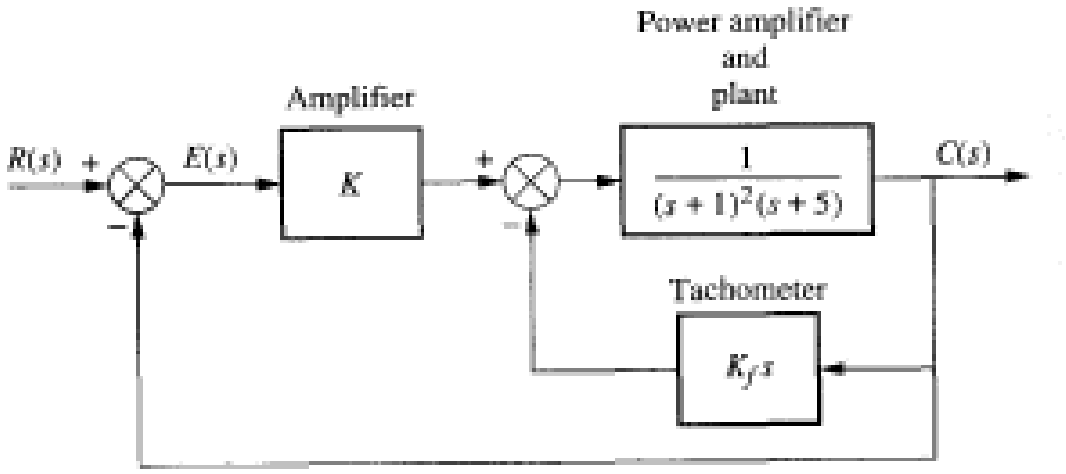
Homework 6: Root Locus Design and Introduction to Bode Analysis

1. For the system below find the values of K_f and K such that the system has the best possible PMO and rise time.



2. Using the Matlab code shown generate a bode diagram showing both the magnitude and phase of the response. This should be done not using the bode command but by brute force. The Matlab code should be run for several different input frequencies. Each run will yield the information to plot one magnitude and one phase point. Generate enough points to plot the Bode diagram.

3. Sketch the Bode diagrams for the open loop transfer function below. Also determine the gain cross-over frequency, phase-crossover frequency, gain margin and phase margin.

$$G(s)H(s) = \frac{12(1 + s)}{s(1 + .5s)(1 + .1s)}$$

Problem Set 2: Frequency Analysis and Bode Plots
This code can be found at:

\\KHENSU\Home02\daves\Public\ME 453\ME452_Brute_Force_Bode.m

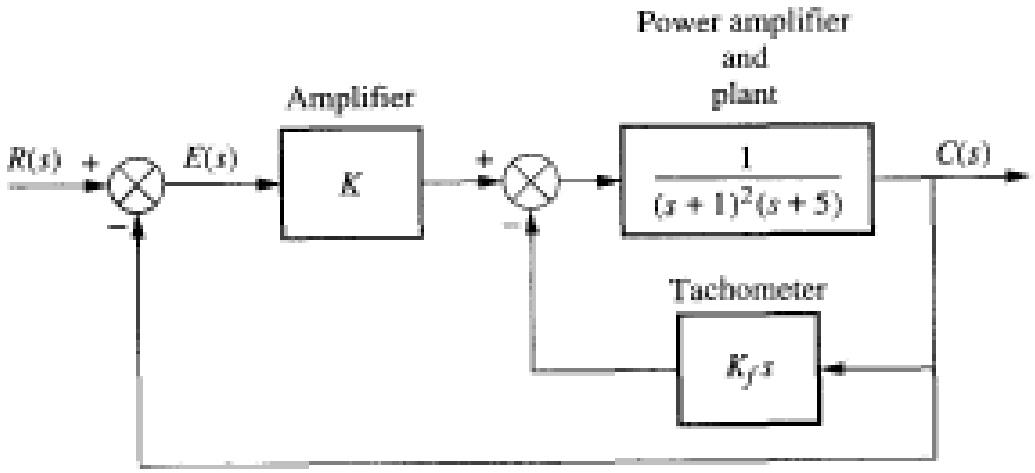
MatLab Code For Problem 2

```
% Set up the test system

omegan = 2;
zeta = .2;
num=omegan^2;
den=[1 2*zeta*omegan omegan^2];
```

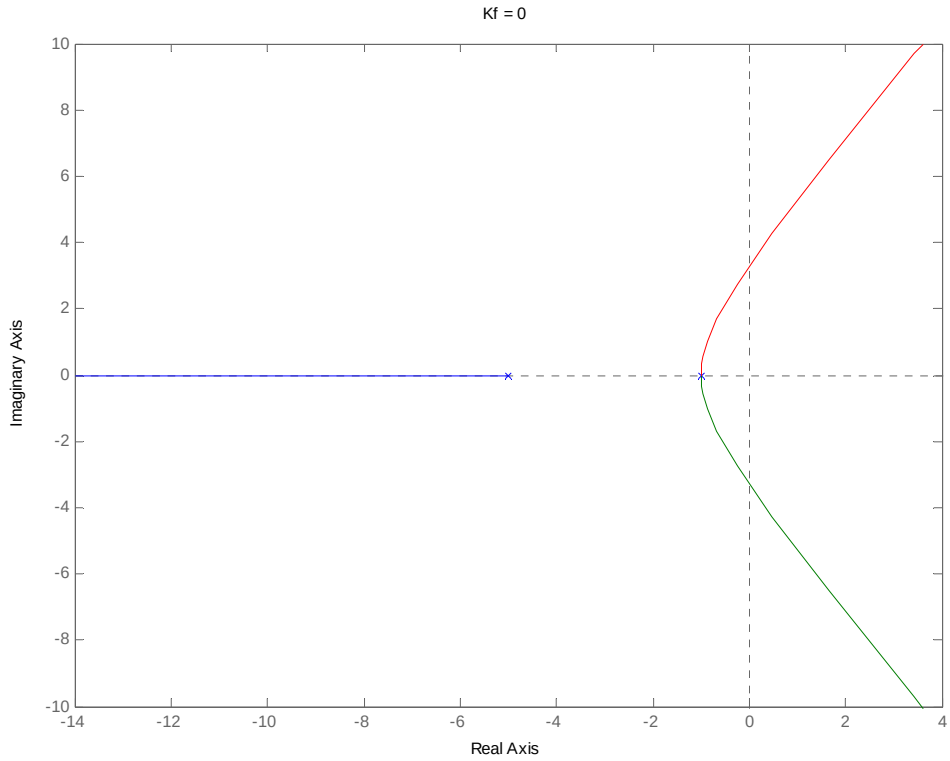
```
Num_cycles = 10;

% Define the output and input system

sys2 = tf(num,den);
input = tf(1,1);

% Define the input (forcing) frequency

omega = 3;
tend = 2*pi/omega*Num_cycles;
dt = tend/(500*Num_cycles);

% Define the input

t=0:dt:tend;
u = sin(omega*t);

% Find the and plot the response

figure
lsim(input,sys2,u,t);
```

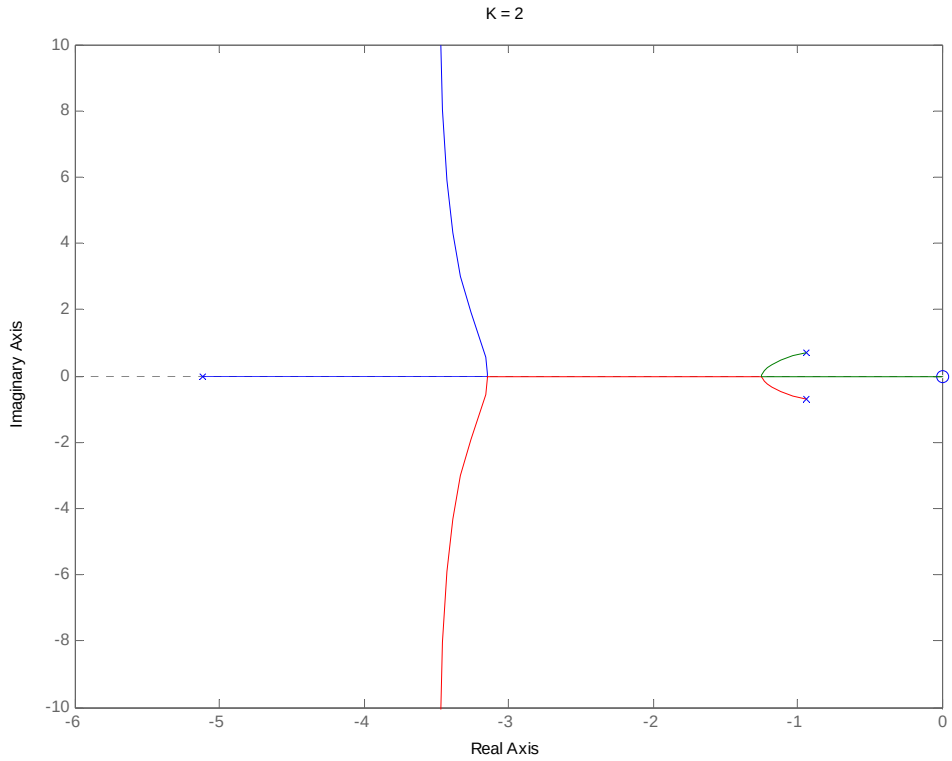
Solution Homework 6

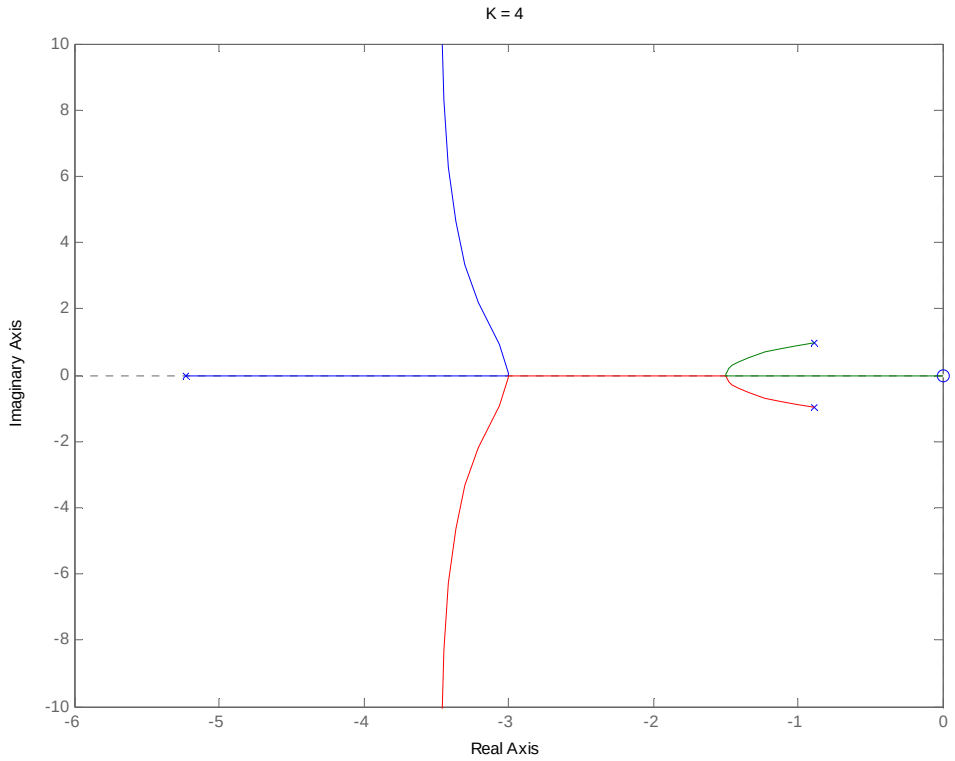
1. For the system below find the values of K_f and K such that the system has the best possible PMO and rise time.

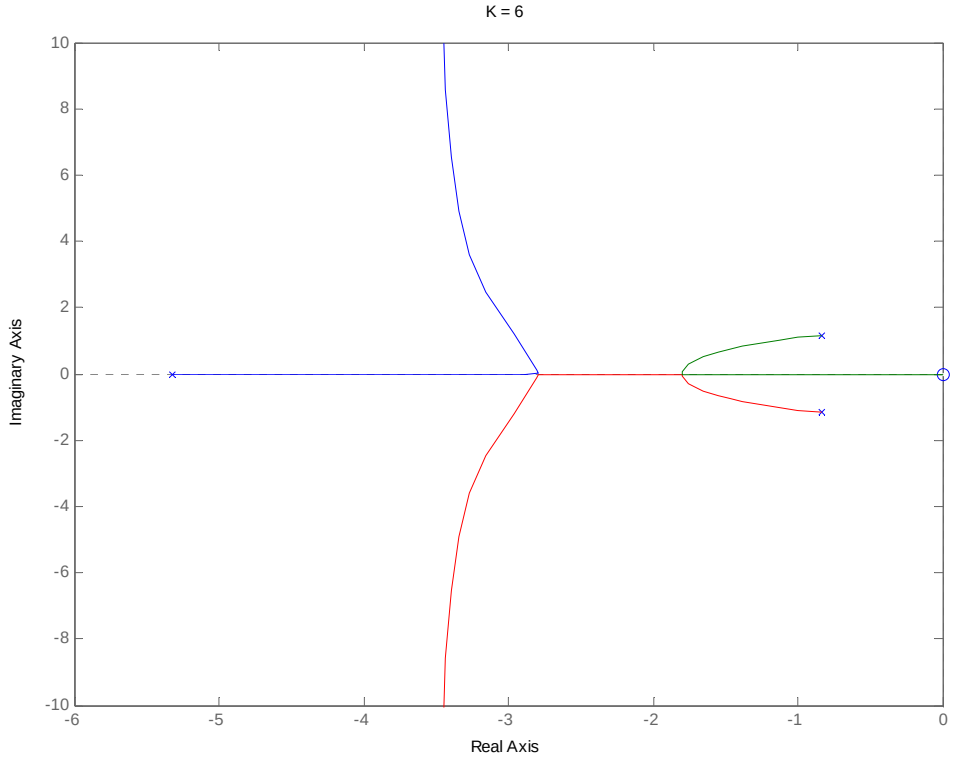


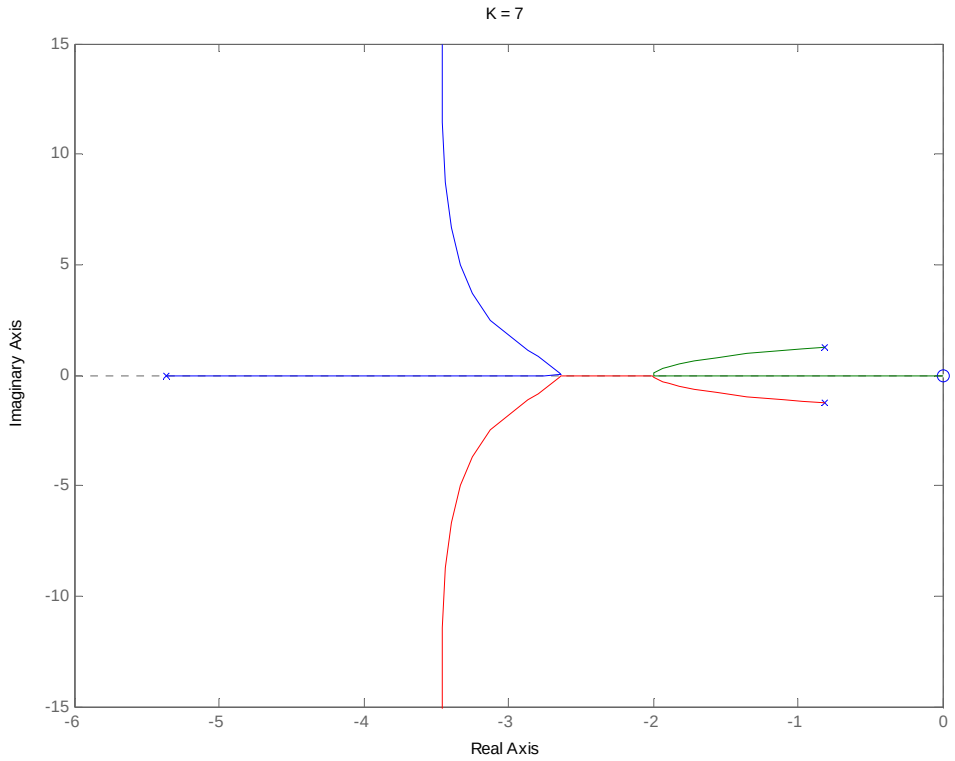
```
clear;
close all;

num_base = 1;
den_base = [1 7 11 5];
sys_base = tf(num_base,den_base);

figure
rlocus(sys_base);
title('Kf = 0')

K=[2 4 6 7 8 16 32 64]
for ii=1:length(K)
    num = [1 0];
    den = [1 7 11 (5+K(ii))];
    sys_K(ii)=tf(num,den);
    figure
    rlocus(sys_K(ii));
    title(['K = ' num2str(K(ii))])
end

figure
rlocus(sys_base,sys_K(1),sys_K(2),sys_K(3),sys_K(4),sys_K(5),sys_K(6),sys_K(7),sys_K(8))

% Plot first response
K = 7;
Kf = 5;
num_cl = 1;
den_cl = [1 7 (11+Kf) (5+K)];
sys_cl = tf(num_cl,den_cl)

roots(den_cl)

figure
step(sys_cl,0:.01:10)

% Plot second response
K = 8;
Kf = 5.46;
num_cl = 1;
den_cl = [1 7 (11+Kf) (5+K)];
sys_cl = tf(num_cl,den_cl)

roots(den_cl)

figure
step(sys_cl,0:.01:10)
```

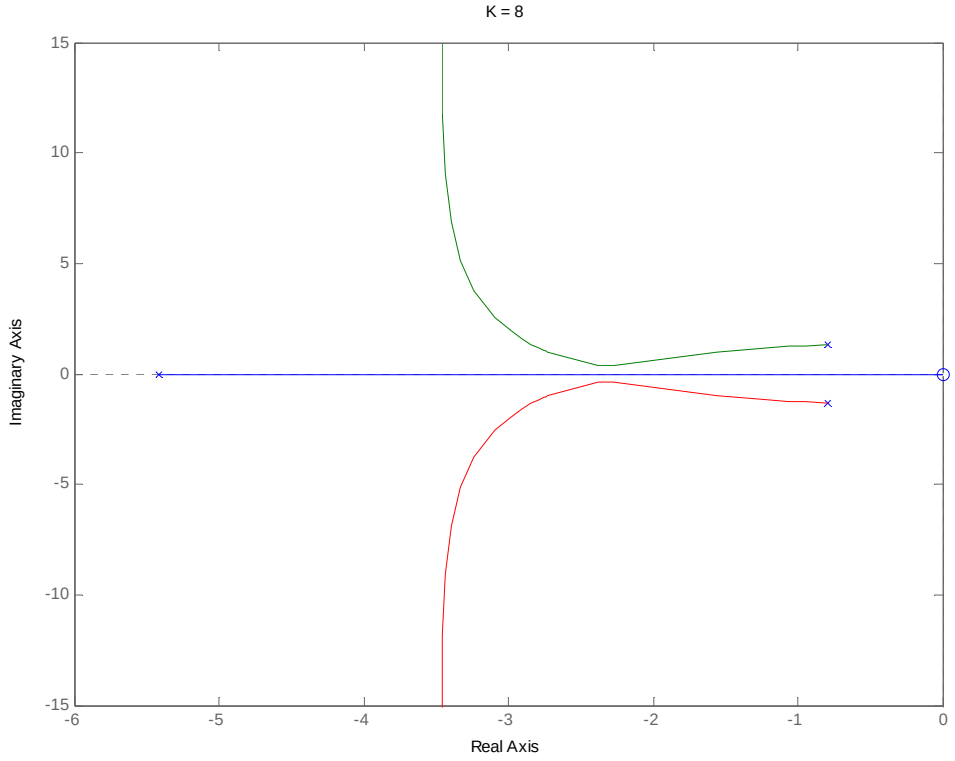

Kf = 0
Imaginary Axis
Real Axis
10
8
6
4
2
0
-2
-4
-6
-8
-10
-14
-12
-10
-8
-6
-4
-2
0
2
4

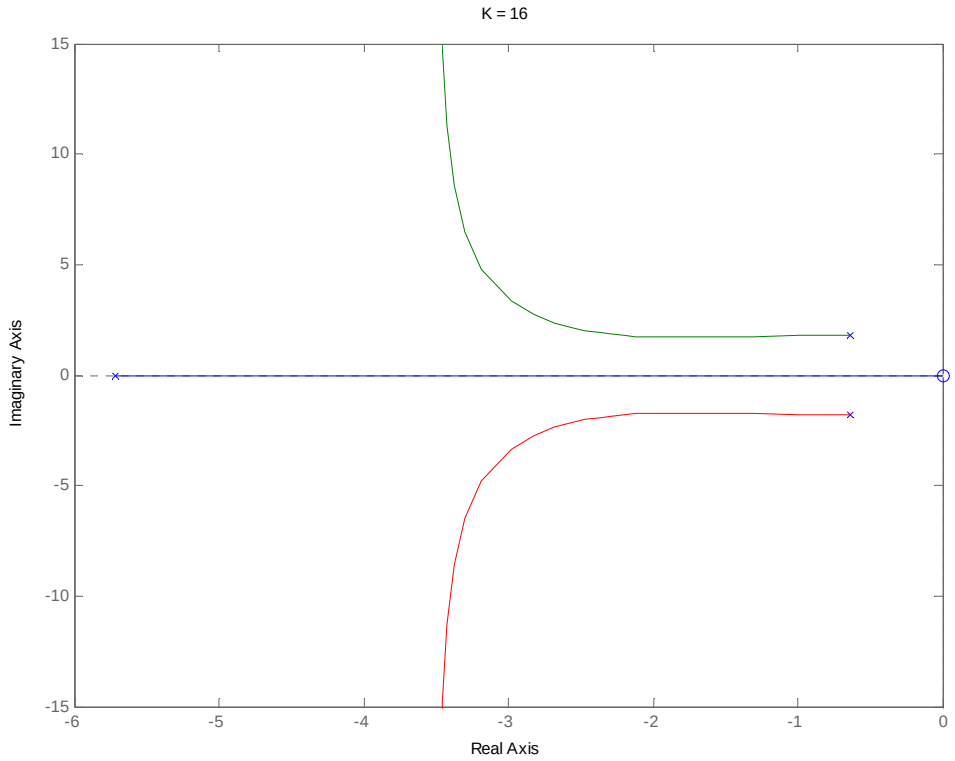

K = 2
Imaginary Axis
Real Axis
10
8
6
4
2
0
-2
-4
-6
-8
-10
-6
-5
-4
-3
-2
-1
0

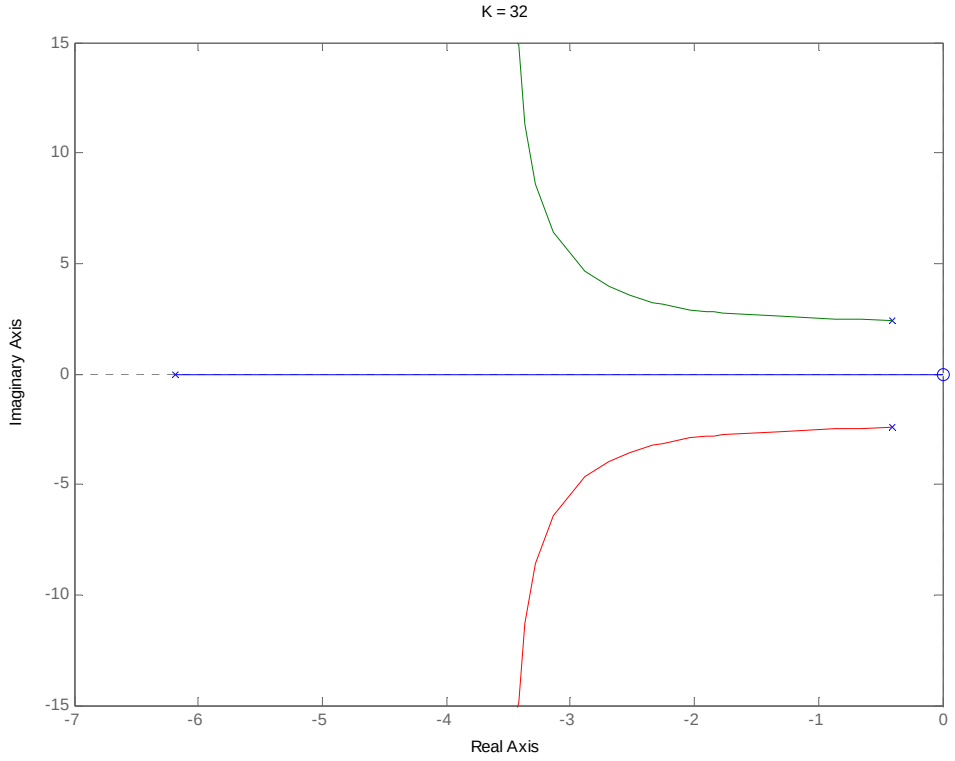

K = 4
Imaginary Axis
Real Axis
10
8
6
4
2
0
-2
-4
-6
-8
-10
-6
-5
-4
-3
-2
-1
0

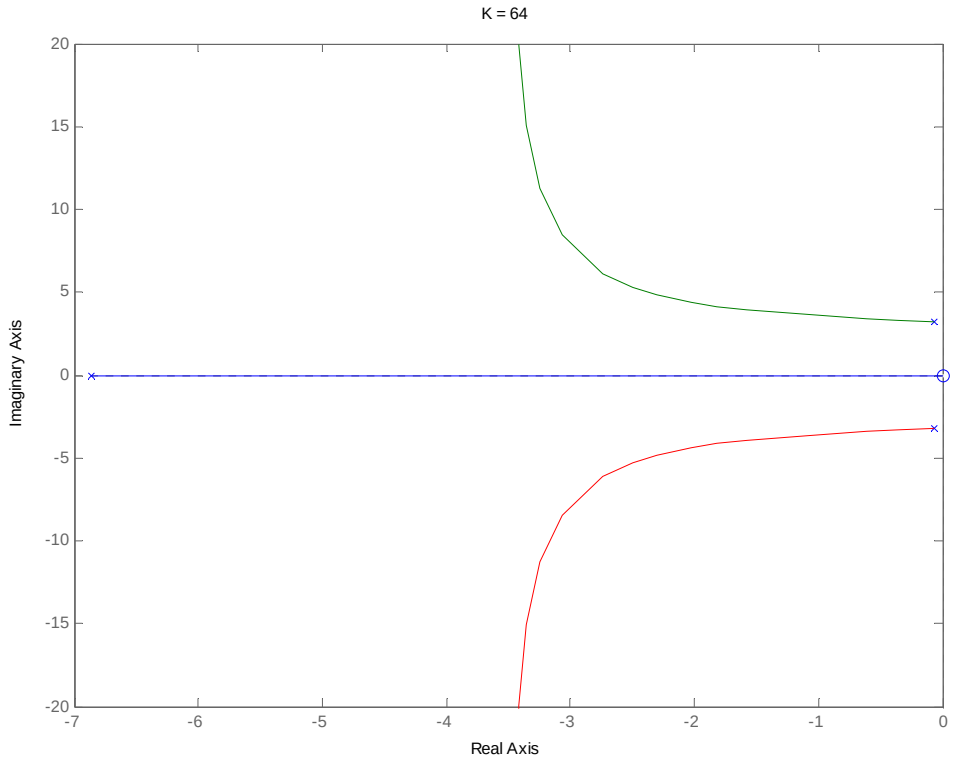

K = 6
Imaginary Axis
Real Axis
10
8
6
4
2
0
-2
-4
-6
-8
-10
-6
-5
-4
-3
-2
-1
0

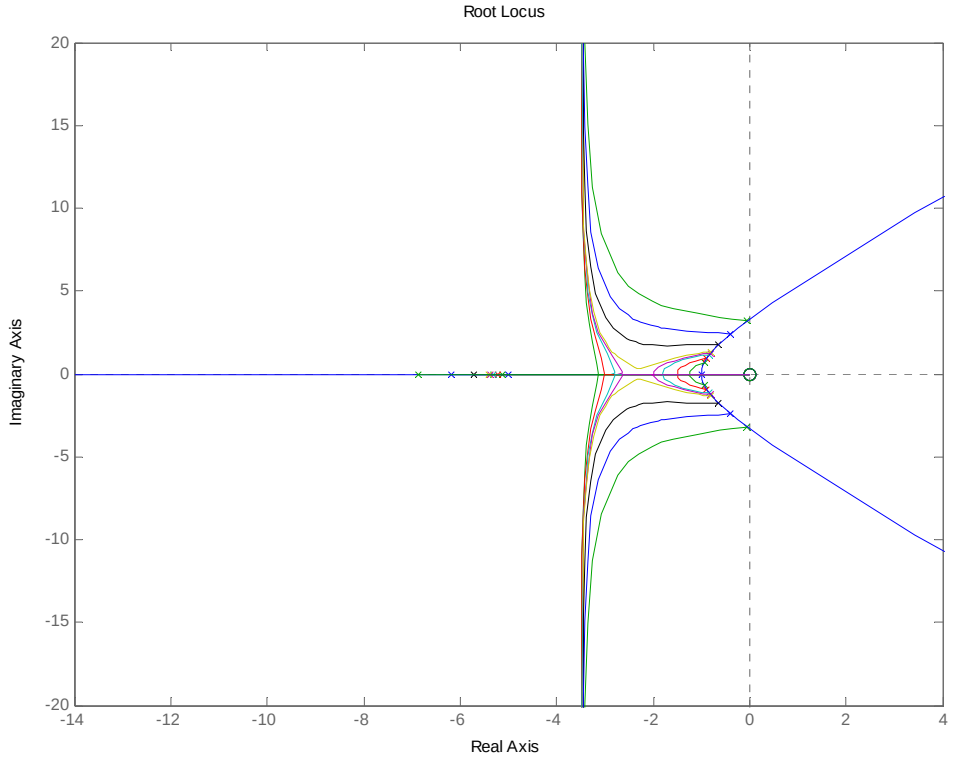

K = 7
Imaginary Axis
Real Axis
15
10
5
0
-5
-10
-15
-6
-5
-4
-3
-2
-1
0

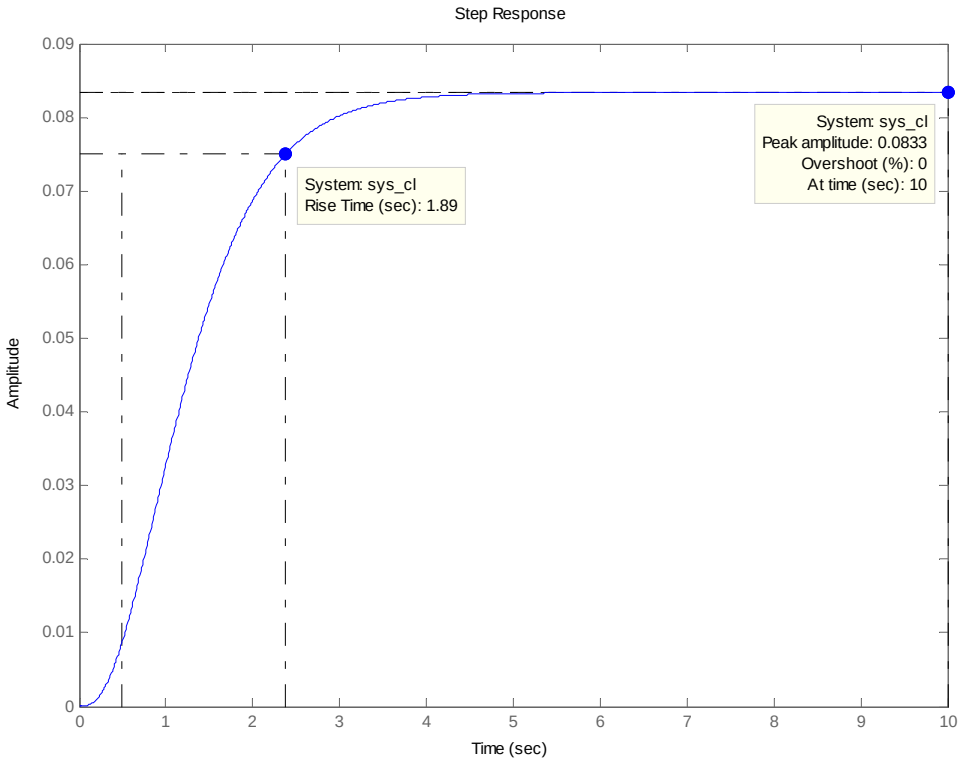

K = 8
Imaginary Axis
Real Axis
15
10
5
0
-5
-10
-15
-6
-5
-4
-3
-2
-1
0

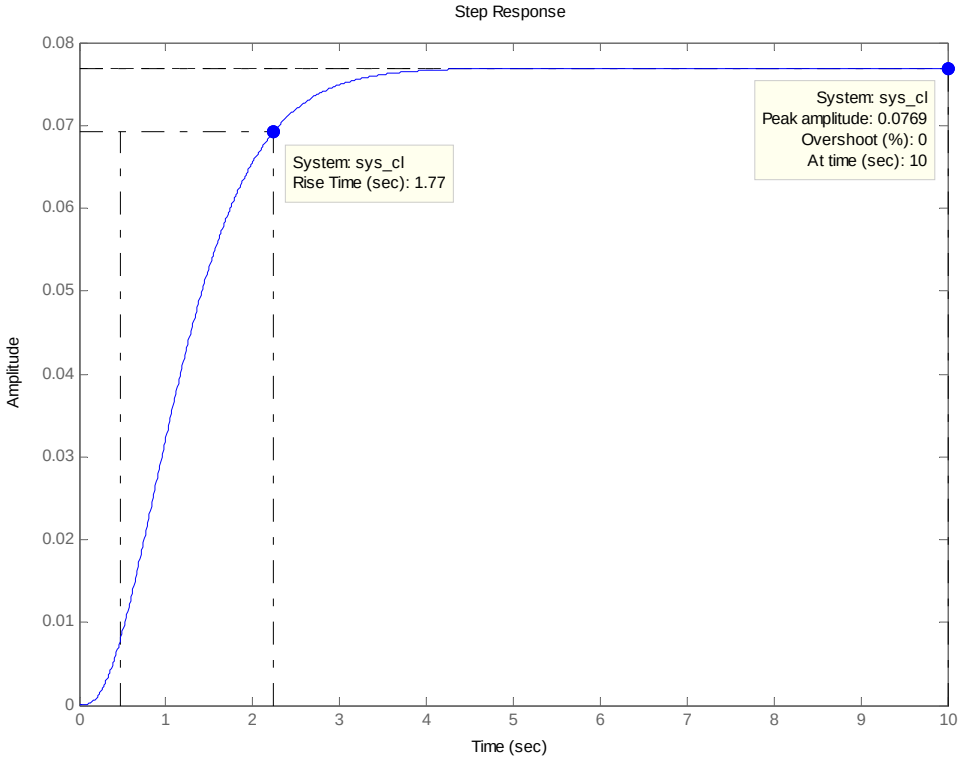

K = 16
Imaginary Axis
Real Axis
15
10
5
0
-5
-10
-15
-6
-5
-4
-3
-2
-1
0


K = 32
Imaginary Axis
Real Axis
15
10
5
0
-5
-10
-15
-7
-6
-5
-4
-3
-2
-1
0


K = 64
Imaginary Axis
Real Axis
20
15
10
5
0
-5
-10
-15
-20
-7
-6
-5
-4
-3
-2
-1
0


Root Locus
Imaginary Axis
Real Axis
20
15
10
5
0
-5
-10
-15
-20
-14
-12
-10
-8
-6
-4
-2
0
2
4


Step Response
System: sys_cl
Peak amplitude: 0.0833
Overshoot (%): 0
At time (sec): 10
System: sys_cl
Rise Time (sec): 1.89
Amplitude
Time (sec)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0
1
2
3
4
5
6
7
8
9
10


Step Response
System: sys_cl
Peak amplitude: 0.0769
Overshoot (%): 0
At time (sec): 10
System: sys_cl
Rise Time (sec): 1.77
Amplitude
Time (sec)
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0
1
2
3
4
5
6
7
8
9
10

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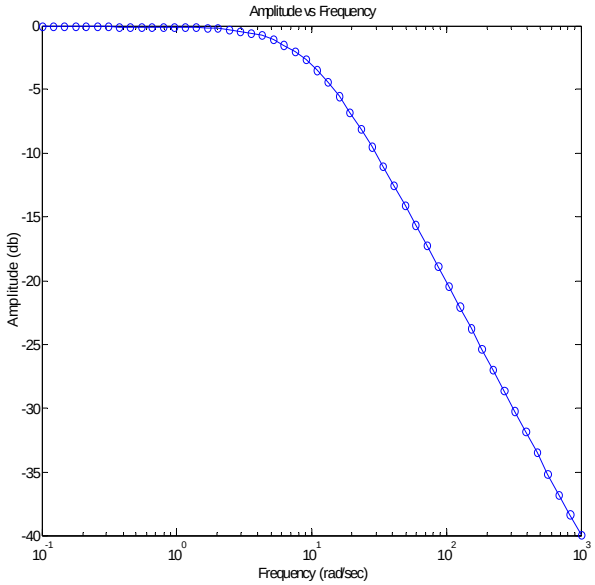

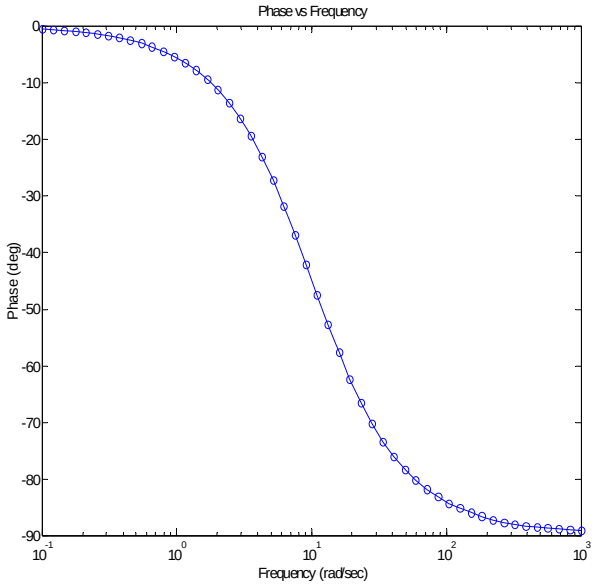

3. Sketch the Bode diagrams for the open loop transfer function below. Also determine the gain cross-over frequency, phase-crossover frequency, gain margin and phase margin.

$$G(s)H(s) = \frac{12(1 + s)}{s(1 + .5s)(1 + .1s)}$$