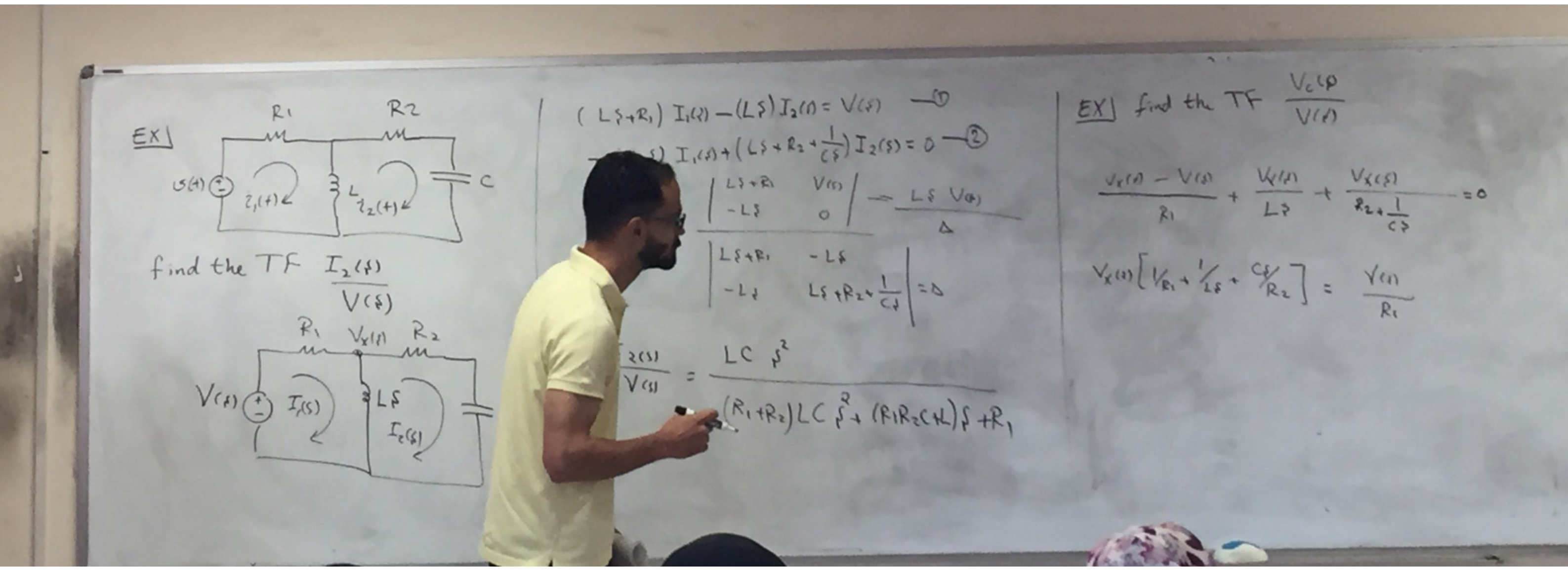


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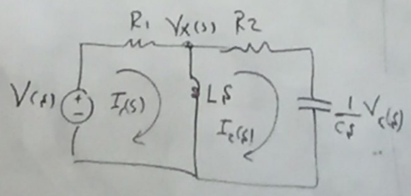
$$\therefore\ V_c(s) = \frac{\frac{1}{Cs}}{\frac{1}{Cs} + R_2}\, V_x(s)$$

$$= \frac{1}{1 + R_2 C s} \cdot V_x(s)$$




$$(Ls + R_1)\, I_1(s) - (Ls)\, I_2(s) = V(s) \quad \text{— (1)}$$

$$-(Ls)\, I_1(s) + \left(Ls + R_2 + \frac{1}{Cs}\right) I_2(s) = 0 \quad \text{— (2)}$$

$$I_2(s) = \frac{\begin{vmatrix} Ls + R_1 & V(s) \\ -Ls & 0 \end{vmatrix}}{\begin{vmatrix} Ls + R_1 & -Ls \\ -Ls & Ls + R_2 + \frac{1}{Cs} \end{vmatrix} = \Delta} \rightarrow \frac{Ls\, V(s)}{\Delta}$$

$$\frac{I_2(s)}{V(s)} = \frac{LC s^2}{(R_1 + R_2) LC s^2 + (R_1 R_2 C + L) s + R_1}$$

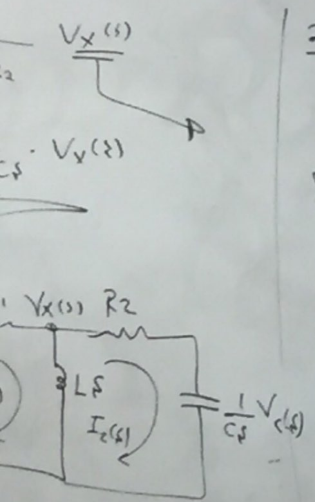
EX| find the TF $\frac{V_c(s)}{V(s)}$

$$\frac{V_x(s) - V(s)}{R_1} + \frac{V_x(s)}{Ls} + \frac{V_x(s)}{R_2 + \frac{1}{Cs}} = 0$$

$$V_x(s)\left[\frac{1}{R_1} + \frac{1}{Ls} + \frac{Cs}{R_2}\right] = \frac{V(s)}{R_1}$$

$$V_x(s)\left[G_1 + G_2 C s + \frac{1}{Ls}\right] = G_1 V(s)$$

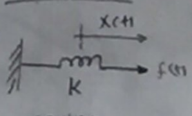
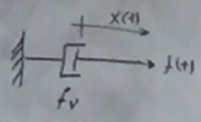
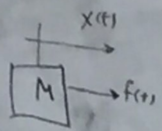
$$V_x(s) = \frac{G_1}{G_1 + G_2 C s + \frac{1}{Ls}}\, V(s) = \frac{G_1 L s}{G_2 C L s^2 + G_1 L s + 1}\, V(s)$$




## 2.5) Translational Mechanical system Transfer function

→ Mechanical system :- 3 passive linear components

① spring } energy storage element
② Mass }
③ Viscous damper → dissipates energy.

| component | force-displacement | Impedance $Z_M(s) = \frac{F(s)}{X(s)}$ |
|---|---|---|
|   spring | $f(t) = K\,x(t)$<br>$F(s) = K\,X(s)$ | $K$ |
|   viscous damper | $f(t) = f_v \frac{d}{dt} x(t)$<br>$F(s) = f_v s\,X(s)$ | $f_v s$ |
|   | $f(t) = M \frac{d^2}{dt^2} x(t)$<br>$F(s) = M s^2 X(s)$ | $M s^2$ |

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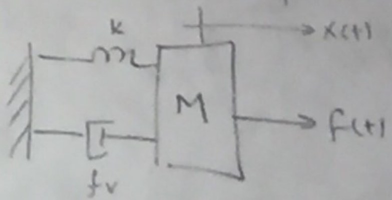
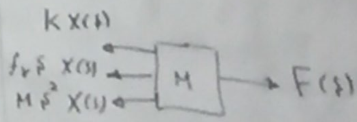
- How to find the Transfer function?
  - assume direction of +ve motion
  - draw free-body diagram
  - Newton's law

    $$\sum f(t) = \text{Zero}$$

  - assuming zero IC's

EX) find the TF $\frac{X(s)}{F(s)}$

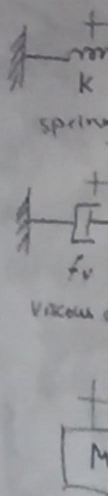



$$\left[M s^2 + f_v s + k\right] X(s) = F(s)$$

$$\therefore H(s) = G(s) = \frac{X(s)}{F(s)} = \frac{1}{M s^2 + f_v s + k}$$

Compone



→ Solving by defining Impedance for mechanical systems:-

$$Z_M(s) = \frac{F(s)}{X(s)}$$

$$F(s) = Z_M(s)\, X(s).$$

[Sum of impedances] X(s) = Sum of applied forces

↳ # of equations of motion required is equal to the # of linearly independent motions!

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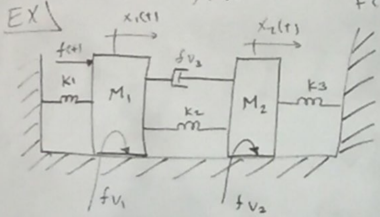
EX

find the TF $\frac{X_2(s)}{F(s)}$




$$\left[M_1 s^2 + (f_{v_1} + f_{v_3})s + (K_1 + K_2)\right] X_1(s) - \left[f_{v_3} s + K_2\right] X_2(s) = F(s) \quad \text{— (1)}$$

$$-\left[f_{v_3} s + K_2\right] X_1(s) + \left[M_2 s^2 + (f_{v_2} + f_{v_3})s + (K_2 + K_3)\right] X_2(s) = 0 \quad \text{— (2)}$$

$$\begin{bmatrix} \text{Sum of Mech} \\ \text{impedances Connected} \\ \text{to the motion at} \\ x_1 \end{bmatrix} X_1(s) - \begin{bmatrix} \text{Sum of} \\ \text{impedances} \\ \text{btwn} \\ x_1 \,\&\, x_2 \end{bmatrix} X_2(s) = \begin{bmatrix} \text{Sum of} \\ \text{applied forces} \\ \text{at } x_1 \end{bmatrix} \quad \text{— (1)}$$

$$-\begin{bmatrix} \quad \end{bmatrix} X_1(s) + \begin{bmatrix} \\ x_2 \end{bmatrix} X_2(s) = \begin{bmatrix} \\ \text{at } x_2 \end{bmatrix} \quad \text{— (2)}$$

→ Solving by defining Impedance for mechanical systems: -

$$Z_M(s) = \frac{F(s)}{X(s)}$$

$$F(s) = Z_M(s)\, X(s).$$

[Sum of impedances] $X(s)$ = Sum of applied forces

↱ # of equations of motion required is equal to the # of linearly independent motions

$$\left[M_1 s^2 + (f_{v_1} + f_{v_3}) s + (K_1 + K_2)\right] X_1(s) - \left[f_{v_3} s + K_2\right] X_2(s) = F(s) \quad \text{— (1)}$$

$$-\left[f_{v_3} s + K_2\right] X_1(s) + \left[M_2 s^2 + (f_{v_2} + f_{v_3}) s + (K_2 + K_3)\right] X_2(s) = 0 \quad \text{— (2)}$$

$$X_2(s) = \frac{\begin{vmatrix} M_1 s^2 + (f_{v_1} + f_{v_3}) s + (K_1 + K_2) & F(s) \\ -(f_{v_3} s + K_2) & 0 \end{vmatrix}}{\Delta}$$

$$X_2(s) = \begin{bmatrix} \text{Sum of} \\ \text{applied forces} \\ \text{at } x_1 \end{bmatrix} \quad \text{— (1)}$$

$$\begin{bmatrix} \\ \text{at } x_2 \end{bmatrix} \text{—}$$

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