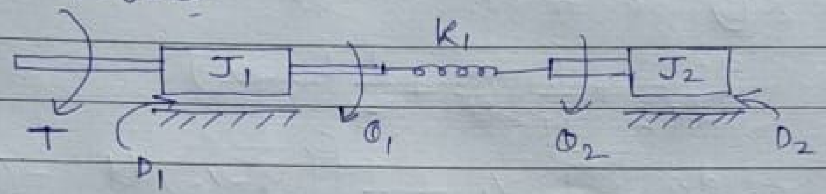
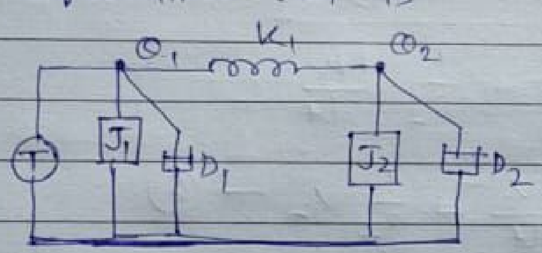
① ~~Determine the system eqn for the system shown in fig. also find ⓐ Torque voltage (T-V) and Torque (T-I) current analogous.~~



Solⁿ Equivalent ckt. is



जैसा कि आपलोगो को पिछले system (mechanical) ~~बताये थे वैसा ही process~~ में Rotational Motion का Problem solve कराते है। θ_1 एवं θ_2 को node मानते है और जो element जिससे connect होगा उसे जोड़ देते है

At node θ_1

$$T = J_1 \frac{d^2\theta_1}{dt^2} + D_1 \frac{d\theta_1}{dt} + K_1(\theta_1 - \theta_2) \quad -①$$

At node θ_2

$$0 = J_2 \frac{d^2\theta_2}{dt^2} + D_2 \frac{d\theta_2}{dt} + K_1(\theta_2 - \theta_1)$$

$$K_1(\theta_1 - \theta_2) = J_2 \frac{d^2\theta_2}{dt^2} + D_2 \frac{d\theta_2}{dt} \quad -②$$

In torque voltage (T-V) analogy

$T \to V,\ J \to L,\ D \to R,\ K \to \frac{1}{C},\ \theta \to q$

Comparision betⁿ Rotational and electrical Analogy.

eqⁿ ① & ② becomes.

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

$$V = L_1 \frac{di}{dt} + R_1 I_1 + \frac{1}{C_1}(i_1 - i_2)dt \quad -③$$

Similarly, $\frac{1}{C_1}(q_1 - q_2) = L_2 \frac{d^2q_2}{dt^2} + R_2 \frac{dq_2}{dt}$

$$\frac{1}{C_1}\int (i_1 - i_2)dt = L_2 \frac{di_2}{dt} + R_2 i_2 \quad -④$$

The Torque-voltage analogy is shown in fig.

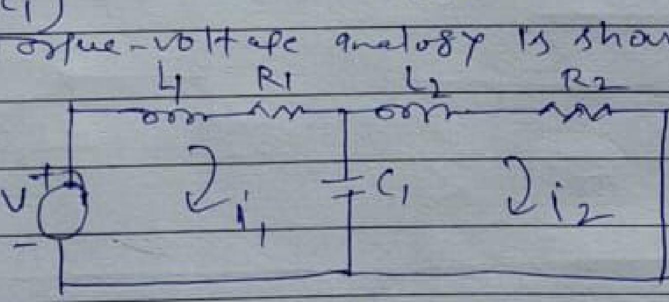


fig: (T-V) Analogy

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(ii) In Torque - current analogy

$T \to i, \; J \to C, \; K \to \frac{1}{L}, \; D \to \frac{1}{R}, \; \theta \to \psi$

eqn ① & ② becomes.

$\boxed{T = J_1 \frac{d^2\theta_1}{dt^2} + D_1\frac{d\theta_1}{dt} + K_1(\theta_1-\theta_2)}$

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

$$i = C_1 \frac{dv_1}{dt} + \frac{1}{R_1} v_1 + \frac{1}{L_1}\int (v_1-v_2)\,dt \quad - ⑤$$

$\boxed{K_1(\theta_1-\theta_2) = J_2 \frac{d^2\theta_2}{dt^2} + D_2\frac{d\theta_2}{dt}}$

$$\frac{\psi_1-\psi_2}{L_1} = C_2 \frac{d^2\psi_2}{dt^2} + \frac{1}{R_2}\frac{d\psi_2}{dt}$$

$$\frac{1}{L_1}\int (v_1-v_2)\,dt = C_2 \frac{dv_2}{dt} + \frac{1}{R_2} v_2 \quad - ⑥$$

form eqn ⑤ & ⑥.

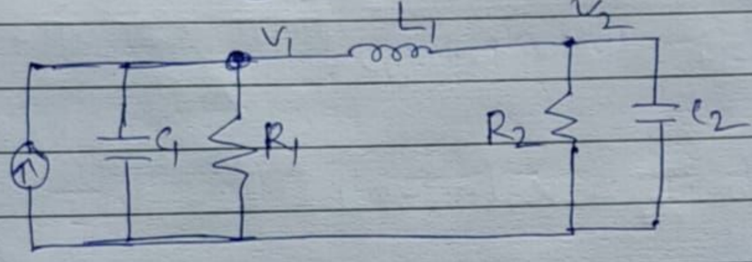

fig: (T-I) Analogy

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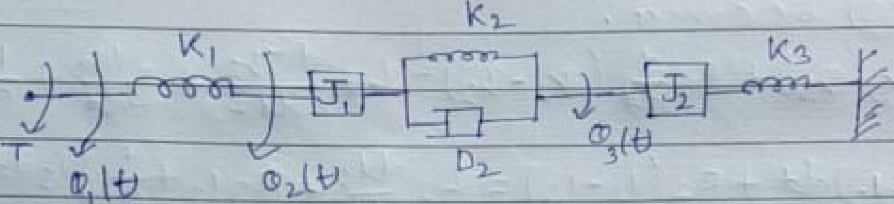
current analogy.



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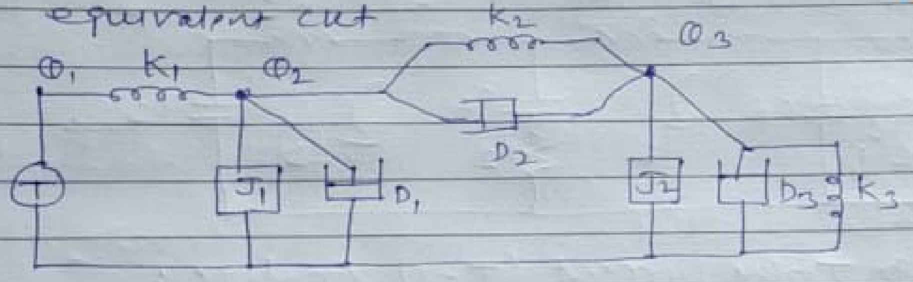
Sol^n equivalent ckt



At node θ_1 :

$$T = k_1(\theta_1 - \theta_2) \quad - (1)$$

At node θ_2

$$0 = J_1 \frac{d^2\theta_2}{dt^2} + D_1 \frac{d\theta_2}{dt} + k_1(\theta_2 - \theta_1) + k_2(\theta_2 - \theta_3) + D_2 \frac{d}{dt}(\theta_2 - \theta_3)$$

$$k_1(\theta_1 - \theta_2) = J_1 \frac{d^2\theta_2}{dt^2} + D_1 \frac{d\theta_2}{dt} + k_2(\theta_2 - \theta_3) + D_2 \frac{d}{dt}(\theta_2 - \theta_3) - (2)$$

At node θ_3

$$0 = k_2(\theta_3 - \theta_2) + D_2 \frac{d}{dt}(\theta_3 - \theta_2) + J_2 \frac{d^2\theta_3}{dt^2} + D_3 \frac{d\theta_3}{dt} + k_3\theta_3$$

$$k_2(\theta_2 - \theta_3) + D_2 \frac{d}{dt}(\theta_2 - \theta_3) = J_2 \frac{d^2\theta_3}{dt^2} + D_3 \frac{d\theta_3}{d\theta} + k_3\theta_3 - (3)$$

For Torque voltage (T-V) analogy :

$$T \to V, \ J \to L, \ D \to R, \ k \to \frac{1}{C}, \ \theta \to q$$

eq^n (1) becomes

$$V = \frac{1}{C_1}(q_1 - q_2)$$

$$V = \frac{1}{C_1}\int (i_1 - i_2)\,dt \quad - (4)$$

eq^n (2) becomes.

$$\frac{1}{C_1}(q_1 - q_2) = L_1 \frac{d^2q_2}{dt} + R_1 \frac{dq_2}{dt} + \frac{1}{C_2}(q_2 - q_3) + R_2 \frac{d}{dt}(q_2 - q_3)$$

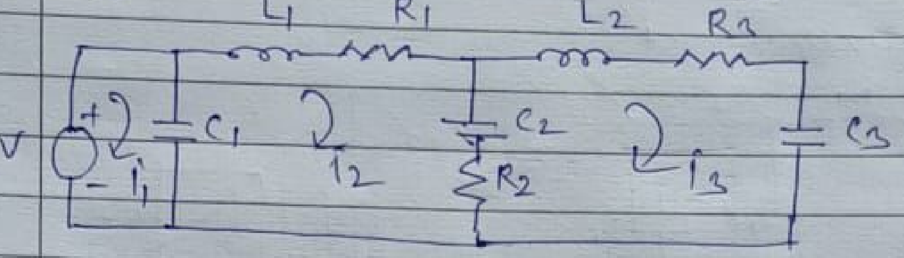
$$\frac{1}{C_1}\int (i_1 - i_2)\,dt = L_1 \frac{di_2}{dt} + R_1 i_2 + \frac{1}{C_2}\int (i_2 - i_3)\,dt + R_2 (i_2 - i_3)\,dt$$

$$- (5)$$

eqn ③ becomes.

$$\frac{1}{C_2}(q_2-q_3)+R_2\frac{d}{dt}(q_2-q_3)=L_2\frac{d^2q_3}{dt^2}+R_3\frac{dq_3}{dt}+\frac{1}{C_3}q_3$$

$$\frac{1}{C_2}\int(i_1-i_3)dt+R_2(i_2-i_3)=L_2\frac{di_3}{dt}+R_3i_3+\frac{1}{C_3}\int i_3dt \quad -⑥$$



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In Torque current (T-I) Analogy:

$T\to i,\ J\to C,\ K\to\frac{1}{L},\ D\to\frac{1}{R},\ \theta\to\psi$

Similarly, eqn ① becomes

$$i=\frac{1}{L_1}(\psi_1-\psi_2)$$

$$=\frac{1}{L_1}\int(v_1-v_2)dt \quad -⑦$$

Candidate may be write $\psi\to\phi$.

eqn ② becomes.

$$\frac{1}{L_1}(\psi_1-\psi_2)=C_1\frac{d^2\psi_2}{dt^2}+\frac{1}{R_1}\frac{d\psi_2}{dt}+\frac{1}{L_2}(\psi_2-\psi_3)+\frac{1}{R_2}\frac{d}{dt}(\psi_2-\psi_3)$$

$$\frac{1}{L_1}\int(v_1-v_2)dt=C_1\frac{dv_2}{dt}+\frac{1}{R_1}v_2+\frac{1}{L_2}\int(v_2-v_3)dt+\frac{1}{R_2}(v_2-v_3) \quad -⑧$$

eqn ③ becomes.

$$\frac{1}{L_2}(\psi_2-\psi_3)+\frac{1}{R_2}\frac{d}{dt}(\psi_2-\psi_3)=C_2\frac{d^2\psi_3}{dt^2}+\frac{1}{R_3}\frac{d\psi_3}{dt}+\frac{1}{L_3}\psi_3$$

$$\frac{1}{L_2}\int(v_2-v_3)dt+\frac{1}{R_2}(v_2-v_3)=C_2\frac{dv_3}{dt}+\frac{v_3}{R_3}+\frac{1}{L_3}\int v_3dt \quad -⑨$$

From ⑦, ⑧, ⑨ eqs