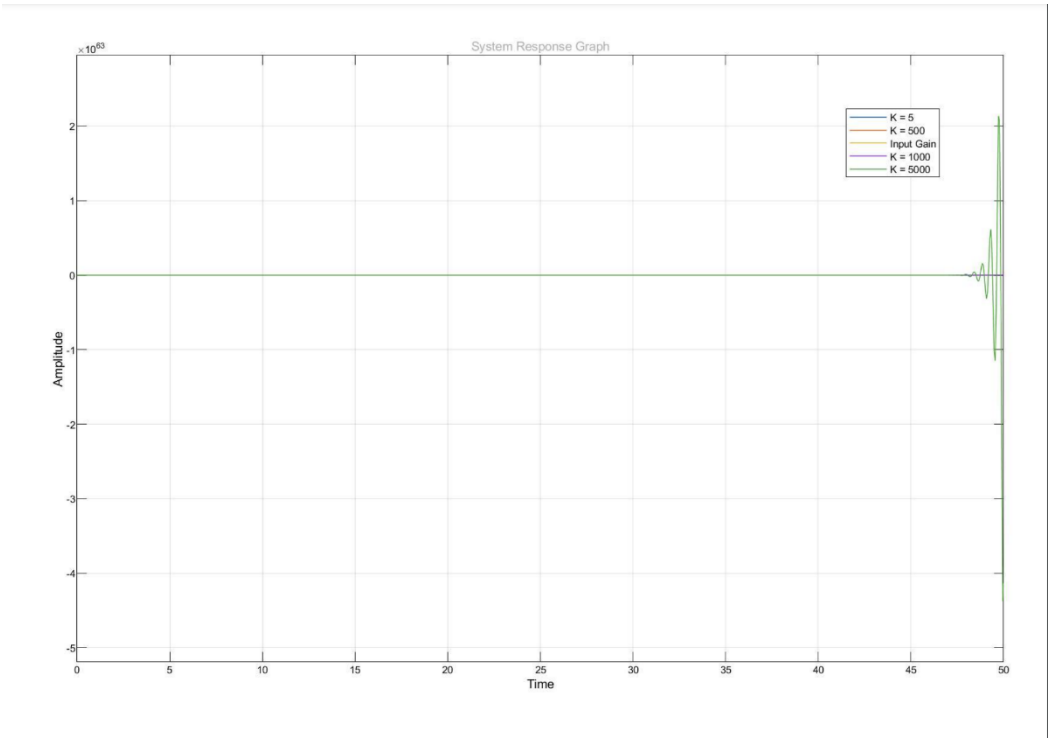

Figure 18 - A graph of the error signal of the system for an input of 5 for (7)

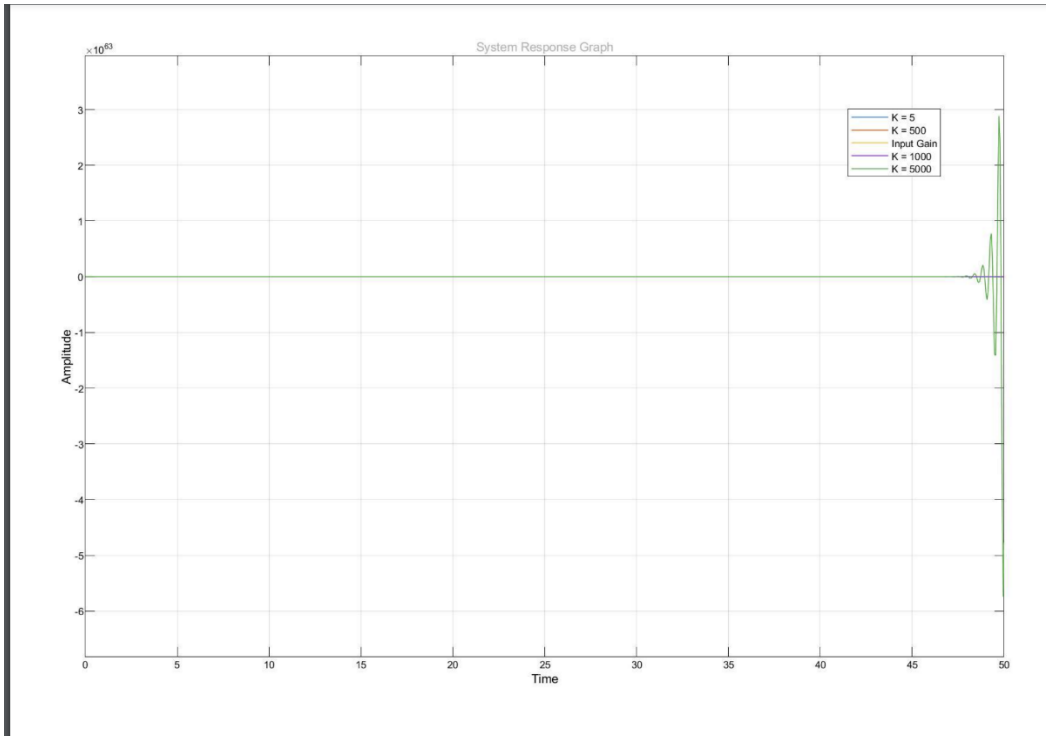

Figure 19 - A graph of the error signal of the system for an input of 5t for (7)

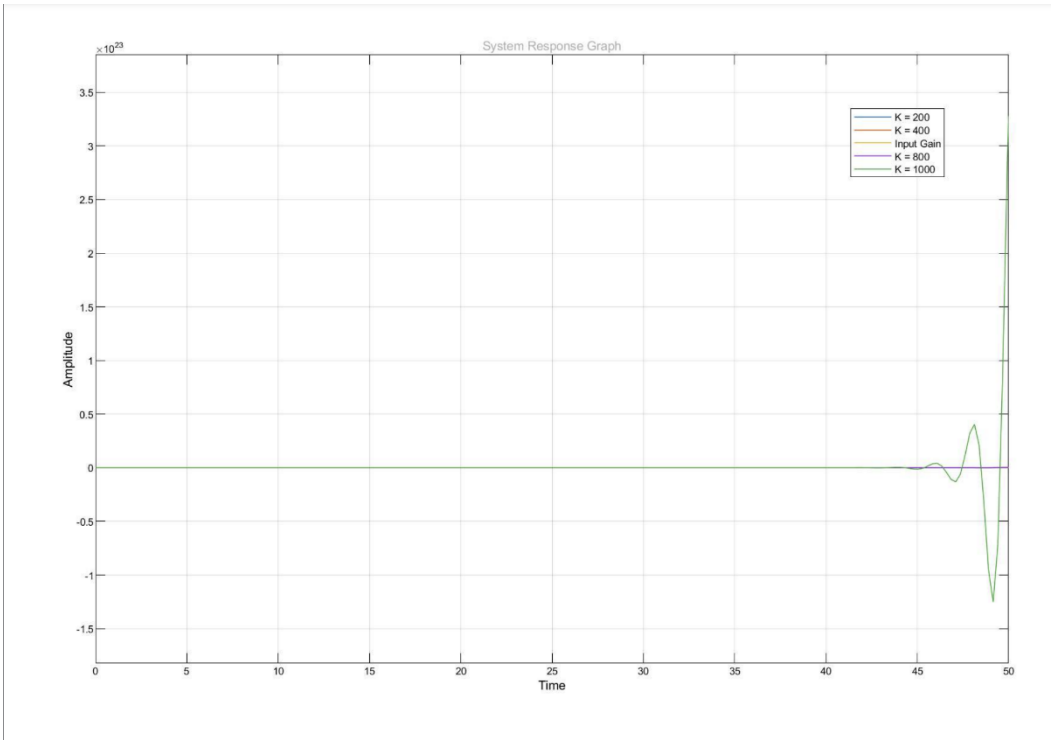

Figure 20 - A graph of the error signal of the system for an input of 5t^2 for (7)

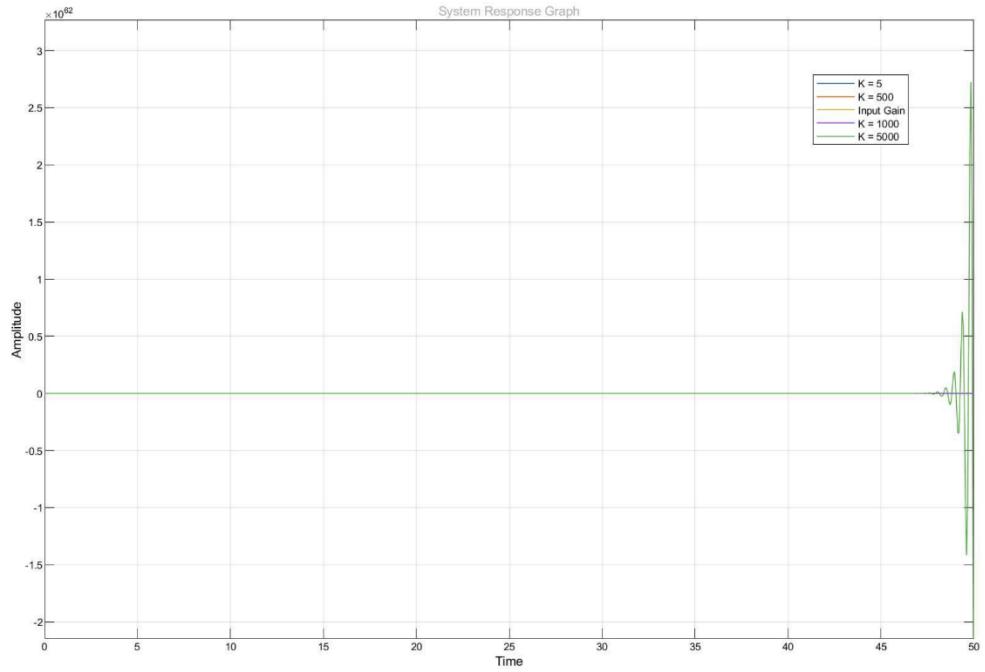

Figure 21 - A graph of the error signal of the system for an input of 5 for (8)

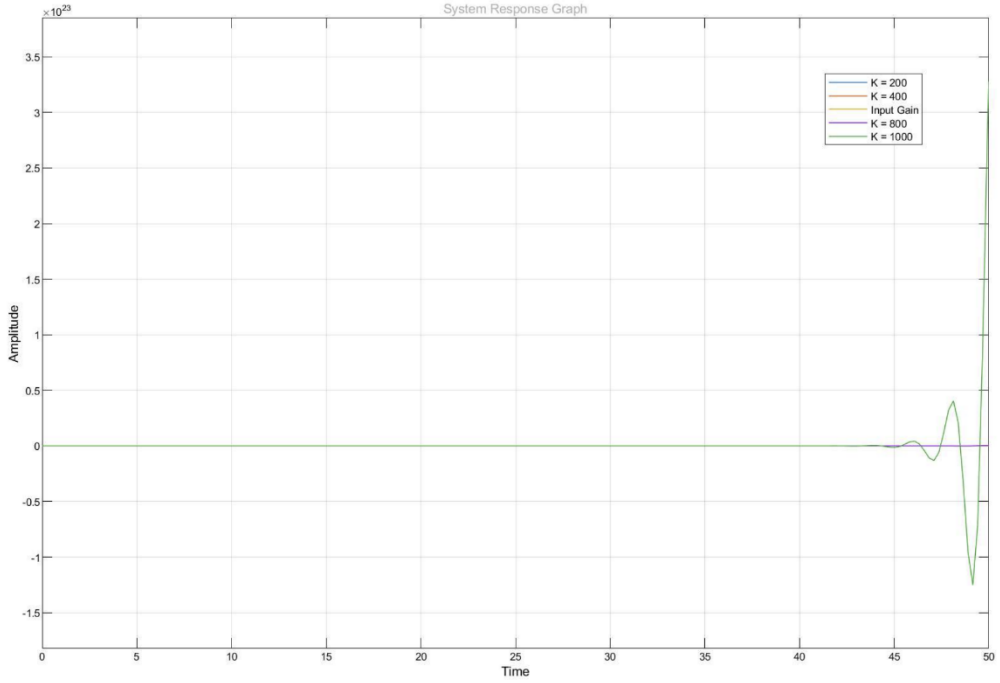

Figure 22 - A graph of the error signal of the system for an input of 5t for (8)

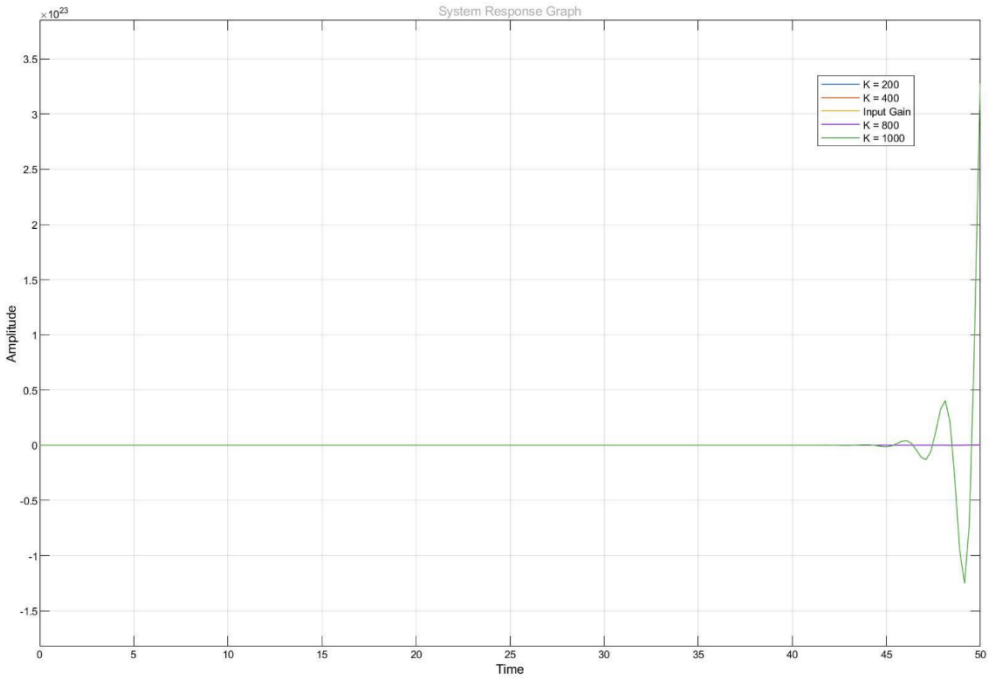

Figure 23 - A graph of the error signal of the system for an input of 5t^2 for (8)

Post-Lab

1. Regarding Question (6): You can compare the error signals of the system for various inputs (step, ramp, and parabolic) using the Simulink graphs (Figures 15–17). If there are differences between the predicted steady-state errors and the ones observed in the plots, the Simulink model's approximation, numerical errors made during simulation, or unmodeled dynamics could be the cause. Verify that the predicted theoretical values from the pre-lab and the steady-state errors match. For example, in a Type 0 system, the steady-state error for a step input should be finite, but for a ramp input, it should be infinite, and so on.

2. Regarding Question (7): In this instance, the graphs for input 5, 5t, and $5t^2$ (Figures 18–20) will provide comparable insights. Compare them to the theoretically predicted figures for the steady-state errors of various sorts of systems. Different system assumptions or unforeseen transient behaviours affecting steady-state conditions can cause discrepancies.

3. Regarding Question (8): In a similar manner, compare the graphs with your theoretical pre-lab calculations for the system in (8) (Figures 21–23). Large disparities could be caused by modelling assumptions that weren't taken into consideration in the pre-lab or by Simulink settings (such solver tolerances).