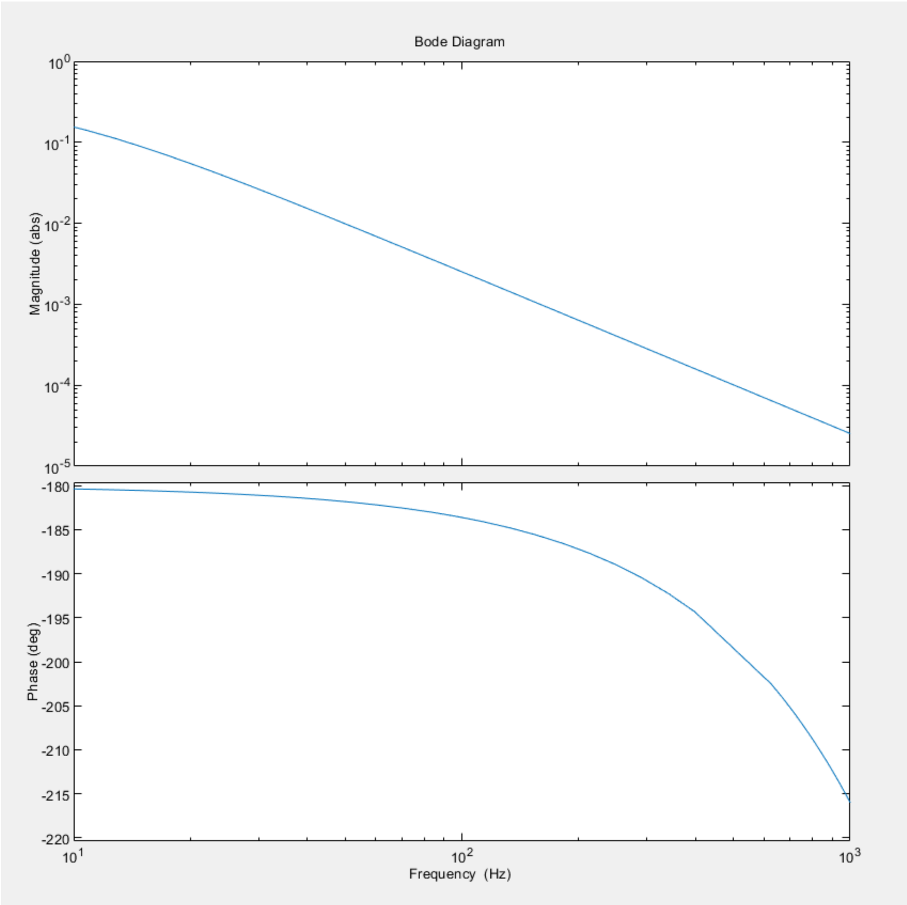
Ratthamnoon Prakitpong
#63205165
MECH421 Design Problem

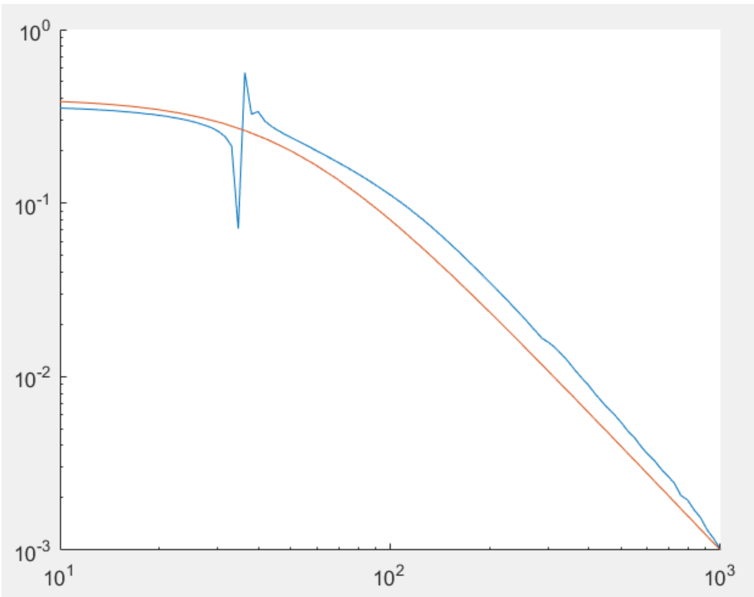
Q1.

We already have Td = 0.0001 from HW7. To make this process easier, I assumed K2 = 0. The guess I made is:

```
P = tf([1],[.001 0 -2.5],'InputDelay',.0001);
```

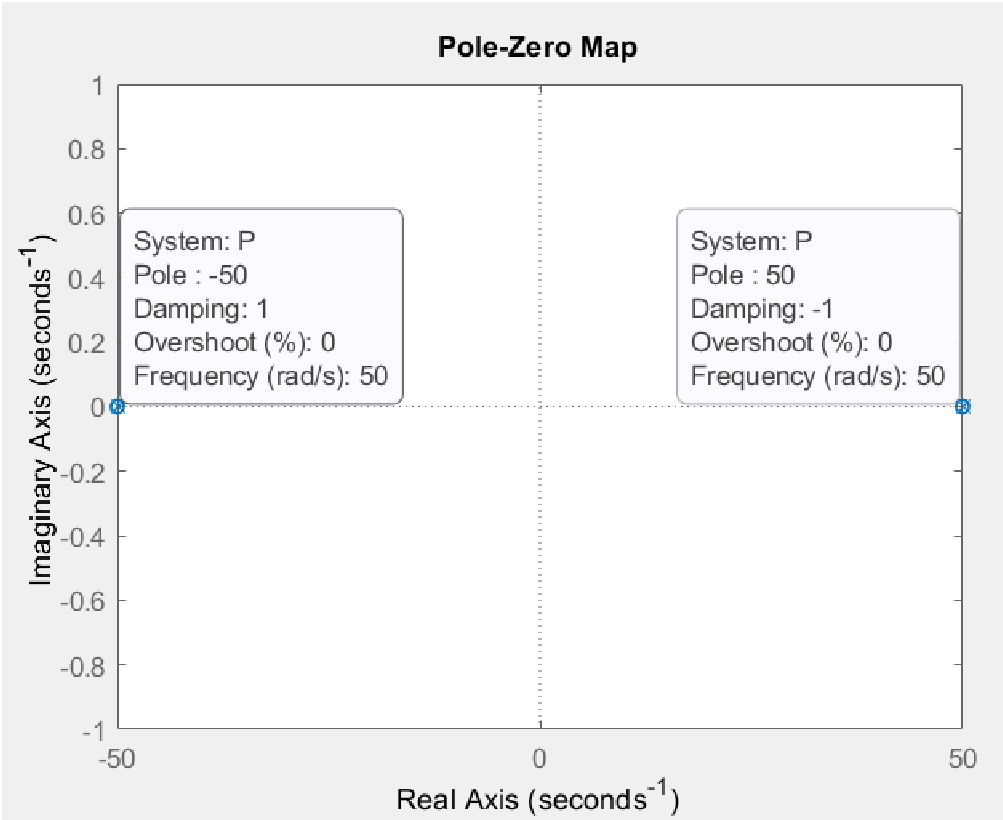


To compare the gain plots:



Red is from my estimate, blue is from data. The phase plot visually looks the same (steady state at -180, starts to dip at ~100 Hz), so comparison plot is omitted.

Q2.



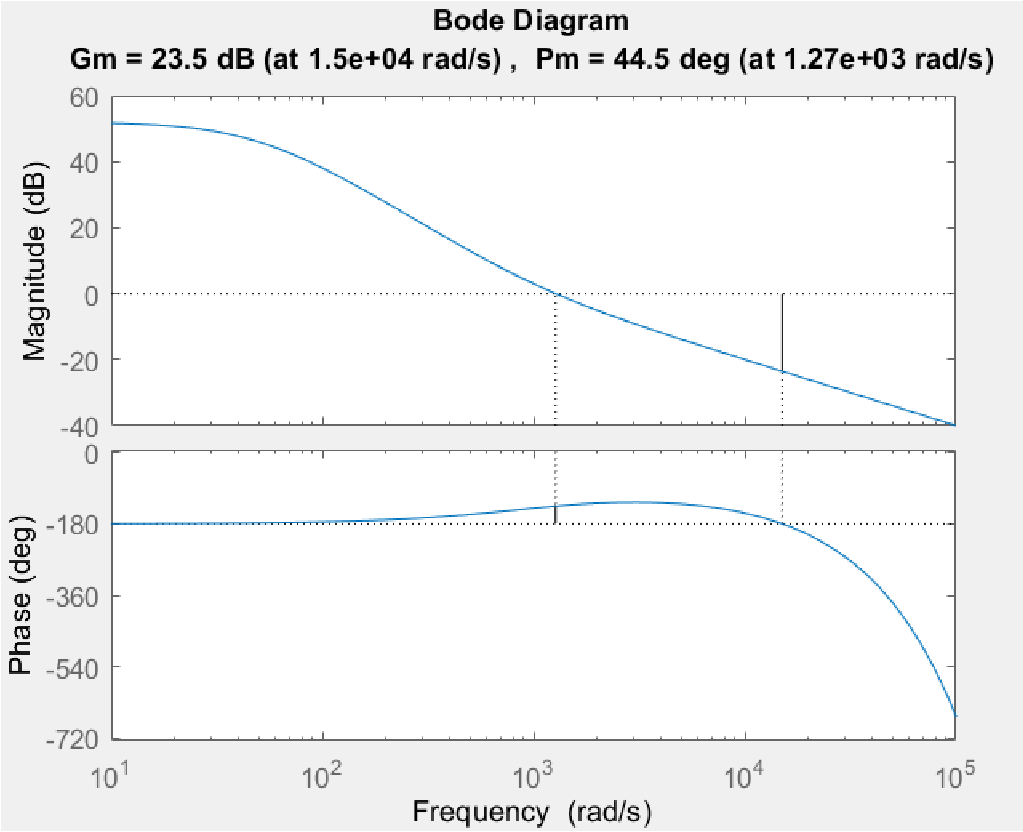
There is one unstable pole at 50 rad/s.

Q3.
After guess-and-check iterations, I found a suitable controller:

```
C = tf([1 1000],[1]);
```

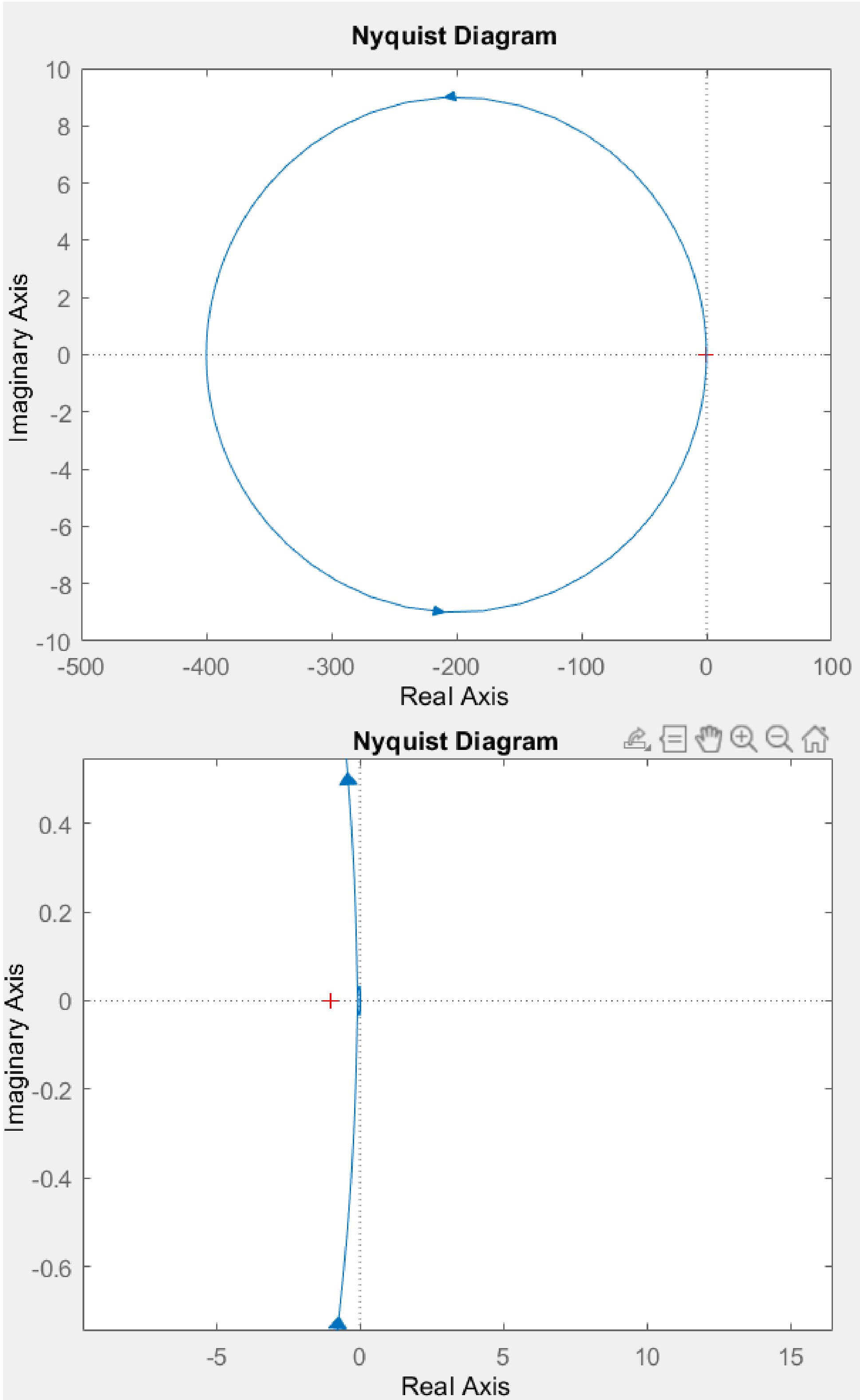
• Stabilizing the closed-loop system	=> discussed in Q5
• Phase margin φm > 30◦	=> discussed in Q4
• No integral control	=> no integral control (denominator = 1)

Q4.



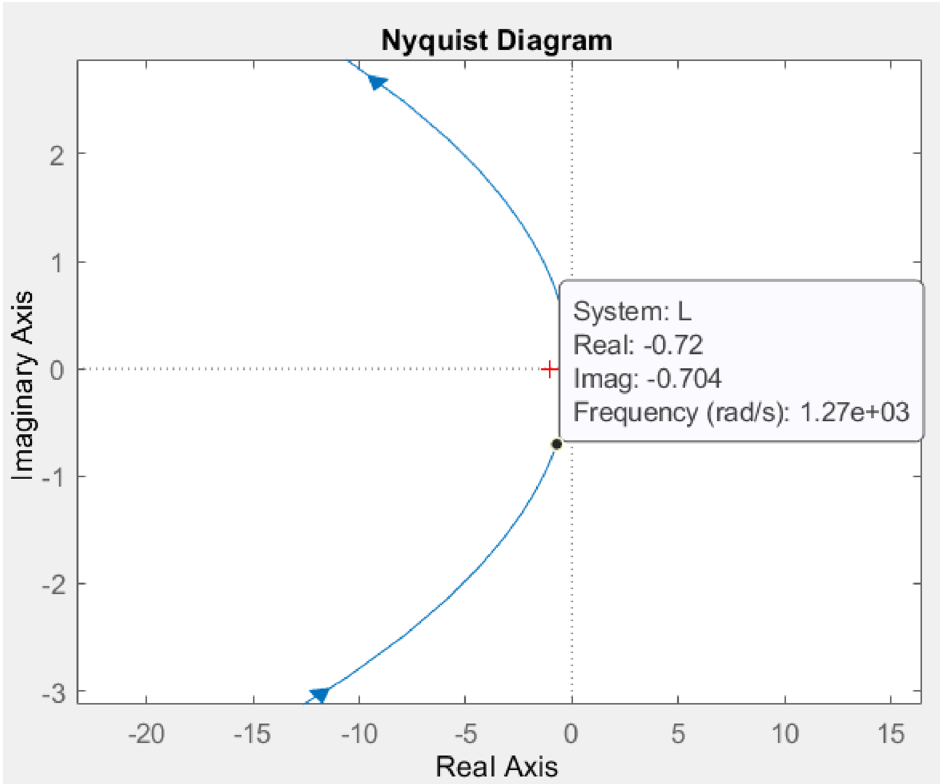
L=CP:
Phase margin = 44.5 deg > 30 deg
Crossover frequency = 1270 rad/s

Q5.



Number of poles of open loop transfer function in right half of s plane = P = 1 (at 50 rad/s, from Q2).
Number of encirclements around critical point = N = 1 (see above).
Number of zeros of closed 1+L in right half of s plane = Z = 0.
N = P – Z => Nyquist stability OK

Q6.



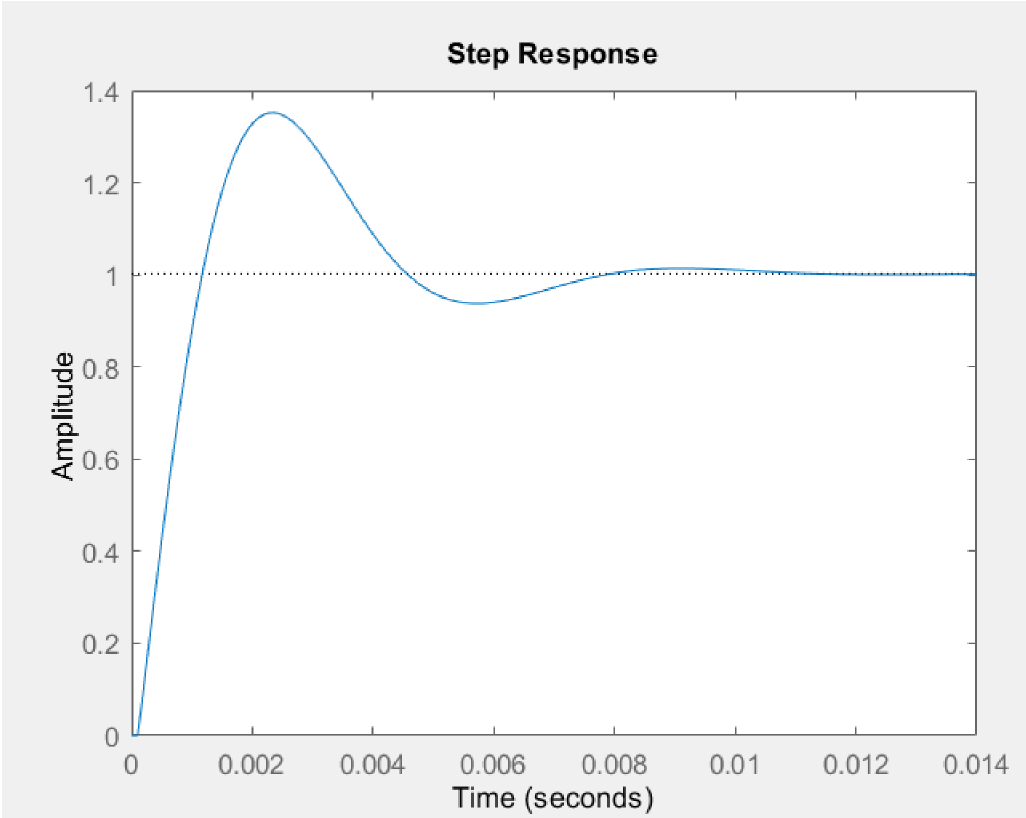

```
>> 180+rad2deg(angle(-.72-i*0.704))

ans =

   44.3563
```

44.35 deg ~= 44.5 deg (from Q4)

Q7.



Step Response
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Amplitude
0
0.002
0.004
0.006
0.008
0.01
0.012
0.014
Time (seconds)

Appendix: MATLAB

```
clf;
% q1
a = load('MaglevPlant.mat');
x = a.Plant_frf(:,1);
y = a.Plant_frf(:,2);
gain = abs(y);
theory_phase = angle(y)*180/pi;
hold on;
set(gca, 'XScale', 'log', 'YScale', 'log');
loglog(x,gain);
%loglog(x,phase);
P = tf([1],[.001 0 -2.5],'InputDelay',.0001);
options = bodeoptions;
options.FreqUnits = 'Hz';
options.MagScale = 'log';
options.MagUnits = 'abs';
options.Xlim = [10,1000];
%bode(P,options);
[mag,theory_phase,wout] = bode(P,options);
theory_phase = squeeze(theory_phase)+360;
theory_gain = squeeze(mag);
%loglog(wout,squeeze(mag));
%loglog(wout,phase);
hold off;
%{
% tried this, didnt work, guess matched only 7%
guess = tfest(a.Plant_frf, 4, 2, .0001);
bode(guess,options);
%}
% q2
pzmap(P);
% q3
C = tf([1 1000],[1]);
L = P*C;
closedloop = L/(1+L);
% q4
margin(L);
% q5,6
nyquist(L);
% q7
step(closedloop);
```