CMR
INSTITUTE OF
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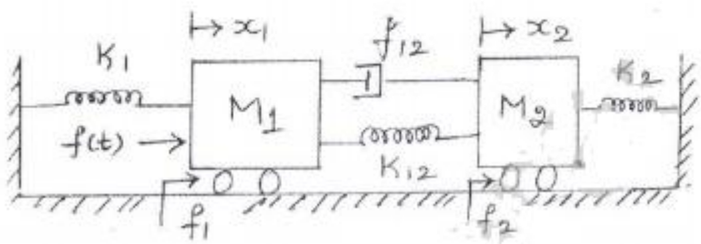
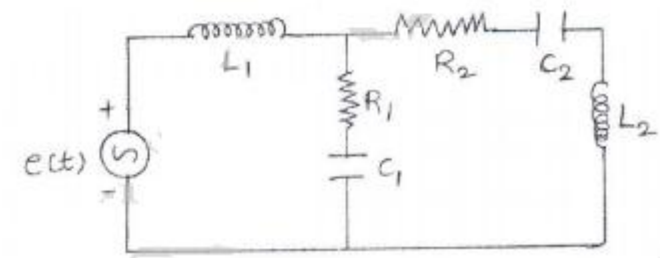
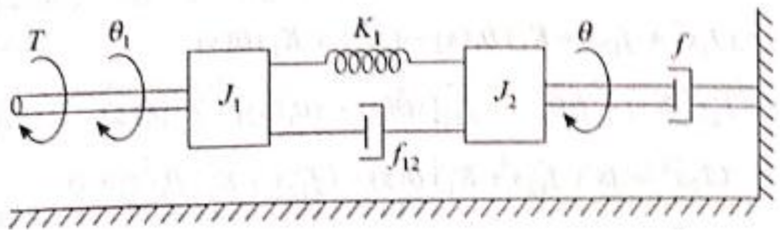
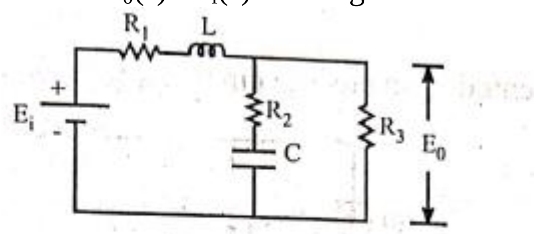
Internal Assesment Test - I

Sub:	**CONTROL SYSTEMS**							Code:	18EE61
Date:	21/05/2021	Duration:	90 mins	Max Marks:	50	Sem:	6th	Branch:	EEE

Answer Any FIVE FULL Questions

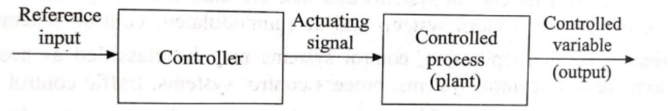
		Marks	OBE CO	OBE RBT
1	With the help of neat block diagram, define Open Loop and Closed Loop control systems. Write two examples for each systems	10	CO1	L1
2	Construct mathematical model for the mechanical system shown in Fig Q2. Draw electrical equivalent network based on force voltage analogy and force current analogy  Fig Q2	10	CO1	L4
3	Draw an equivalent mechanical network using force voltage analogy as shown in Fig Q3. Write the modelling equations.  Fig Q3	10	CO1	L4
4	For the mechanical system as shown in fig Q4. Draw the electrical network based on Torque current analogy and Torque voltage analogy. Write its performance equations.  Fig Q4	10	CO1	L4

5	Obtain the transfer function $E_0(s) / E_i(s)$ of the given network in the Fig Q5  Fig Q5	10	CO1	L4
6	Obtain the mathematical model for armature controlled dc motor and derive the transfer function	10	CO1	L4
7	With neat circuit diagram of AC servomotor, derive the transfer function and design the expression for Motor Gain and Motor time constant	10	CO1	L4

IAT 1 Solution

1.

1. Open-Loop Control Systems:

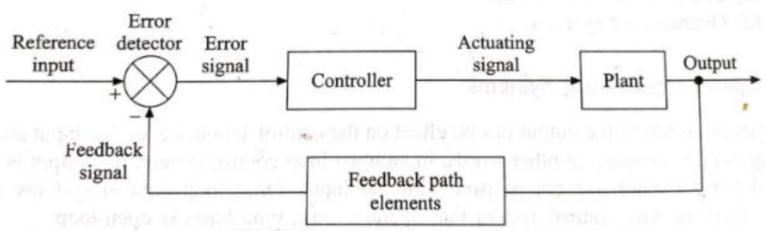


Any physical system which does not automatically correct the variation in its output.

- It is not a feedback system
- It operates on a time basis

Example: Washing machine, Electric Toaster, Traffic control.

2. Closed-Loop Control Systems:

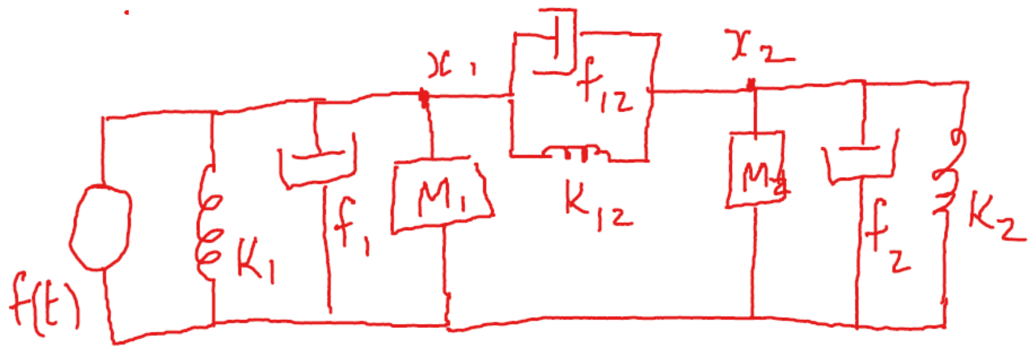


- Feedback control system.

- A system that maintains a prescribed relationship between the output and the reference input by comparing them and using the difference as a means of control.

Example: Traffic control, Room heating system.

2.

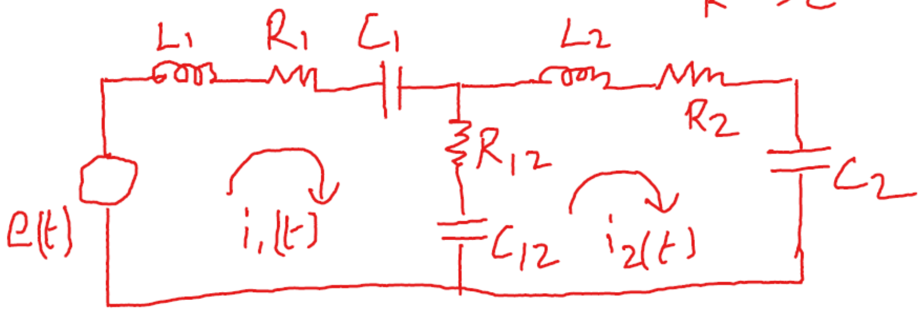


Mathematical model:-

$$M_1\frac{d^2x_1}{dt^2}+f_1\frac{dx_1}{dt}+K_1x_1+f_{12}\frac{d(x_1-x_2)}{dt}+K_{12}(x_1-x_2)t=f(t)$$

$$M_2\frac{d^2x_2}{dt^2}+f_2\frac{dx_2}{dt}+K_2x_2+f_{12}\frac{d(x_2-x_1)}{dt}+K_{12}(x_2-x_1)=0$$

Force-Voltage Analogy $M\to L,\ f\to R,\ K\to C.$

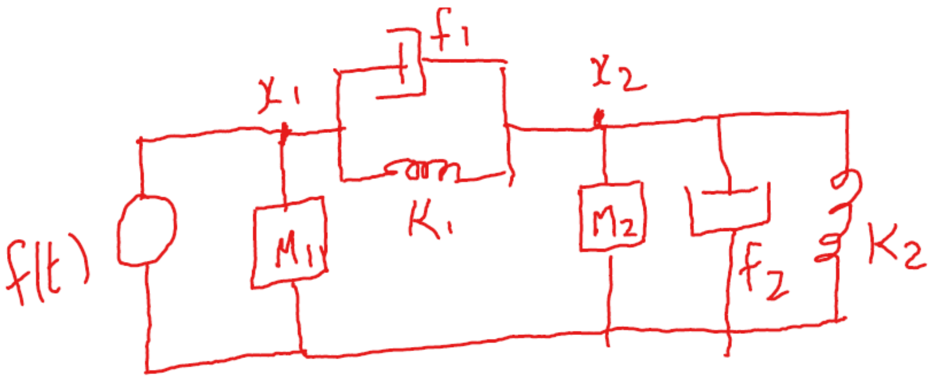


Mathematical Model

$$L_1\frac{di_1}{dt} + R_1 i_1(t) + \frac{1}{C_1}\int i_1(t)\,dt + R_{12}(i_1 - i_2)t + \frac{1}{C_{12}}\int (i_1 - i_2)t\,dt = e(t)$$

$$L_2\frac{di_2}{dt} + R_2 i_2(t) + \frac{1}{C_2}\int i_2(t)\,dt + R_{12}(i_2 - i_1)t + \frac{1}{C_{12}}\int (i_2 - i_1)t\,dt = 0.$$

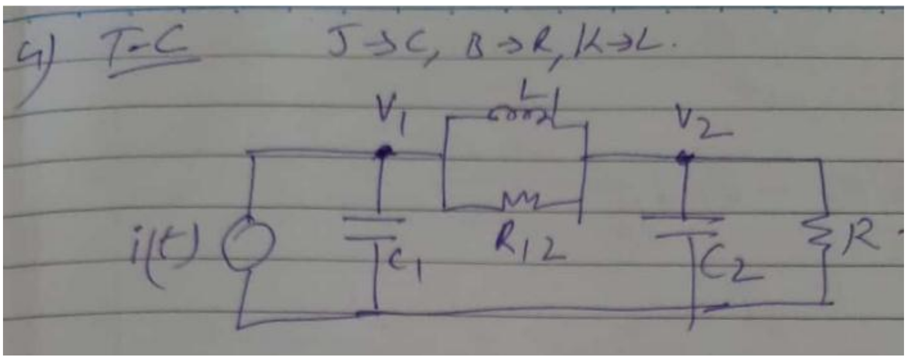
3.

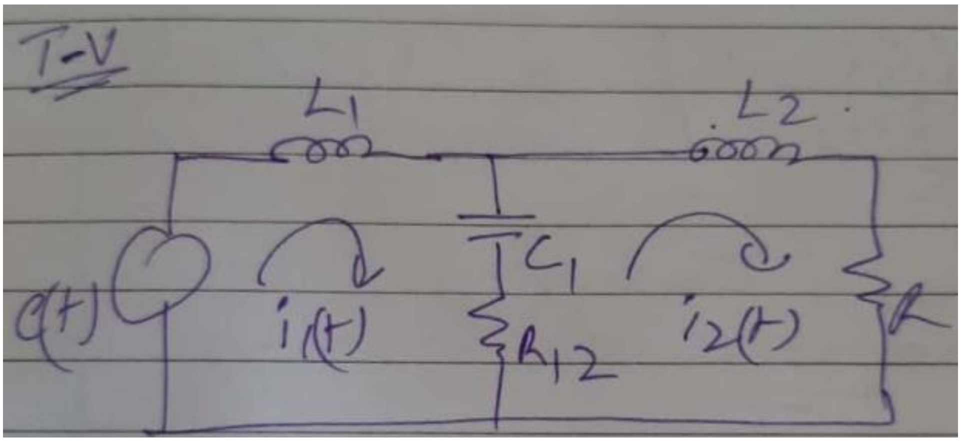


$$M_1\frac{d^2x_1}{dt^2} + f_1\frac{d(x_1 - x_2)}{dt} + K_1(x_1 - x_2) = f(t)$$

$$M_2\frac{d^2x_2}{dt^2} + f_2\frac{dx_2}{dt} + K_2 x_2 + f_1\frac{d(x_2 - x_1)}{dt} + K_1(x_2 - x_1) = 0$$

4.





5.

5) $\frac{V_1}{R_1} + \frac{1}{L}\int V_1\,dt + \frac{V_1}{R_1} + C\frac{dV_1}{dt} + \frac{V_1 - E_0}{R_3} = E_i$

6.

Derivation.

Let i_f = constant.

$R_a i_a + L_a \frac{di_a}{dt} + e_b = V_a$.

$R_a i_a + L_a \frac{di_a}{dt} = V_a - e_b$ — (1).

$T \propto i_a \Rightarrow T = K_a i_a$ — (2)

$J\frac{d^2\theta}{dt^2} + B\frac{d\theta}{dt} = T$ — (3)

$e_b \propto \frac{d\theta}{dt} \Rightarrow e_b = K_b \frac{d\theta}{dt}$ — (4)

L.T (1), $R_a I_a(s) + L_a s\, I_a(s) = V_a(s) - E_b(s)$

$I_a(s)\left[R_a + L_a s\right] = V_a(s) - E_b(s)$

$$I_a(s) = \frac{V_a(s) - E_b(s)}{R_a + L_a s} \quad \text{--- (5)}$$

L.T (2), $T(s) = K_a I_a(s)$ — (6)

L.T (3), $\theta(s)\left[Js^2 + Bs\right] = T(s)$ — (7)

L.T (4),

$E_b(s) = K_b s\, \theta(s)$ — (8)

From (5), (6), (8)

$$T(s) = K_a\left[\frac{V_a(s) - K_b s\, \theta(s)}{R_a + L_a s}\right] \quad \text{--- (9)}$$

(9) in (7),

$$\theta(s)\left[Js^2 + Bs\right] = \frac{K_a V_a(s) - K_a K_b s\, \theta(s)}{R_a + L_a s}$$

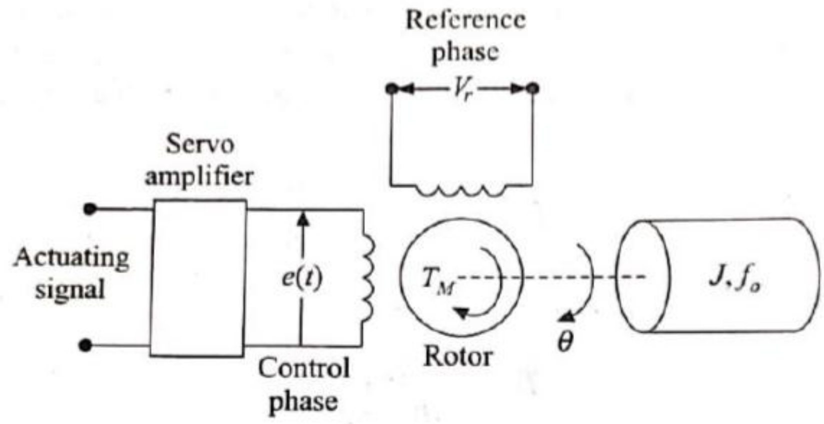
$$\theta(s)\left\{\left[Js^2 + Bs\right]\left[R_a + L_a s\right]\right\} = K_a V_a(s) - K_a K_b s\, \theta(s)$$

$$\theta(s)\left\{\left(Js^2 + Bs\right)\left(R_a + L_a s\right)\right\} + K_a K_b s\, \theta(s) = K_a V_a(s)$$

$$\theta(s)\left[\left(Js^2 + Bs\right)\left(R_a + L_a s\right) + K_a K_b s\right] = K_a V_a(s)$$

$$\therefore \frac{\theta(s)}{V_a(s)} = \frac{K_a}{\left(Js^2 + Bs\right)\left(R_a + L_a s\right) + K_a K_b s}$$

7.



Mechanical Load,

$$J\frac{d^2\theta}{dt^2} + f\frac{d\theta}{dt} = T_M \quad \text{— (1)}$$

Motor Torque; $T_M = K_1 e_c - K_2 \frac{d\theta}{dt}$. — (2)

(2) in (1),

$$J\frac{d^2\theta}{dt^2} + f\frac{d\theta}{dt} = K_1 e_c - K_2 \frac{d\theta}{dt} \quad \text{— (3)}$$

L.T (3),

$$Js^2\theta(s) + fs\,\theta(s) = K_1 E_c(s) - K_2 s\,\theta(s)$$

$$Js^2\theta(s) + fs\,\theta(s) + K_2 s\,\theta(s) = K_1 E_c(s)$$

$$\theta(s)\left[Js^2 + s(f+K_2)\right] = K_1 E_c(s).$$

$$\therefore \frac{\theta(s)}{E_c(s)} = \frac{K_1}{s\left[Js + (f+K_2)\right]} = \frac{K_1}{s(f+K_2)\left(\frac{Js}{f+K_2} + 1\right)}$$

$$= \frac{K_1/(f+K_2)}{s\left[\frac{Js}{f+K_2} + 1\right]} = \frac{K_m}{s\left[\tau_m s + 1\right]}$$

where $K_m = \frac{K_1}{f+K_2}$, $\tau_m = \frac{J}{f+K_2}$

↳ Motor Gain ↳ Motor Time