Table of Contents

..... 1
Question 1 1
Question 2 2
Question 3 3
Question 4 5
Question 5 6
Question 6 11


```
% Connor Jones
% MECH 7710
% Homework 0

clear all, clc
```

Question 1

```
% Part a
A = [0 1;0 -0.1];
B = [0;1];
C = [1 0];
D = [0];

sys = ss(A,B,C,D)

x0 = [32 12];

% Part b
eigenvalues = eig(A)
```

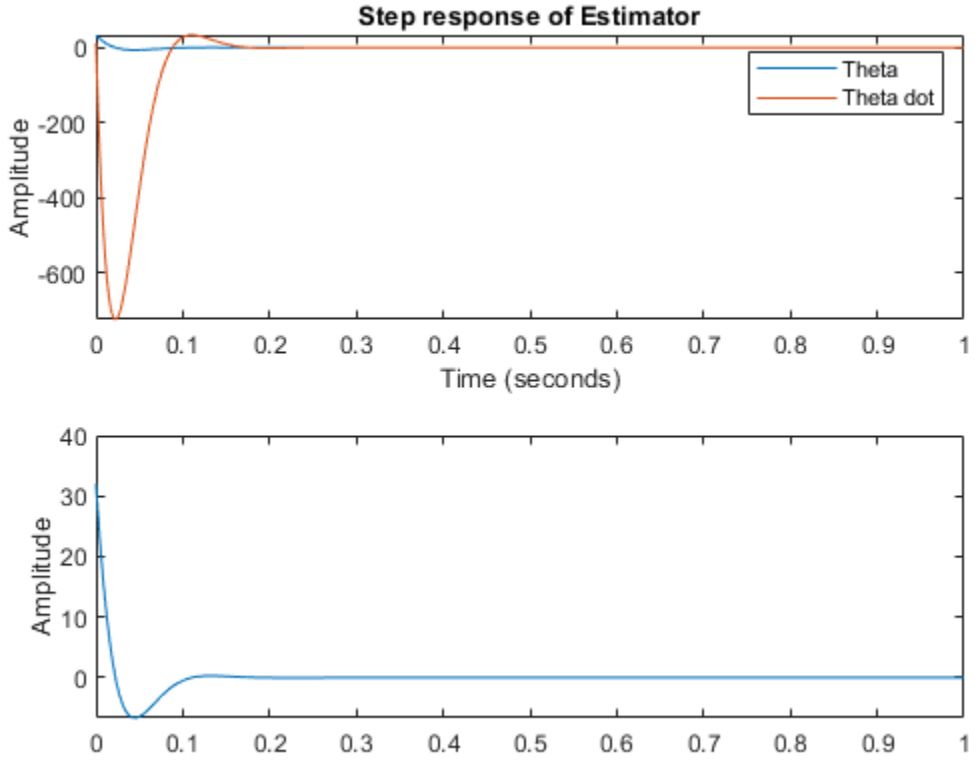
```
sys =

  A =
         x1    x2
   x1     0     1
   x2     0  -0.1

  B =
       u1
   x1   0
   x2   1

  C =
       x1  x2
   y1   1   0

  D =
```

```
       u1
  y1   0

Continuous-time state-space model.


eigenvalues =

         0
   -0.1000
```

Question 2

```
% Part a
O = obsv(A,C)
O_rank = rank(O)

% Part b
sys2 = tf([0 0.1],[1 70 2500]);
p = pole(sys2);

L = place(A',C',p)'

% Part c
Ob = ss(A-L*C,B,C,D);

t_vec = 0:0.001:1;
u = ones(size(t_vec))*0.001;
[y,t,x] = lsim(Ob,u,t_vec,x0);

figure
subplot(2,1,1)
plot(t,x(:,1))
hold on
plot(t,x(:,2))
title('Step response of Estimator')
xlabel('Time (seconds)')
ylabel('Amplitude')
legend('Theta','Theta dot')
subplot(2,1,2)
plot(t,y)
ylabel('Amplitude')


O =

     1     0
     0     1


O_rank =
```

```
     2


L =

   1.0e+03 *

    0.0699
    2.4930
```

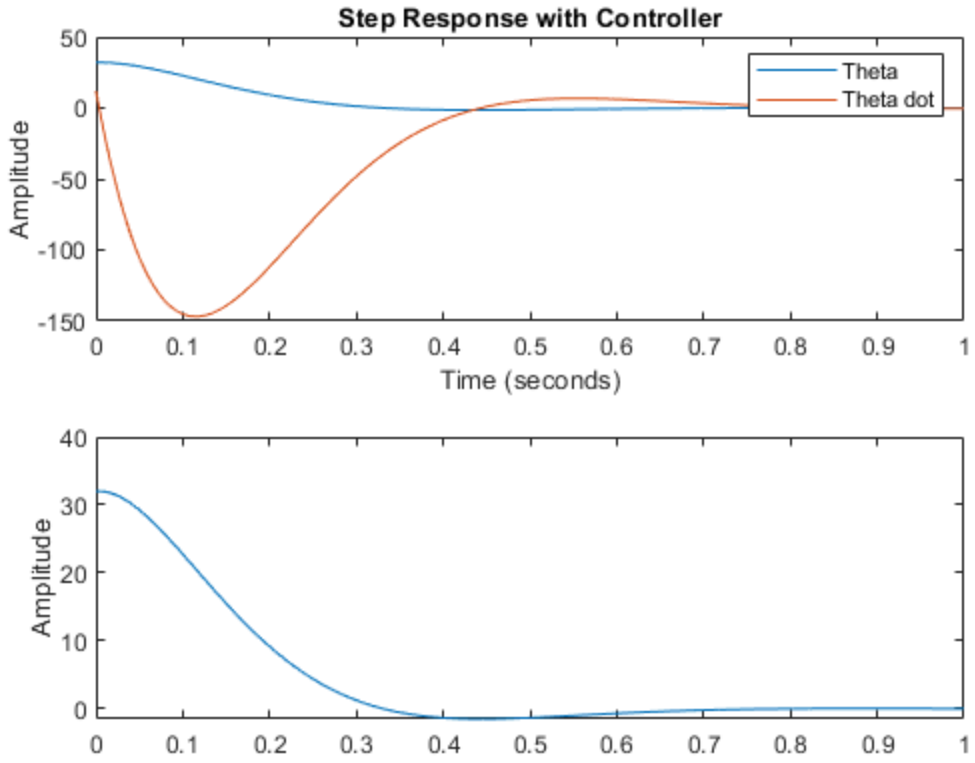


Question 3

```
% Part a
Ao = ctrb(A,B)
Ao_rank = rank(Ao)

% Part b
sys3 = tf([0 0.1],[1 14 100]);
p2 = pole(sys3);

K = place(A,B,p2)

% Part c
Con = ss((A-B*K),B,C,D);
```

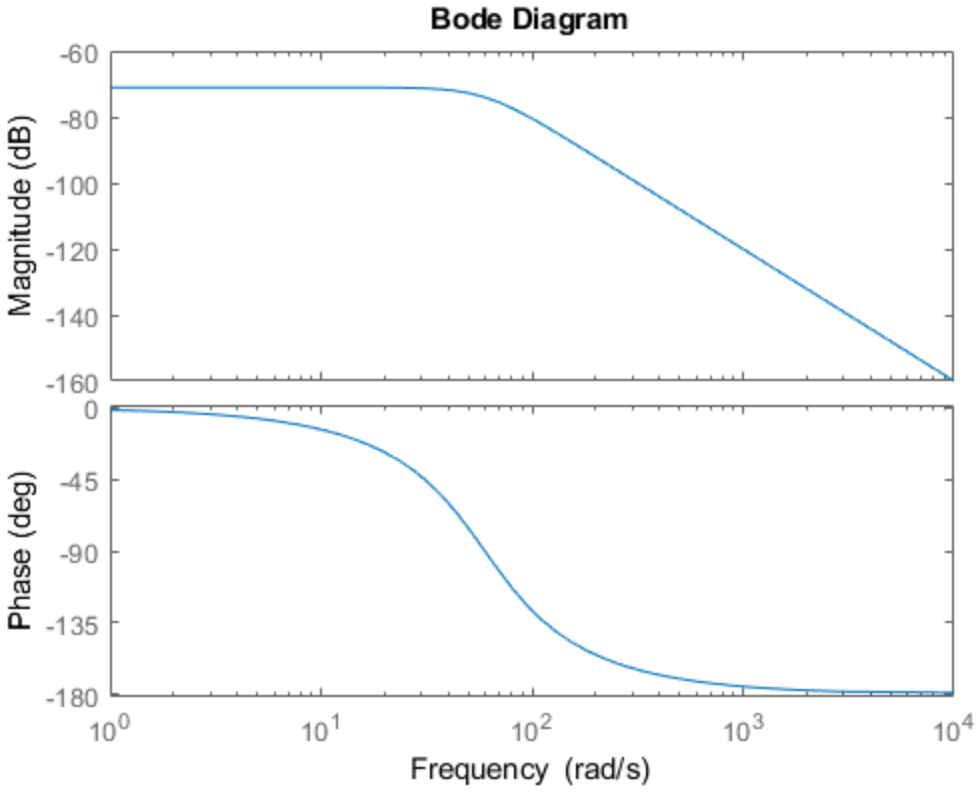
```
[y,t,x] = lsim(Con,u,t_vec,x0);

figure
subplot(2,1,1)
plot(t,x(:,1))
hold on
plot(t,x(:,2))
title('Step Response with Controller')
xlabel('Time (seconds)')
ylabel('Amplitude')
legend('Theta','Theta dot')
subplot(2,1,2)
plot(t,y)
ylabel('Amplitude')
```

```
Ao =

         0    1.0000
    1.0000   -0.1000


Ao_rank =

     2


K =

  100.0000   13.9000
```



Question 4

```
% Part b
format short
[num,den] = ss2tf((A-L*C-B*K),B,C,D);
CLTF = tf(num,den);

% Part c
figure
bode(CLTF)
```



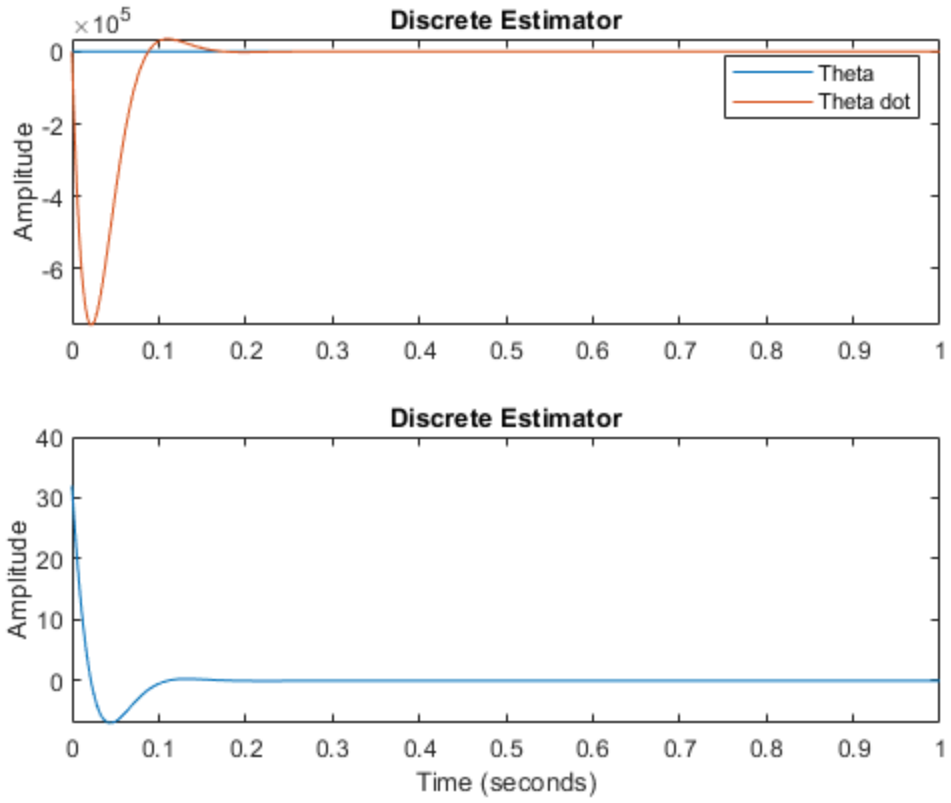
Question 5

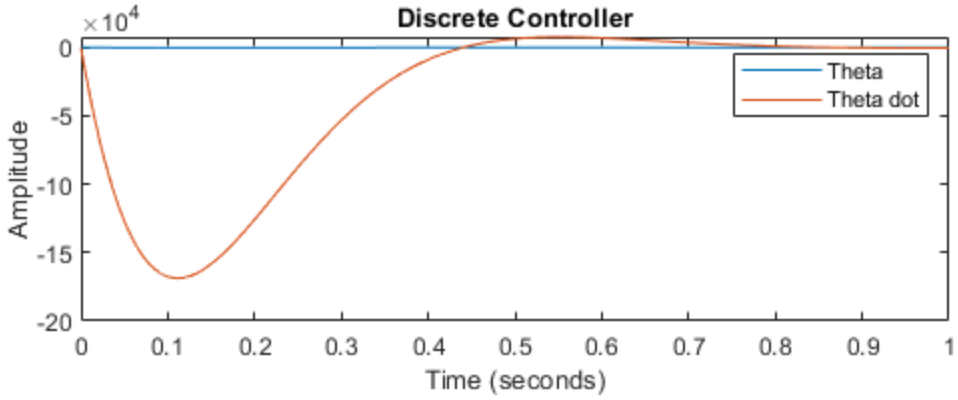
```
% Part a
Ts = 1/1000;
t_vec_dis = 0:Ts:1;
x0 = [32 12];
u = ones(size(t_vec_dis))*0.001;
sys_dis = c2d(sys,Ts,'Tustin')
eigen_dis = eig(sys_dis.A)

% Part b
O_dis = obsv(sys_dis.A,sys_dis.C);

Est_dis = tf([0 0.1],[1 70 2500])
p_est = pole(Est_dis);

L_dis = place(sys_dis.A',sys_dis.C',p_est)'

est_sys = ss(sys_dis.A-L_dis*sys_dis.C,sys_dis.B,sys_dis.C,sys_dis.D);
[y,t,x] = lsim(est_sys,u,t_vec_dis,x0);

figure
subplot(2,1,1)
plot(t,x(:,1))
hold on
```

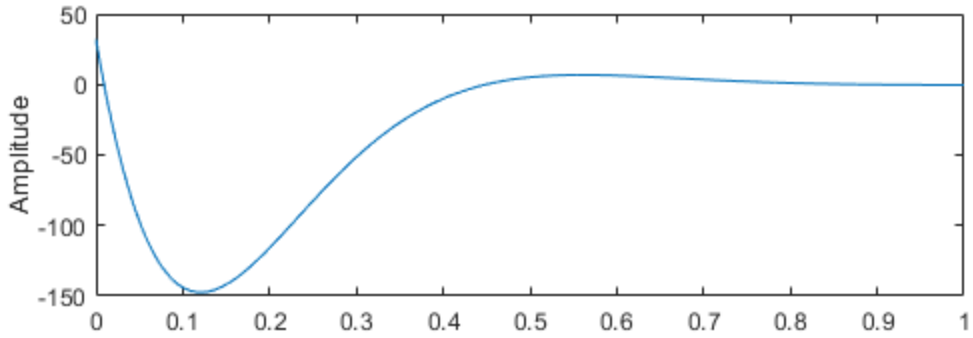
```
plot(t,x(:,2))
title('Discrete Estimator')
ylabel('Amplitude')
legend('Theta','Theta dot')
subplot(2,1,2)
plot(t,y)
title('Discrete Estimator')
xlabel('Time (seconds)')
ylabel('Amplitude')

% Part c
Con_dis = tf([0 0.1],[1 14 100]);
p_con = pole(Con_dis);

K_dis = place(sys_dis.A,sys_dis.B,p_con)

con_sys = ss(sys_dis.A-sys_dis.B*K_dis,sys_dis.B,sys_dis.C,sys_dis.D);
[y,t,x] = lsim(con_sys,u,t_vec_dis,x0);

figure
subplot(2,1,1)
plot(t,x(:,1))
hold on
plot(t,x(:,2))
title('Discrete Controller')
xlabel('Time (seconds)')
ylabel('Amplitude')
legend('Theta','Theta dot')
subplot(2,1,2)
plot(t,y)
ylabel('Amplitude')

% Part d
[num_dis,den_dis] = ss2tf((sys_dis.A-L_dis*sys_dis.C-
sys_dis.B*K_dis),sys_dis.B,sys_dis.C,sys_dis.D);
Dis = tf(num_dis,den_dis)
p = pole(Dis)
z = zero(Dis)
figure
zplane(z,p)


sys_dis =

  A =
           x1      x2
   x1       1   0.001
   x2       0  0.9999

  B =
          u1
   x1  5e-07
   x2  0.001
```

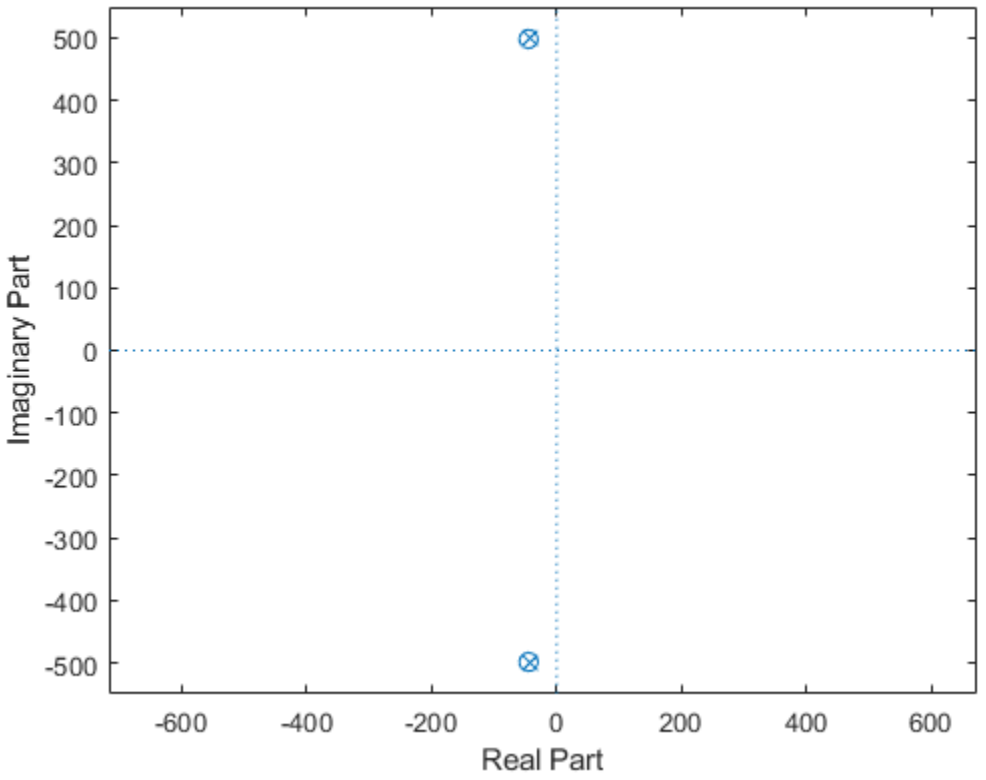
```
  C =
          x1      x2
   y1      1  0.0005

  D =
          u1
   y1  2.5e-07

Sample time: 0.001 seconds
Discrete-time state-space model.


eigen_dis =

    1.0000
    0.9999


Est_dis =

         0.1
  -----------------
  s^2 + 70 s + 2500

Continuous-time transfer function.


L_dis =

   1.0e+06 *

   -0.0012
    2.5712


K_dis =

   1.0e+08 *

    1.1501   -0.0004


Dis =

  2.5e-07 s^2 + 2.25e-05 s + 0.0625
  ---------------------------------
         s^2 + 86 s + 2.5e05

Continuous-time transfer function.


p =

   1.0e+02 *
```

```
  -0.4300 + 4.9816i
  -0.4300 - 4.9816i


z =

   1.0e+02 *

  -0.4500 + 4.9798i
  -0.4500 - 4.9798i
```



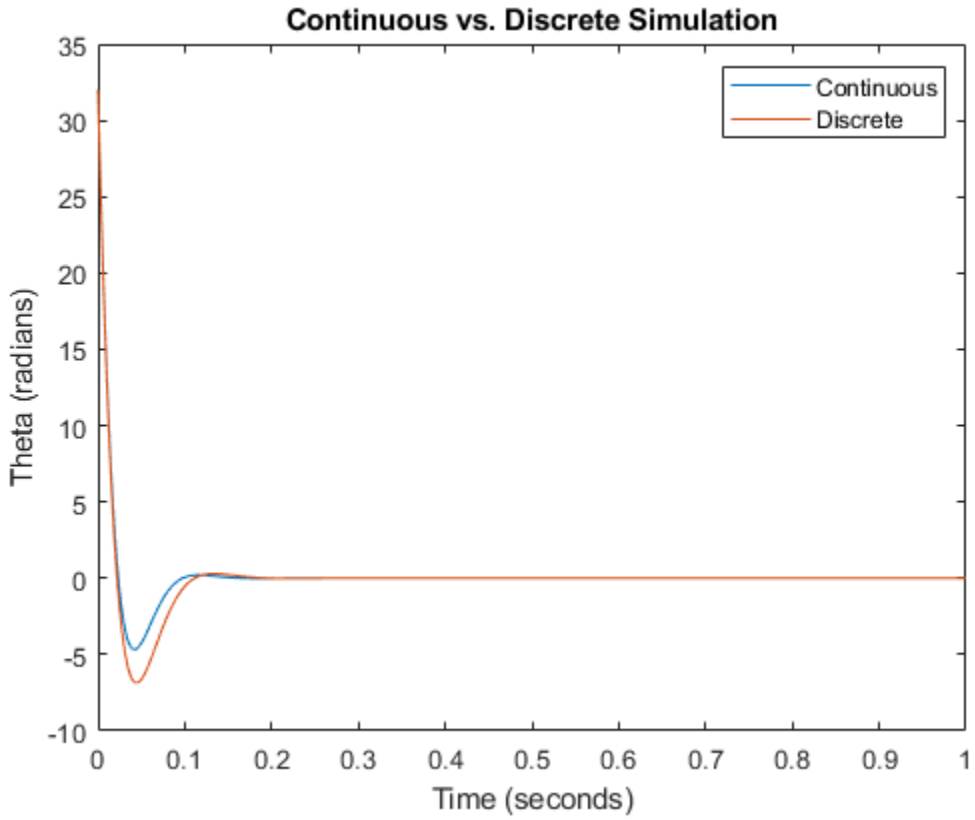

Discrete Controller
×10^4
Theta
Theta dot
Amplitude
Time (seconds)


Amplitude


Imaginary Part
Real Part

Question 6

```
sys1 = ss(A-L*C-B*K,B,C,D);
sys2 = ss(sys_dis.A-L_dis*sys_dis.C-
sys_dis.B*K,sys_dis.B,sys_dis.C,sys_dis.D);

[y1,t1,x1] = lsim(sys1,u,t_vec_dis,x0);
[y2,t2,x1] = lsim(sys2,u,t_vec_dis,x0);

figure
plot(t1,y1)
hold on
plot(t2,y2)
title('Continuous vs. Discrete Simulation')
xlabel('Time (seconds)')
ylabel('Theta (radians)')
legend('Continuous','Discrete')
```



Published with MATLAB® R2019a