\[
\frac{C(s)}{R(s)} = \frac{K T_0 a_1}{T_0 s + 1} + \frac{10}{T_0 s (s + 1)}
\]

\[
= \frac{10K}{(s^2 + 1)(T_0 s + 1) + 10K s + 10K}
\]

Clear poly: \(T_2 s^3 + (1+T_0) s^2 + (10K + 1) s + 10K\)

Desired dominant closed loop poles: \(\bar{p}_d = 0.5, w_0 = \text{rad/sec}\)

\[
s^2 + 2\bar{p}_d w_0 s + w_0^2 = s^2 + 3s + 9.
\]

\[
T s^3 + (1+T_0) s^2 + (10K + 1) s + 10K = (s^2 + 3s + 9)(s + b)
\]

To get a stable closed loop

\[
\epsilon = \frac{-b}{a} < 0 = \frac{b}{a} > 0.
\]
\[
(a^3 + 3a^2 + 3a + 1) (a + b) = a^3 + (3a + b) a^2 + (3b + 9a) a + 9b.
\]

\[
T_2 = a \quad \Rightarrow \quad \frac{2a + b}{a} = \frac{T_2 - 1}{T_2}, \quad \frac{b}{a} = 1 + \frac{1}{T_2}
\]

\[
10k_1 + 1 = 3b + 9a
\]

\[
k_0 = 9b.
\]

From the condition \(\frac{b}{a} > 0\):

\[
\frac{1}{T_2} - 2 > 0 \quad \Rightarrow \quad T_2 < 1/2.
\]

For \(T_2 = 1/3\):

\[
a = 1/3, \quad b = 1/3 \Rightarrow \text{other pole is located at } s = -1
\]

\[
\kappa = 0.3, \quad \tau_1 = 1.
\]
B.7.8)

Closed-loop transfer function

\[
\frac{C(s)}{R(s)} = \frac{K(7s + 1)}{s(s + 2) + K(7s + 1)}
\]

Since the closed-loop poles are located at \( s = -2 \pm j2 \)

\[
s(s + 2) + K(7s + 1) = (s + 2 + j2)(s + 2 - j2)
\]

\[
s^2 + (2 + K) s + K = s^2 + 4s + 8
\]

\[2 + K = 4 \quad \Rightarrow \quad K = 2\]

\[T = 0.25\]
Given an open-loop transfer function $G(s)$ and a feedback gain $K$, the closed-loop transfer function $C(s)$ can be found by solving the equation:

$$C(s) = \frac{G(s)K}{1 + G(s)K}$$

For the given problem, the characteristic polynomial is:

$$s^3 + bs^2 + ks + ka = (s^2 + 2s + 2)(s + \alpha + \beta)$$

This is similar to another transfer function $G_{-7.7}$ with $\beta > 0$. The dominant closed-loop poles are:

$$s = -1 \pm i$$

The expression for $C(s)$ is:

$$C(s) = \frac{k}{s^2 + ks + ka}$$
\[ s^5 + 6s^4 + ks^3 + ka = k s^3 + (2\alpha + \beta)s^2 + (2\alpha + 2\beta)s + 2\beta \]

\[ 1 = \alpha \]
\[ \frac{2\alpha + \beta}{2\alpha + b} = \beta \Rightarrow \frac{\beta}{\alpha} = \beta - 2 \]
\[ k = 2(\alpha - \beta) \]
\[ ka = 2\beta \]

From the condition \( \frac{\beta}{\alpha} > 0 \)

\[ b - 2 > 0 \quad b > 2 \]

Pole \( s = -\frac{\beta}{\alpha} \) should be located far enough from the dominant poles.

For \( b = 5 \)

\[ \alpha = 1, \quad \beta = 3 \]

\[ k = 8 \]

\[ \alpha = \frac{1}{8} \Rightarrow 2 = 0.75 \]

Thus,

\[ G(s) = \frac{2}{s + 0.75} \]

\[ s + 5 \]
MATLAB CODE

```matlab
num=[0 0 1];
den=[1 0 1];
umc=[8 6];
denc=[1 5 8 6];
t=0:0.02:10;
c1=step(num,den,t);
c2=step(numc,denc,t);
plot(t,c1,'.',t,c2,'-')
grid
title('Unit step responses of uncompensated and compensated systems')
xlabel('t(sec)')
ylabel('Outputs')
text(1.9,0.85,'Compensated system')
text(4.1,1.65,'Uncompensated system')
```