CE 7.4a

```
%Previous work
L=1;
J=0.0676;
m=0.9048;
r=0.03;
Jb=0.000326;
g=9.81;
p0=.25;

b=m/[(Jb/r^2)+m];

a=[0 1 0 0; 0 0 -b*g 0; 0 0 0 1; -m*g/(m*p0^2+J+Jb) 0 0 0];
B=[0;0;0;1/(m*p0^2+J+Jb)];
c=[1 0 0 0];
d=0;

sys=ss(a,B,c,d)

P=ctrb(sys);
[num, den]=ss2tf(a,B,c,d)
Pc1=[0 0 0 1; 0 0 1 0; 0 1 0 0; 1 0 0 0];
Tc=P*Pc1;
Tc1=inv(Tc);

Ac1=Tc1*a;
Ac=Ac1*Tc
Bc=Tc1*B
Cc=c*Tc
Dc=d


sys =

  a =
          x1      x2      x3      x4
   x1       0       1       0       0
   x2       0       0  -7.005       0
   x3       0       0       0       1
   x4  -71.31       0       0       0

  b =
         u1
   x1     0
   x2     0
   x3     0
   x4  8.034

  c =
       x1  x2  x3  x4
   y1   1   0   0   0
```

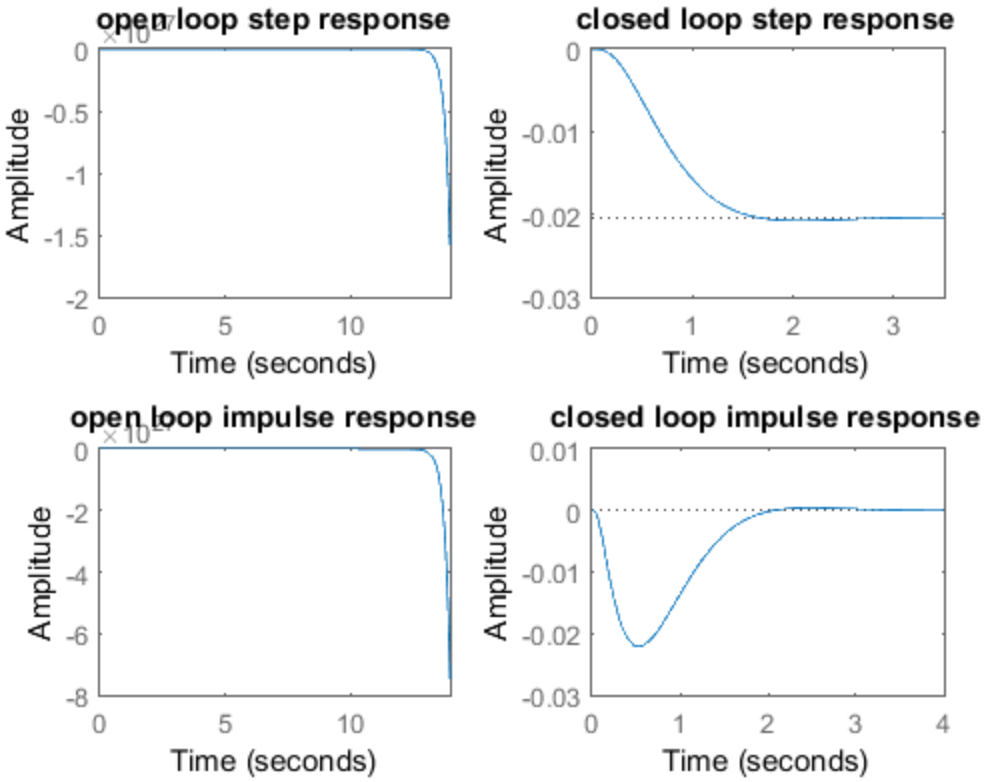
```
  d =
       u1
   y1   0

Continuous-time state-space model.


num =

         0         0         0         0  -56.2797


den =

    1.0000         0    0.0000    0.0000 -499.5435


Ac =

         0    1.0000         0         0
         0         0    1.0000         0
         0         0         0    1.0000
  499.5435         0         0         0


Bc =

     0
     0
     0
     1


Cc =

  -56.2797         0         0         0


Dc =

     0
```

New work

```
%Desired 2% Peak overshoot, 2s settling time
%Chosen eigen values are -20, -21 for fast response
%s^4+45s^3+590s^2+1949s+2763

Pc=[Bc Ac*Bc (Ac^2)*Bc (Ac^3)*Bc];
Pc1=inv(Pc);
d=(Ac^4)+45*(Ac^3)+590*(Ac^2)+1949*(Ac)+2763*I;
```

```
K=[0 0 0 1]*Pc1*d;

Adc=Ac-Bc*K;
eig(Adc)
[num,den]=ss2tf(Adc,Bc,Cc,Dc);
sys1=tf(num,den);

%Plots original system's step response
figure(1);
subplot(2,2,1), step(sys);
title('open loop step response');
subplot(2,2,2), step(sys1);
title('closed loop step response');
subplot(2,2,3), impulse(sys);
title('open loop impulse response');
subplot(2,2,4), impulse(sys1);
title('closed loop impulse response');

stepinfo(sys1)

%All criteria have been met for the system. Overshoot is under 2% and
 the
%settling time is less than 2s. The system stabilizes to 0 so the bar
 would
%be straight when it finished balancing.
```

```
ans =

 -21.4530 + 0.0000i
 -19.5426 + 0.0000i
  -2.0022 + 1.6067i
  -2.0022 - 1.6067i


ans =

        RiseTime: 0.9466
    SettlingTime: 1.5102
     SettlingMin: -0.0208
     SettlingMax: -0.0184
       Overshoot: 1.9588
      Undershoot: 0
            Peak: 0.0208
        PeakTime: 2.0643
```



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