Problem 5) Consider the unity-feedback control system with the following open-loop transfer function:

$$G(s) = \frac{10}{s(s+1)(3s+2)}$$

Determine if this system is stable or not.

Problem 6) Determine the range of gain K for stability of a unity-feedback control system whose open-loop transfer function is

$$G(s) = \frac{K}{(s+1)(s+2)(s+3)}$$

1. For the unity feedback system shown in Figure P7.1, where

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$$G(s) = \frac{450(s+8)(s+12)(s+15)}{s(s+38)(s^2+2s+28)}$$

ind the steady-state errors for the following test inputs: $5u(t)$, $37tu(t)$, $47t^2u(t)$. [Section: 7.2]

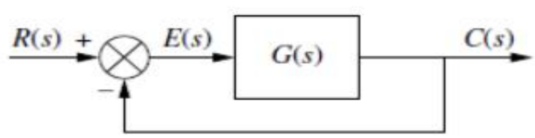

FIGURE P7.1

4. For the system shown in Figure P7.3, what steady-state error can be expected for the following test inputs: $15u(t)$, $15tu(t)$, $15t^2u(t)$. [Section: 7.2]

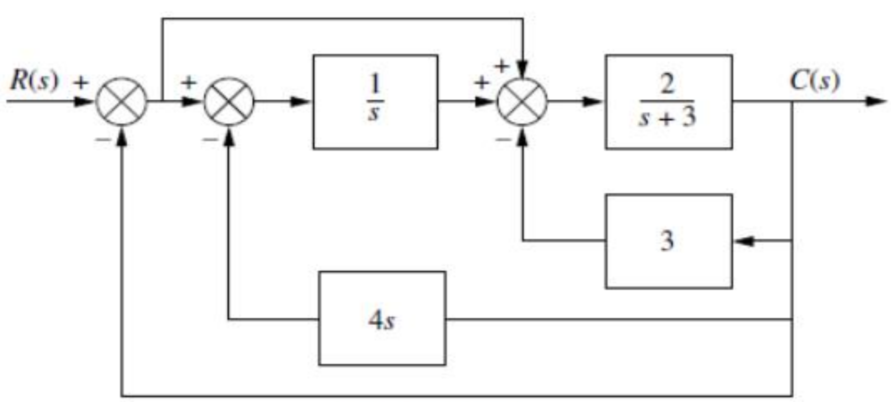

FIGURE P7.3

5) $G(s) = \dfrac{10}{s(s+1)(3s+2)}$ unity feedback $H(s)=1$

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)\cdot H(s)} = \frac{\dfrac{10}{s(s+1)(3s+2)}}{1+\dfrac{10}{s(s+1)(3s+2)}} = \frac{\dfrac{10}{(s^2+s)(3s+2)}}{\dfrac{(s^2+s)(3s+2)+10}{(s^2+s)(3s+2)}}$$

$$\frac{C(s)}{R(s)} = \frac{10}{(s^2+s)(3s+2)+10}$$

$\Rightarrow 3s^3+2s^2+3s^2+2s+10$

$3s^3+5s^2+2s+10=0$

$$\begin{array}{llll}
+s^3 & 3 & 2 & \\
+s^2 & 5 & 10 & \text{LHP} \\
-s^1 & -4 & 0 & \text{RHP} \\
+s^0 & +10 & 0 & \text{RHP}
\end{array}$$

$\therefore$ 1 LHP/2RHP $\Rightarrow$ system is unstable

6) $G(s) = \dfrac{K}{(s+1)(s+2)(s+3)}$ $H(s)=1$

$$\frac{C(s)}{R(s)} = \frac{G(s)}{1+G(s)\cdot H(s)} = \frac{\dfrac{K}{(s+1)(s+2)(s+3)}}{1+\dfrac{K}{(s+1)(s+2)(s+3)}}$$

$$\frac{K}{(s+1)(s+2)(s+3)+K} = \frac{K}{s^3+6s^2+11s+6+K}$$

$\Rightarrow s^3+6s^2+11s+6+K=0$

$$\begin{array}{llll}
s^3 & 1 & 11 & 0 \\
s^2 & 6 & 6+K & 0 \\
s^1 & \frac{60-K}{6} & 0 & \\
s^0 & 6+K & &
\end{array}$$

$\dfrac{60-K}{6} > 0 \rightarrow K<60$

$6+K>0 \rightarrow K>-6$

$\boxed{-6<K<60}$

1.

$$e(\infty) = \lim_{s \to 0} s\,E(s) = \lim_{s \to 0} \frac{s\,R(s)}{1+G(s)}$$

where

$$G(s) = \frac{450(s+12)(s+8)(s+15)}{s(s+38)(s^2+2s+28)}.$$

For step, $e(\infty) = 0$. For 37tu(t), $R(s) = \frac{37}{s^2}$. Thus, $e(\infty) = 6.075 \times 10^{-2}$. For parabolic input, $e(\infty) = \infty$.

4.

Reduce the system to an equivalent unity feedback system by first moving 1/s to the left past the summing junction. This move creates a forward path consisting of a parallel pair, $\left(\frac{1}{s}+1\right)$ in cascade with a feedback loop consisting of $G(s) = \frac{2}{s+3}$ and $H(s) = 7$. Thus,

$$G_e(s) = \left(\frac{(s+1)}{s}\right)\left(\frac{2/(s+3)}{1+14/(s+3)}\right) = \frac{2(s+1)}{s(s+17)}$$

Hence, the system is Type 1 and the steady-state errors are as follows:

Steady-state error for $15u(t) = 0$.

Steady-state error for $15tu(t) = \frac{15}{K_v} = \frac{15}{2/17} = 127.5$.

Steady-state error for $15t^2u(t) = \infty$

Input	Steady-state error formula	Type 0 Static error constant	Type 0 Error	Type 1 Static error constant	Type 1 Error	Type 2 Static error constant	Type 2 Error
Step, $u(t)$	$\frac{1}{1+K_p}$	$K_p =$ Constant	$\frac{1}{1+K_p}$	$K_p = \infty$	0	$K_p = \infty$	0
Ramp, $tu(t)$	$\frac{1}{K_v}$	$K_v = 0$	∞	$K_v =$ Constant	$\frac{1}{K_v}$	$K_v = \infty$	0
Parabola, $\frac{1}{2}t^2u(t)$	$\frac{1}{K_a}$	$K_a = 0$	∞	$K_a = 0$	∞	$K_a =$ Constant	$\frac{1}{K_a}$