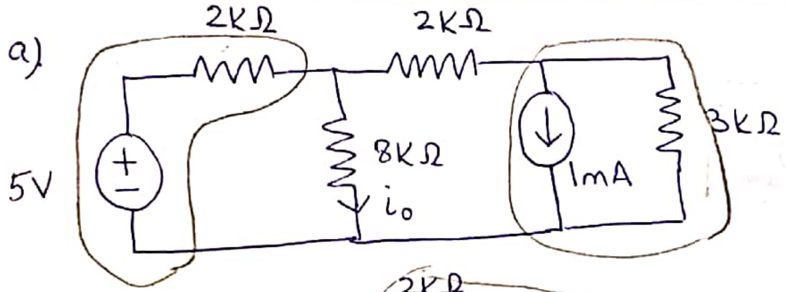
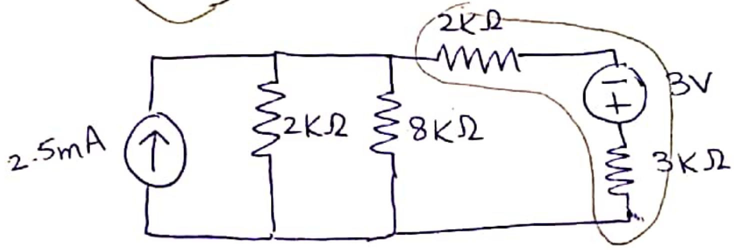
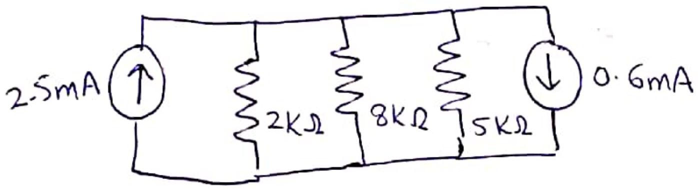
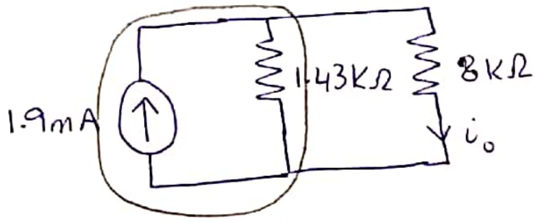
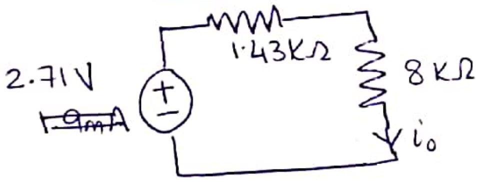
1 a)







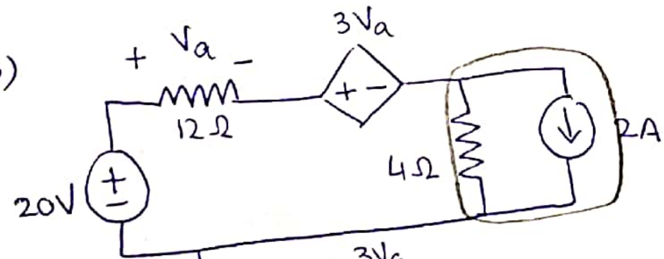


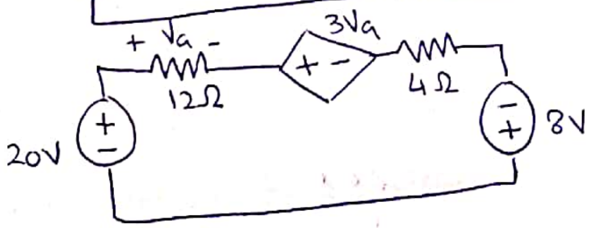


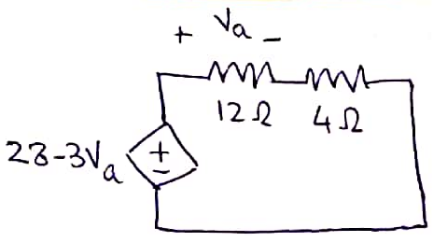
$$i_o = \frac{2.71}{(8+1.43)\times 10^3}$$

$$\boxed{i_o = 0.287\,mA}$$ ANS

b)







$$V_a = \frac{12}{16} \times (28 - 3V_a)$$

$$V_a = 21 - 2.25V_a$$

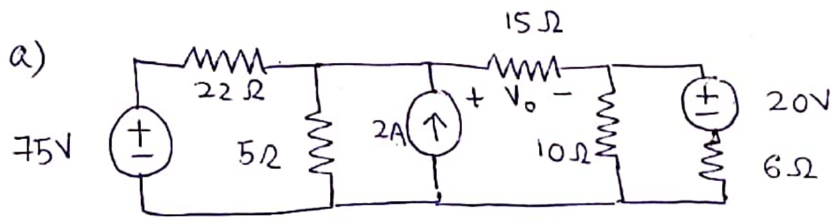
$$3.25V_a = 21$$

$$V_a = 6.46\,V$$

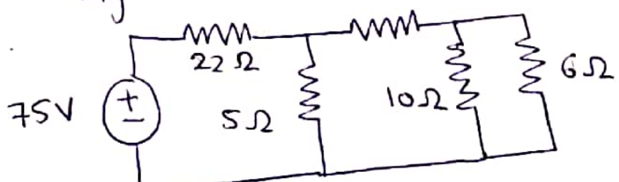
$$i_o = \frac{6.46}{12}$$

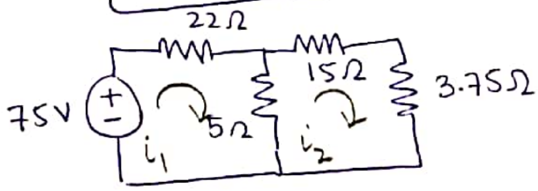
$$\boxed{i_o = 0.538A}$$

2 a)



using 75V source : 15Ω





$$75 = 22i_1 + 5i_1 - 5i_2$$

$$27i_1 - 5i_2 = 75 \quad ①$$

$$\cancel{5i_2 - 5i_2 + 15}$$

$$5i_2 - 5i_1 + 15i_2 + 3.75i_2 = 0$$

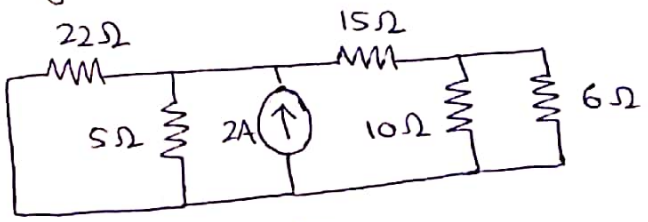
$$23.75i_2 - 5i_1 = 0 \quad ②$$

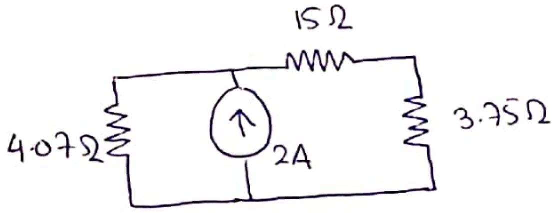
* solving ① & ② simultaneously

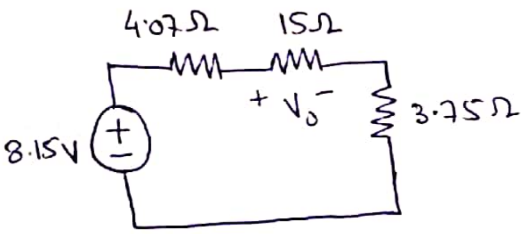
$$i_1 = 2.89\,A$$
$$i_2 = 0.609\,A$$

$$V_{o(75V)} = 15 \times 0.609 \qquad \boxed{V_{o(75)} = 9.13V}$$

Using 2A source:



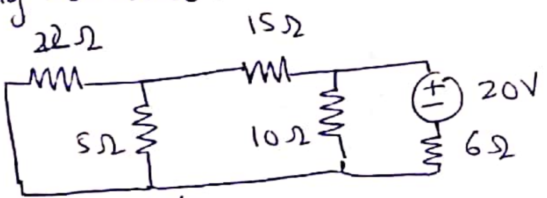


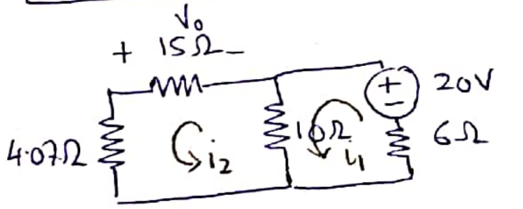


$$V_{o(2A)} = \frac{15}{15+3.75+4.07} \times 8.15$$

$$\boxed{V_{o(2A)} = 5.36\text{ V}}$$

Using 20V source:





$$20 = 6i_1 + 10i_1 - 10i_2$$

$$16i_1 - 10i_2 = 20 \quad (1)$$

$$10i_2 - 10i_1 + 15i_2 + 4.07i_2 = 0$$

$$29.07i_2 - 10i_1 = 0 \quad (2)$$

solving (1) & (2) simultaneously

$$i_2 = 0.548\text{ A}$$

since i_2 is flowing from − to +, V_o will be negative

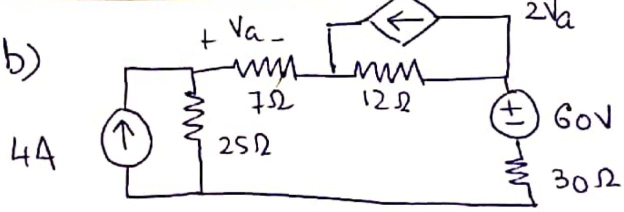
$$V_{o(20V)} = -0.548 \times 15$$

$$\boxed{V_{o(20V)} = -8.22\text{ V}}$$

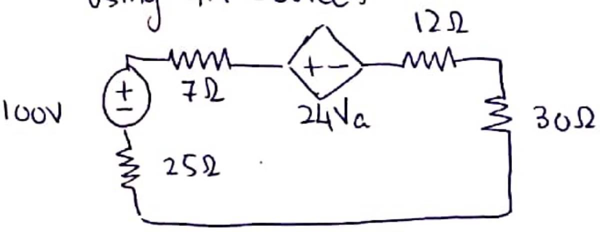
$$V_o = 9.13 + 5.36 - 8.22$$

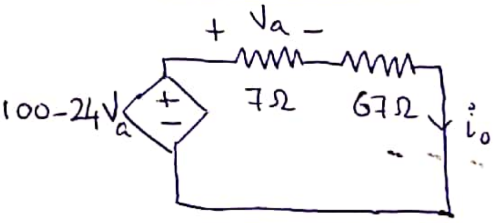
$$\boxed{V_o = 6.27\text{ V}}$$ ANS

b)



using 4A source:





$$V_a = \frac{7}{74} \times (100 - 24V_a)$$

$$74V_a = 700 - 168V_a$$

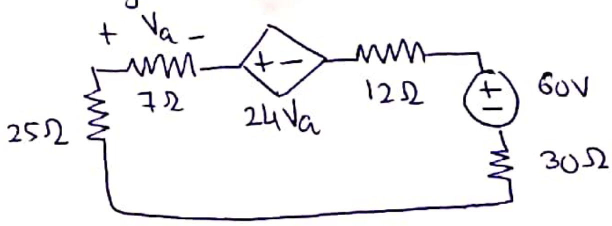
$$242V_a = 700$$

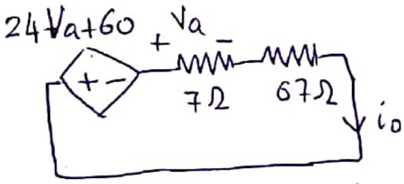
$$V_a = 2.89V$$

$$i_o(4A) = \frac{2.89}{7}$$

$$\boxed{i_o(4A) = 0.413A}$$

using 60V source:





+ since flow of current is from negative to positive in the 7Ω resistor, Va will be negative

$$V_a = -\frac{7}{74} \times (24V_a + 60)$$

$$74V_a = -168V_a - 420$$

$$242V_a = -420$$

$$V_a = -1.735V$$

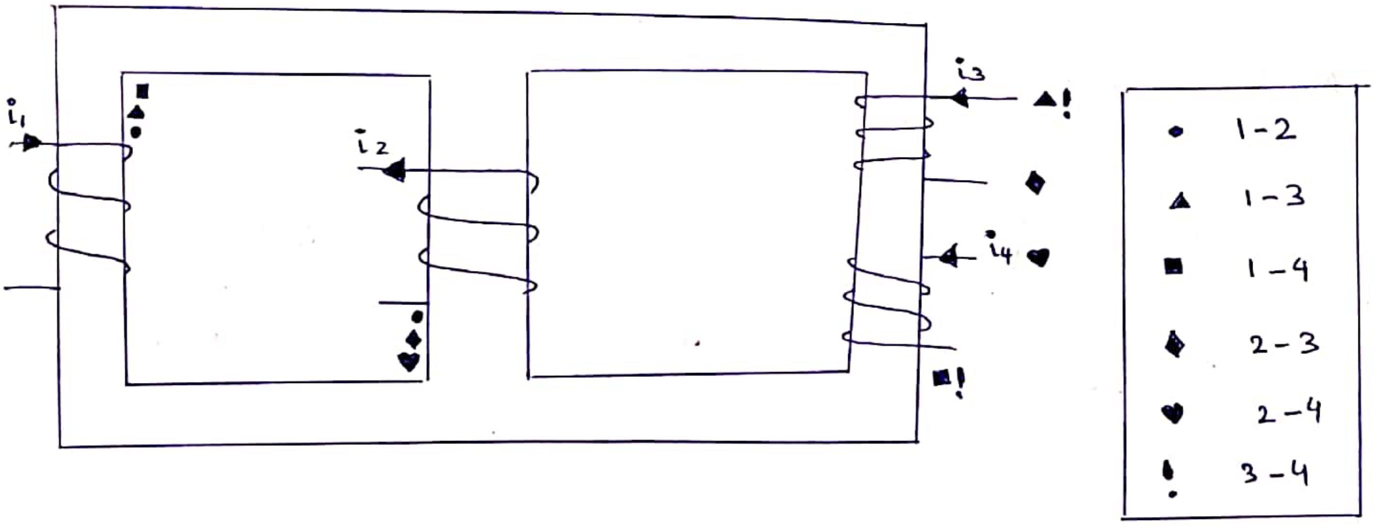
$$i_o(60V) = \frac{-1.735}{7}$$

$$\boxed{i_o(60V) = -0.243A}$$

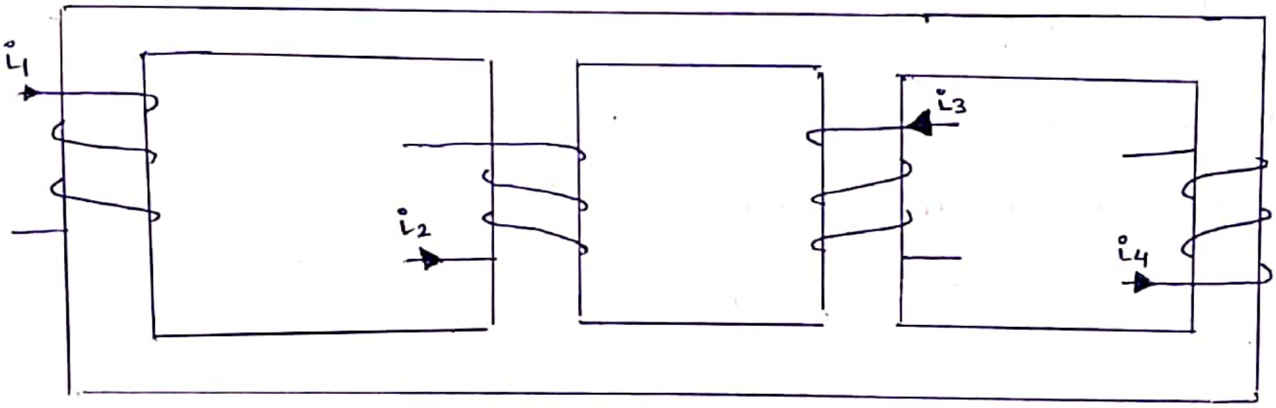
$$i_o = 0.413 - 0.243$$

$\boxed{i_o = 0.165A}$ ANS

Q3-

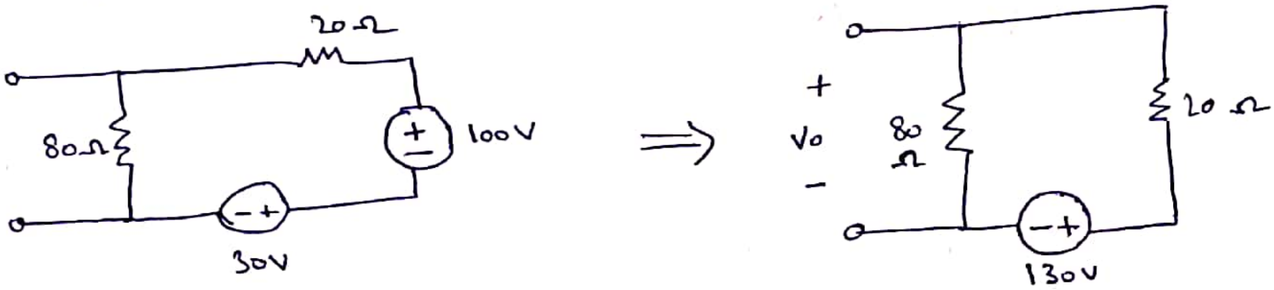


Q4.



Q5-

① Using source transformation :

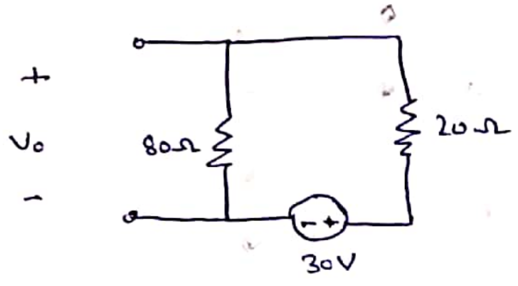


$$V_o = \frac{80}{80+20} \times 130 = 104 \text{ V}$$ Ans.

(voltage division rule)

② Using principle of superposition

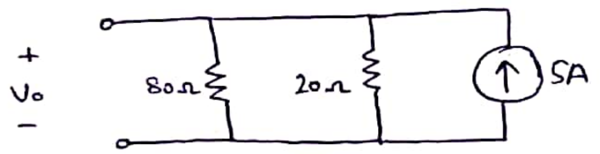
1) 5A off → open circuit



V_o using potential divider :

$$V_o = \frac{80}{80+20} \times 30 = 24\ V$$

2) 30V off → short circuit



Let current through 80Ω resistor = i_o

i_o (using current division rule)

$$= \frac{20}{80+20} \times 5 = 1\ A$$

$\therefore V_o = iR = 80\ V$

$\Rightarrow$ Total $V_o = 24 + 80$

$= 104\ V$ Ans.

30 PTS

Loop Analysis
Mutual Ind.
Graphs/Trees/Nodes

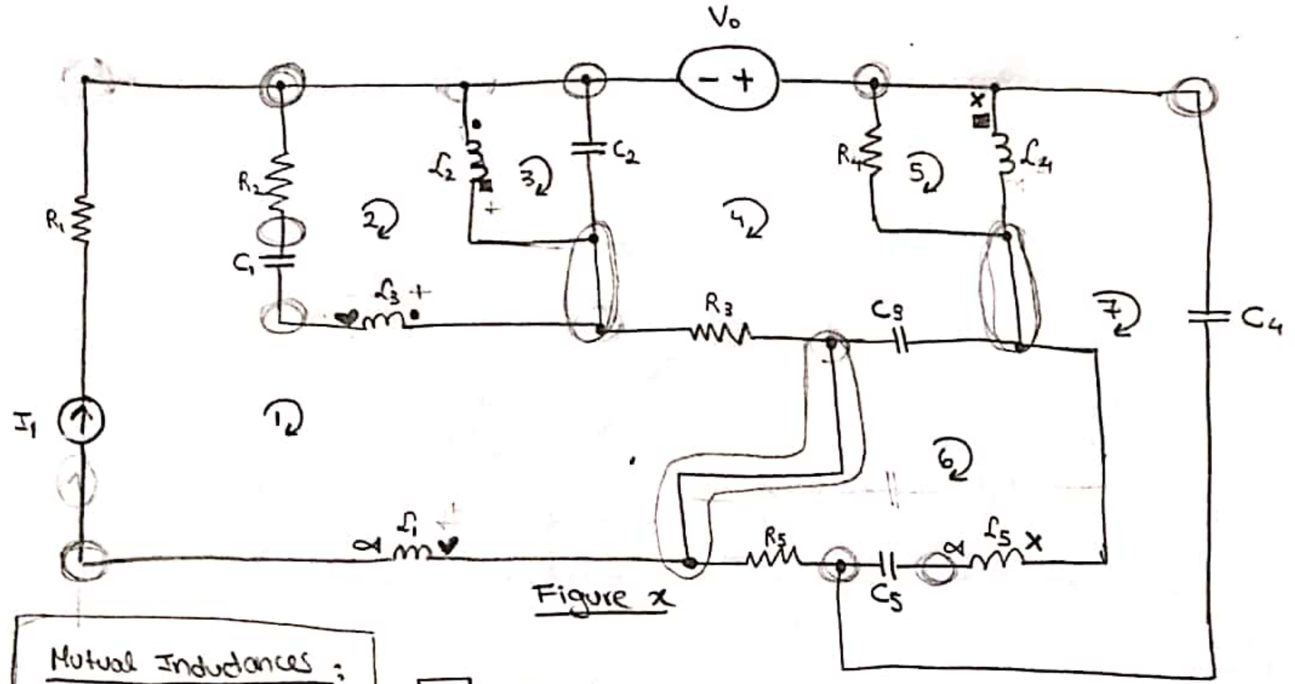


Figure x

Mutual Inductances:

$\mathcal{L}_1$ & $\mathcal{L}_3$ = M_a
$\mathcal{L}_1$ & $\mathcal{L}_5$ = M_b
$\mathcal{L}_2$ & $\mathcal{L}_3$ = M_c
$\mathcal{L}_2$ & $\mathcal{L}_4$ = M_d
$\mathcal{L}_4$ & $\mathcal{L}_5$ = M_e

Q: For the circuit
a) given below with the stipulated mutual inductances, apply Mesh Analysis to write the complete set of loop equations. You may define your own loops & loop currents. (HINT: Pay attention to dot convention)

½ pt per nonzero term in Eq. = 22pts OR 3pts per Eq.? = 21

b) For the same circuit, identify the # of nodes & label them on the diagram. How many nodal equations will this circuit yield?

(4pts) ¼ pt per node, 1pt for # of Eq.

c) GRAPHS & TREES:
1pt → i) Calculate the # of branches in this circuit
2pt ii) Draw the graph of the circuit
2pt iii) Draw a tree.

$\boxed{1}$
$$R_1(I_1) + R_2(I_1-I_2) + \frac{1}{C_1}\int(I_1-I_2)dt + \mathcal{L}_3\frac{d(I_1-I_2)}{dt} + R_3(I_1-I_4) + \mathcal{L}_1\frac{d(I_1)}{dt} + M_a\frac{d(I_1)}{dt} + M_a\frac{d}{dt}(I_1-I_2) - M_c\frac{d}{dt}(I_2-I_3) = 0$$

$\boxed{2}$
$$\frac{1}{C_1}\int(I_2-I_1)dt + R_2(I_2-I_1) + \mathcal{L}_2\frac{d}{dt}(I_2-I_3) + \mathcal{L}_3\frac{d}{dt}(I_2-I_1) - M_d\frac{d}{dt}(I_5-I_7) + M_c\frac{d}{dt}(I_2-I_1) + M_c\frac{d}{dt}(I_2-I_3) - M_a\frac{d}{dt}(I_1) = 0$$

$\boxed{3}$
$$\mathcal{L}_2\frac{d}{dt}(I_3-I_2) + \frac{1}{C_2}\int(I_3-I_4)dt - M_c\frac{d}{dt}(I_2-I_1) + M_d\frac{d}{dt}(I_5-I_7) = 0$$

$\boxed{4}$
$$R_4(I_4-I_5) + \frac{1}{C_3}\int(I_4-I_6) + R_3(I_4-I_1) + \frac{1}{C_2}\int(I_4-I_3) = V_0$$

$\boxed{5}$
$$R_4(I_5-I_4) + \mathcal{L}_4\frac{d}{dt}(I_5-I_7) + M_e\frac{d}{dt}(I_6-I_7) + M_c\frac{d}{dt}(I_3-I_2) = 0$$

$\boxed{6}$
$$\frac{1}{C_3}\int(I_6-I_4)dt + \mathcal{L}_5\frac{d(I_6-I_7)}{dt} + \frac{1}{C_5}\int(I_6-I_7)dt + R_5(I_6) + M_e\frac{d}{dt}(I_5-I_7) + M_c\frac{d}{dt}(I_1) = 0$$

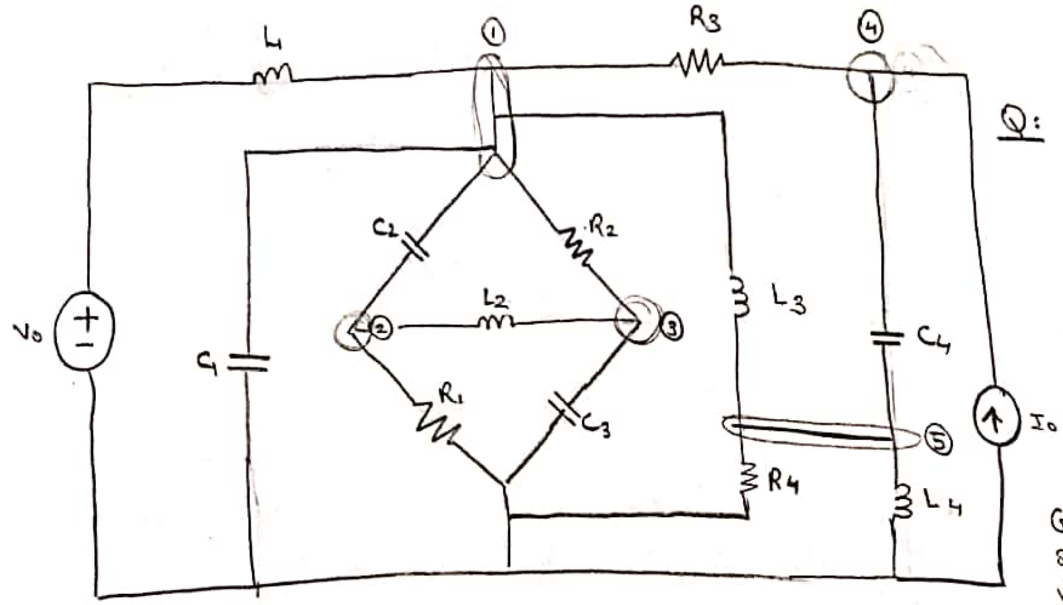
$\boxed{7}$
$$\frac{1}{C_5}\int(I_7-I_6)dt + \mathcal{L}_5\frac{d(I_7-I_6)}{dt} + \mathcal{L}_4\frac{d}{dt}(I_7-I_5) + \frac{1}{C_4}\int I_7 dt - M_d\frac{d(I_3-I_2)}{dt} + M_e\frac{d}{dt}(I_7-I_6) + M_e\frac{d}{dt}(I_7-I_5) - M_b\frac{d}{dt}(I_1) = 0$$

44

$\boxed{b}$ → labeled → Nodes = 12
Nodal Eqs = $(n-1)\underbrace{-1}_{\text{due to } V_s}$ = 10

$\boxed{c}$ Branches:
Graph:
Tree:

10 PTS
Nodal Analysis



Q: For the circuit given below, apply Kirchhoff's Current Law (KCL) to write the complete set of Nodal Equations

Goal: to test whether students can correctly visualize nodes / connections AND correctly formulate Nodal Equations

Solution:

1. $\frac{1}{L_1}\int (V_1 - V_0)\,dt + C_1\frac{dV_1}{dt} + \frac{1}{L_4}\int V_1 - V_5\,dt + C_2\frac{d(V_1 - V_2)}{dt} + \frac{V_1 - V_3}{R_1} = 0$

2. $C_2\frac{d(V_2 - V_1)}{dt} + \frac{V_2}{R_1} + \frac{1}{L_2}\int V_2 - V_3\,dt = 0$

3. $\frac{V_3 - V_1}{R_2} + C_3\frac{d(V_3)}{dt} + \frac{1}{L_2}\int V_3 - V_2\,dt = 0$

4. $\frac{V_4 - V_1}{R_3} + C_4\frac{d(V_4 - V_5)}{dt} = I_o$

5. $\frac{V_5}{R_4} + \frac{1}{L_4}\int V_5\,dt = 0$

2pts p/ Nodal Equation