MECH 6323 - Homework 2

Author: Jonas Wanger

Date: 2022-02-13

Problem 2

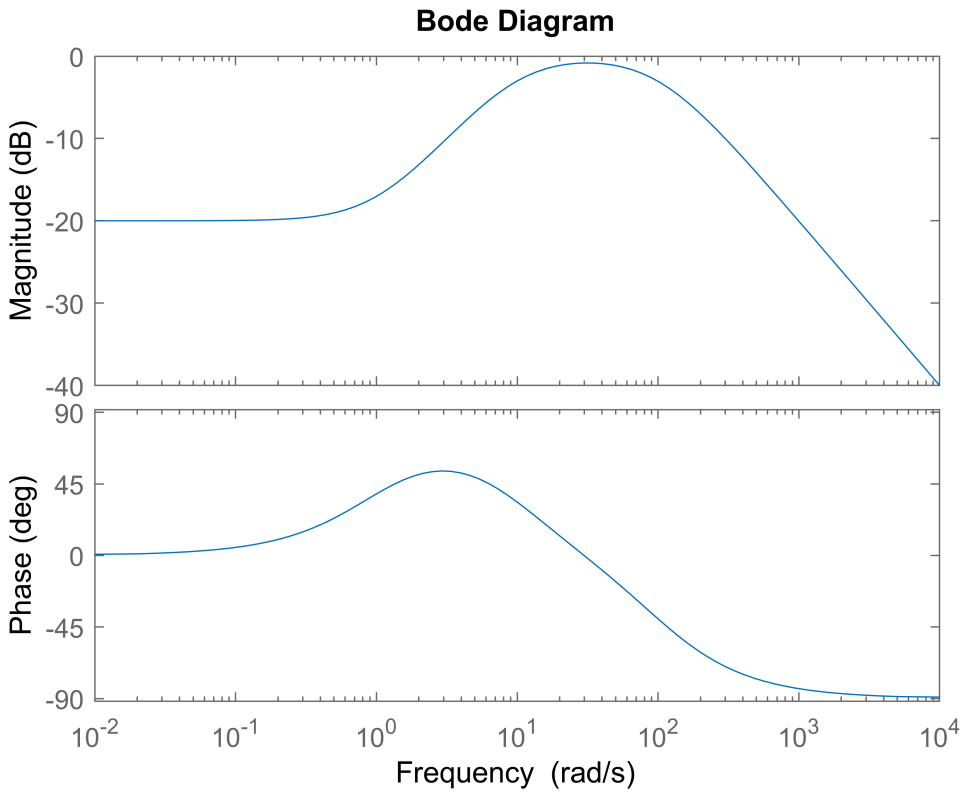
```
% a
G = zpk(tf([100 100],[1 110 1000]))
```

```
G =

    100 (s+1)
  --------------
  (s+100) (s+10)

Continuous-time zero/pole/gain model.
```

```
bode(G)
```



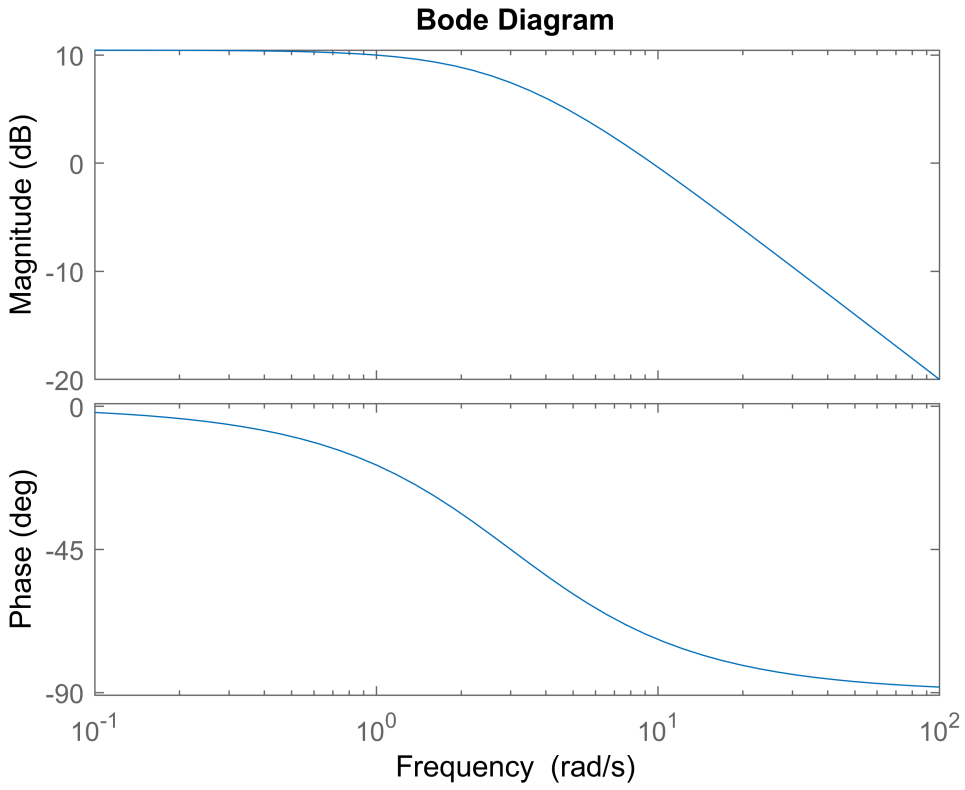

```
% b
G = zpk(tf([10 0],[1 3 0]))
```

```
G =

   10 s
  -------
  s (s+3)
```

```
Continuous-time zero/pole/gain model.
```

```
bode(G)
```



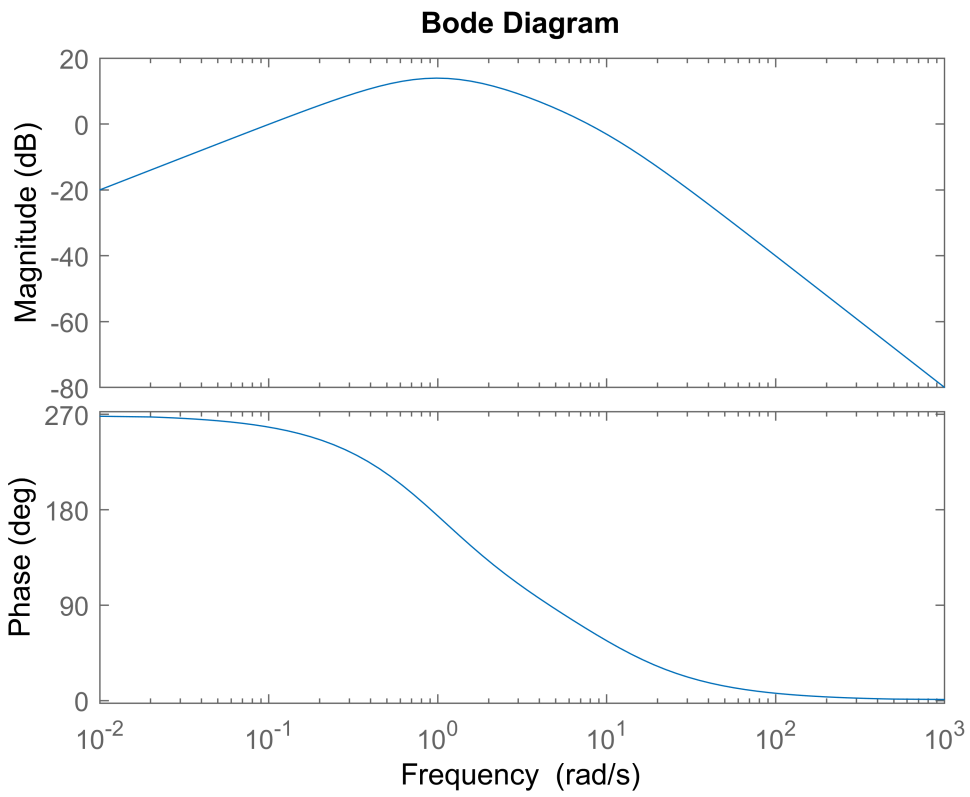

```
% c
G = zpk([0],[-1 -1 -10],-100)
```

```
G =

      -100 s
  --------------
  (s+1)^2 (s+10)

Continuous-time zero/pole/gain model.
```

```
bode(G)
```



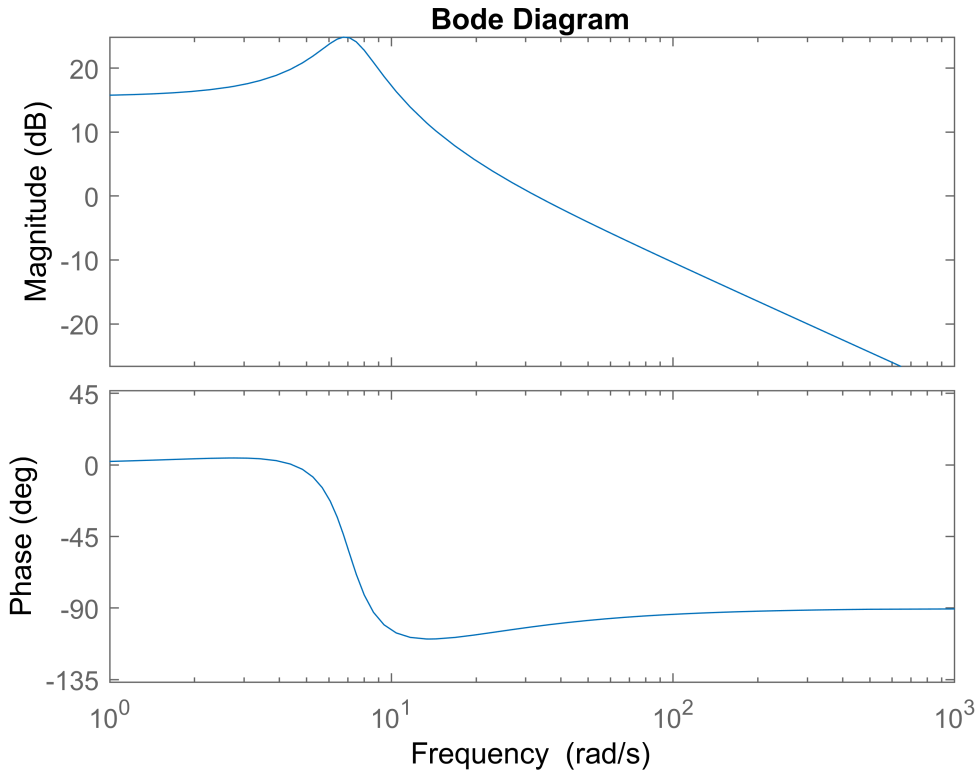

```
% d
G = zpk(tf(30*[1 10],[1 3 50]))
```

```
G =

     30 (s+10)
  ---------------
  (s^2 + 3s + 50)

Continuous-time zero/pole/gain model.
```

```
bode(G)
```



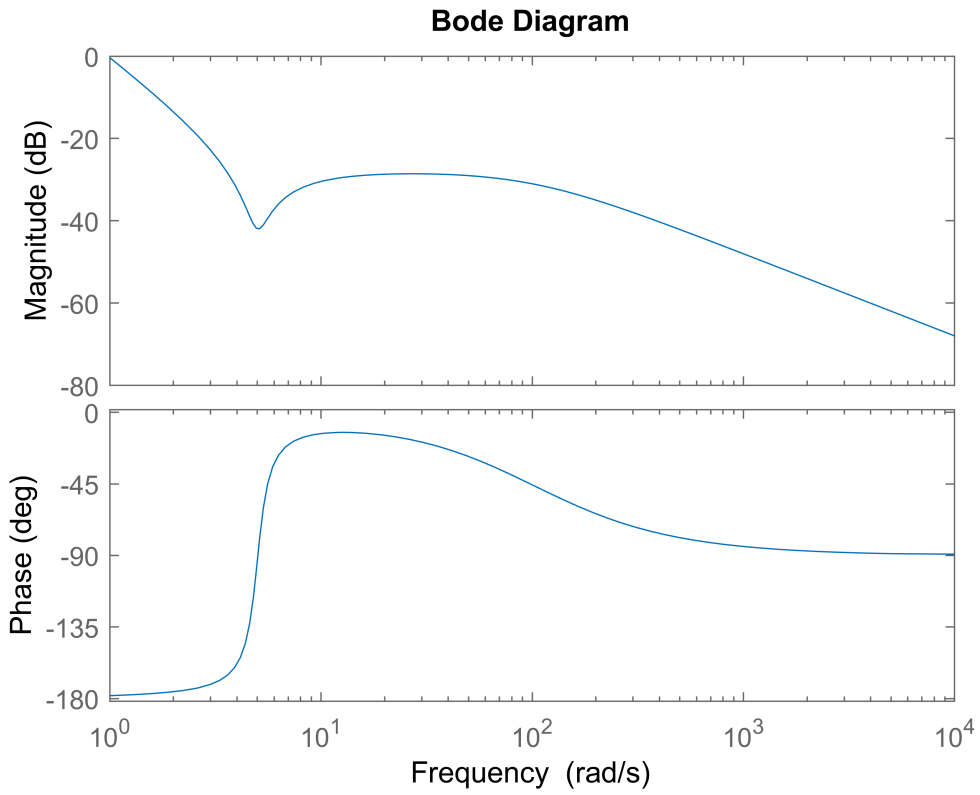

```
% e
G = zpk(tf(4*[1 1 25],[1 100 0 0]))
```

```
G =

  4 (s^2 + s + 25)
  ----------------
    s^2 (s+100)

Continuous-time zero/pole/gain model.
```

```
bode(G)
```



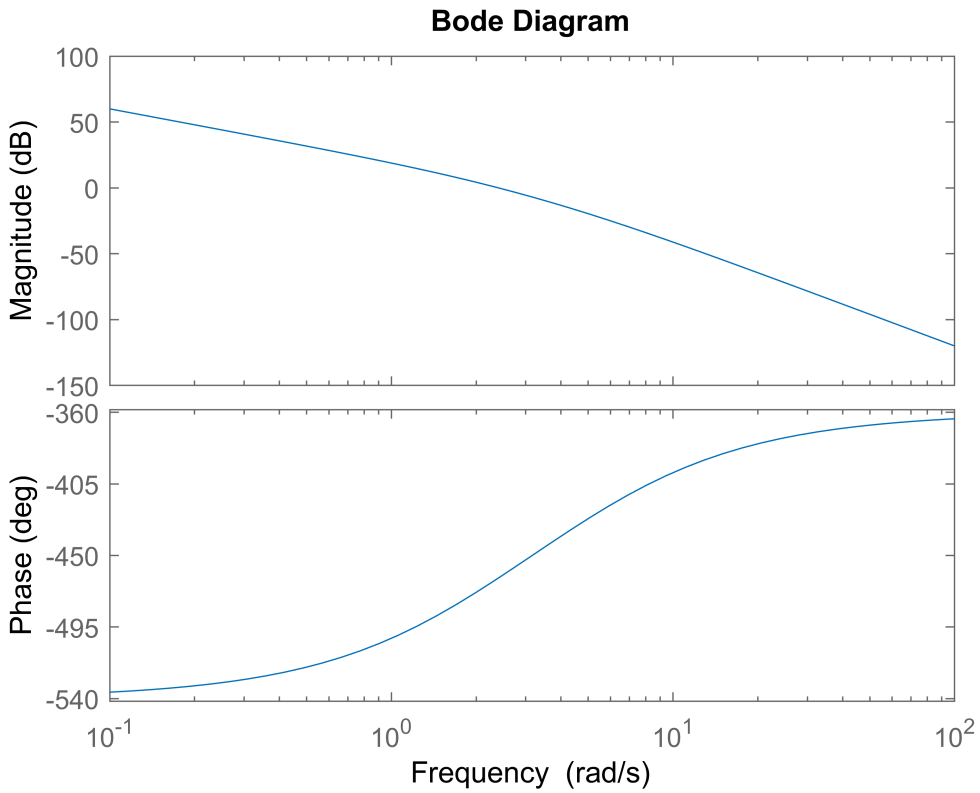

```
% f
G = zpk([],[0 0 -5 -2],100)
```

```
G =

        100
  ---------------
  s^2 (s-5) (s-2)

Continuous-time zero/pole/gain model.
```

```
bode(G)
```



Problem 3

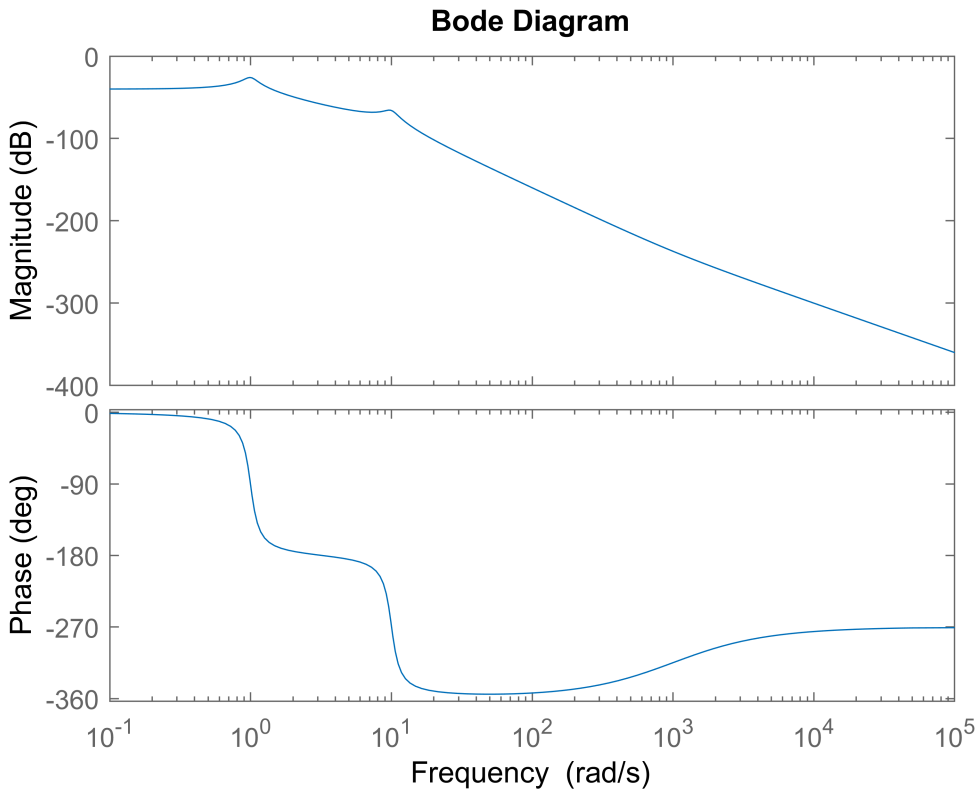
```
% 2nd TF
H1 = zpk(-1000,[],1/10);
H2 = tf([1/1], [1 2*(1/10)*1 1^2]);
H3 = tf([1/(10^2)], [1 2*(1/10)*10 (10)^2]);
H = H1 * H2 * H3
```

```
H =

          0.001 (s+1000)
  --------------------------------
  (s^2 + 0.2s + 1) (s^2 + 2s + 100)

Continuous-time zero/pole/gain model.
```

```
bode(H)
```



Problem 4

```
C = zpk(-3,0,10)
```

```
C =

  10 (s+3)
  --------
     s

Continuous-time zero/pole/gain model.
```

```
P1 = zpk([],[3],-0.5);
P2 = tf([1 0 -2000],[1 50 1000]);
P = P1 * P2
```

```
P =

  -0.5 (s-44.72) (s+44.72)
  ------------------------
  (s-3) (s^2 + 50s + 1000)

Continuous-time zero/pole/gain model.
```

```
% Part a
H = feedback(C*P,1)
```

```
H =
```

```
        -5 (s+3) (s+44.72) (s-44.72)
  ----------------------------------------
  (s^2 + 11.73s + 73.9) (s^2 + 30.27s + 406)

Continuous-time zero/pole/gain model.
```

```
isstable(H)
```

```
ans = logical
   1
```

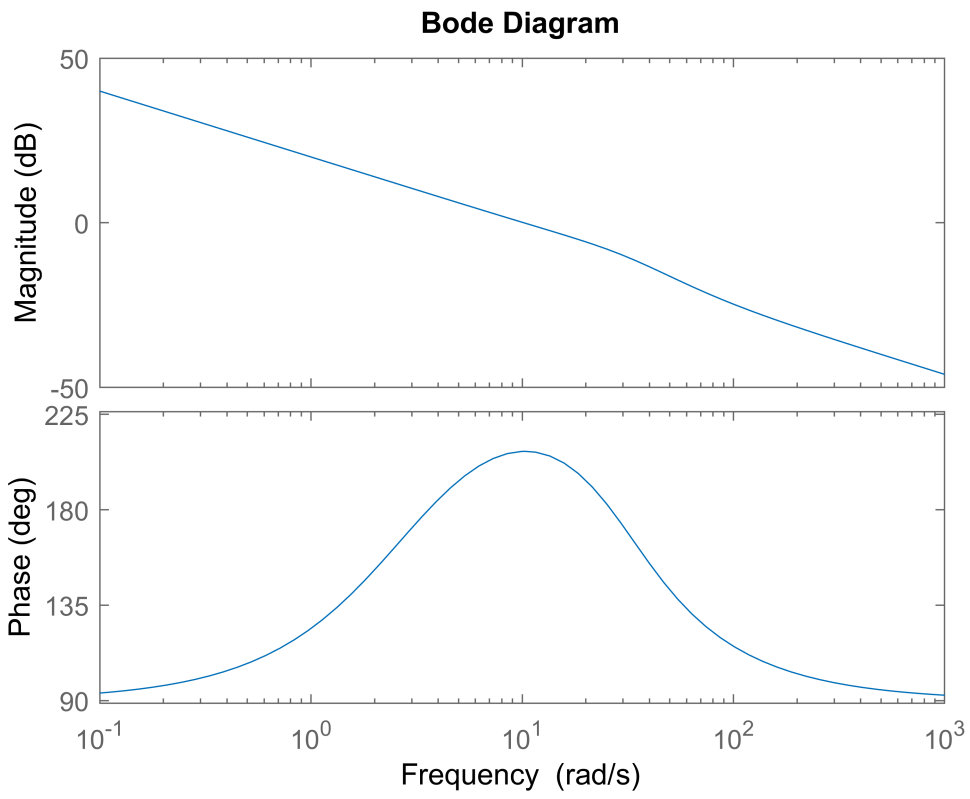
```
% Part b
L = C*P
```

```
L =

  -5 (s+3) (s+44.72) (s-44.72)
  ----------------------------
   s (s-3) (s^2 + 50s + 1000)

Continuous-time zero/pole/gain model.
```

```
bode(L)
```




```
margins = allmargin(L)
```

```
margins = struct with fields:
     GainMargin: [0.3585 2.6490]
    GMFrequency: [3.5966 26.3797]
    PhaseMargin: 27.5718
    PMFrequency: 10.2049
    DelayMargin: 0.0472
```

```
    DMFrequency: 10.2049
         Stable: 1
```

```
% Part c
g1 = margins.GainMargin(1)
```

```
g1 = 0.3585
```

```
L1 = g1 * L
```

```
L1 =

  -1.7927 (s+3) (s+44.72) (s-44.72)
  ---------------------------------
     s (s-3) (s^2 + 50s + 1000)

Continuous-time zero/pole/gain model.
```

```
H1 = feedback(L1,1)
```

```
H1 =

           -1.7927 (s-44.72) (s+44.72) (s+3)
  ---------------------------------------------------
  (s^2 + 0.0008164s + 12.93) (s^2 + 45.21s + 831.7)

Continuous-time zero/pole/gain model.
```

```
poles1 = roots([1 0.0008164 12.93])
```

```
poles1 = 2×1 complex
  -0.0004 + 3.5958i
  -0.0004 - 3.5958i
```

```
g2 = margins.GainMargin(2)
```

```
g2 = 2.6490
```

```
L2 = g2 * L
```

```
L2 =

  -13.245 (s+3) (s+44.72) (s-44.72)
  ---------------------------------
     s (s-3) (s^2 + 50s + 1000)

Continuous-time zero/pole/gain model.
```

```
H2 = feedback(L2,1)
```

```
H2 =

       -13.245 (s+3) (s+44.72) (s-44.72)
  ----------------------------------------
  (s+29.94) (s+3.814) (s^2 + 0.003402s + 696)

Continuous-time zero/pole/gain model.
```

```
poles2 = roots([1 0.003402 696])
```

```
poles2 = 2×1 complex
  -0.0017 +26.3818i
  -0.0017 -26.3818i
```

```
% Part d
S = 1/(1+P*C)
```

```
S =

         s (s-3) (s^2 + 50s + 1000)
  ----------------------------------------
  (s^2 + 11.73s + 73.9) (s^2 + 30.27s + 406)

Continuous-time zero/pole/gain model.
```

```
T = (P*C)/(1+P*C)
```

```
T =

        -5 s (s-44.72) (s+44.72) (s+3) (s-3) (s^2 + 50s + 1000)
  ------------------------------------------------------------------------
  s (s-3) (s^2 + 11.73s + 73.9) (s^2 + 30.27s + 406) (s^2 + 50s + 1000)

Continuous-time zero/pole/gain model.
```

```
S_minus_T = minreal(S-T)
```

```
S_minus_T =

   (s-10.45) (s+2.059) (s^2 + 60.4s + 1394)
  ----------------------------------------
  (s^2 + 11.73s + 73.9) (s^2 + 30.27s + 406)

Continuous-time zero/pole/gain model.
```

```
[NINF,w_p] = hinfnorm(S_minus_T)
```

```
NINF = 4.0763
w_p = 10.0798
```

```
% Part e
m = 1/NINF
```

```
m = 0.2453
```

```
dm = diskmargin(P*C)
```

```
dm = struct with fields:
           GainMargin: [0.6060 1.6501]
          PhaseMargin: [-27.5672 27.5672]
           DiskMargin: 0.4906
           LowerBound: 0.4906
           UpperBound: 0.4906
            Frequency: 10.0623
    WorstPerturbation: [1×1 ss]
```

```
m = dm.DiskMargin/2
```

```
m = 0.2453
```

```
% Part f
z = 1/evalfr(S-T,j*w_p);
z = (z / abs(z)) * abs(m)
```

```
z = -0.0063 - 0.2452i
```

```
alpha = (1+z)/(1-z)
```

```
alpha = 0.8760 - 0.4572i
```

```
alpha_L_plus_1 = alpha*evalfr(L,j*w_p) + 1
```

```
alpha_L_plus_1 = -2.7529e-08 - 1.2029e-06i
```