CMR
INSTITUTE OF
TECHNOLOGY

USN

Internal Assesment Test - II

Sub:	**CONTROL SYSTEMS**							Code:	18EE61
Date:	24/05/2023 8.30 to 10 AM	Duration:	90 mins	Max Marks:	50	Sem:	6th	Branch:	EEE

Answer Any FIVE FULL Questions

		Marks	OBE CO	OBE RBT
1	Obtain the closed loop transfer function using block diagram reduction technique for the fig Q1 shown.		CO2	L3

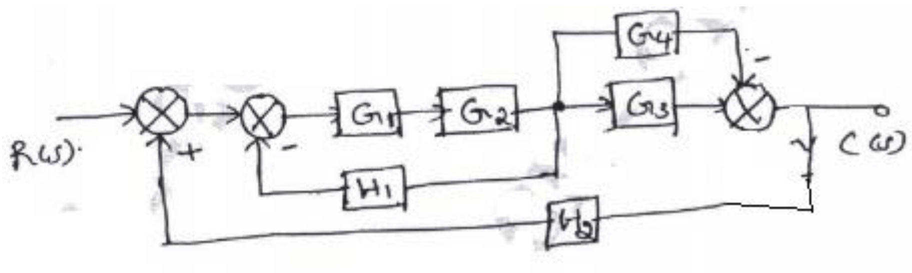
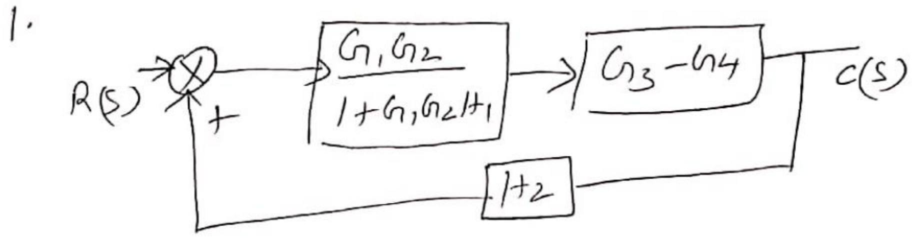


Fig Q1

Solution:

1.

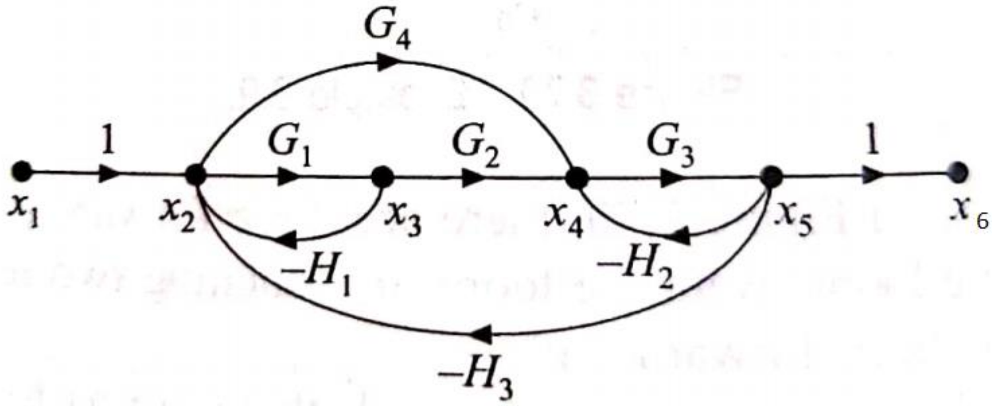


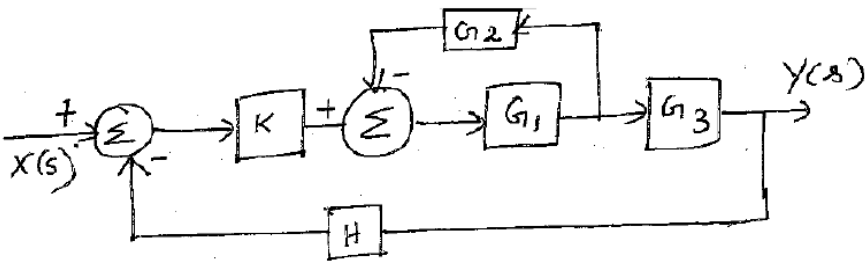
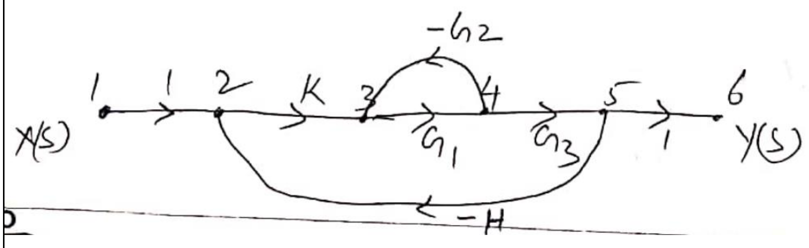
$$\frac{C(s)}{R(s)} = \frac{\dfrac{(G_1G_2)(G_3-G_4)}{1+G_1G_2H_1}}{1-\left[\dfrac{G_1G_2(G_3-G_4)}{1+G_1G_2H_1}\times H_2\right]}$$

6

$$\frac{C(s)}{R(s)} = \frac{G_1G_2(G_3-G_4)}{1+G_1G_2H_1-G_1G_2H_2(G_3-G_4)}$$

4

2	Apply the Mason's Gain formula to the signal flow graph shown in fig Q2 to find the transfer function x_6 / x_1  Fig Q2 Solution: 2) Forward Path Gain. $M_1 = G_1 G_2 G_3, \quad \Delta_1 = 1.$ $M_2 = G_3 G_4, \quad \Delta_2 = 1.$ Individual loop Gain. $L_{11} = -G_1 H_1$	2	CO2	L3

	$L_{12} = -G_3H_2$. $L_{13} = -G_1G_2G_3H_3$. $L_{14} = -G_3G_4H_3$	4		
	Two Non-Touching loop Gain $L_{21} = G_1G_3H_1H_2$	2		
	$\Delta = 1 - [L_{11}+L_{12}+L_{13}+L_{14}] + L_{21}$ $= 1 + G_1H_1 + G_3H_2 + G_1G_2G_3H_3 + G_3G_4H_3 + G_1G_3H_1H_2$.			
	$\therefore \frac{C(s)}{R(s)} = \frac{M_1\Delta_1 + M_2\Delta_2}{\Delta}$ $= \frac{G_1G_2G_3 + G_3G_4}{1+G_1H_1+G_3H_2+G_1G_2G_3H_3+G_3G_4H_3+G_1G_3H_1H_2}$.	2		
3	Draw the signal flow graph for the block diagram shown in fig Q3 and determine the transfer function using Mason's gain formula.  Fig Q3 Solution:  	4	CO2	L3

<table>
<tr><td></td><td>Forward path Gain

$M_1 = G_1G_3K, \quad \Delta_1 = 1.$

Individual loop Gain

$L_{11} = -G_1G_2$
$L_{12} = -KG_1G_3H$
$\Delta = 1 - [L_{11} + L_{12}] = 1 + G_1G_2 + KG_1G_3H.$

$\therefore \frac{Y(s)}{X(s)} = \frac{M_1\Delta_1}{\Delta}$

$= \frac{KG_1G_3}{1+G_1G_2+KG_1G_3H}$</td><td>1

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1

2</td><td></td><td></td></tr>
<tr><td>4</td><td>Draw the signal flow graph for the electrical network shown in fig Q4 and find its transfer function

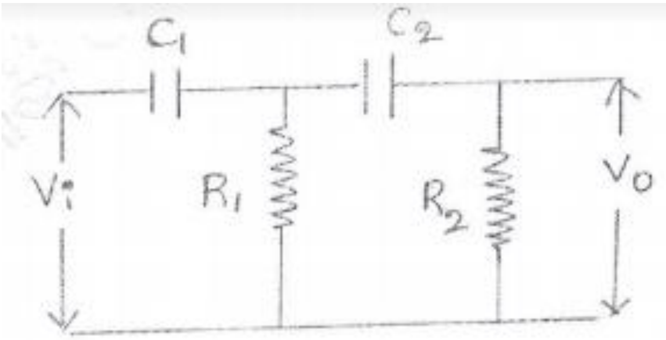
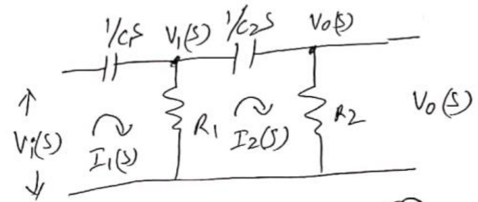



Fig Q4
Solution:
4)

$V_0(s) = I_2(s)R_2$ — ①.
$I_2(s) = [V_1(s) - V_0(s)]C_2s = V_1(s)C_2s - V_0(s)C_2s$ — ②
$V_1(s) = I_1(s)R_1 - I_2(s)R_1$ — ③.</td><td>4</td><td>CO2</td><td>L3</td></tr>
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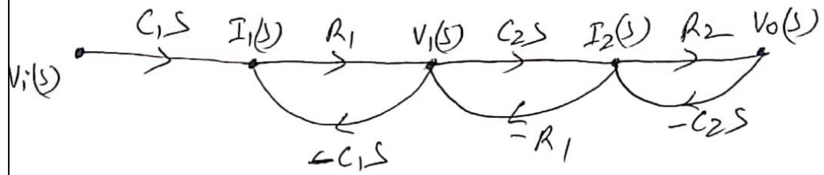
$$I_1(s) = [V_i(s) - V_1(s)]\,C_1 s = V_i(s)C_1 s - V_1(s)C_1 s \quad \text{--- } (4)$$

From (1), (2), (3), (4).



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Forward Path Gain:-

$$M_1 = R_1 R_2 C_1 C_2 s^2, \quad \Delta_1 = 1.$$

Individual loop Gains

$$L_{11} = -R_1 C_1 s.$$

$$L_{12} = -R_1 C_2 s$$

$$L_{13} = -R_2 C_2 s$$

Two Non-Touching loop Gains 2

$$L_{21} = R_1 R_2 C_1 C_2 s^2$$

	$\Delta = 1 - [L_{11} + L_{12} + L_{13}] + L_{21}$ $= 1 + R_1C_1S + R_1C_2S + R_2C_2S + R_1R_2C_1C_2S^2.$ $\therefore \frac{V_o(s)}{V_i(s)} = \frac{M_1\Delta_1}{\Delta}$ $= \frac{R_1R_2C_1C_2s^2}{1 + R_1C_1S + R_1C_2S + R_2C_2S + R_1R_2C_1C_2s^2}$ $\frac{V_o(s)}{V_i(s)} = \frac{R_1R_2C_1C_2s^2}{R_1R_2C_1C_2s^2 + (R_1C_1 + R_1C_2 + R_2C_2)s + 1}$	2		
5	Obtain the expression for time response of the first order system subjected to unit step input and unit impulse input. Solution: Unit Step Input. $\frac{C(S)}{R(S)} = \frac{1}{1+TS} = \frac{1/T}{S + \frac{1}{T}}$ $C(S) = R(S) \frac{1/T}{S + \frac{1}{T}}$ Unit Step Input, $R(S) = \frac{1}{S}$ $C(S) = \frac{1}{S} \times \frac{1/T}{S + 1/T}$ By Partial Fraction Expansion,	2	CO3	L3

	$C(S) = \frac{A}{S} + \frac{B}{S+\frac{1}{T}}$ $\frac{A}{S} = \frac{1/T}{S(S+1/T)}$ $A = \frac{1/T}{\cancel{S}(S+1/T)} \times \cancel{S} \Big]_{S=0}$ $A = \frac{1/T}{1/T} = 1.$	2		
	$\frac{B}{S+1/T} = \frac{1/T}{S(S+\frac{1}{T})}$ $B = \frac{1/T}{S\cancel{(S+1/T)}} \cancel{(S+1/T)} \Big]_{S=-\frac{1}{T}}$ $= \frac{1/T}{-1/T} = -1.$ $\therefore C(S) = \frac{1}{S} - \frac{1}{S+1/T}$ $C(t) = L^{-1}[C(S)]$ $= 1 - e^{-t/T}$	2		

Unit Impulse:

$$C(S) = R(S)\,\frac{1/T}{S+1/T}$$

Unit Impulse, $R(S) = 1$.

$$C(S) = \frac{1/T}{S+1/T}$$

$$c(t) = L^{-1}\left[C(S)\right]$$

$$c(t) = \frac{1}{T}e^{-t/T}$$

2

2

6 Derive the output response of second order system for critically damped system and input is unit step. CO3 L3

Solution:

Critically damped, $\delta = 1$.

Step Input, $R(S) = \frac{1}{S}$.

Second order system, $\frac{C(S)}{R(S)} = \frac{\omega_n^2}{S^2 + 2\delta\omega_n S + \omega_n^2}$

Let $\delta = 1$, $\frac{C(S)}{R(S)} = \frac{\omega_n^2}{S^2 + 2\omega_n S + \omega_n^2} = \frac{\omega_n^2}{(S+\omega_n)^2}$

$$C(S) = R(S)\,\frac{\omega_n^2}{(S+\omega_n)^2}$$

$$C(S) = \frac{\omega_n^2}{S(S+\omega_n)^2} = \frac{A}{S} + \frac{B}{(S+\omega_n)^2} + \frac{C}{S+\omega_n}$$

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$$\omega_n^2 = A\frac{\cancel{s}(s+\omega_n)^2}{\cancel{s}} + B\frac{s\cancel{(s+\omega_n)^2}}{\cancel{(s+\omega_n)^2}} + C\frac{s(s+\omega_n)^{\cancel{2}\,1}}{\cancel{s+\omega_n}}$$

$$\omega_n^2 = A(s^2+2\omega_n s+\omega_n^2) + Bs + Cs(s+\omega_n)$$

$$\omega_n^2 = As^2 + A2\omega_n s + A\omega_n^2 + Bs + Cs^2 + C\omega_n s$$

$$s^2 \Rightarrow 0 = A + C$$

$$s^1 \Rightarrow 0 = A2\omega_n + B + C\omega_n$$

$$s^0 \Rightarrow \omega_n^2 = A\omega_n^2$$

$$A = 1$$

$$C = -1$$

$$0 = 2\omega_n + B - \omega_n$$

$$B = -\omega_n$$

$$\therefore C(s) = \frac{1}{s} - \frac{\omega_n}{(s+\omega_n)^2} - \frac{1}{s+\omega_n}$$

$$c(t) = L^{-1}[C(s)]$$

$$\therefore c(t) = 1 - \omega_n t e^{-\omega_n t} - e^{-\omega_n t}$$

$$\therefore \boxed{c(t) = 1 - e^{-\omega_n t}(1+\omega_n t)}$$
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