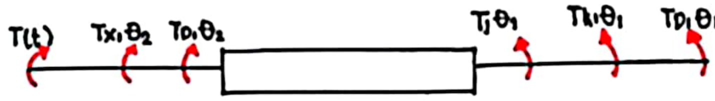
Problem No. 1

FBD



$T(t) = T_J\theta_1 + T_{D_1}\theta_1 + T_{K_1}\dot{\theta}_1 - T_{D_1}\theta_2 - T_{K_1}\theta_2$

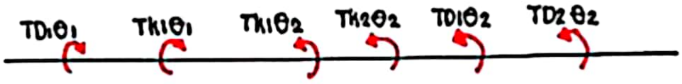
$T(t) = j\ddot{\theta}_1 + D_1\theta_1 + k\theta_1 - D_1\theta_2 - k\theta_2$

$\mathcal{L}\{T(t) = \ddot{\theta}_1 + \dot{\theta}_1 + \theta_1 - \ddot{\theta}_2 - \dot{\theta}_1\}$

$T(s) = s^2\theta_1(s) + s\theta_1(s) + \theta_1(s) - s(\theta_2)(1) - \theta_2(s)$

$\underset{A}{T(s)} = \theta_1(s)_A\,[G^2 1 s + 1] - \theta_2(1)[s+1]$ ①

FBD 2



$0 = T_{D_1}\theta_2 + T_{D_2}\theta_2 + T_{K_1}\theta_2 + T_{K_2}\theta_2 + T_{K_2}\theta_2 - T_{D_1}\theta_1 - T_{K_1}\theta_1$

$0 = D_1\dot{\theta}_2 + D_2\dot{\theta}_2 + k_1\theta_2 + k_2\dot{\theta}_2 - D_1\dot{\theta}_1 - k_1\theta_1$

$\mathcal{L}\{0 = 2\theta_2 + 2\theta_2 - \dot{\theta}_1 - \theta_1\}$

$0 = 2s\theta_2(s) + 2(\theta_2)(s) - s\theta_1(s) - \theta_1(s)$

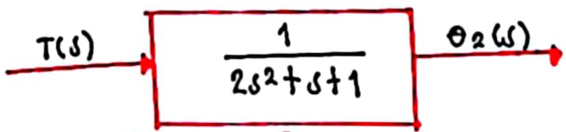
$0 = 2\theta_s(s)[s+1] - \theta_1(s)[s+1]$ ②

$$\theta_2(s) = \frac{\begin{bmatrix} s^2+s+1 & T(s) \\ -(s+1) & 0 \end{bmatrix}}{\begin{array}{cc} \begin{bmatrix} (s^2+s+1) & -(s+1) \\ -(s+1) & 2(s+1) \end{bmatrix} \\ A \quad\quad B \end{array}} - \frac{0-[-T(s)(s+1)]}{2(s+1)(s^2+1)-(s+1)^2}$$

$$= \frac{T(s)(s+1)}{(s+1)[2(s^2+s+1)-(s+1)]}$$

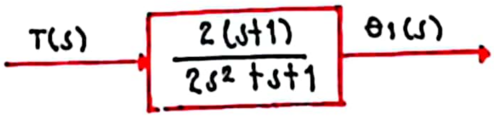
$$\theta_2(s) = \frac{T(s)}{2s^2+s+1}$$

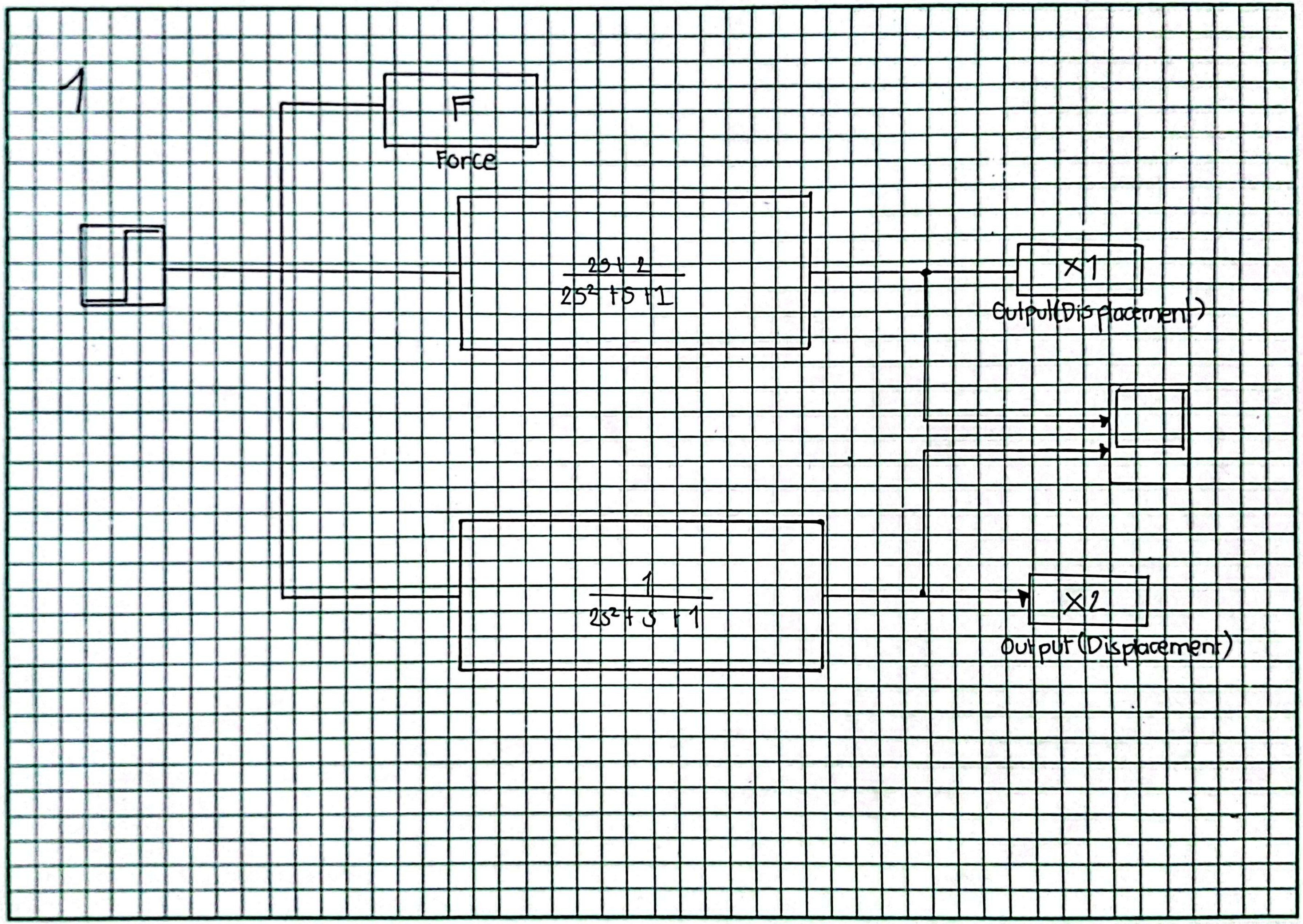
$$\frac{\theta_2(s)}{T(s)} = \frac{1}{2s^2+s+1}$$



$$\theta_1(s) = \frac{\begin{array}{cc} C & B \\ \begin{bmatrix} T(s) & -(s+1) \\ 0 & 2(s+1) \end{bmatrix} \end{array}}{\begin{array}{cc} \begin{bmatrix} s^2+s+1 & -s+1 \\ -(s+1) & 2(s+1) \end{bmatrix} \\ A \quad\quad B \end{array}} = \frac{2(s+1)T(s)}{2s^2+s+1}$$

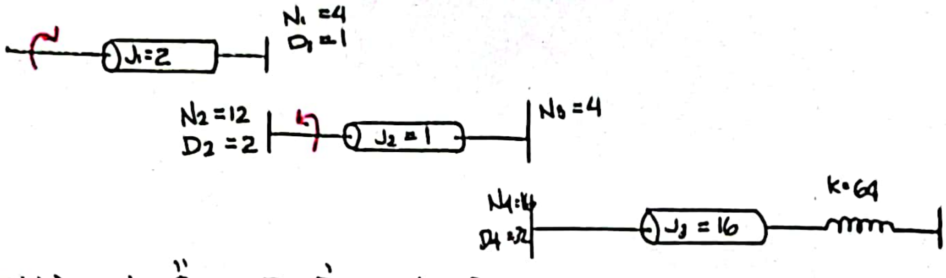
$$\frac{\theta_1(s)}{T(s)} = \frac{2(s+1)}{2s^2+s+1}$$





1
F
Force
2s + 2
2s² + s + 1
X1
Output(Displacement)
1
2s² + s + 1
X2
Output (Displacement)

PROBLEM 2



$$R \cdot T(t) = J_e \ddot{\theta}_2 + D_e \dot{\theta}_2 + k_e \theta_2$$

$$R = \frac{N_D}{N_S} = \frac{N_2}{N_1} \quad \frac{12}{4} = 3$$

$$J_e = \Sigma\left(\frac{N_D}{N_S}\right)^2 = J_1\left(\frac{N_2}{N_1}\right)^2 + J_2\left(\frac{N_2}{N_2} \cdot \frac{N_3}{N_3}\right)^2 + J_3\left(\frac{N_3}{N_4}\right)^2$$

$$J_e = 2\left(\frac{12}{4}\right)^2 + 1\left(\frac{12}{12} \cdot \frac{4}{4}\right)^2 + 16\left(\frac{4}{16}\right)^2$$

$$J_e = 20$$

$$D_e = \Sigma\left(\frac{N_D}{N_S}\right)^2 = D_1\left(\frac{N_2}{N_1}\right)^2 + D_2\left(\frac{N_2}{N_2} \cdot \frac{N_3}{N_3}\right)^2 + D_3\left(\frac{N_2}{N_4}\right)^2$$

$$D_e = 1\left(\frac{12}{4}\right)^2 + 2\left(\frac{12}{12} \cdot \frac{4}{4}\right)^2 + 32\left(\frac{4}{16}\right)^2$$

$$D_e = 13$$

$$k_e = \Sigma\left(\frac{N_D}{N_S}\right)^2 = 64\left(\frac{4}{16}\right)^2$$

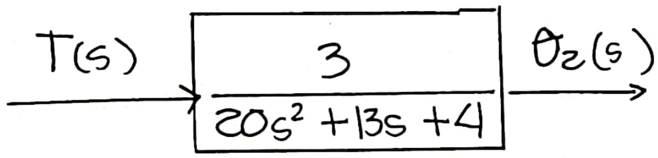
$$k_e = 4$$

$$3T(t) = 20\ddot{\theta}_2 + 13\dot{\theta}_2 + 4\theta_2$$

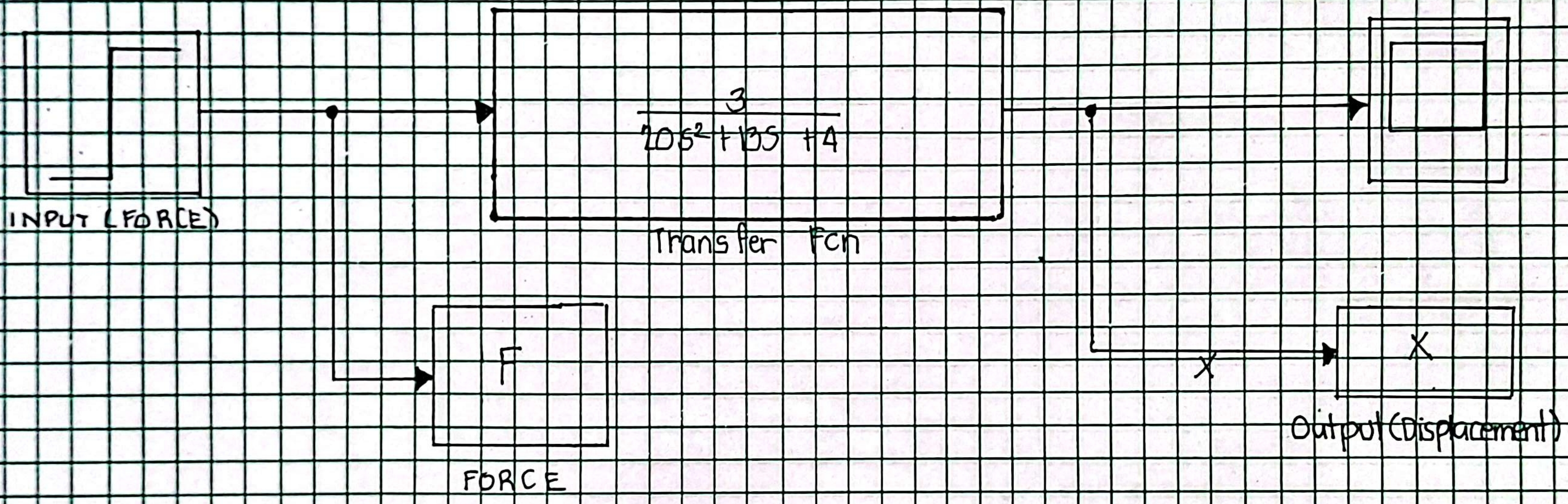
$$3T(s) = 20s^2\theta_2(s) + 13s\theta_2(s) + 4\theta_2(s)$$

$$3T(s) = \theta_2(s)\left[20s^2 + 13s + 4\right]$$

$$\frac{\theta_2(s)}{T(s)} = \frac{3}{20s^2 + 13s + 4}$$

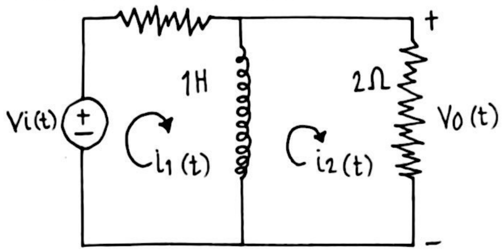


2


INPUT (FORCE)
3
20s^2 + 13s + 4
Transfer Fcn
F
FORCE
x
X
Output (Displacement)

LABORATORY NO. 3
GROUP 2

PROBLEM NO. 3 FIG. A



KVL @ loop $i_1(t)$

$$V_i(t) = R_1 i_1(t) + L\frac{di_1(t)}{d(t)} - L\frac{di_2(t)}{d(t)}$$

$$\mathcal{L}\{V_i(t) = i_1(t) + \frac{di_1(t)}{d(t)} - \frac{di_2(t)}{d(t)}\}$$

$$V_i(s) = I_1(s) + sI_1(s) - sI_2(s)$$

$$V_i(s) = I_1(s)[s+1] - sI_2(s) \quad ①$$

KVL @ loop $i_2(t)$

$$0 = L\frac{di_2(t)}{d(t)} - R_2 i_2(t) - L\frac{di_1(t)}{d(t)}$$

$$\mathcal{L}\{0 = \frac{di_2(t)}{d(t)} + 2i_2(t) - \frac{di_1(t)}{d(t)}\}$$

$$0 = sI_2(s) + 2I_2(s) - sI_1(s)$$

$$0 = I_2(s)[s+2] - sI_1(s) \quad ②$$

$$I_2(s) = \frac{\begin{bmatrix} s+1 & V_i(s) \\ -s & 0 \end{bmatrix}}{\begin{bmatrix} s+1 & -s \\ -s & s+2 \end{bmatrix}} = \frac{0-[-sV_i(s)]}{(s+1)(s+2)-s^2}$$

$$I_2(s) = \frac{sV_i(s)}{\cancel{s^2} + 2s + 1s + 2 \cancel{-s^2}}$$

$$\frac{I_2(s)}{V_i(s)} = \frac{s}{3s+2}$$

$$V_{R2}(s) = R_2 I(s)$$

$$V_{R2}(s) = 2I(s)$$

$$I(s) = \frac{V_{R2}(s)}{2}$$

$$2\left[\frac{V_{R2}(s)}{2V_i(s)} = \frac{s}{3s+2}\right]2$$

$$\frac{V_{R2}(s)}{V_i(s)} = \frac{2s}{3s+2}$$

$$V_i(s) \longrightarrow \boxed{\frac{2s}{3s+2}} \longrightarrow V_{R2}(s)$$

FOR $I_1(s)$:

$$I_1(s) = \frac{\begin{bmatrix} V(s) & -s \\ 0 & s+2 \end{bmatrix}}{\begin{bmatrix} 1+s & -s \\ -s & s+2 \end{bmatrix}} = \frac{V(s)}{s+2s+s^2+2s-s^2}$$

$$I_1(s) = \frac{V(s)[s+2]}{3s+2}$$

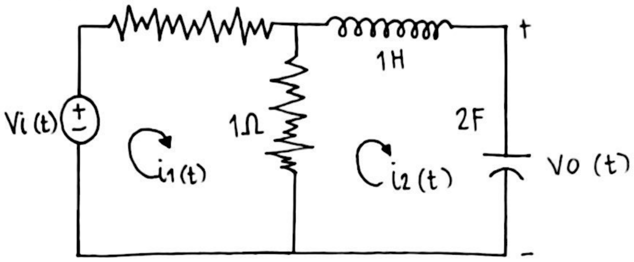
$$\frac{I_1(s)}{V(s)} = \frac{s+2}{3s+2}$$

$$V(s) \longrightarrow \boxed{\frac{s+2}{3s+2}} \longrightarrow I_1(s)$$

OR

$$V(s) \longrightarrow \boxed{\frac{s}{s+2}} \longrightarrow I_1(s)$$

FIGURE (b)



KVL @ loop 1

$$\mathcal{L}\{V(t) = R_1 i_1(t) + R_2 i_1(t) - R_2 i_2(t)\}$$

$$V(s) = R_1 I_1(s) + R_2 I_1(s) - R_2 I_2(s)$$

$$\underset{C}{V(s)} = \underset{A}{2} I_1(s) \underset{B}{-} I_2(s) \quad ①$$

KVL @ loop 2

$$0 = R_2 i_2(t) + L\frac{di_2(t)}{d(t)} + \frac{1}{C}\int i_2(t)\,dt - R_2 i_1(t)$$

$$\mathcal{L}\{0 = i_2(t) + \frac{di_2(t)}{d(t)} + \frac{1}{2}\int i_2(t)\,dt - i_1(t)\}$$

$$0 = I_2(s) + s I_2(s) + {}^1/_{2s}\, I_2(s) - I_1(s)$$

$$\underset{C}{0} = I_2(s)\underset{B}{\left[\frac{2s + 2s^2 + 1}{2s}\right]} - \underset{A}{I_1(s)} \quad ②$$

$$I_2(s) = \frac{\begin{array}{cc} A & C \\ \end{array}\begin{bmatrix} 2 & V(s) \\ -1 & 0 \end{bmatrix}}{\begin{bmatrix} 2 & -1 \\ -1 & \frac{2s+2s^2+1}{2s} \end{bmatrix}} = \frac{0 - [-V(s)]}{2\left[\frac{2s+2s^2+1}{2s}\right] - 1}$$

$$I_2(s) = \frac{V(s)}{\frac{4s + 4s^2 + 4}{2s} - 1}$$

$$I_2(s) = \frac{V(s)}{\frac{4s + 4s^2 + 2 - 2s}{2s}}$$

$$\frac{I_2(s)}{V(s)} = \frac{2s}{4s^2 + 2s + 2}$$

$$\frac{V_C(s)}{I(s)} = \frac{1}{Cs}$$

$$\frac{V_C(s)}{I(s)} = \frac{1}{2s}$$

$$2s\, V_C(s) = I(s)$$

$$\frac{1}{\cancel{2s}}\left[\frac{2s V_C(s)}{V(s)} = \frac{2s}{4s^2 + 2s + 2}\right]\frac{1}{\cancel{2s}}$$

$$\frac{V_C(s)}{V(s)} = \frac{1}{4s^2 + 2s + 2}$$

$$V(s) \longrightarrow \boxed{\frac{1}{4s^2 + 2s + 2}} \xrightarrow{V_C(s)}$$

FOR $I_1(s)$; FIG. B

$$I_1(s) = \frac{\begin{bmatrix} V(s) & -1 \\ 0 & \frac{2s+2s^2+1}{2s} \end{bmatrix}}{\begin{bmatrix} 2 & -1 \\ -1 & \frac{2s+2s^2+1}{2s} \end{bmatrix}} \quad \frac{V(s)\left[\frac{2s+2s^2+1}{2s}\right]}{\frac{4s+4s^2+4}{2s} - 1}$$

$$\frac{I_1(s)}{V(s)} = \frac{\frac{2s^2+2s+1}{2s}}{\frac{4s^2+2s+2}{2s}}$$

$$\frac{I_1(s)}{V(s)} = \frac{2s^2+2s+1}{\cancel{2s}} \cdot \frac{\cancel{2s}}{4s^2+2s+2}$$

$$\frac{I_1(s)}{V(s)} = \frac{2s^2+2s+1}{4s^2+2s+2}$$

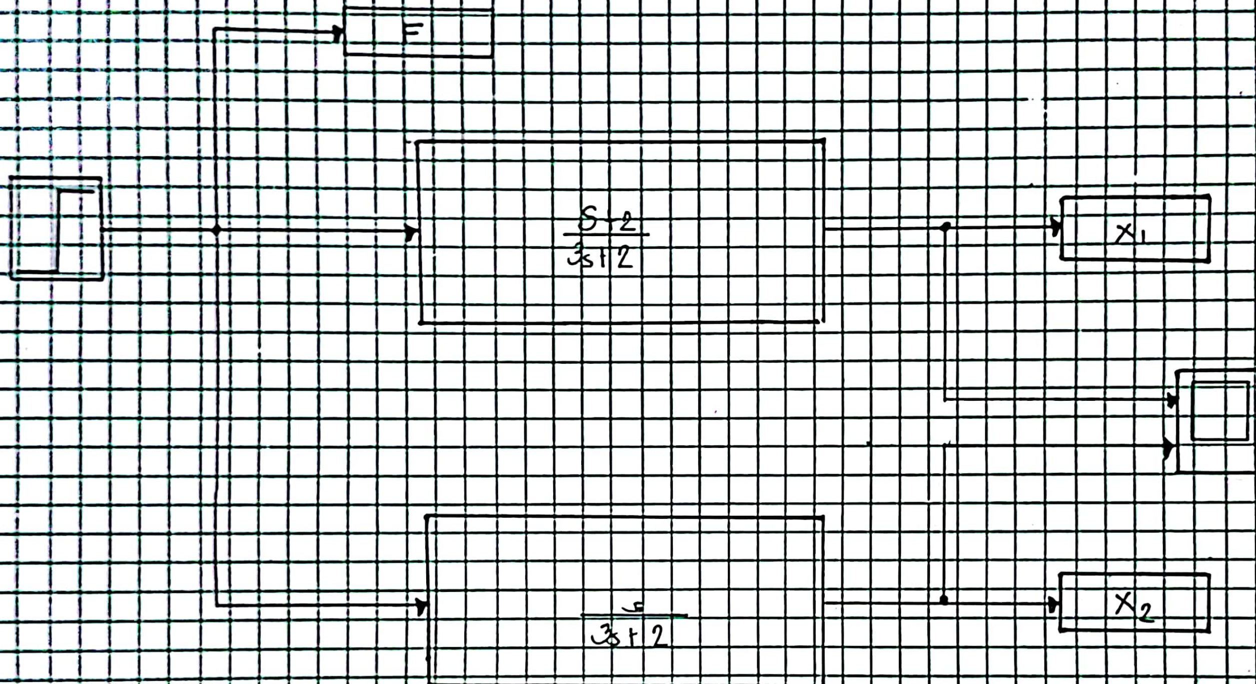
$$\frac{I_1(s)}{V(s)} = \frac{2s^2+2s+1}{2[2s^2+s+1]}$$

$$V(s) \longrightarrow \boxed{\frac{2s^2+2s+1}{2[2s^2+s+1]}} \longrightarrow I_1(s)$$

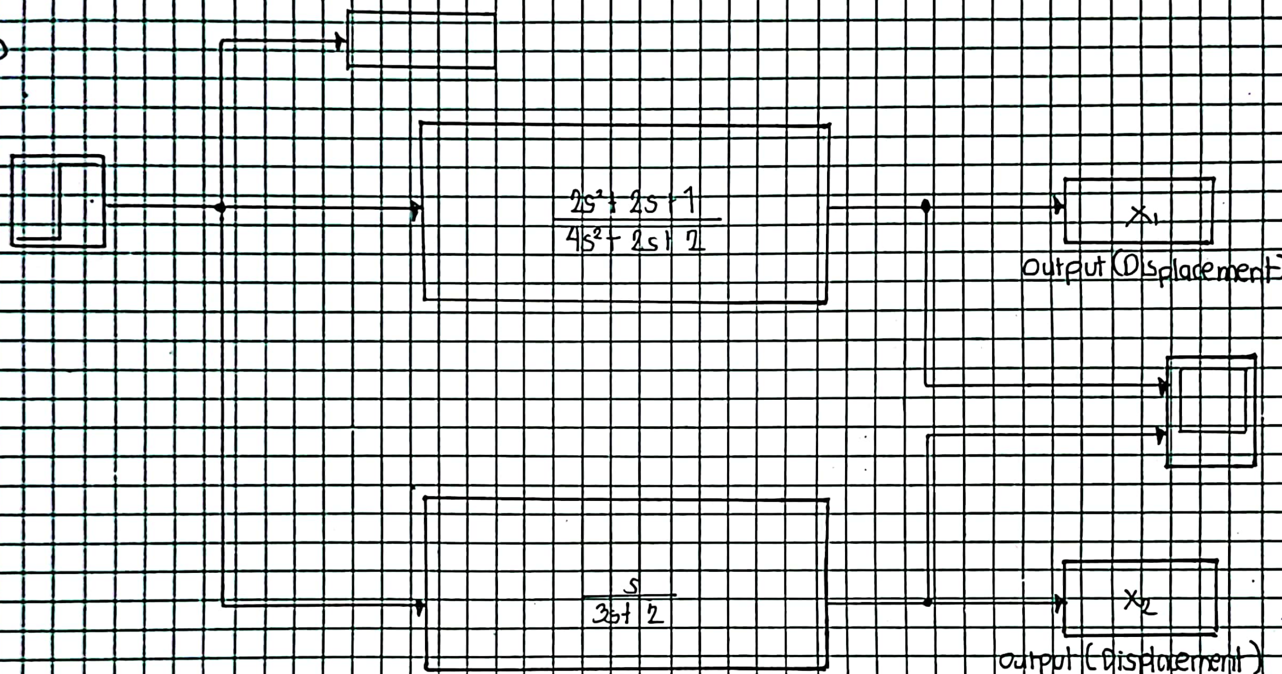
AND

$$V(s) \longrightarrow \boxed{\frac{2s}{4s^2+2s+2}} \longrightarrow I_2(s)$$

3



3b



$\frac{2s^2+2s+1}{4s^2+2s+2}$
x_1
Output (Displacement)
$\frac{s}{3s+2}$
x_2
Output (Displacement)