Experiment 7.1

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Objectives

To verify the effect of input waveform, loop gain, and system type upon steady-state errors.

Minimum Required Software Packages

MATLAB, Simulink, and the Control System Toolbox.

Prelab

Problem 1

What system types will yield zero steady-state error for step inputs?

Answer:

Type 1 and 2 sytems

Problem 2

What system types will yield zero steady-state error for ramp inputs?

Answer:

Type 2

Problem 3

What system types will yield infinite steady-state error for ramp inputs?

Answer:

Types 0

Problem 4

What system types will yield zero steady-state error for parabolic inputs?

Answer:

Type 3 and higher

Problem 5

What system types will yield infinite steady-state error for parabolic inputs?

Answer:

Types 0 and 1

Problem 6

For the negative feedback system of Figure P6.19 where $G(s) = \dfrac{K(s+6)}{(s+4)(s+7)(s+9)(s+12)}$ and $H(s) = 1$, calculate the steady-state error in terms of *K* for the following inputs: $5u(t)$, $5tu(t)$, and $5t^2u(t)$.

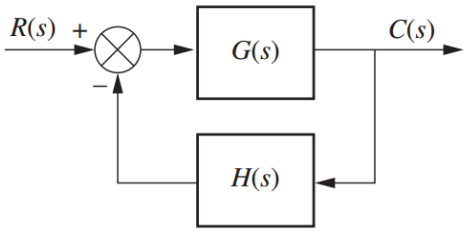


FIGURE P6.19

Answer:

$\dfrac{1}{1+\dfrac{30K}{3024}}$, 0 , 0

Problem 7

Repeat Prelab 6 for $G(s) = \dfrac{K(s+6)(s+8)}{s(s+4)(s+7)(s+9)(s+12)}$ and $H(s) = 1$.

Answer:

$\infty \dfrac{3024}{240K}$,0

Problem 8

Repeat Prelab 6 for $G(s) = \dfrac{K(s+1)(s+6)(s+8)}{s^2(s+4)(s+7)(s+9)(s+12)}$ and $H(s) = 1$.

Answer:

∞,∞,$\frac{3024}{120K}$

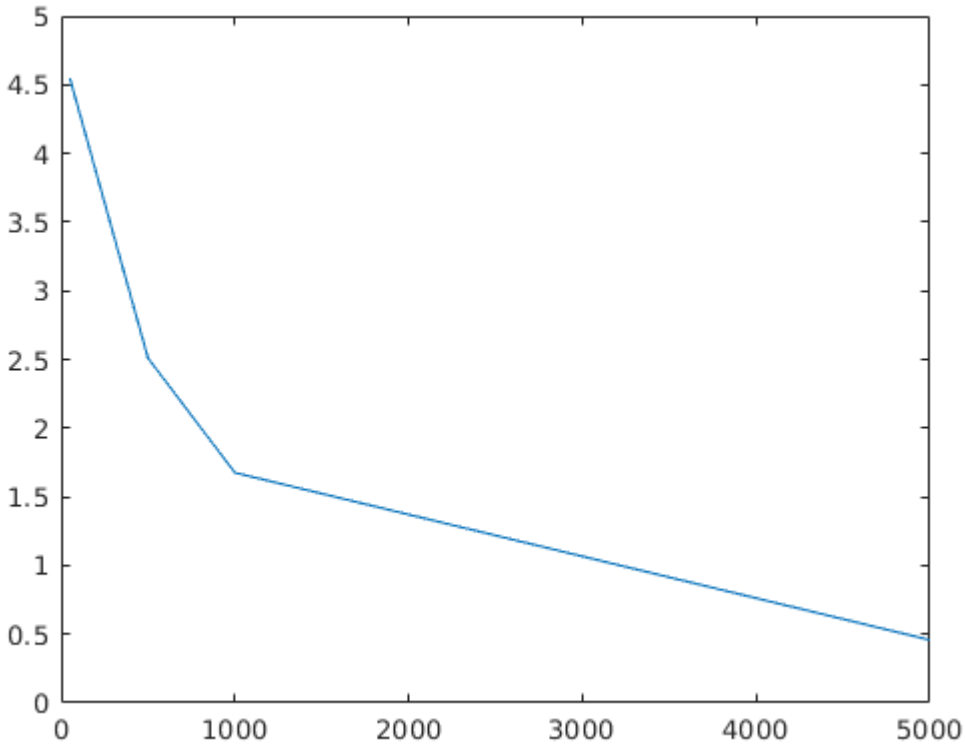
Lab

Problem 1

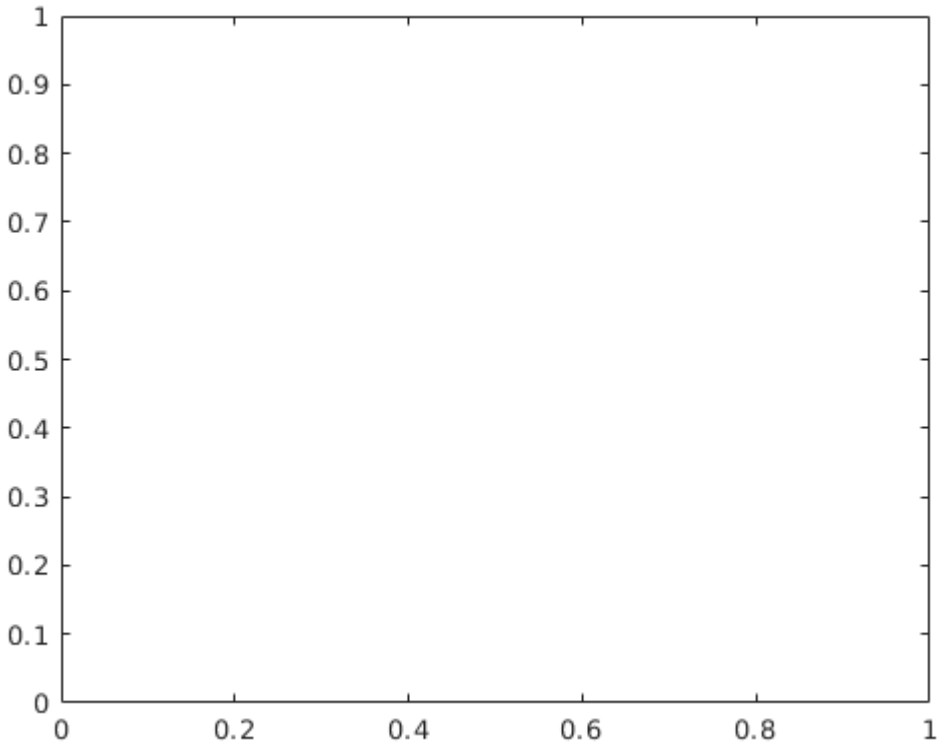
Using Simulink, set up the negative feedback system of Prelab 6. Plot on one graph the error signal of the system for an input of $5u(t)$ and *K*=50, 500, 1000, and 5000. Repeat for inputs of $5tu(t)$ and $5t^2u(t)$.

For your Simulink, please provide a screenshot that clearly shows the system.

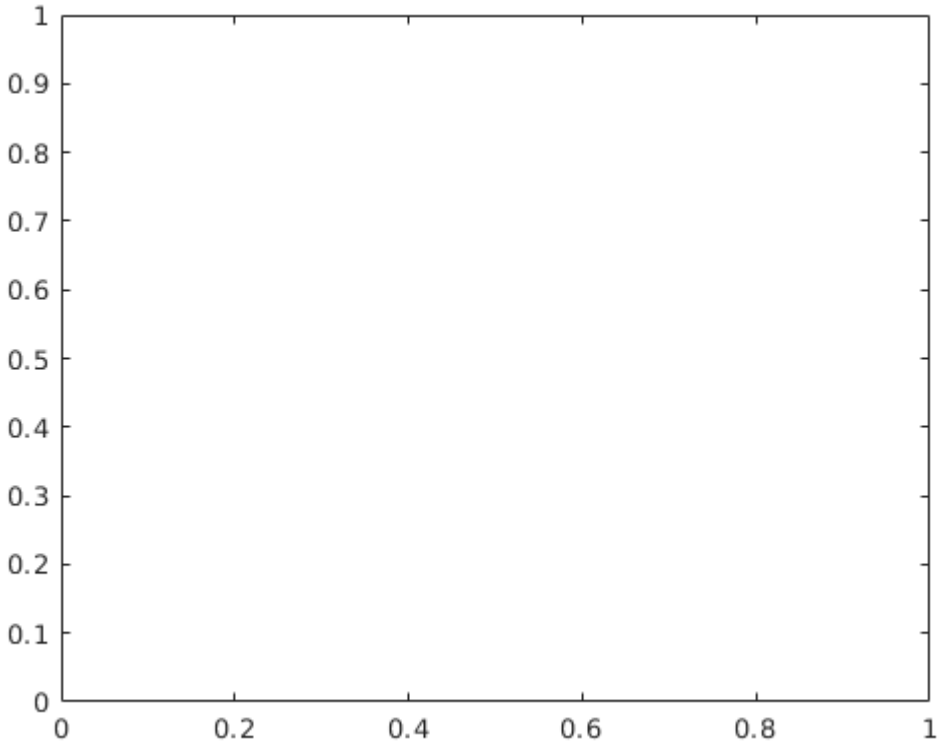
```
% P1
%  print('-sP1','-dpng','P1.png');

syms s
K = [50 500 1000 5000];

for i=1:4
    G = (K(i) * (s+6))/ ( (s+4)*(s+7)*(s+9)*(s+12));

    Kp = limit(G,s,0);
    e_ss0(i) = 5 /( 1 + Kp);

    Kv = limit((5*s*G),s,0);
    e_ss1(i) = 1 /(Kv);

    Ka = limit(5/2*s^2*G,s,0);
    e_ss2(i) = 1 /(Ka);
end
plot(K,e_ss0)
```

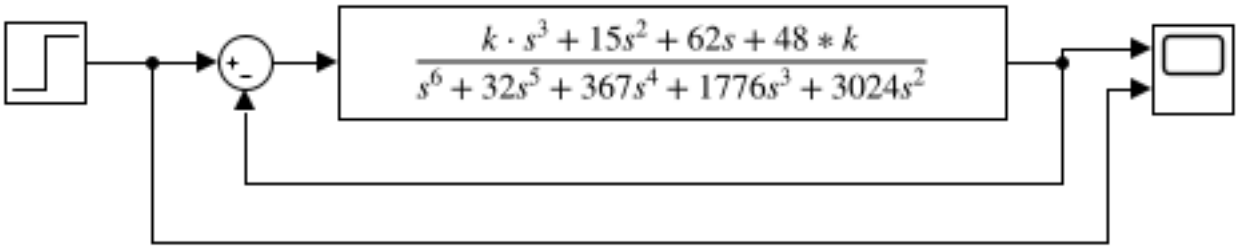

5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
0
1000
2000
3000
4000
5000

```
plot(K,e_ss1)
```


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1

```
plot(K,e_ss2)
```





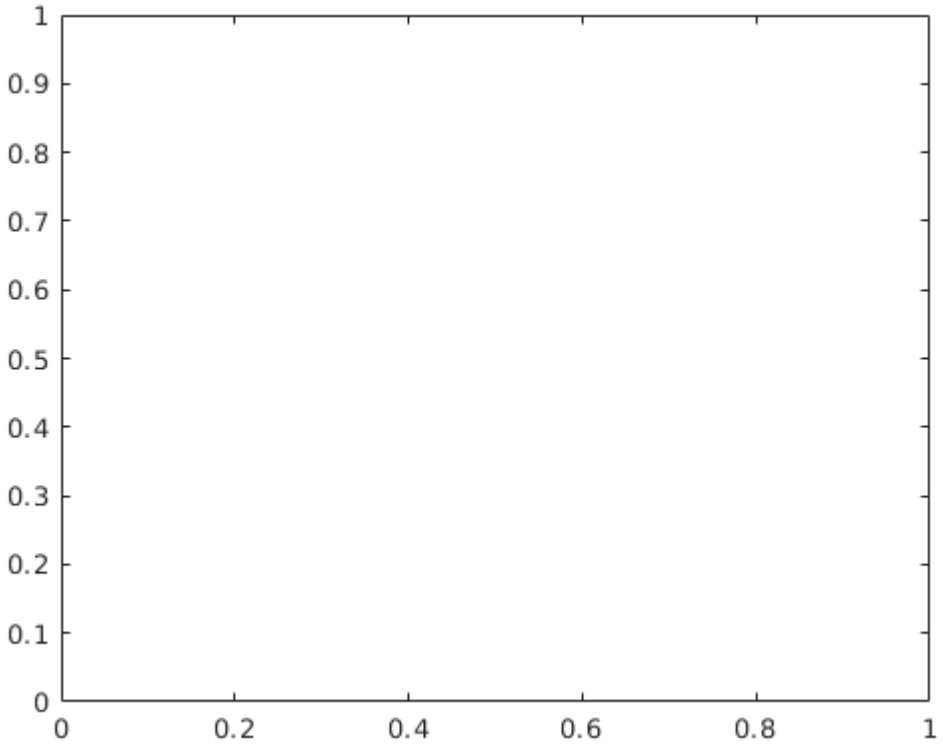
Problem 2

Using Simulink, set up the negative feedback system of Prelab 7. Plot on one graph the error signal of the system for an input of $5u(t)$ and *K*=50, 500, 1000, and 5000. Repeat for inputs of $5tu(t)$ and $5t^2u(t)$.

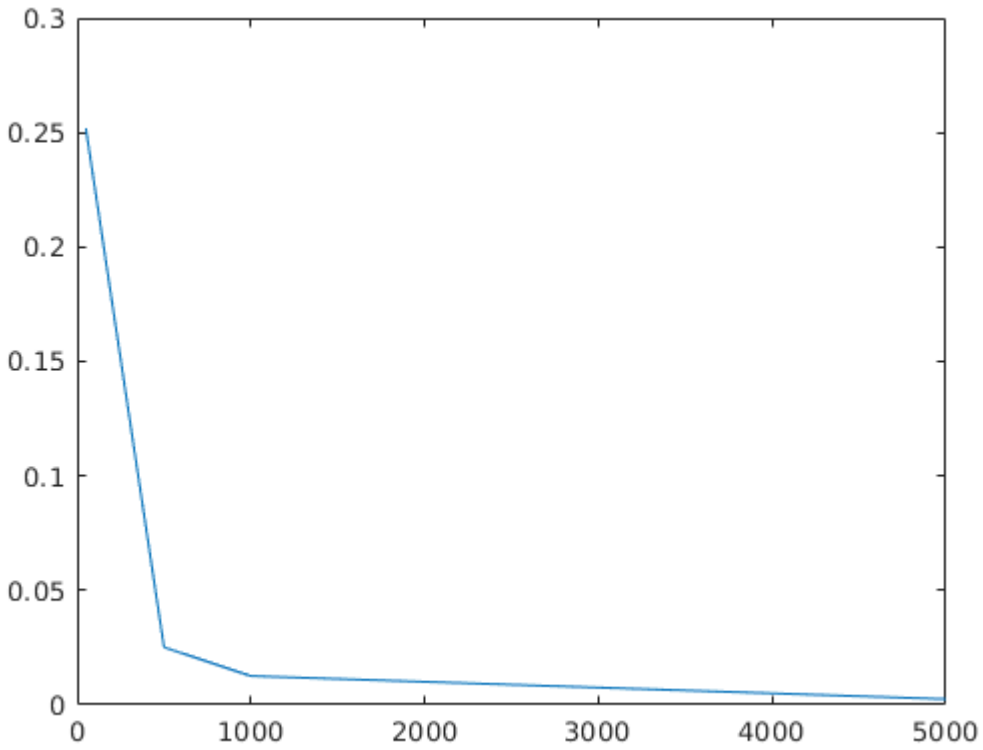
For your Simulink, please provide a screenshot that clearly shows the system.

```
%  P2
%  print('-sP2','-dpng','P2.png');

syms s
K = [50 500 1000 5000];

for i=1:4
```

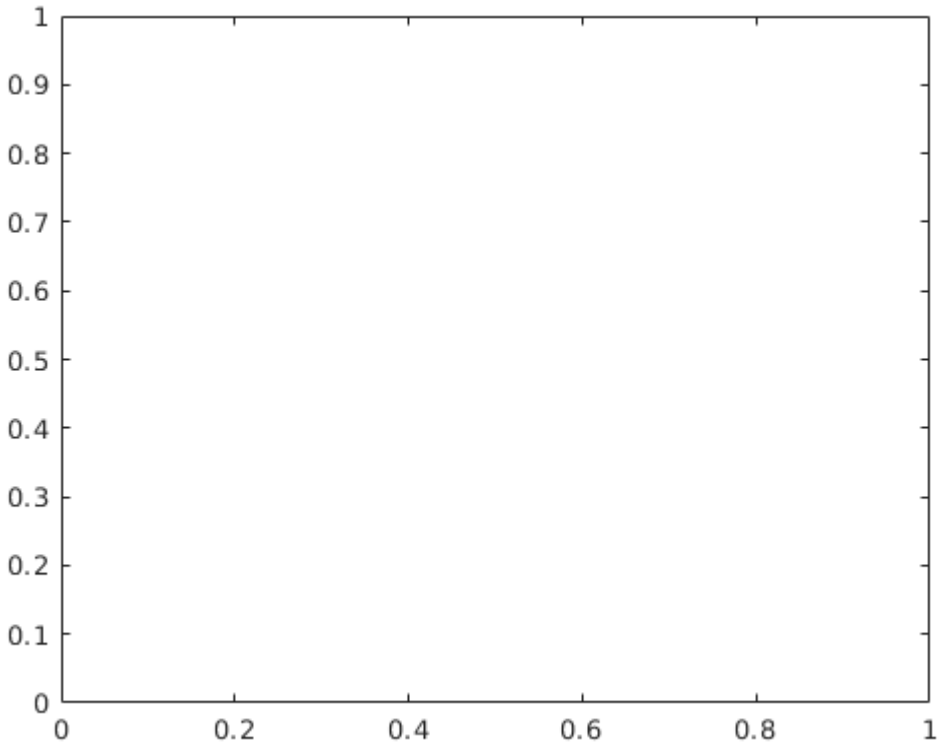
```
    G = (K(i) * (s+6) * (s+8)) / ( s*(s+4)*(s+7)*(s+9)*(s+12));

    Kp = limit(G,s,0);
    e_ss0(i) = 5 /( 1 + Kp);

    Kv = limit((5*s*G),s,0);
    e_ss1(i) = 1 /(Kv);

    Ka = limit(5/2*s^2*G,s,0);
    e_ss2(i) = 1 /(Ka);
end
plot(K,e_ss0)
```

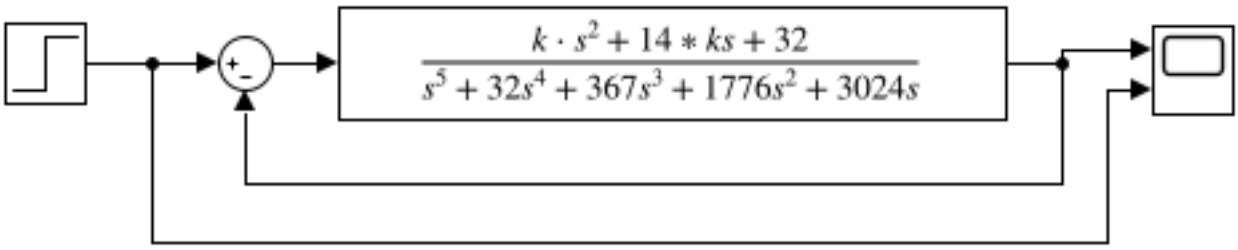



```
plot(K,e_ss1)
```


0.3
0.25
0.2
0.15
0.1
0.05
0
0
1000
2000
3000
4000
5000

```
plot(K,e_ss2)
```


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1

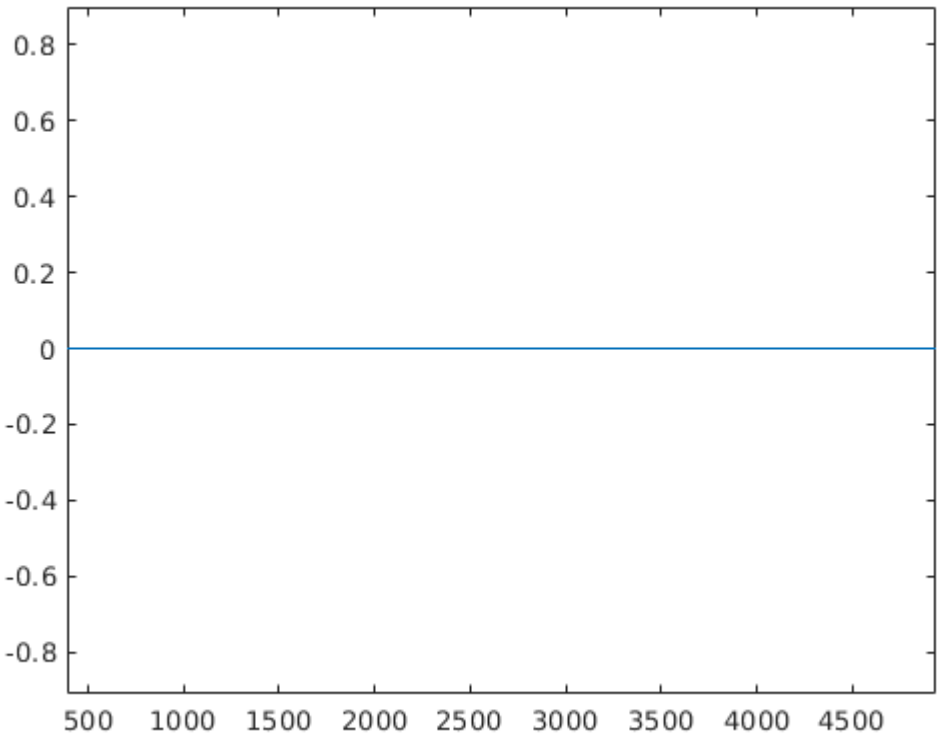


Problem 3

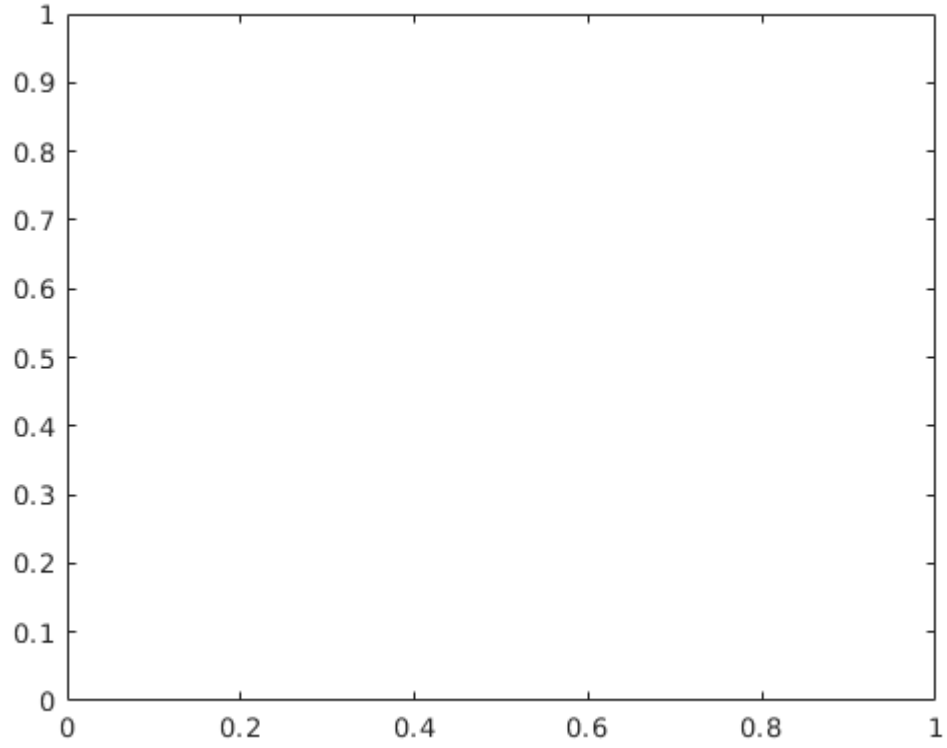
Using Simulink, set up the negative feedback system of Prelab 8. Plot on one graph the error signal of the system for an input of $5u(t)$ and *K*= 200, 400, 800, and 1000. Repeat for inputs of $5tu(t)$ and $5t^2u(t)$.

For your Simulink, please provide a screenshot that clearly shows the system.

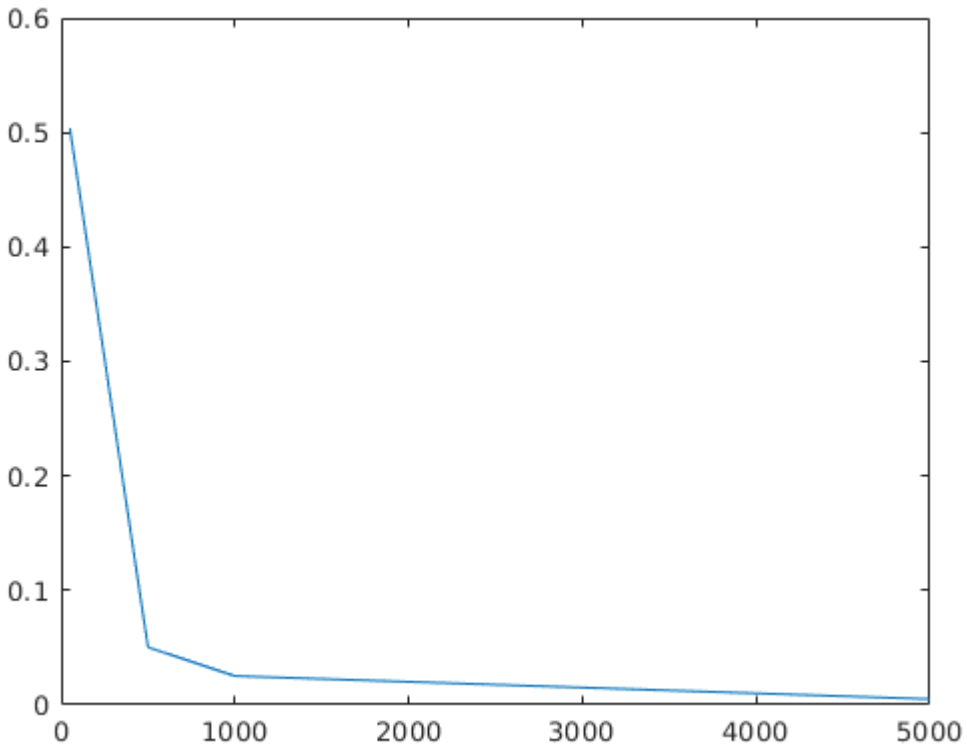
```
%  P3
%  print('-sP3','-dpng','P3.png');

syms s
K = [50 500 1000 5000];

for i=1:4
    G = (K(i) * (s+1) * (s+6) * (s+8)) / ( s^2 *(s+4)*(s+7)*(s+9)*(s+12));

    Kp = limit(G,s,0);
    e_ss0(i) = 5 /( 1 + Kp);

    Kv = limit((5*s*G),s,0);
    e_ss1(i) = 1 /(Kv);

    Ka = limit(5/2*s^2*G,s,0);
    e_ss2(i) = 1 /(Ka);
end
plot(K,e_ss0)

xlim([390 4936])
ylim([-0.91 0.90])
```

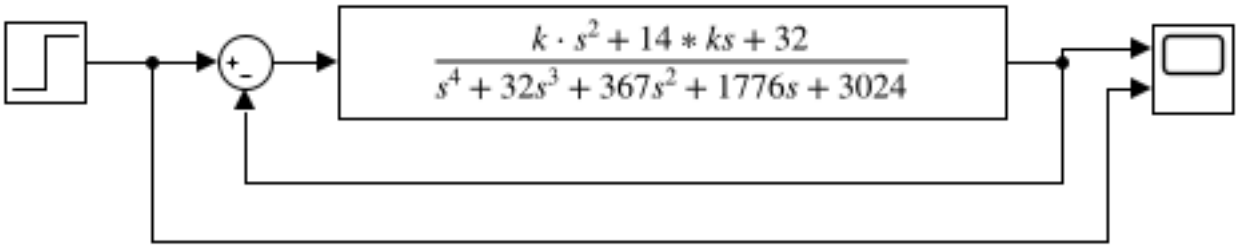

0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
500
1000
1500
2000
2500
3000
3500
4000
4500

```
plot(K,e_ss1)
```


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
1

```
plot(K,e_ss2)
```





Postlab

Problem 1

Use your plots from Lab 1 and compare the expected steady-state errors to those calculated in the Prelab. Explain the reasons for any discrepancies.

The steady state errors calculated in prelab 1 matched the steady state errors in problem 1.

Problem 2

Use your plots from Lab 2 and compare the expected steady-state errors to those calculated in the Prelab. Explain the reasons for any discrepancies.

The steady state errors calculated in prelab 2 matched the steady state errors in problem 2.

Problem 3

Use your plots from Lab 3 and compare the expected steady-state errors to those calculated in the Prelab. Explain the reasons for any discrepancies.

The steady state errors calculated in prelab 3 matched the steady state errors in problem 3.