Task 6

A)

Checking the stability of system below.

```
Ag=[0 0 0 1 0 0;0 0 0 0 1 0;0 0 0 0 0 1;...
    7.3809 0 0 0 2 0;0 -2.1904 0 -2 0 0;0 0 -3.1904 0 0 0]
```

```
Ag = 6×6
         0         0         0    1.0000         0         0
         0         0         0         0    1.0000         0
         0         0         0         0         0    1.0000
    7.3809         0         0         0    2.0000         0
         0   -2.1904         0   -2.0000         0         0
         0         0   -3.1904         0         0         0
```

```
Bg=[[0 0 0 1 0 0]' [0 0 0 0 1 0]' [0 0 0 0 0 1]']
```

```
Bg = 6×3
     0     0     0
     0     0     0
     0     0     0
     1     0     0
     0     1     0
     0     0     1
```

```

e=eig(Ag)
```

```
e = 6×1 complex
  -2.1587 + 0.0000i
   2.1587 + 0.0000i
   0.0000 + 1.8626i
   0.0000 - 1.8626i
   0.0000 + 1.7862i
   0.0000 - 1.7862i
```

The equilibrium point in not a stable position because one pole is on the right side of the complex plane.

B-C)

Controllability:

```
system_order = length(Ag)
```

```
system_order = 6
```

```
M = ctrb(Ag, Bg(:,1));
rank_of_M = rank(M)
```

```
rank_of_M = 4
```

```
M = ctrb(Ag, Bg(:,2));
rank_of_M = rank(M)
```

```
rank_of_M = 4
```

```
M = ctrb(Ag, Bg(:,3));
rank_of_M = rank(M)
```

```
rank_of_M = 2
```

From the fact that the controllability matrix for u1 u2 and u3 is of lower rank than the order of the system we conclude the system is not controllable from any input u.

D)

Determining the transfer function for y=[0 1 0 0 0 0]x

```
Cg=[0 1 0 0 0 0];
Dg=0;

[NUM,DEN]=ss2tf(Ag,Bg(:,2),Cg,Dg)
```

```
NUM = 1×7
         0         0    1.0000    0.0000   -4.1905    0.0000  -23.5480
DEN = 1×7
    1.0000    0.0000    1.9999    0.0000  -19.9653    0.0000  -51.5796
```

```
sys=tf(NUM,DEN)
```

```
sys =

              s^4 + 4.441e-16 s^3 - 4.191 s^2 + 1.776e-15 s - 23.55
  -----------------------------------------------------------------------------
  s^6 + 1.943e-16 s^5 + 2 s^4 + 3.325e-15 s^3 - 19.97 s^2 + 8.629e-15 s - 51.58

Continuous-time transfer function.
```

E)

Controlabillity for y=[0 1 0 0 0 0]x

```
zeros=zero(sys)
```

```
zeros = 4×1 complex
  -2.7168 + 0.0000i
   2.7168 + 0.0000i
   0.0000 + 1.7862i
   0.0000 - 1.7862i
```

```
poles=pole(sys)
```

```
poles = 6×1 complex
  -2.1587 + 0.0000i
   2.1587 + 0.0000i
   0.0000 + 1.8626i
   0.0000 - 1.8626i
  -0.0000 + 1.7862i
  -0.0000 - 1.7862i
```

```
K=1;
zeros=[zeros(1:2)]
```

```
zeros = 2×1
   -2.7168
    2.7168
```

```
poles=[poles(1:4)]
```

```
poles = 4×1 complex
  -2.1587 + 0.0000i
   2.1587 + 0.0000i
   0.0000 + 1.8626i
   0.0000 - 1.8626i
```

```
sys=zpk(zeros,poles,K)
```

```
sys =

         (s+2.717) (s-2.717)
  ---------------------------------
  (s+2.159) (s-2.159) (s^2 + 3.469)

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

```
NUM=conv([1 2.717],[1 -2.717])
```

```
NUM = 1×3
    1.0000         0   -7.3821
```

```
DEN=conv([1 2.159],[1 -2.159]);
DEN=conv(DEN,[1 0 3.469])
```

```
DEN = 1×5
    1.0000         0   -1.1923         0  -16.1700
```

```
[A,B,C,D] = tf2ss(NUM,DEN)
```

```
A = 4×4
         0    1.1923         0   16.1700
    1.0000         0         0         0
         0    1.0000         0         0
         0         0    1.0000         0
B = 4×1
     1
     0
     0
     0
C = 1×4
         0    1.0000         0   -7.3821
D = 0
```

```


system_order = length(A)
```

```
system_order = 4
```

```
M = ctrb(A,B);
rank_of_M = rank(M)
```

```
rank_of_M = 4
```

```
N = obsv(Ag, Cg);
```

```
rank_of_N = rank(N)
```

```
rank_of_N = 4
```

The system is now controllable given the uniformity of the rank of controllability matx with system order.

F)

Designing a controller for system stabilisation.

```
desiredpoles = [-1+1i;-1-1i;-10;-10]
```

```
desiredpoles = 4×1 complex
  -1.0000 + 1.0000i
  -1.0000 - 1.0000i
 -10.0000 + 0.0000i
 -10.0000 + 0.0000i
```

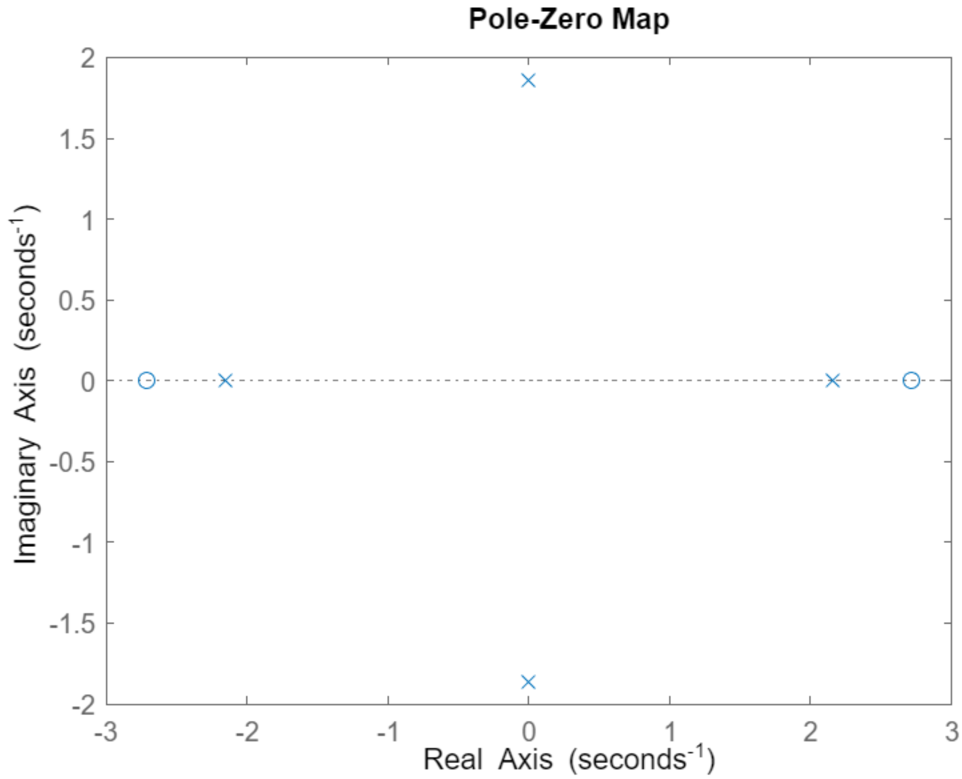
```
K = acker(A,B,desiredpoles)
```

```
K = 1×4
   22.0000  143.1923  240.0000  216.1700
```

```


[num2,den2] = ss2tf(A - B * K,B,C,D);
G = tf(num2,den2)
```

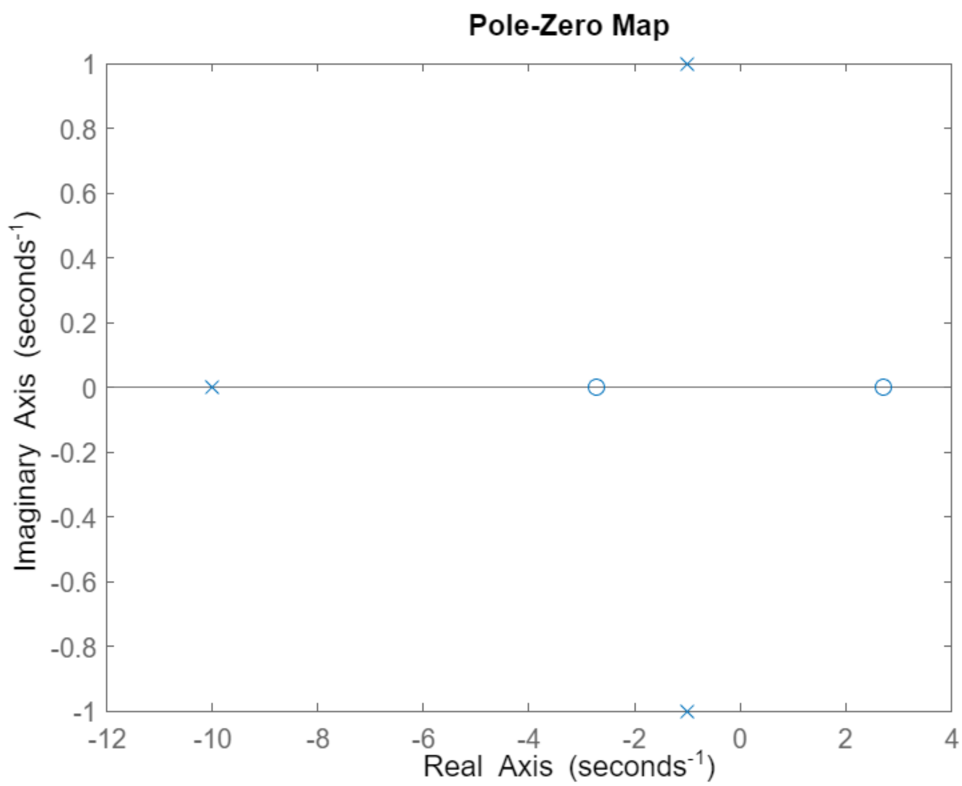
```
G =

              s^2 - 7.382
  ------------------------------------
  s^4 + 22 s^3 + 142 s^2 + 240 s + 200

Continuous-time transfer function.
```

```
pzmap(sys)
```



Pole-Zero Map
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-3
-2
-1
0
1
2
3


```
pzmap(G)
```



Pole-Zero Map
Imaginary Axis (seconds^{-1})
Real Axis (seconds^{-1})
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-12
-10
-8
-6
-4
-2
0
2
4

```
roots(den2)
```

```
ans = 4×1 complex
 -10.0000 + 0.0000i
 -10.0000 - 0.0000i
  -1.0000 + 1.0000i
  -1.0000 - 1.0000i
```

No positve real parts of poles imply stabilized system.