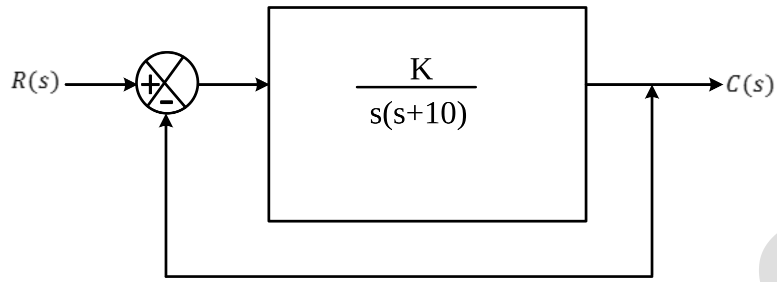
Time Response Analysis (Part - I)

1. The unity feedback system shown in figure has:



(a) Zero steady state position error
(b) Zero steady state velocity error
(c) Steady state position error K/10 units
(d) Steady state velocity error K/10 units

[GATE 1987: 2 Marks]

Soln. $$G(s) = \frac{k}{s(s+10)}$$

$$H(s) = 1$$

Position error coefficient $k_p = \lim_{s\to 0} G(s)\, H(s)$

$$k_p = \lim_{s\to 0} \frac{k}{s(s+10)} = \infty$$

Steady state error $e_{ss} = \frac{1}{1+k_p} = 0$

Option (a)

2. The steady state error of a stable 'type 0' unity feedback system for a unit step function is

(a) 0
(b) $\frac{1}{1+K_P}$
(c) ∞
(d) $\frac{1}{K_P}$

[GATE 1990: 2 Marks]

Soln. **The steady state error of a stable type 0 unity feedback system for a unit step function is**

$$\frac{1}{1+k_p}$$

Option (b)

3. A unity-feedback control system has the open-loop transfer function $G(s) = \frac{4(1+2s)}{S^2(S+2)}$ if the input to the system is a unity ramp, the steady-state error will be

(a) 0
(b) 0.5
(c) 2
(d) Infinity

[GATE 1991: 2 Marks]

Soln. $$G(s) = \frac{4(1+2s)}{s^2(s+2)}$$

For unity feedback system $H(s) = 1$ open loop transfer function

$$= G(s)\, H(s) = \frac{4(1+2s)}{s^2(s+2)}$$

For a ramp input $R(s) = \frac{1}{s^2}$

Static velocity error coefficient $k_u = \lim_{s \to 0} S\, G(s)\, H(s)$

$$k_u = \lim_{s \to 0} \frac{s\, 4(1+2s)}{s^2(s+2)}$$

$$= \lim_{s \to 0} \frac{4(1+2s)}{s(s+2)}$$

$$= \infty$$

$$e_{ss} = \frac{A}{k_u} = \frac{A}{\infty} = 0$$

Option (a)

4. The step error coefficient of a system $G(s) = \frac{1}{(S+6)(S+1)}$ with unity feedback is
   (a) 1/6 (c) 0
   (b) ∞ (d) 1

[GATE 1995: 1 Mark]

Soln. Step error coefficient $\boldsymbol{k_p = \lim_{s\to 0} G(s)\, H(s)}$

$$\boldsymbol{= \lim_{s\to 0} \frac{1}{(s+6)(s+1)} = \frac{1}{6}}$$

Option (a)

5. Consider a unity feedback control system with open-loop transfer function $G(s) = \frac{K}{S(S+1)}$ the steady state error of the system due to a unit step input is
   (a) zero (c) 1/K
   (b) K (d) infinite

[GATE 1998: 1 Mark]

Soln. Step error coefficient $\boldsymbol{k_p = \lim_{s\to 0} G(s)\, H(s)}$

$$\boldsymbol{= \lim_{s\to 0} \frac{k}{s(s+1)}}$$

$$\boldsymbol{= \infty}$$

Steady state error $\boldsymbol{= \frac{A}{1+k_p} = \frac{A}{1+\infty} = 0}$

Option (a)

6. For a second-order system with the closed-loop transfer function $T(s) = \frac{9}{s^2+4s+9}$ the settling time for 2-percernt band, in seconds, is

(a) 1.5

(b) 2.0

(c) 3.0

(d) 4.0

[GATE 1999: 1 Mark]

Soln. **Closed loop transfer function** $T(s) = \frac{9}{s^2+4s+9}$ **comparing with 2nd order equation** $s^2 + 2\xi\,\omega_n s + \omega_n^2$

$$2\xi\omega_n = 4$$

$$\xi\omega_n = 2$$

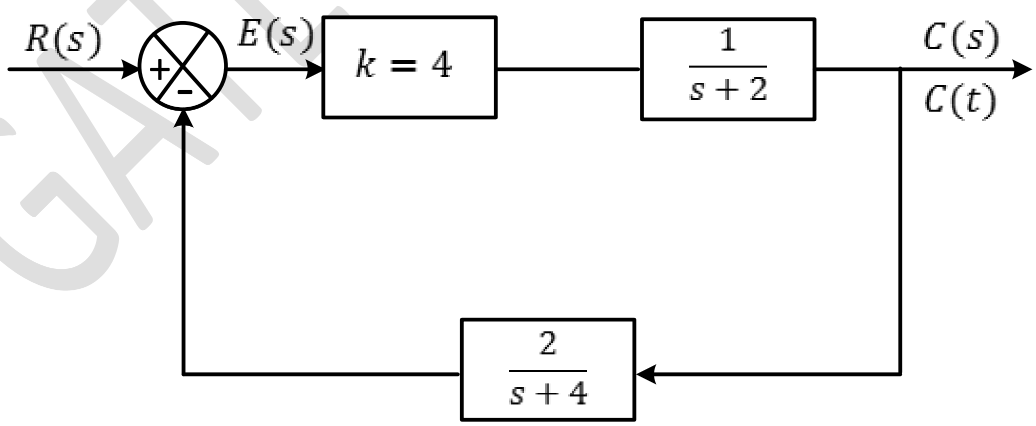
Time constant $T = \frac{1}{\xi\omega_n}$

Settling time for 2% band is $t_s = 4T = \frac{4}{\xi\omega_n} = \frac{4}{2} = 2$

Option (b)

7. The steady state error of the system shown in the figure of a unit step input is _________

Soln.



$$G(s) = \frac{4}{s+2} \quad , \quad H(s) = \frac{2}{s+4}$$

For unit step input $k_p = \lim_{s\to 0} \left(\frac{4}{s+2}\right)\left(\frac{2}{s+4}\right)$

$$= \frac{4}{2} \times \frac{2}{4} = 1$$

Steady state error $e_{ss} = \frac{1}{1+k_p} = \frac{1}{2} = 0.50$