

John Sigmon

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HW 4

EE 362K

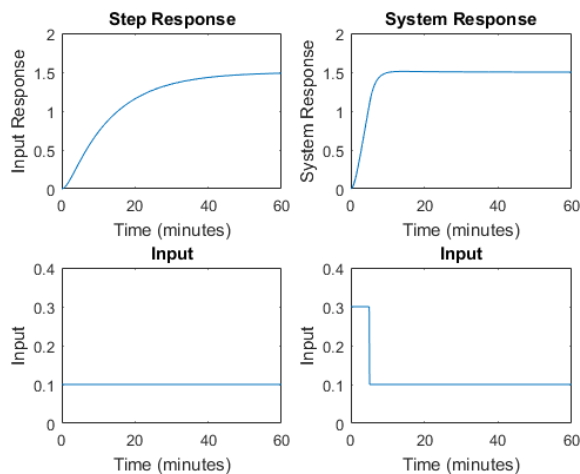
1.)

See attached.

2.)

I scaled my inputs by 1/10 to match the example in the book. (e.g. my step input is 0.1 instead of 1)

```
1 function problem2
2 k0 = 0.1;
3 k1 = 0.1;
4 k2 = 0.5;
5 b0 = 1.5;
6
7 a = [-k0-k1, k1; k2, -k2];
8 b = [b0, 0]';
9 c = [0, 1];
10 d = 0;
11 sys = ss(a, b, c, d);
12
13 t = 0:0.1:60;
14 u = ones(1, length(t));
15 u = u./10;
16 %Step Response
17 subplot(2,2,1);
18 plot(t, lsim(sys, u, t));
19 xlabel('Time (minutes)');
20 ylabel('Input Response');
21 title('Step Response');
22 xlim([0 60]);
23 ylim([0 2]);
24
25 %Step Input
26 subplot(2,2,3);
27 plot(t, u);
28 xlabel('Time (minutes)');
29 ylabel('Input');
30 title('Input');
31 xlim([0 60]);
32 ylim([0 0.4]);
33
34 for i = 1: 51
35     u(i) = 0.3;
36 end
37
38 %Pulse Response
39 subplot(2,2,2);
40 plot(t, lsim(sys, u, t));
41 xlabel('Time (minutes)');
42 ylabel('System Response');
43 title('System Response');
44 xlim([0 60]);
45 ylim([0 2]);
46
47 %Pulse Input
48 subplot(2,2,4);
49 plot(t, u);
50 xlabel('Time (minutes)');
51 ylabel('Input');
52 title('Input');
53 xlim([0 60]);
54 ylim([0 0.4]);
55
```



3.)

Find the R.C.F. for system

$$\dot{\bar{z}} = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -2 & 3 & 5 \end{bmatrix} \bar{z} + \begin{bmatrix} 0 \\ 0 \\ 1/2 \end{bmatrix} u$$

$$\bar{y} = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \bar{z} + \begin{bmatrix} 0 \end{bmatrix} u$$

R.C.F. is determined by the characteristic equation.

$$\det(\lambda I - A) = 0$$

$$\det \begin{bmatrix} -\lambda & 1 & 0 \\ 0 & -\lambda & 1 \\ -2 & 3 & -\lambda - 5 \end{bmatrix} = 0$$

$$-\lambda \cdot \det \begin{bmatrix} \lambda & 1 \\ 3 & -\lambda - 5 \end{bmatrix} - 1 \cdot \det \begin{bmatrix} 0 & 1 \\ -2 & -\lambda - 5 \end{bmatrix} = 0$$

$$\lambda(\lambda(\lambda - 5) - 3) - 1(0 - (-2)) = 0$$

$$\lambda^3 + 5\lambda^2 + 3\lambda - 2 = 0$$

```
>> problem3
System is reachable
```

R.C.F. for A is:

$$\begin{bmatrix} a_1 & a_2 & a_3 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \rightarrow \begin{bmatrix} -5 & -3 & 2 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}$$

and B is $\begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$

So, R.C.F. for the system is

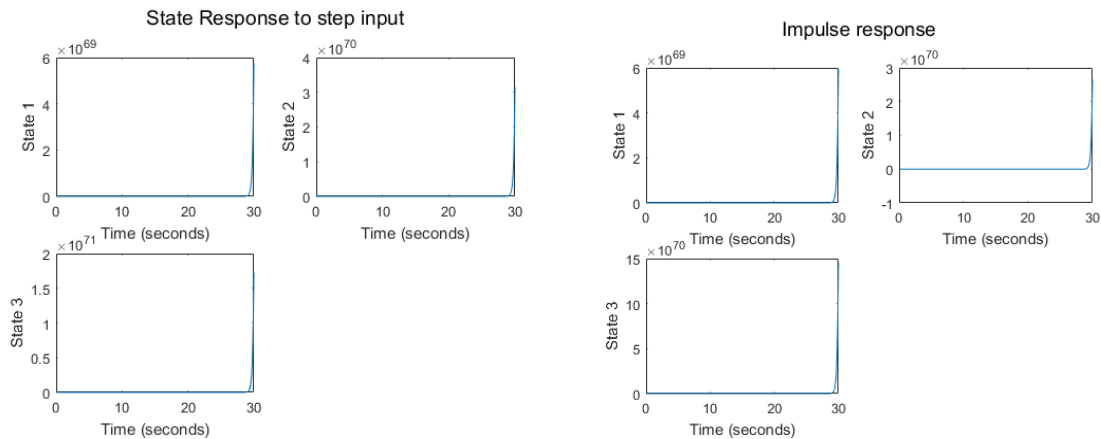
$$\dot{\bar{z}} = \begin{bmatrix} -5 & -3 & 2 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix} \bar{z} + \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} \bar{u}$$

$$\bar{y} = \begin{bmatrix} 1 & 0 & 0 \end{bmatrix} \bar{z} + \begin{bmatrix} 0 \end{bmatrix} \bar{u}$$

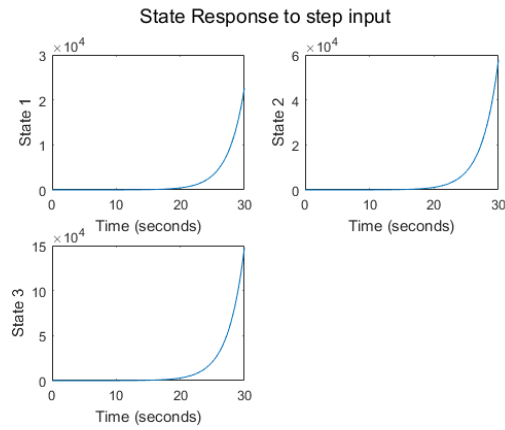
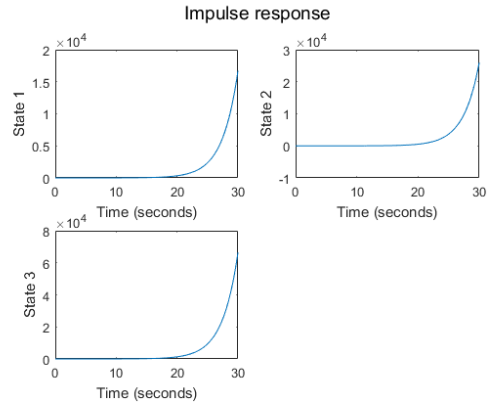
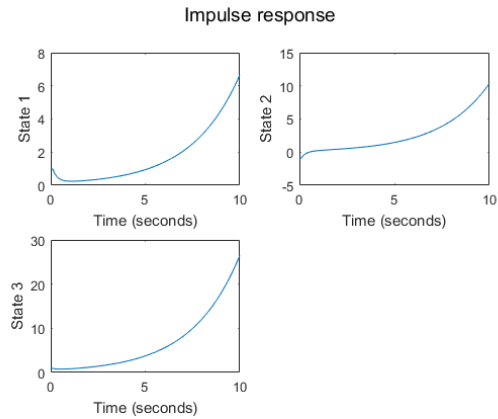
```
problem3.m
1 function problem3
2
3 A = [0,1,0;0,0,1;-2,3,5];
4 B = [0,0,0.5]';
5 wr = ctrb(A,B);
6 reachable = 0;
7 if (rank(wr) == size(A))
8     reachable = 1;
9     disp("System is reachable");
10 else
11     disp("System is not reachable");
12 end
```

4.)

Step response and impulse response for given system.



Step response and impulse response for RCF. (10 second span gave more information so I included it)



Code for Step and Impulse Responses.

```

1 function xprime = mysystem(E,x)
2
3 u = 1;
4 A = [-5,-3,2;1,0,0;0,1,0]; %RCF
5 B = [1,0,0]'; %RCF
6 %A = [0, 1, 0; 0, 0, 0; -2, 3, 5];
7 %B = [0, 0, 0.5]';
8 C = [1,0,0];
9 D = 0;
10
11 xprime = A*x + B*u;
12
13
14 function problem4
15
16 %Part A Step Response
17 %Part B Impulse Response
18
19 [t,y] = ode45('mysystem', [0 30], [1 0 1]');
20
21 subplot(2,2,1);
22 plot(t,y(:,1));
23 xlabel('Time (seconds)');
24 ylabel('State 1');
25 subplot(2,2,2);
26 plot(t,y(:,2));
27 xlabel('Time (seconds)');
28 ylabel('State 2');
29 subplot(2,2,3);
30 plot(t,y(:,3));
31 xlabel('Time (seconds)');
32 ylabel('State 3');
33 subplot(2,2,4);
34 plot(t,y(:,4));
35 xlabel('Time (seconds)');
36 ylabel('State 4');
37
38 title('State Response to step input');
39
40
41 %Part B Impulse Response
42 %Part C Impulse Response
43
44 A = [0, 1, 0; 0, 0, 1; -2, 3, 5];
45 B = [0, 0, 0.5]';
46 %A = [-5,-3,2;1,0,0;0,1,0]; %RCF
47 %B = [1,0,0]'; %RCF
48 C = [1,0,0];
49 D = 0;
50
51 t = 0:0.1:30;
52 u = zeros(1, length(t));
53 u(1) = 3; %impulse of value 3
54 sys1 = ss(A, B, C, D);
55 sys2 = ss(A, B, C, D);
56 sys3 = ss(A, B, C, D);
57 z1 = lsim(sys1, u, t, [1 0 1]');
58 z2 = lsim(sys2, u, t, [1 0 1]');
59 z3 = lsim(sys3, u, t, [1 0 1]');
60 subplot(2,2,1);
61 plot(t,z1(:,1));
62 xlabel('Time (seconds)');
63 ylabel('State 1');
64 subplot(2,2,2);
65 plot(t,z2(:,1));
66 xlabel('Time (seconds)');
67 ylabel('State 2');
68 subplot(2,2,3);
69 plot(t,z3(:,1));
70 xlabel('Time (seconds)');
71 ylabel('State 3');
72 subplot(2,2,4);
73 plot(t,z4(:,1));
74 xlabel('Time (seconds)');
75 ylabel('State 4');
76
77 title('Impulse response');
78
79

```

5.)

```

>> problem5
wr is
Columns 1 through 2

    0    0
    0    0.5000
    0.5000    2.5000

Column 3

    0.5000
    2.5000
    14.0000

wrtilda is
    1    5    28
    0    1    5
    0    0    1

    1
    0
    0

    5    3    -2
    1    0    0
    0    1    0

Transformation matrix is
    0    0    2
    0    2    0
    2    0    0

```

```

1 function problem5
2
3 A = [0, 1, 0; 0, 0, 1; -2, 3, 5];
4 B = [0; 0; 0.5];
5 Atilda = [5, 3, -2; 1, 0, 0; 0, 1, 0]; %RCF
6 Btilda = [1; 0; 0]; %RCF
7
8 wr = ctrb(A, B);
9 %wr = [B A*B (A^2)*B];
10 wrtilda = ctrb(Atilda, Btilda);
11
12 disp('wr is')
13 disp(wr)
14 disp('wrtilda is')
15 disp(wrtilda)
16
17 %wrtilda = [Btilda Atilda*Btilda (Atilda.^2)*Btilda];
18 T = wrtilda/wr;
19 disp(T*B);
20 disp(T*A/T);
21 disp('Transformation matrix is');
22 disp(T);
23

```

6.)

```

>> problem6
k2/2 - k1/2 - k3/2 + 1

(3*k2)/2 - k1/2 - (9*k3)/2 + 61

3*k2 - k1/2 - 18*k3 + 376

k is:
32
60
30

k2 - k1/2 - 2*k3 + 20

- k1/2 + k2*(1/2 - 5i/2) + k3*(12 + 5i) - (199 - 75i)

- k1/2 + k2*(1/2 + 5i/2) + k3*(12 - 5i) - (199 + 75i)

k is:
100
66
18

```

```

1 function problem6
2 syms k1 k2 k3
3 %part a
4 f1 = cecalcuator(-1);
5 f2 = cecalcuator(-3);
6 f3 = cecalcuator(-6);
7
8 [A,b] = equationsToMatrix([f1,f2,f3], [k1,k2,k3]);
9 k = linsolve(A,b);
10 disp('k is:')
11 disp(k)
12
13
14 %part b
15 f4 = cecalcuator(-2);
16 f5 = cecalcuator(-1+5*i);
17 f6 = cecalcuator(-1-5*i);
18 [A,b] = equationsToMatrix(f4,f5,f6);
19 k = A\b;
20 disp('k is:')
21 disp(k)
22

```

```

1 function [f] = cecalcuator(lambda)
2
3 syms k1 k2 k3;
4
5 f = -(lambda.^3) + (lambda.^2)*(5-k3*0.5) + lambda*(3-k2*0.5) - k1*0.5 - 2;
6 disp(f);
7

```

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Plotting the states turned out to be a little difficult. I ran out of time, and attempted to go based off one of the slides, but couldn't figure out how to do it. Here is what I got done. I compiled the two systems into function files and tried to run ode45 to at least plot the solutions, but got dimension errors in zprime.

```
1 function zprimel = mysystem1(t,z)
2
3 - A = [0,1,0;0,0,1;-2,3,5];
4 - B = [0;0;0.5];
5 - C = [1,0,0];
6
7 - [k1,k2] = problem6;
8
9 - yr = 1;
10 - kr = -1/(C*(inv(A-B*k1')*B));
11
12 - zprimel = (A - B*k1')*z + B*kr*yr;
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John Sigmon

Js85773

```
>> problem8
[ b1,      0,      0]
[  0,      0,  a1*b1]
[  0,  a1*b1,  a1*b1]
```

```
-a1^2*b1^3
```

The only values of alpha that make wr not full rank are:

```
0
0
```

The only values of beta that make wr not full rank are:

```
0
0
0
```

```
1  function problem8
2
3  - syms a1      %alpha
4  - syms b1      %beta
5
6  - f(a1) = [0,1,0;0,0,1;a1,1,1];
7  - g(b1) = [b1;0;0];
8  - wr = [g(b1) f(a1)*g(b1) (f(a1)^2)*g(b1)];
9  - disp(wr);
10 - disp(det(wr));
11
12 - S1 = solve(det(wr) == 0, a1);
13 - disp('The only values of alpha that make wr not full rank are:')
14 - disp(S1);
15 - S2 = solve(det(wr) == 0, b1);
16 - disp('The only values of beta that make wr not full rank are:')
17 - disp(S2);
```