(۱) $T(s)=\frac{k\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}$ $\quad ۲\% \longrightarrow \frac{4}{\zeta\omega_n}$ $\quad mp=100\,e^{\frac{-\pi\zeta}{\sqrt{1-\zeta^2}}}=24.3$ $\quad \zeta^2+0.45\zeta^2=0.45$

$\zeta=0.5$ قابل قبول
$\zeta=0.5$ غیر قابل قبول
$\zeta=0.5$ ×

$t_s=\frac{4}{\zeta\omega_n}=1.21$ $\quad \omega_n=11.43$ $\quad \frac{L(s)}{1+L(s)}=\frac{k\omega_n^2}{s^2+2\zeta\omega_n s+\omega_n^2}\Rightarrow L(s)=\frac{k\omega_n^2}{s^2+2\zeta\omega_n s+(1-k)\omega_n}$

$=\frac{204}{s^2+17.45s+79.47}$ $\quad \lim_{s\to 0} sY(s)=\lim_{s\to 0} s\times T(s)\times\frac{1}{s}=1.25$ $\Rightarrow \frac{k\omega_n^2}{\omega_n^2}=1.25$ $\quad k=1.25$

(۲) الف)

$T_d=0$ $\quad \frac{W(s)}{R(s)}=T(s)$ $\quad G_1=\frac{\frac{40}{s+0.2}}{1+\frac{40}{s+0.2}\times 0.5}=\frac{40}{s+40.2}$ $\quad G_2=\frac{\frac{40}{s+0.2}}{1+\frac{40}{s+0.2}}=\frac{40}{s+40.2}=T(s)$

$L(s)=\frac{40}{s+0.2}$ حلقه باز

ب) تیپ صفر $\Rightarrow k_p=\lim_{s\to 0} L(s)=\frac{40}{0.2}=1$ $\quad e_{ss}=\frac{R(s)}{1+R(s)}=\frac{1}{2}=0.5$

(۳) الف

تیپ ۱ $\Rightarrow e_{ss}=0$ $\quad T(s)=\frac{L(s)}{1+L(s)}\xrightarrow{L(s)=\frac{14}{s^2+4s}} T(s)=\frac{14}{s^2+4s+14}$ $\quad \omega_n=4\Rightarrow \zeta=0.5$ سیستم فرومیرا

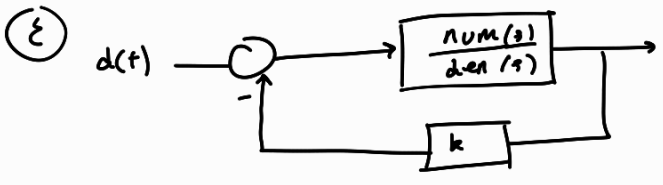
$mp=1-e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}\Rightarrow mp=16.3\%$ فراجهش $\quad t_s=\frac{3.2}{\zeta\omega_n}=\frac{3.2}{4\times 0.5}=1.6$

ب

$T(s)=\frac{k}{s^2+4s+k}\Rightarrow mp=1-e^{\frac{-\zeta\pi}{\sqrt{1-\zeta^2}}}=5\%\Rightarrow \zeta=0.707$ $\quad \zeta\omega_n=2\Rightarrow \omega_n=2.83$ $\quad k=8$

ج) $k=4\Rightarrow T(s)=\frac{4}{s^2+4s+4}\Rightarrow \omega_n=2$ $\quad \zeta=1$ $\quad \Delta(s)=s^2+4s+4$ $\quad s=-2$ $\Rightarrow$ میرای بحرانی $\Rightarrow$ فراجهش $\times$

(۴)



$T(s)=\frac{num(s)}{den(s)+k\,num(s)}$

حذف: $\frac{1}{1+\frac{num(s)}{den(s)}}=-B$ $\quad \frac{num}{den(s)}=-\left(\frac{B+1}{B}\right)$

حذف: $\frac{1}{1+kG(s)}=\frac{1}{1+\left(\frac{-k(1+B)}{B}\right)}$

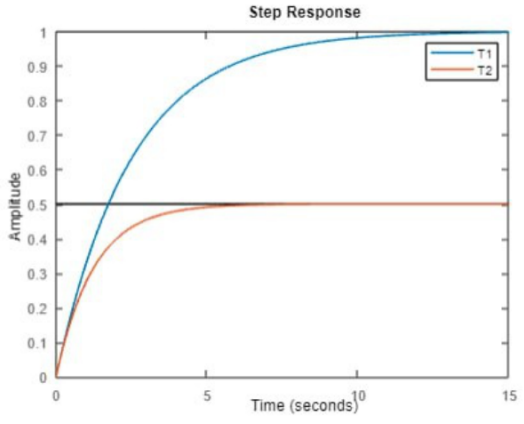
(۵) $I=\int_0^\infty e(t)\,dt$ $\quad X(s)=\frac{1}{s}$ $\quad T(s)=\frac{Y(s)}{X(s)}=\frac{L(s)}{1+L(s)}$ $\quad \lim_{t\to\infty} e(t)=\lim_{s\to 0} sE(s)\times\frac{1}{s}=E(0)$

$E(s)=\frac{1}{s}-Y(s)\Rightarrow E(s)=\frac{\prod_{i=1}^{m}(B_i s+1)-\prod_{i=1}^{n}(A_i s+1)}{s\prod_{i=1}^{n}(B_i s+1)}$

$E(s)=\frac{\left(\prod_{j=1}^{m} B_j-\prod_{i=1}^{n} A_i\right)}{=E(0)}$

سوال ۲

```
s =

  s

Continuous-time transfer function.
Model Properties
T1 =

    0.4
  -------
  s + 0.4

Continuous-time transfer function.
Model Properties
T2 =

    0.4
  -------
  s + 0.8

Continuous-time transfer function.
Model Properties
```

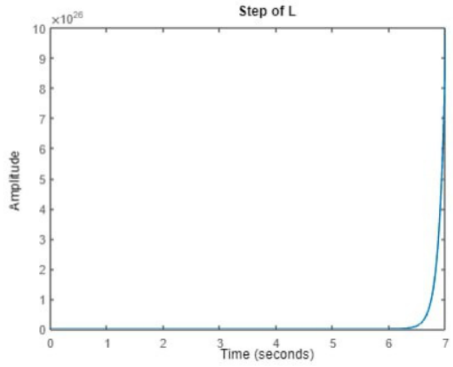


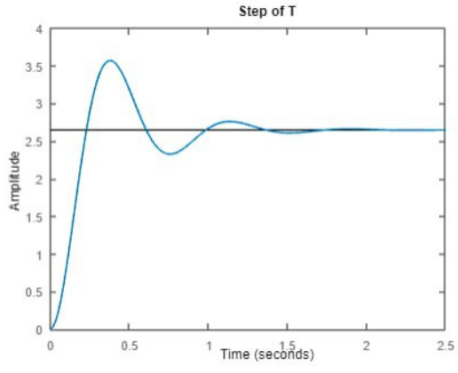

```
   Pole          Damping       Frequency       Time Constant
                               (rad/seconds)     (seconds)

 -8.00e-01     1.00e+00      8.00e-01          1.25e+00

   Pole          Damping       Frequency       Time Constant
                               (rad/seconds)     (seconds)

 -4.00e-01     1.00e+00      4.00e-01          2.50e+00
Open Loop: 0.6667
Colsed Loop: 0.5000
```

```
clc
s = tf('s')
T1 = 0.4/(s + 0.4)
T2 = 0.4/(s + 0.8)
hold on
step(T1)
step(T2)
legend
damp(T2)
damp(T1)
Kp_openloop= dcgain(T2);
ess_openloop = 1 / (1 + Kp_openloop);
Kp_closedloop = dcgain(T1);
ess_closedloop = 1 / (1 + Kp_closedloop);
fprintf('Open Loop: %.4f\n', ess_open);
fprintf('Colsed Loop: %.4f\n', ess_closed);
```

سوال ۱

```
L =

        203.5
  --------------------
  s^2 + 5.647 s - 128.8

Continuous-time transfer function.
Model Properties
```






```
s = tf('s');
T = 203 / (s^2 + 5.57*s + 76.7);
L = T / (1 - T);
L = minreal(G);
L
figure;
step(L);
title('Step of L');
figure;
step(T);
title('Step of T');
```

سوال ۳

```
s = tf('s')

T = 7.84/(s^2 + 4*s + 7.84)

step(T)
```

```
        7.84
  ----------------
  s^2 + 4 s + 7.84

Continuous-time transfer function.
Model Properties
```