$$\frac{\theta_o}{\theta_e} = \frac{K_3 K K_1 K_i N}{S\left[(R_a + L_a S)(J_t S + B_t) + K_2 K_1 (J_t S + B_t) + K_b K_i + K_t K K_1 K\right]}$$

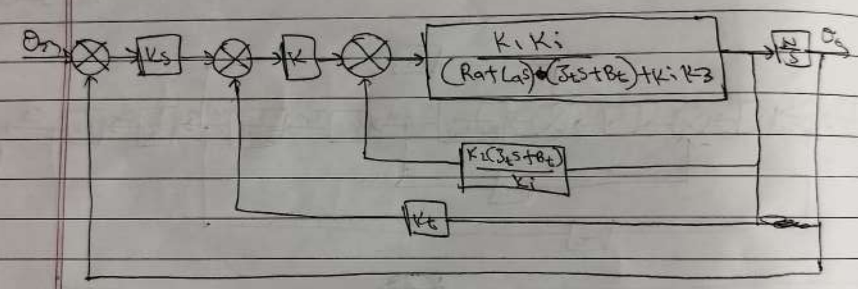
$K_i \to K_d$
$K_3 \to K_b$

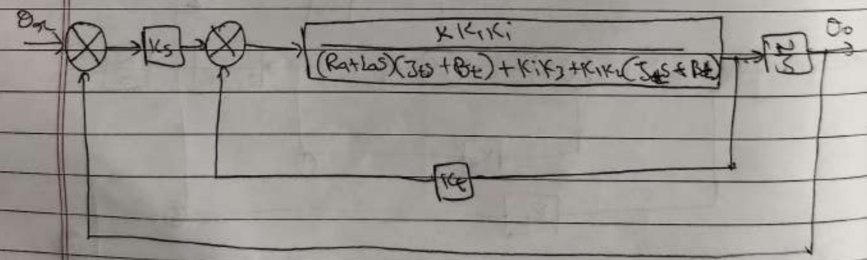
Considering loops

loop ① $\rightarrow L_1 = \dfrac{-K_1K_2}{R_a + L_a s}$

loop ② $\rightarrow L_2 = \dfrac{-K_3K_i}{(R_a+L_a s)(J_t s + B_t)}$

loop ③ $\rightarrow L_3 = \dfrac{-K_t K K_1 K_i}{(R_a+L_a s)(J_t s + B_t)}$





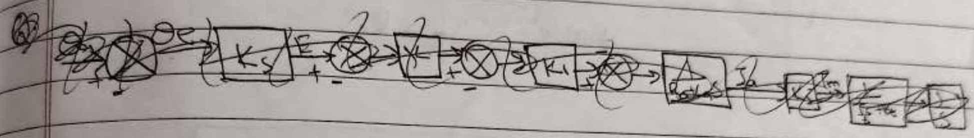
$$\frac{\theta_o(s)}{\theta_r(s)} = \frac{\dfrac{N}{S} \times \dfrac{K_s K K_1 K_i}{(R_a+L_a s)(J_t s+B_t) + K_3K_i + K_1K_2(J_t s + B_t) + KK_1K_iK_t}}{1 + \left(\dfrac{N}{S} \times \dfrac{K_s K K_1 K_i}{(R_a+L_a s)(J_t s+B_t) + K_3K_i + K_1K_2(J_t s+B_t) + KK_1K_iK_t}\right)}$$

$$\boxed{\frac{\theta_o(s)}{\theta_r(s)} = \frac{N K_s K K_1 K_i}{S\left((R_a+L_a s)(J_t s+B_t) + K_iK_3 + K_1K_2(J_t s+B_t) + KK_1K_iK_t\right) + NK_sKK_1K_i}}$$

$$\frac{10(4+s)}{s^2+6s} \times E = Y\left(1 - \frac{20}{s^2+6s}\right)$$

$$10(4+s)E = Y(s^2+6s-20)$$

$$\boxed{\frac{Y(s)}{E(s)} = \frac{10(4+s)}{s^2+6s-20}}$$



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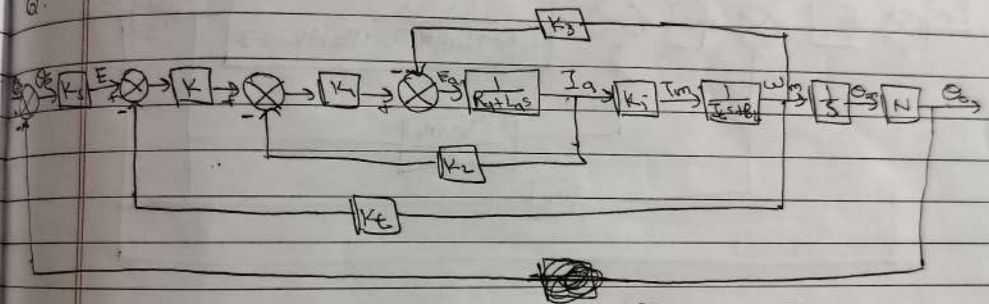
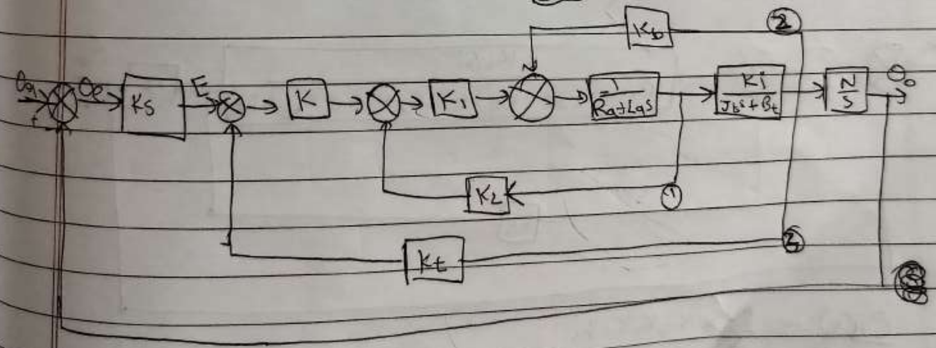
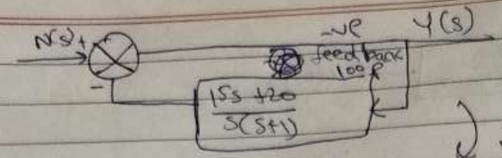




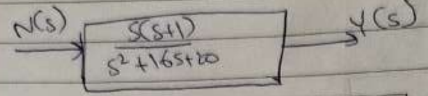
If we only consider no loops

$$\theta_e = \left(K_s \times K \cdot K_1 \times \frac{1}{R_a+L_a s} \times \frac{K_i}{J_t s+B_t} \cdot \frac{N}{s}\right)\theta_o$$

$$= \frac{K_s K K_1 K_i N}{(R_a+L_a s)(J_t s+B_t)s}\,\theta_o$$

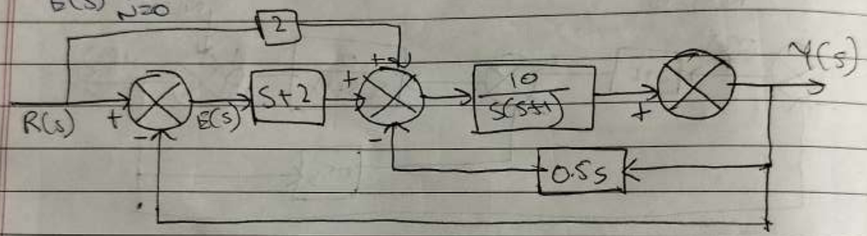


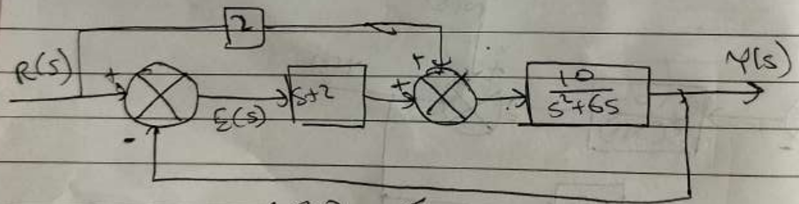
$$\frac{1}{1+\frac{15s+20}{s(s+1)}}$$



$$\boxed{\left.\frac{Y(s)}{N(s)}\right|_{R(s)=0} = \frac{s(s+1)}{s^2+16s+20}}$$

(2) $\left.\frac{Y(s)}{E(s)}\right|_{N=0}$





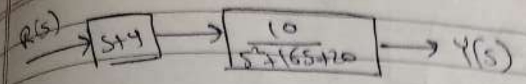
$$\left[2R + (\cancel{R-Y})(s+2)\right]\frac{10}{s^2+6s} = Y$$

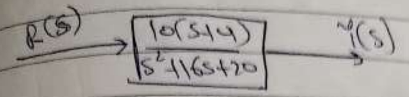
$$\left[2R + (R-Y)(s+2)\right]\frac{10}{s^2+6s} = Y \qquad \boxed{E = R-Y}$$

$$\left(2(E+Y) + E(s+2)\right)\frac{10}{s^2+6s} = Y$$

$$\cancel{2E+2Y}\left(E(4+s) + 2Y\right)\frac{10}{s^2+6s} = Y$$

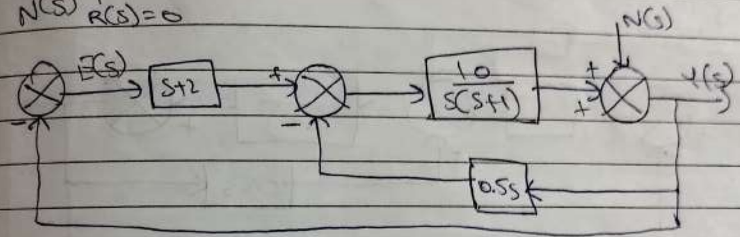
$$E(4+s)\times\frac{10}{s^2+6s} + \frac{20Y}{s^2+6s} = Y$$

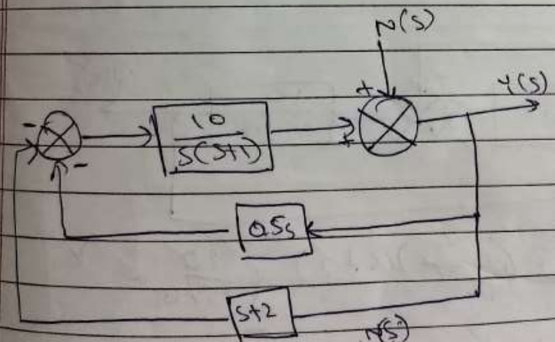


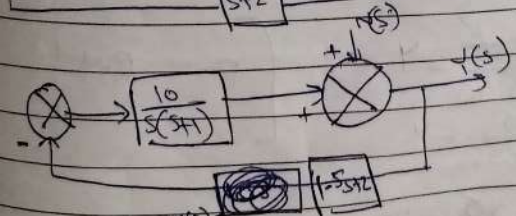


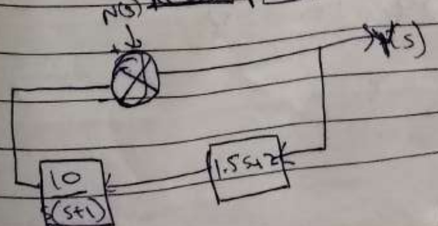
Hence, $\boxed{\dfrac{Y(s)}{R(s)} = \dfrac{10\,(s+4)}{s^2+16s+20}}$

③ Ⓑ $\left.\dfrac{Y(s)}{N(s)}\right|_{R(s)=0}$









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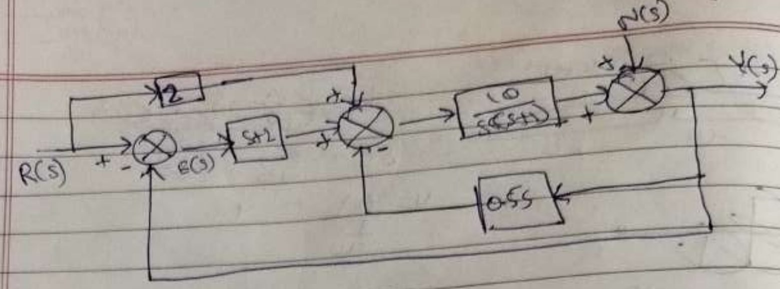
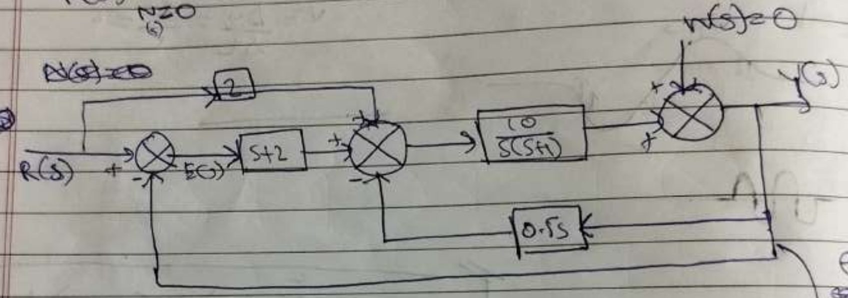
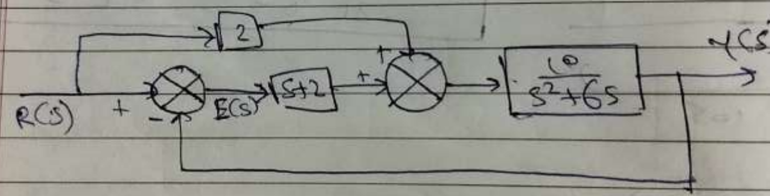
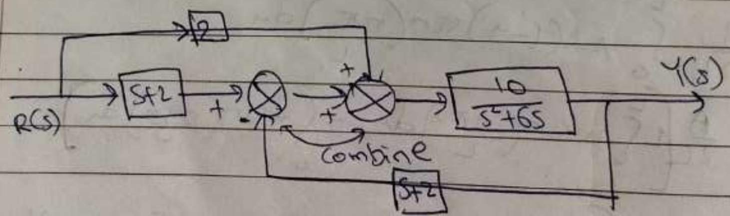


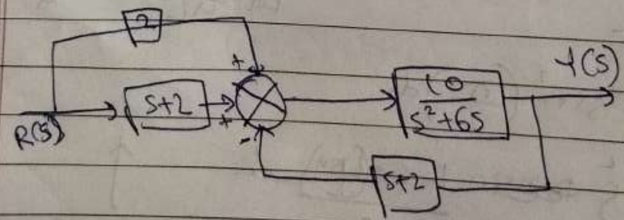
① $\left.\dfrac{Y(s)}{R(s)}\right|_{N(s)=0}$



eliminating a feedback loop $\left(\frac{5}{(s+1)}\right)$







eliminating feedback loop