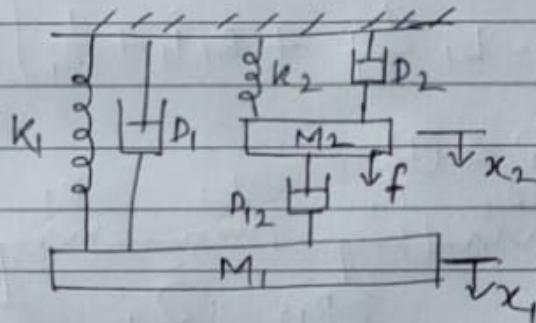
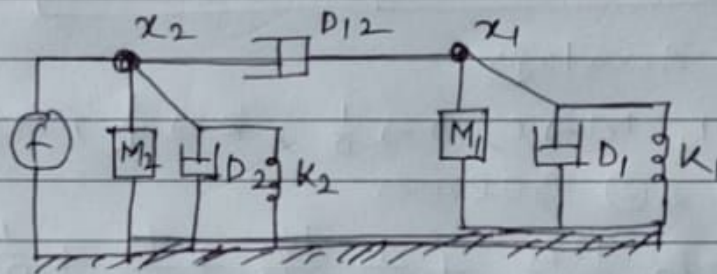


- ① obtain the system eqn of the system. Determine the (1) Force voltage (F-V) and Force current (F-I) analogy.



② equivalent circuit:



For node x_2 , we can write

$$f = M_2 \frac{d^2 x_2}{dt^2} + D_2 \frac{dx_2}{dt} + D_{12} \frac{d(x_2 - x_1)}{dt} + K_2 x_2 \quad \text{--- ①}$$

For node x_1 , we can write

$$0 = D_{12} \frac{d(x_1 - x_2)}{dt} + M_1 \frac{d^2 x_1}{dt^2} + D_1 \frac{dx_1}{dt} + K_1 x_1 \quad \text{--- ②}$$

$$D_{12} \frac{d}{dt} (x_2 - x_1) = M_1 \frac{d^2 x_1}{dt^2} + D_1 \frac{dx_1}{dt} + K_1 x_1 \quad \text{--- ③}$$

$$D_{12} \frac{d}{dt} (x_2 - x_1) = M_1 \frac{d^2 x_1}{dt^2} + D_1 \frac{dx_1}{dt} + K_1 x_1 \quad \text{--- ④}$$

eqn ① & ④ represent the system eqn

Force voltage analogy

$$f \rightarrow v, M \rightarrow L, D \rightarrow R, K \rightarrow \frac{1}{C}, x \rightarrow q$$

eqn ① & ④ becomes

$$v = L_2 \frac{dq_2}{dt^2} + R_2 \frac{dq_2}{dt} + R_{12} \frac{d}{dt} (q_2 - q_1) + \frac{q_2}{C_2}$$

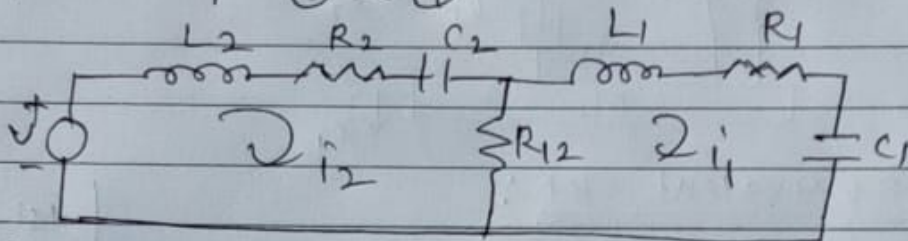
$$v = L_2 \frac{di_2}{dt} + R_2 i_2 + R_{12} (i_2 - i_1) + \frac{1}{C} \int i_2 dt \quad \text{--- ⑤}$$

Analogously,

$$R_{12} \frac{d}{dt} (q_2 - q_1) = L_1 \frac{d^2 q_1}{dt^2} + R_1 \frac{dq_1}{dt} + \frac{1}{C_1} q_1$$

$$R_{12} (\dot{i}_2 - \dot{i}_1) = L_1 \frac{di_1}{dt} + R_1 \dot{i}_1 + \frac{1}{C_1} \int i_1 dt \quad (4)$$

From eqn (3) & (4)



For (F-I) Analogy,

$$f \rightarrow i, M \rightarrow C, D \rightarrow \frac{1}{R}, K \rightarrow \frac{1}{L}, x \rightarrow \psi$$

eqn (1) & (2) become

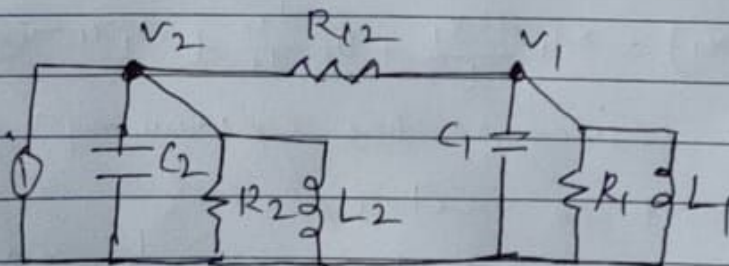
$$\dot{i} = C_2 \frac{d^2 \psi_2}{dt^2} + \frac{1}{R_2} \frac{d\psi_2}{dt} + \frac{\psi_2}{L_2} + \frac{1}{R_{12}} \frac{d}{dt} (\psi_2 - \psi_1)$$

$$= C_2 \frac{dv_2}{dt} + \frac{v_2}{R_2} + \frac{1}{L_2} \int v_2 dt + \frac{v_2 - v_1}{R_{12}} \quad (5)$$

$$\frac{1}{R_{12}} \frac{d}{dt} (\psi_2 - \psi_1) = C_1 \frac{d^2 \psi_1}{dt^2} + \frac{1}{R_1} \frac{d\psi_1}{dt} + \frac{\psi_1}{L_1}$$

$$\frac{v_2 - v_1}{R_{12}} = C_1 \frac{dv_1}{dt} + \frac{v_1}{R_1} + \frac{1}{L_1} \int v_1 dt \quad (6)$$

from (5) & (6)



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