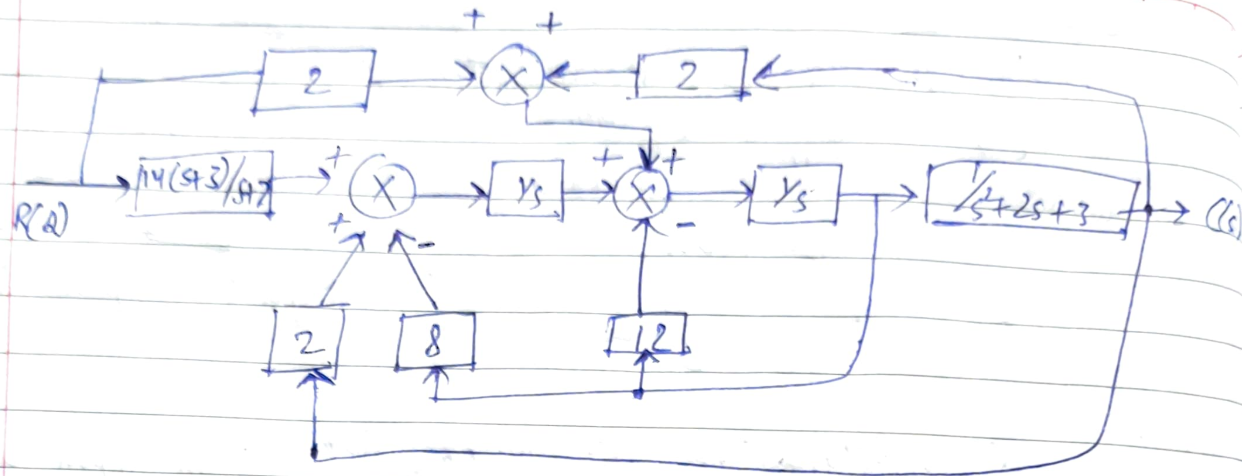
Let $\frac{14(s+3)}{s+2} = G_1$, $\frac{1}{s} = I$, $\frac{1}{s^2+2s+3} = G_2$

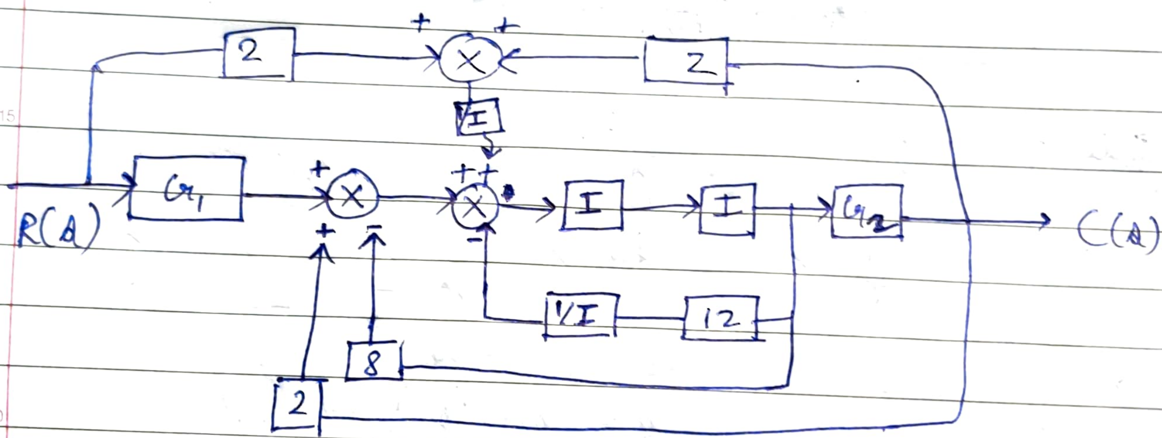
Q2.

Ans

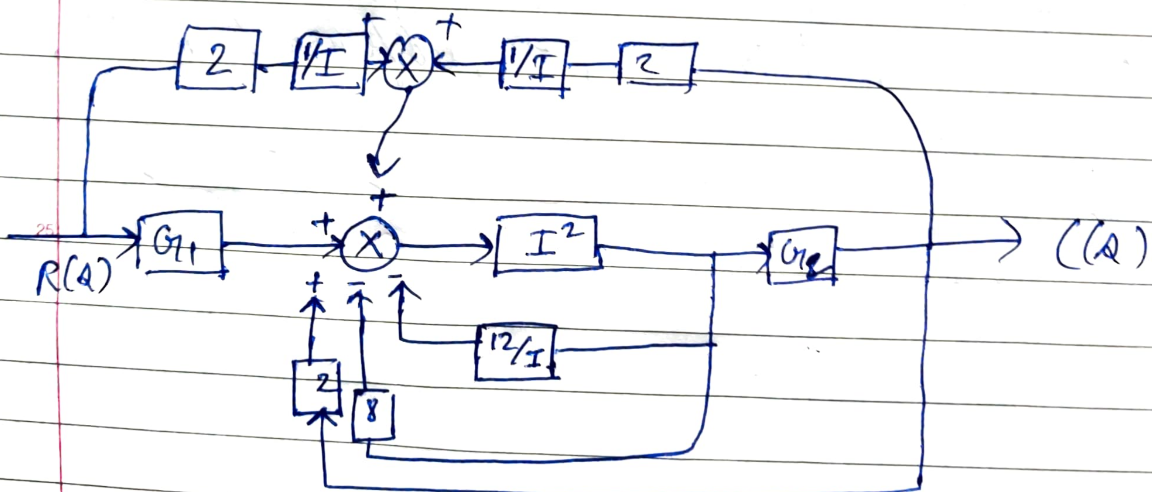


Ans <u>using reduction block diagram method-</u>

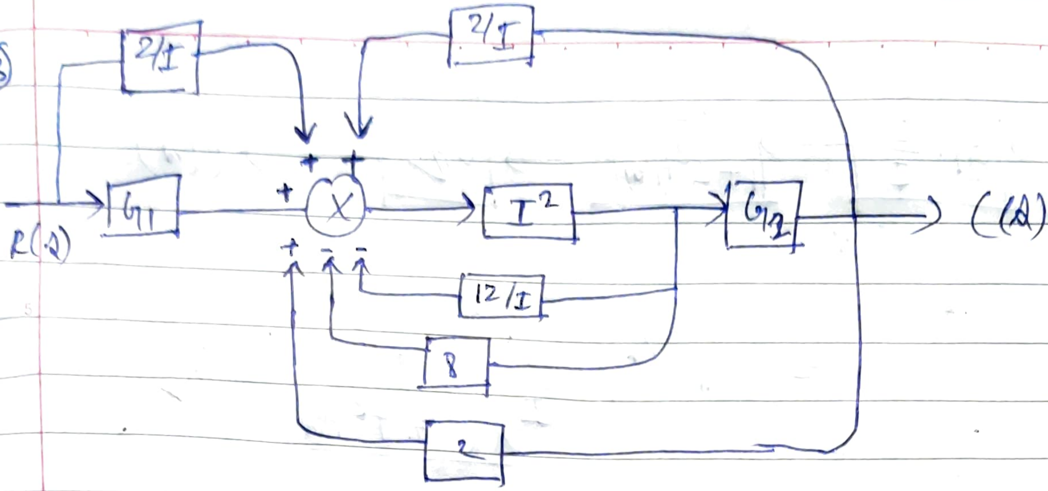
①



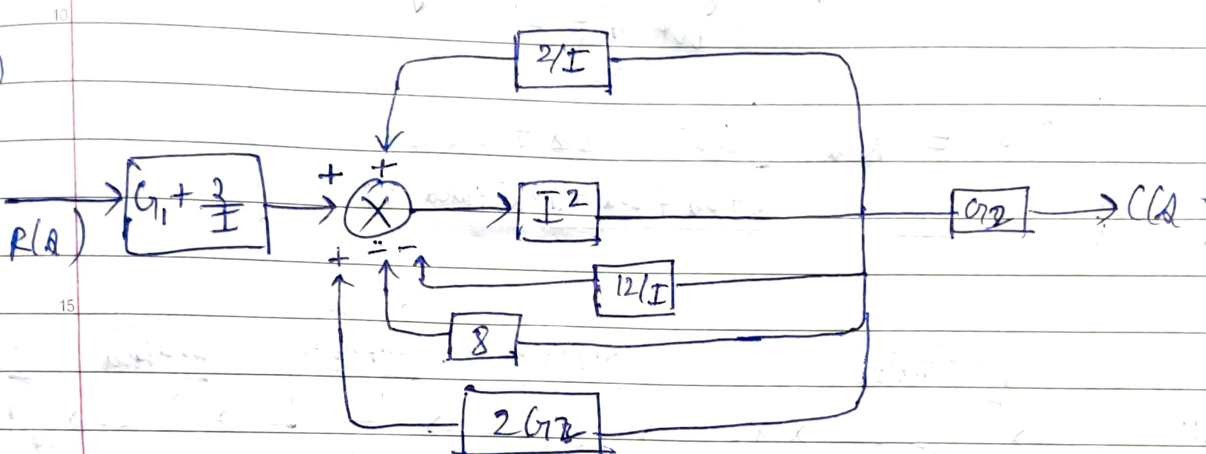
②



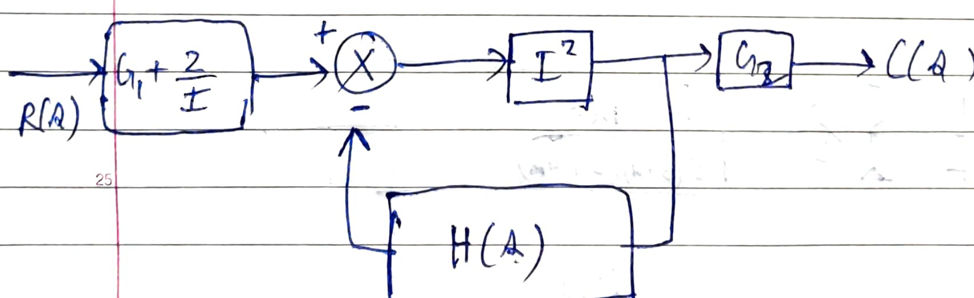
③



④



⑤



$$H(s) = \left(-\frac{2}{I} - 2G_2 + 8 + \frac{12}{I}\right)$$

6

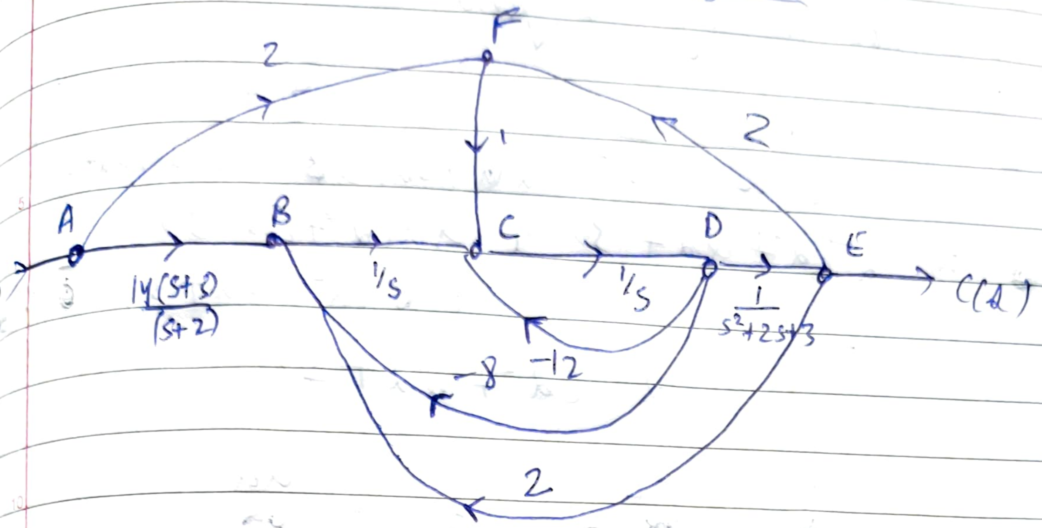
$$R(s) \rightarrow \boxed{G_1 + \frac{2}{I}} \rightarrow \boxed{\frac{I^2}{1 + I^2 H(s)}} \rightarrow \boxed{G_2} \rightarrow C(s)$$

$$\boxed{C(s) = R(s)\left(G_1 + \frac{2}{I}\right)\left(\frac{I^2}{1 + I^2 H(s)}\right)\left(G_2\right)}$$

simplifying after putting the values we get -

$$\boxed{C(s) = R(s)\left(\frac{2s^2 + 18s + 42}{s^5 + 16s^4 + 60s^3 + 117s^2 + 128s + 44}\right)}$$

Signal flow graph for block Diagram -



Forward paths -

$A \to B \to C \to D \to E$

$$P_1 = \frac{14(s+3)}{s+2} \times \frac{1}{s} \times \frac{1}{s} \times \frac{1}{s^2+2s+3}$$

$A \to F \to C \to D \to E$

$$P_2 = 2 \times \frac{1}{s} \times \frac{1}{s^2+2s+3}$$

Loop gain -

① $C \to D \to C$

$$L.G = \frac{-12}{s}$$

② $B \to C \to D \to B$

$$L.G = \frac{-8}{s^2}$$

③ $B \to C \to D \to E \to B$

$$L.G = \frac{2}{s^2(s^2+2s+3)}$$

④ $C \to D \to E \to F \to C$

$$\frac{2}{s(s^2+2s+3)}$$

sum of 2 non touching loop gains = 0

sum of 3 non touching loop gains = 0

so

$$\Delta = 1 - \left(\frac{-12}{s} - \frac{8}{s^2} + \frac{2}{s^2(s^2+2s+3)} + \frac{2}{s(s^2+2s+3)} \right)$$

$$\Delta = \frac{s^2(s^2+2s+3) + 12s(s^2+2s+3) + 8(s^2+2s+3) - 2 - 2s}{s^2(s^2+2s+3)}$$

$$\Delta = \frac{s^4 + 14s^3 + 35s^2 + 50s + 22}{s^2(s^2+2s+3)}$$

$\Delta_1 = 1 -$ (non touching forward path 1)

$= 1$

$\Delta_2 = 1 -$ (non touching forward path 2)

$= 1$

so

$$G(s) = \frac{C(s)}{R(s)} = \frac{\sum_k T_k \Delta_k}{\Delta}$$

$$= \frac{\left(\frac{14(s+3)}{(s+2)\,s^2\cancel{(s^2+2s+3)}} + \frac{2}{\cancel{s(s^2+2s+3)}} \right)}{\frac{(s^4+14s^3+35s^2+50s+22)}{s^2\cancel{(s^2+2s+3)}}}$$

$$= \frac{\left(\frac{14(s+3)}{s+2} + 2s \right)}{s^4+14s^3+35s^2+50s+22}$$

$$= \frac{2s^2+18s+42}{s^5+16s^4+63s^3+120s^2+122s+44}$$