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%question 1: deisging of controller of a state space model  using pole placement↙
technique
% two meathods of desging controller Ackerman's formule and transformation approach

% meathod 1: desging of pole placement using transformation approach ie, given system↙
is not in controllable cannonical form then first
% we need to convert the given system into the CCF format.
clc ;
close all;
clear all;

A =[-4 1 0;0 -3 1;0 0 -2];
B =[0; 0; 16];
C= [2 1 0];
D = 0;
disp('given system of eqution');
sys = ss(A,B,C,D);

%check controllablity
M = [B A*B A^2*B];
px  = poly(A);
AZ = [0 1 0; 0 0 1;-24 -26 -9];
BZ = [0;0; 16];
MZ = [BZ AZ*BZ AZ^2*BZ];
MZd = det(MZ);
% deteminant of MZ is not eqaul to zero hence, given system is controllable

p = M*inv(MZ);

%our desired characterstics eqution is:
%s^3+9.709s^2+33.853s+69.58
 % coeffecient of desired characterstics eqaution.
 az0 = 69.58;az1 = 33.853;az2 =9.709;
 % coffecient of charactertics eqution of given system.
 a0 = px(4);a1 = px(3);a2 = px(2);
 % it is the value of K tranaformed system
 kz = [az0-a0 az1-a1 az2-a2]/16;
 % it is the value of k for our given system
 kx = (kz*inv(p));


% method 2 : finding the value of K using ackermas formulae for the same above problem:
%our desired characterstics eqation is s^3+9.709s^2+33.853s+69.58
%our controllablity would remains same.
Qc = M;
%characterstics matrix associated with desired chractertsics equation
pA = A*A*A + 9.709*A*A + 33.853*A + 69.58*eye(3);
%putting the value of different quantity the ackerman's fomulae.
kc = [0 0 1]*inv(Qc)*pA;
```

```
% question number 2
disp('question number 2');
%(' design a state space observeber using transformation and ackermans formule');
%given : (' the unit step response of a plant has to have peak overshoot of less than
20% and settling time is 2sec');
A1=[-3 1 ;-2 0];
B1 = [1;2];
C1 = [1 0];
D1 = 0;
sys1 = ss(A1,B1, C1, D1);

%check observablity
Q = [C1' A1'*C1']';
Qd = det(Q);

%since determinant of Q is not eqaul to zero hence th given system is observable
%our desired characterstics equation is
%s^2+3.96s+19.36
Qx = poly(A1);
Kq = [3.96-Qx(2) 19.36-Qx(3)];

% method 2 for state space observeber design suing ackerman's formulae .
disp('solving th same problem using ackermans formule for oserveber design');
disp('our desired characterstics equation is ');
disp('s^2+3.96s+19.36');
Qa = A1^2+ 3.96*A1 + 19.36*eye(2);
%putting the different quantity into ackerman's formulae for observeber design
Kqa = Qa*inv(Q)*[0;1];
```

```
given system of eqution
>> sys

sys =

  A =
       x1  x2  x3
   x1  -4   1   0
   x2   0  -3   1
   x3   0   0  -2

  B =
       u1
   x1   0
   x2   0
   x3  16

  C =
       x1  x2  x3
   y1   2   1   0

  D =
       u1
   y1   0

Continuous-time state-space model.

>> disp('controllablity matrix is: ')
controllablity matrix is:
>> M

M =

     0     0    16
     0    16   -80
    16   -32    64

>> disp('charactertics equation of A')
charactertics equation of A
>> px

px =

     1     9    26    24

>> disp('controllable matrix  of transformed matrix:')
controllable matrix  of transformed matrix:
>> MZ

MZ =
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```
     0     0    16
     0    16  -144
    16  -144   880

>> disp(' determinant of contrallabity matrix:')
 determinant of contrallabity matrix:
>> det(M)

ans =

       -4096

>> det(MZ)

ans =

       -4096

>> disp('determinant of controllablity matrix of both form is not equal to zero hence↙
it means matrix is controllable')
determinant of controllablity matrix of both form is not equal to zero hence it means↙
matrix is controllable
>> disp('transformed matrix is :')
transformed matrix is :
>> p

p =

     1     0     0
     4     1     0
    12     7     1

>> disp('K value for transformed system')
K value for transformed system
>> kz

kz =

    2.8487    0.4908    0.0443

>> disp('K value for actual system')
K value for actual system
>> kx

kx =

    1.5945    0.1806    0.0443

>> disp('finding the value of k using Ackermans formulae')
```

```
finding the value of k using Ackermans formulae
>> disp('controllablity matrx')
controllablity matrx
>> Qc

Qc =

     0     0    16
     0    16   -80
    16   -32    64

>> disp('characterstics matrix of desired polynomial')
characterstics matrix of desired polynomial
>> pA

pA =

   25.5120    2.8900    0.7090
         0   28.4020    4.3080
         0         0   32.7100

>> disp('value of Kc is')
value of Kc is
>> kc

kc =

    1.5945    0.1806    0.0443

>>
>>
>>
>>
>>
>> disp('coming to question number 2,  designa state sapce observeber using↙
transformation approach and ackermans formulae')
coming to question number 2,  designa state sapce observeber using transformation↙
approach and ackermans formulae
>> disp('given system is ')
given system is
>> sys1

sys1 =

  A =
       x1  x2
   x1  -3   1
   x2  -2   0

  B =
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```
       u1
   x1   1
   x2   2

  C =
       x1  x2
   y1   1   0

  D =
       u1
   y1   0

Continuous-time state-space model.

>> disp('observablity matrix is :')
observablity matrix is :
>> Q

Q =

     1     0
    -3     1

>> det(Q)

ans =

     1

>> disp('since diterminant is not equal to zero hence our matrix is observable')
since diterminant is not equal to zero hence our matrix is observable
>> disp('charactertsics matrix of desired polynomial')
charactertsics matrix of desired polynomial
>> Qx

Qx =

     1     3     2

>> disp('value of k obtained is:')
value of k obtained is:
>> kq
Unrecognized function or variable 'kq'.

Did you mean:
>> kq
Unrecognized function or variable 'kq'.

Did you mean:
>> Kq
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```
Kq =

    0.9600   17.3600

>> disp('state sapace  oberveber design using ackermans formulae')
state sapace  oberveber design using ackermans formulae
>> disp('observality matrix for ackermans formulae')
observality matrix for ackermans formulae
>> disp('scharactertsics matrix polynomial for desired equation')
scharactertsics matrix polynomial for desired equation
>> Qa

Qa =

   14.4800    0.9600
   -1.9200   17.3600

>> disp('value of k obtained using Ackermans oberseveber design formulae')
value of k obtained using Ackermans oberseveber design formulae
>> kqa
Unrecognized function or variable 'kqa'.

Did you mean:
>> Kqa

Kqa =

    0.9600
   17.3600

>>
```