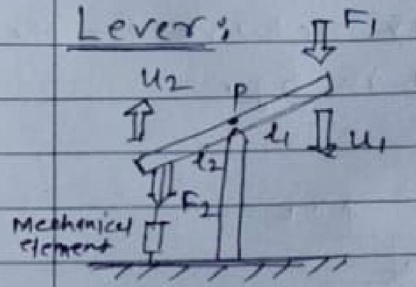
Lever:



Mechanical lever is used to lift heavy weights by applying a relatively small effort. fig. shows a liver which rests on a rigid fulcrum P.

Assumed, the liver is massless but rigid. and its left end is connected to the ground through some mechanical elements which resists motion. If a force F_1 applied to the right makes it move with velocity u_1. Taking moment about point P, we have, we have

$$F_1 l_1 = F_2 l_2$$

$$\frac{F_1}{F_2} = \frac{l_2}{l_1} \quad \text{—①}$$

If angular velocity of the lever about the fulcrum is ω, then the linear velocities of the two ends of the lever are

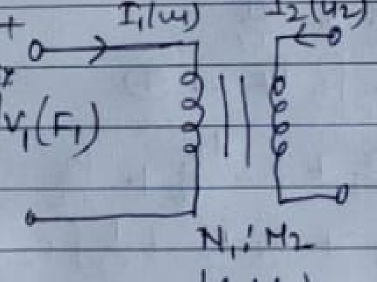
$$u_1 = l_1 \omega$$

$$u_2 = l_2 \omega$$

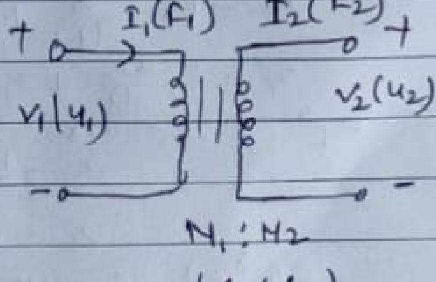
$$\frac{u_1}{u_2} = \frac{l_1}{l_2} \quad \text{—②}$$

If we consider F_1 and F_2 correspond to voltages V_1 and V_2 of the transformer and l_2 and l_1 as the number of turns N_1 and N_2

For (F-V) Analogy
$u_1 : u_2 \to I_1 : I_2$
$l_2 : l_1 \to N_1 : N_2$
$F_1 : F_2 \to V_1 : V_2$



$N_1 : N_2$
$(l_2 : l_1)$
(F-V) Analogy



$N_1 : N_2$
$(l_1 : l_2)$
(F-I) Analogy

For (F-I) Analogy
$u_1 : u_2 \to V_1 : V_2$
$l_1 : l_2 \to N_1 : N_2$
$F_1 : F_2 \to I_1 : I_2$

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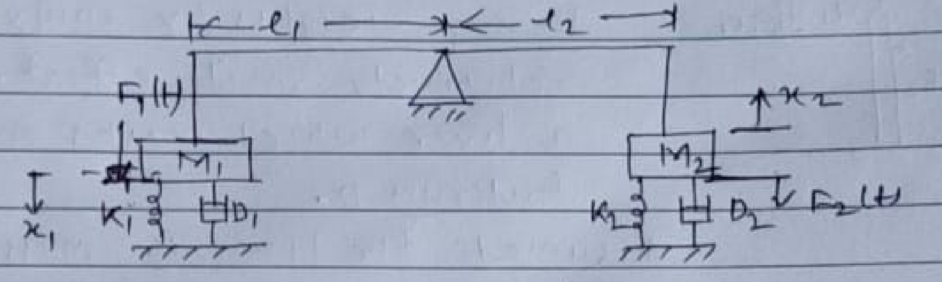
(1) Draw the force-voltage analogy network for the Mechanical system shown in fig.



Sol. The displacement x_1 of Mass M_1 is due to force $F_1(t)$

$$F_1(t) = M_1 \frac{d^2x_1}{dt^2} + D_1 \frac{dx_1}{dt} + K_1 x_1 \quad -(1)$$

The force transmitted to mass M_2 is given by

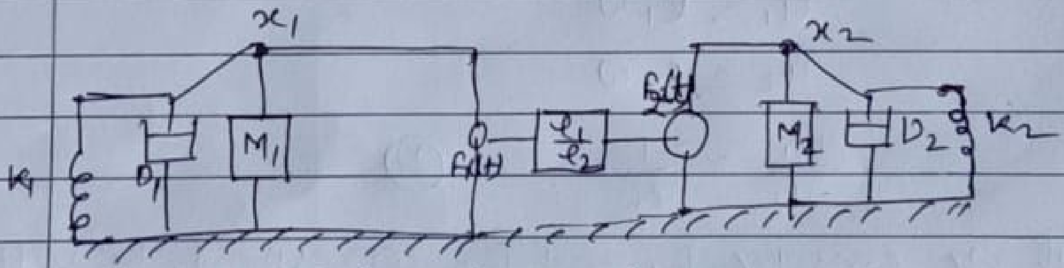
$$F_1(t) \times l_1 = F_2(t) \times l_2$$

$$F_2(t) = F_1(t) \times \left(\frac{l_1}{l_2}\right) \quad -(2)$$

For Mass M_2 the displacement is x_2 is due to force $F_2(t)$

$$F_2(t) = M_2 \frac{d^2x_2}{dt} + D_2 \frac{dx_2}{dt} + K_2 x_2$$

$$F_1(t) \times \left(\frac{l_1}{l_2}\right) = M_2 \frac{d^2x_2}{dt^2} + D_2 \frac{dx_2}{dt} + K_2 x_2 \quad -(3)$$



For (F-V) Analogy

$F \to V$, $M \to L$, $D \to R$, $K \to \frac{1}{C}$, $x \to q$

eqn (1) becomes

$$v_1 = L_1 \frac{d^2q_1}{dt^2} + R_1 \frac{dq_1}{dt} + \frac{q_1}{C_1}$$

$$v_1 = L_1 \frac{di_1}{dt} + R_1 i_1 + \frac{1}{C_1}\int i_1\, dt \quad -(4)$$

eqn (3) becomes

$$v_2 = L_2 \frac{d^2q_2}{dt^2} + R_2 \frac{dq_2}{dt} + \frac{q_2}{C_2}$$

$$v_2 = L \frac{di_2}{dt} + R_2 i_2 + \frac{1}{C_2}\int i_2\, dt \quad -(5)$$

eqn (2) becomes

$$v_2 = v_1 \left(\frac{l_1}{l_2}\right) \quad -(6)$$

From (4), (5) & (6)