ME EN 6200
Homework 11
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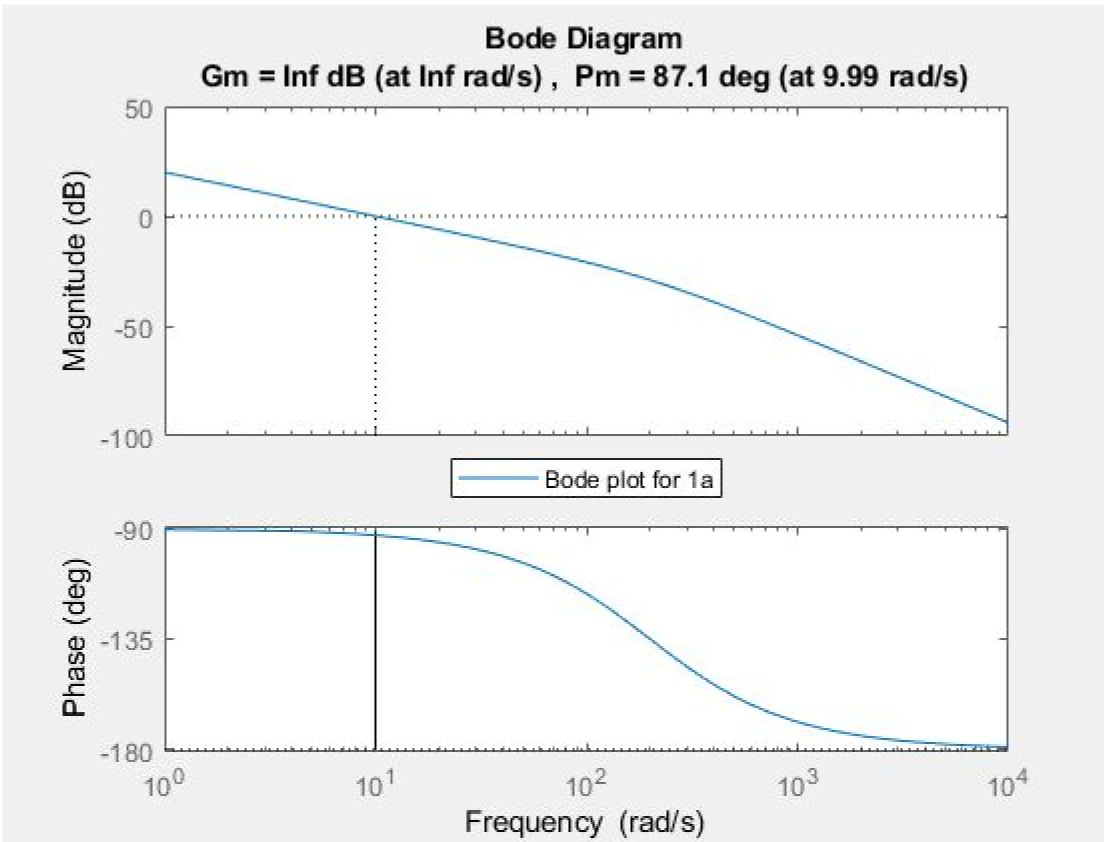
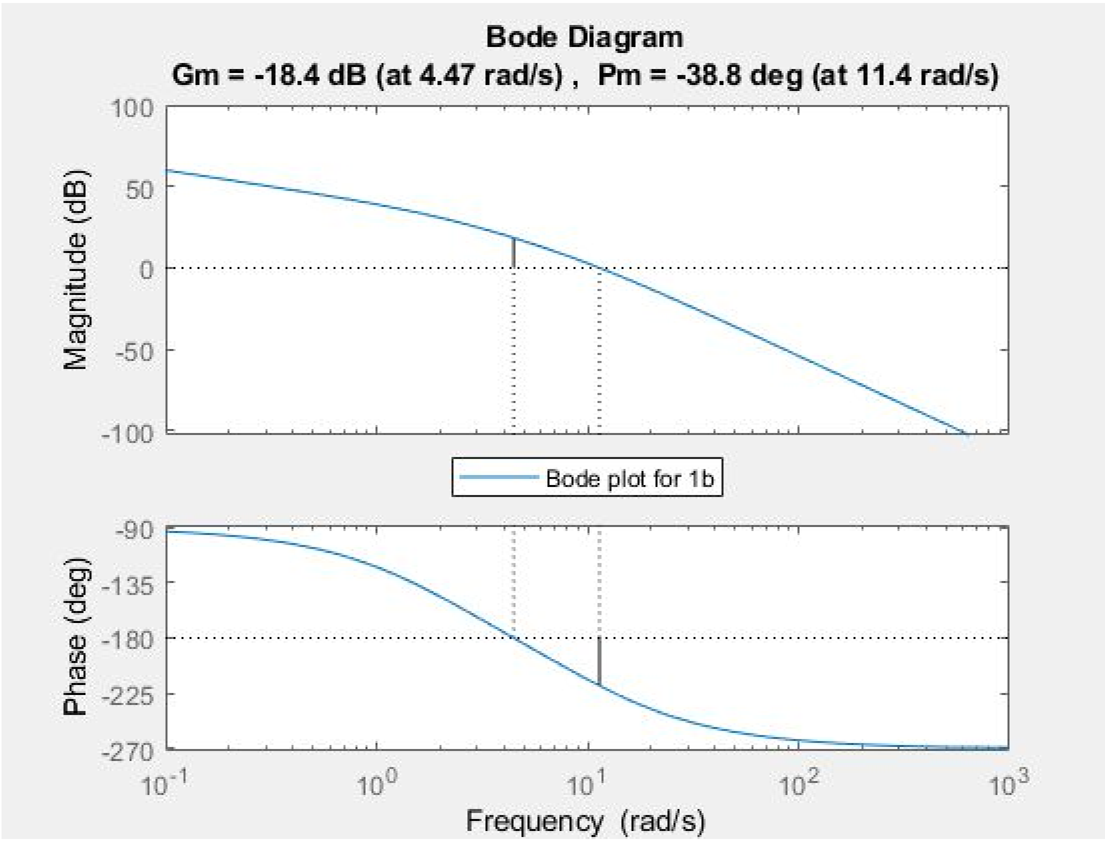
<u>Problem 1</u>
a)



The gain margin is infinite because the phase plot never crosses -180 degrees.
The phase margin is 87.1 degrees which is the degrees from the phase at the frequency where the gain is 0 dB to the phase of -180 degrees.

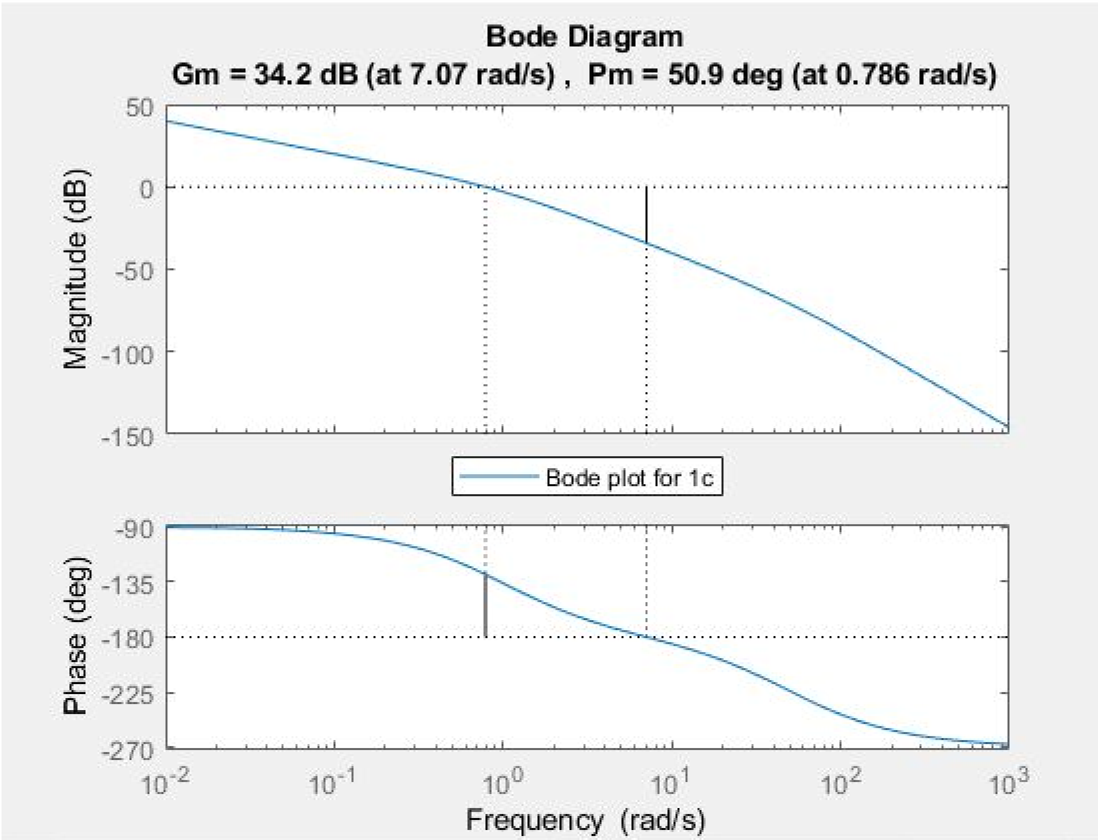
b)



The gain margin is -18.4 dB since that is the gain which will result in the closed loop system being marginally stable. (It is the gain from the corresponding -180 degree phase gain point to 0 dB)

The phase margin is -38.8 degrees, this is the phase that will result in a marginally stable system. (It is the phase from the corresponding 0 dB phase point to the -180 degree phase point)

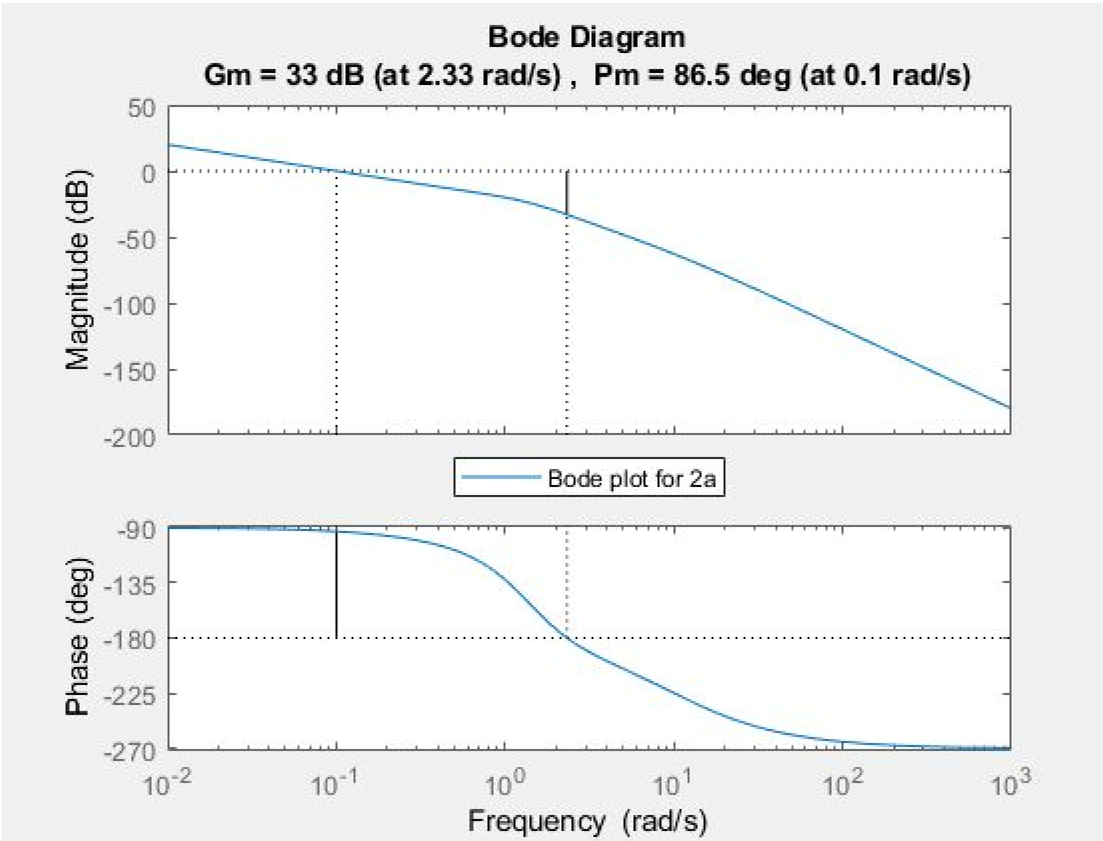
c)



The gain margin is 34.2 dB. It is the gain from the corresponding -180 degree phase gain point to 0 dB. This is how much gain can be added before the system is marginally stable.
The phase margin is 50.9 degrees. It is the phase from the corresponding 0 dB phase point to the -180 degree phase point. It is how much we can change the phase before the system is marginally stable.

Problem 2

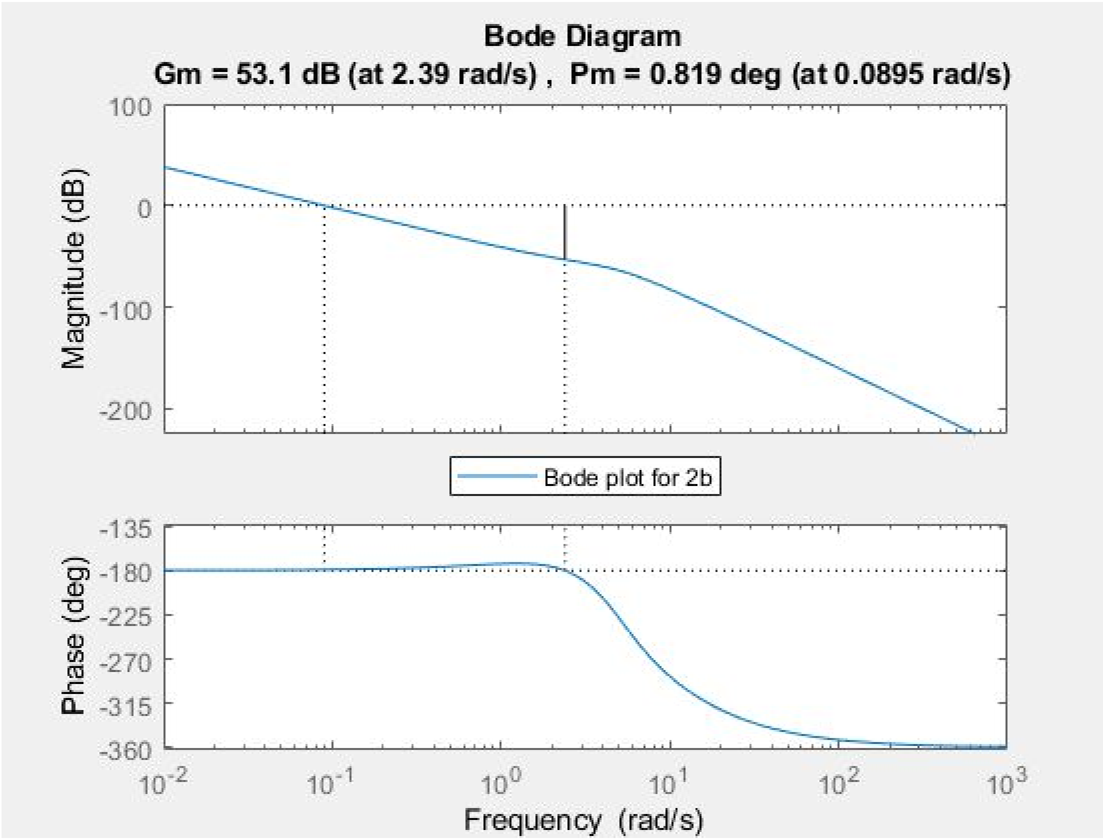
a)



The gain margin is 33 dB. It is the gain from the corresponding -180 degree phase gain point to 0 dB. This is how much gain can be added before the system is marginally stable.

The phase margin is 86.5 degrees. It is the phase from the corresponding 0 dB phase point to the -180 degree phase point. It is how much we can change the phase before the system is marginally stable.

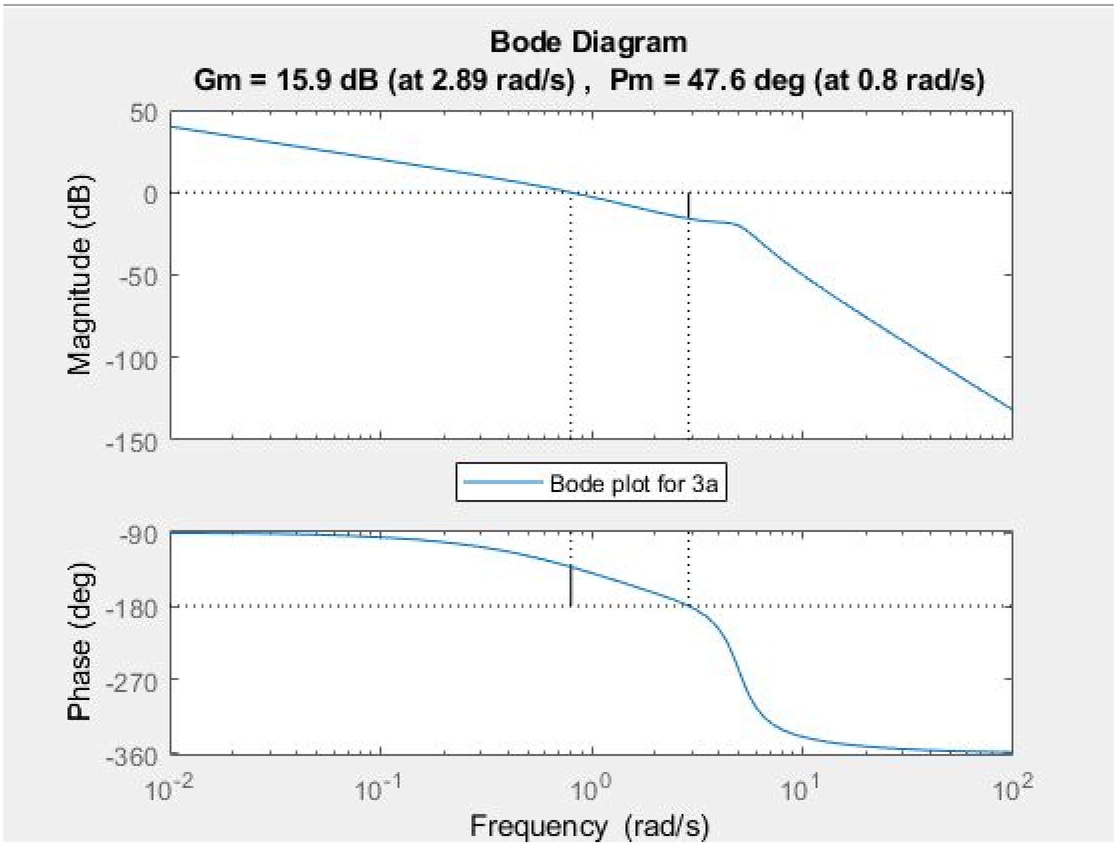
b)



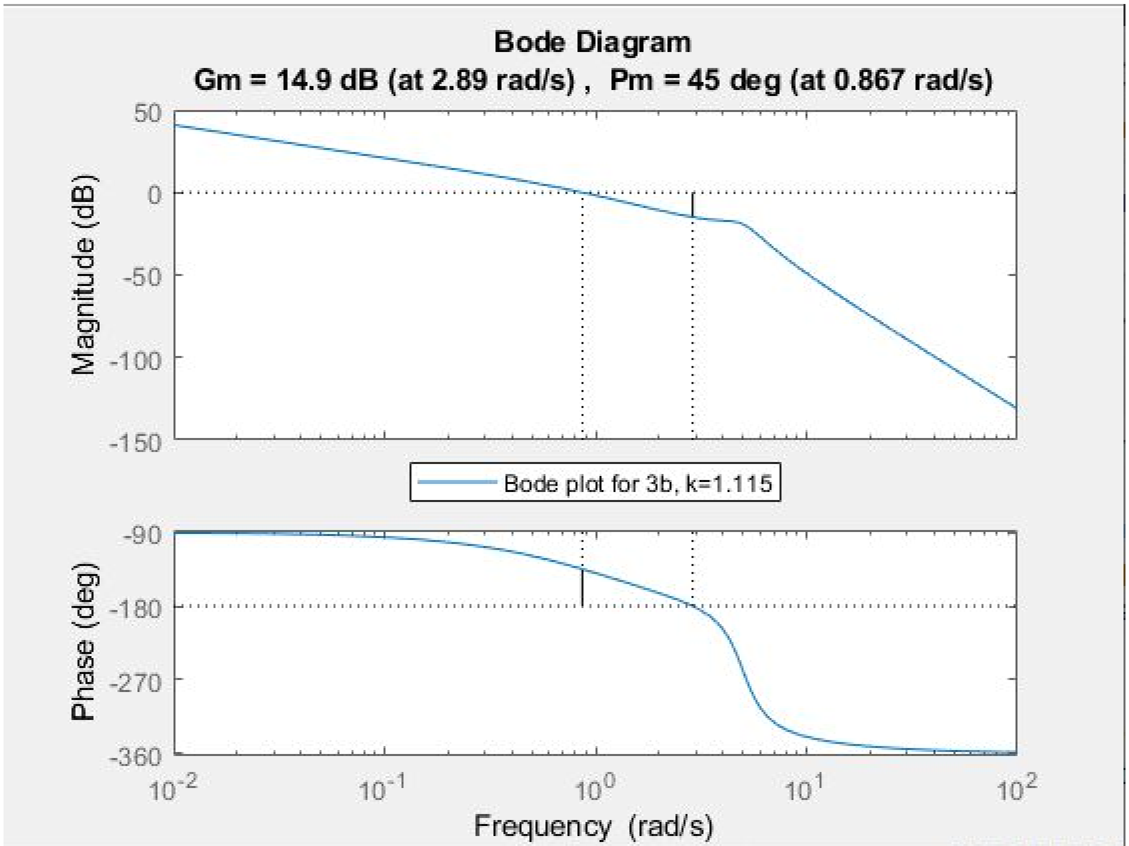
The gain margin is 53.1 dB. It is the gain from the corresponding -180 degree phase gain point to 0 dB. This is how much gain can be added before the system is marginally stable.
The phase margin is 0.8 degrees. It is the phase from the corresponding 0 dB phase point to the -180 degree phase point. It is how much we can change the phase before the system is marginally stable.

Problem 3

a) Assuming K = 1

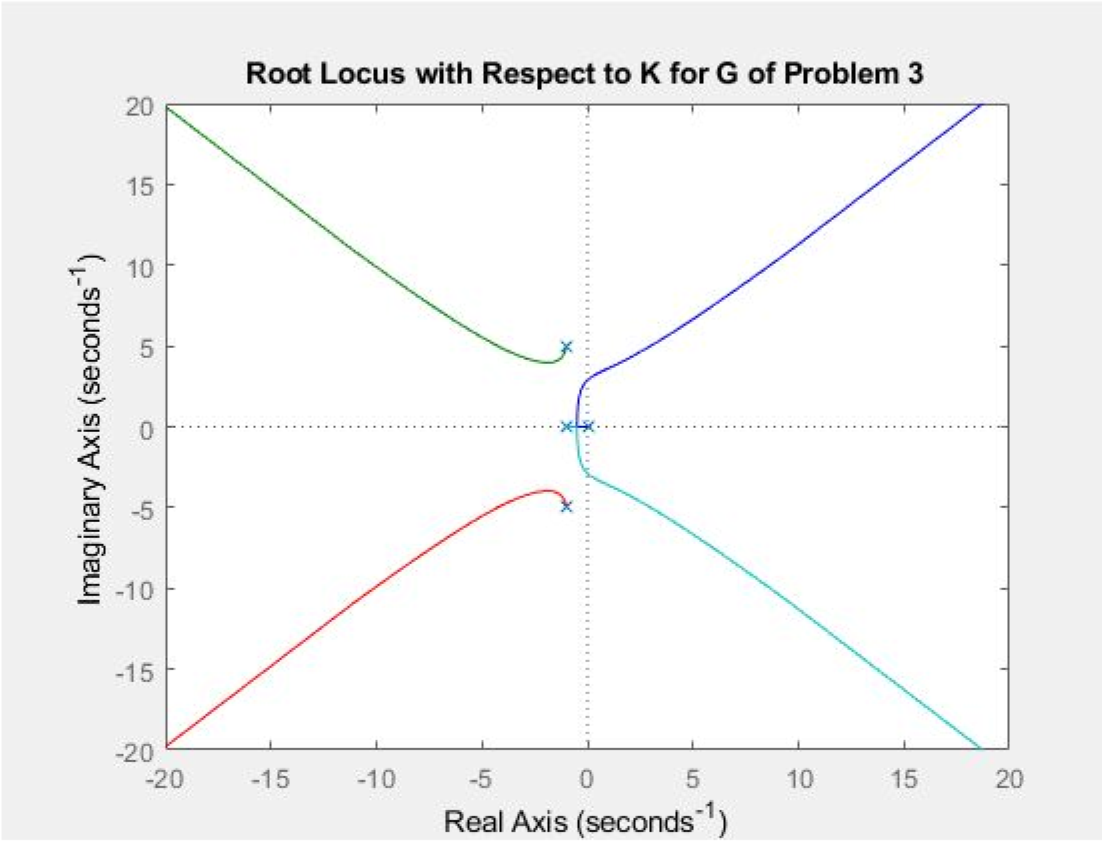


b) K = 1.115 gives PM = 45 degrees and GM = 14.9 dB
See handwritten attachment.



c) See handwritten attachment.

d) See handwritten attachment.




```
The poles for which the phase margin is 45 degrees are:
  -1.0269 + 4.7786i
  -1.0269 - 4.7786i
  -0.4731 + 0.9711i
  -0.4731 - 0.9711i
```

3. a) $G(s) = \dfrac{K}{s(s+1)\left[(s^2/25)+0.4(s/5)+1\right]} \Rightarrow \dfrac{K}{(s^2+s)((s^2/25)+(0.4)(s/5)+1)}$

$K=1 \rightarrow$

$\hat{G}(s) = \dfrac{1}{s^4/25 + 2s^3/25 + s^2 + s^3/25 + 2s^2/25 + s}$

$\hat{G}(s) = \dfrac{1}{(1/25)s^4 + (3/25)s^3 + (27/25)s^2 + s} \Rightarrow$ MATLAB

b) By inspection we must shift the magnitude plot by approximately 1 dB to decrease phase margin from 47.6° to 45°.

$1\,dB = 20\log(K)$ $\boxed{K = 1.122}$ ← guess and check to refine

After fine tuning, $\boxed{K = 1.115}$ gives a phase margin of 45°

The corresponding gain margin is $\boxed{14.9\,dB}$

c) K_v when $K = 1.115$?

$K_v = \lim_{s\to 0} s\,G(s) \Rightarrow \lim_{s\to 0} \dfrac{\cancel{s}\,1.115}{\cancel{s}(s+1)\left[(s^2/25)+0.4(s/5)+1\right]}$

$K_v = \dfrac{1.115}{[1][1]} = \boxed{1.115 = K_v = K}$

d)

↓

3.d)

Zeroes : N/A

Poles: $s = 0, -1, -1 \pm 4.899j$

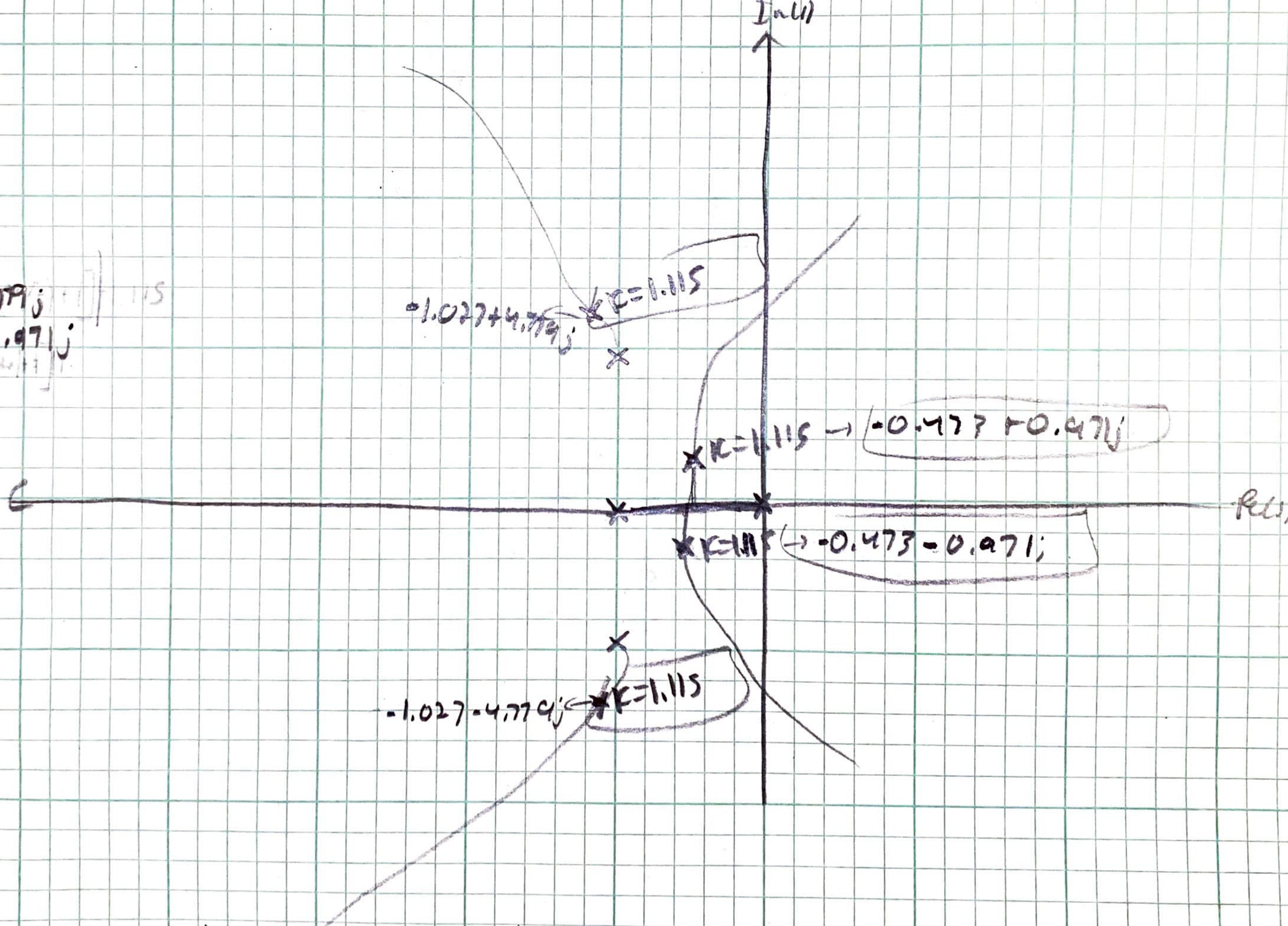
$$\hat{G}(s) = \frac{1}{s(s+1)[s^2/25 + 0.4(s/5) + 1]}$$

$1 + K\hat{G}(s) = 0$

s.t.e following poles sol'n for $K = 1.115$

↳ $s = -1.027 \pm 4.779j$

$s = -0.473 \pm 0.971j$



Break off occurs at some breakoff point:

↳ Exact point is solved by determining s_0 for → $\frac{d}{ds}\left(-\frac{1}{G(s)}\Big|_{s_0}\right) = 0$

```matlab
%% ME EN 6200 Homework 11 Ryan Dalby
%%
clear;
close all;

%% 1
% a
La = tf(2000,[1 200 0]);
figure;
margin(La);
legend('Bode plot for 1a', 'Location', 'northoutside');
% b
Lb = tf(100,[0.05 0.6 1 0]);
figure;
margin(Lb);
legend('Bode plot for 1b', 'Location', 'northoutside');
% c
Lc = tf(1,[0.02 1.02 1 0]);
figure;
margin(Lc);
legend('Bode plot for 1c', 'Location', 'northoutside');
%% 2
% a
La = tf([1 2],[1 12 22 20 0]);
figure;
margin(La);
legend('Bode plot for 2a', 'Location', 'northoutside');
% b
Lb = tf([1 2],[1 16 85 250 0 0]);
figure;
margin(Lb);
legend('Bode plot for 2b', 'Location', 'northoutside');

%% 3
% a
G_a = tf(1,[1/25,3/25,27/25,1,0]);
figure;
margin(G_a);
legend('Bode plot for 3a', 'Location', 'northoutside')

% b
G_b = tf(1.115,[1/25,3/25,27/25,1,0]);
figure;
```

```
margin(G_b);
legend('Bode plot for 3b, k=1.115', 'Location', 'northoutside')

% d
disp('The poles for which the phase margin is 45 degrees are:')
disp(pole(feedback(G_b, 1)));
disp(' ');
figure;
rlocus(G_a);
title('Root Locus with Respect to K for G of Problem 3');
```