9/8/22

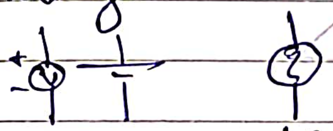
ECA

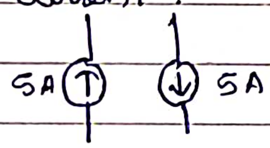
Unit 1 - Circuit simplification techniques.

Networks:
1. Active/ Passive
2. Linear/ Non-linear
3. Unilateral / Bi-lateral.

Main comp. - Resistance, Inductance, Capacitance, sources.

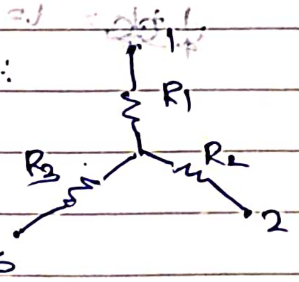
*) Sources - giving energy
1. Voltage
2. Current

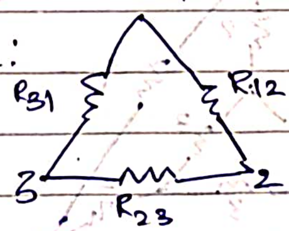
Voltage: 
DC AC.

Current: 

*) Independent Vltg/ current.
→ value is not dependent on anything.

*) Dependent
Vltg. dependent vltg source $v = kv_1$
Current " " " $v = ki_1$
Vltg " current " $i = kv_1$
Current " " " $i = ki_1$

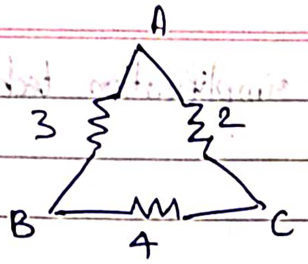
Star: 

Delta: 

S to D - $R_{12} = R_1 + R_2 + \frac{R_1R_2}{R_3}$

D to S :: $R_1 = \frac{R_{12}R_{31}}{R_{12}+R_{23}+R_{31}}$

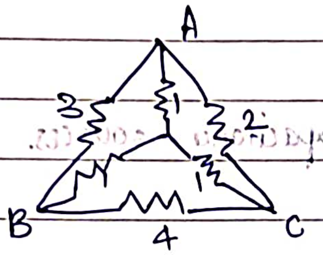
$R_{23} = R_2 + R_3 + \frac{R_2R_3}{R_1}$

Q. 

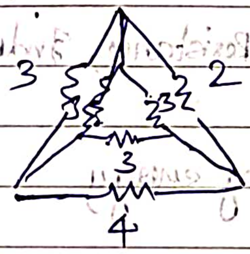
$R_{AB} = \frac{3\times 4}{3+2+4}$ $\qquad \frac{1}{6}+\frac{1}{3}$

$= \frac{12}{9}$ $\qquad = \frac{1}{6}+\frac{2}{6}$

$= \frac{4}{3}$. $\qquad = 2\,\Omega$.

Q. 

$R_{AB} = ?$



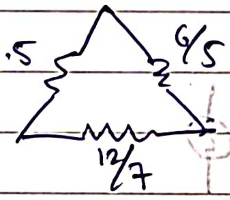
$\frac{1}{6}+\frac{1}{2}$

$\frac{1}{6}+\frac{3}{6}$

$\frac{4}{6}+\frac{2}{3}$

$\frac{4}{6}+\frac{2}{6}$

$= 1\,\Omega$.



$\frac{6}{5}+\frac{12}{7} = \frac{42+60}{35}$

$= \frac{102}{35}$

$\frac{35}{102}+\frac{1}{1.5}$

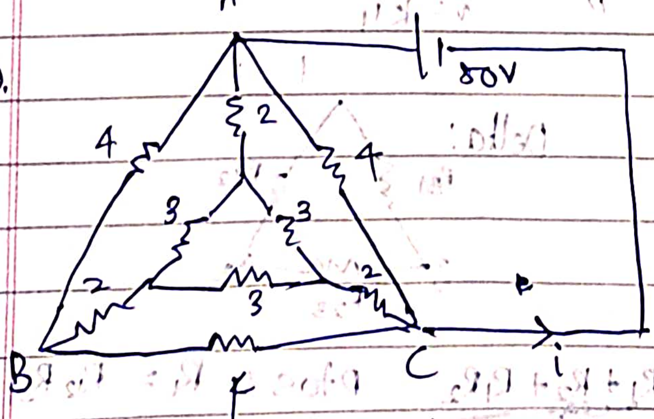
$= \frac{52.5+102}{153}$

$= \frac{153}{154.5}\,\Omega$

2.35 × 15 = 175 + 35× = 52.5

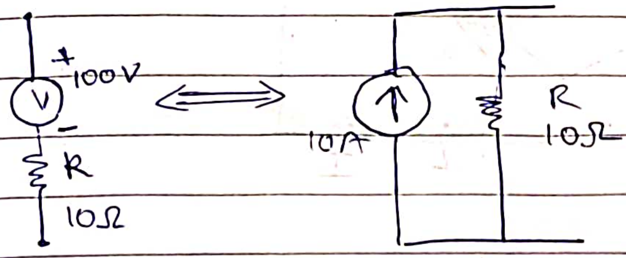
102 × 15 = 510 + 102× = 1530

52.5 + 102.0 = 154.5

Q. 

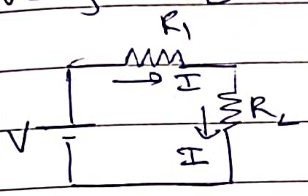
$i = ?$

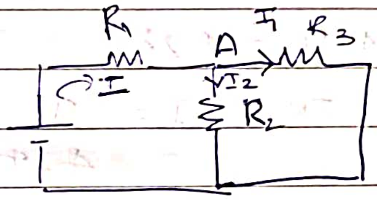
1) Source Transformation



$V = IR$ Ohm's law $I = \frac{V}{R}$

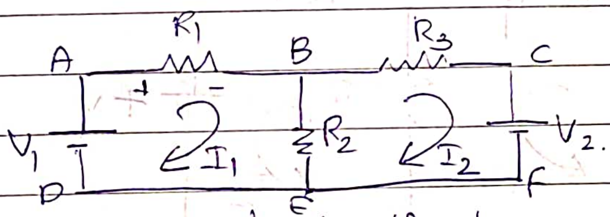
2) KVL & KCL





$V = IR_1 + IR_2$. $I = I_1 + I_2$.

Mesh analysis Nodal analysis



Let 1) assume currents in the loops

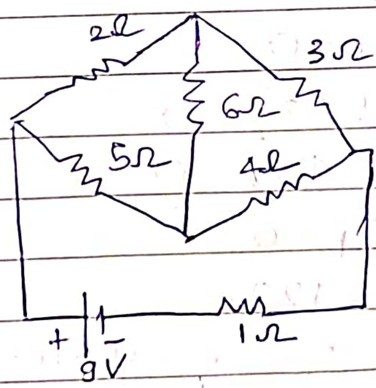
2) No. of currents assumed = no. of loops

For loop ABED.

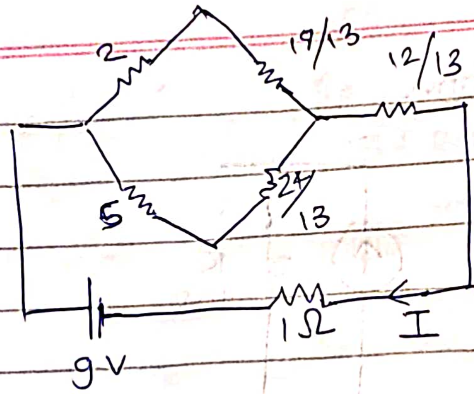
$-I_1R_1 - R_2(I_1 - I_2) + V_1 = 0$. —①

For loop BCFE

$-I_2R_3 - V_2 - R_2(I_2 - I_1) = 0$ —②



Using star-Delta conversion calculate current in 1Ω resis.



3.38   6.84

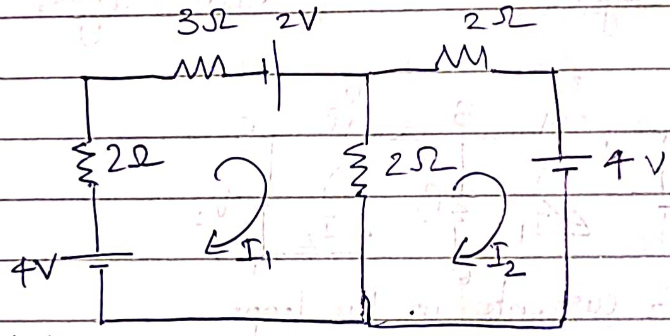
0.29 + 0.14 : 0.43

= 2.32.

3.24 + 1 = 4.24

V = IR $I = \frac{9}{4.24}$

= 2.12 A.



Calculate current in 3Ω series using KVL eqn.

Soln:

$4 - 2I_1 - 3I_1 + 2 - 2(I_1 - I_2) = 0$ — ①

$-2I_2 - 4 - 2(I_2 - I_1) = 0$ — ②

$4 - 7I_1 + 2 + 2I_2 = 0$ $-4 - 4I_2 + 2I_1 = 0$

$6 - 7I_1 + 2I_2 = 0$

$-4I_2 - 6 + 2I_1 = 0$

$12 - 14I_1 + \cancel{4I_2} = 0$

$-6 + 2I_1 - \cancel{4I_2} = 0$

$6 - 12I_1 = 0$

$6 = 12I_1$

$I_1 = \frac{1}{2} = 0.5A.$

$6 - 7I_1 + 2I_2 = 0$

$6 = 7I_1 - 2I_2$

$4 = 2I_1 - 4I_2$

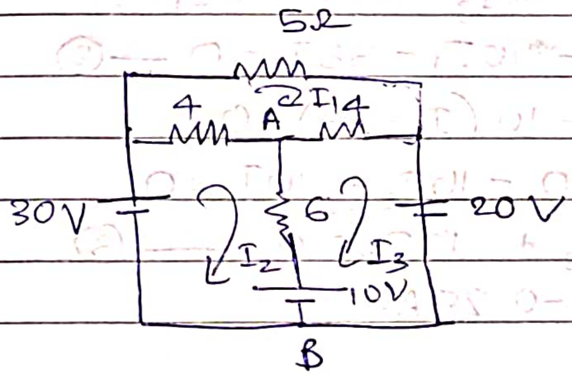
$12 = 14I_1 - \cancel{4I_2}$

$-4 = -2I_1 + \cancel{4I_2}$

$8 = 12I_1$

$I_1 = \frac{\cancel{8}^{2}}{\cancel{12}\,3}$

$$\boxed{I_1 = \frac{2}{3} A}$$



Calculate current in AB.

$\frac{\cancel{30}^{15}}{\cancel{4}\,2}$

$-5I_1 - 4(I_1 - I_3) - 4(I_1 - I_2) = 0$

$-13I_1 - 4I_3 - 4I_2 = 0$

$30 - 4(I_2 - I_1) - 6(I_2 - I_3) - 10 = 0$

$30 - 10I_2 - 4I_1 - 6I_3 - 10 = 0$

$20 - 10I_2 - 4I_1 - 6I_3 = 0$

$-4(I_3 - I_1) - 20 + 10 - 6(I_3 - I_2) = 0$

$-10I_3 - 4I_1 - 10 - 6I_2 = 0$

$10 = -4I_1 - 6I_2 - 10I_3$

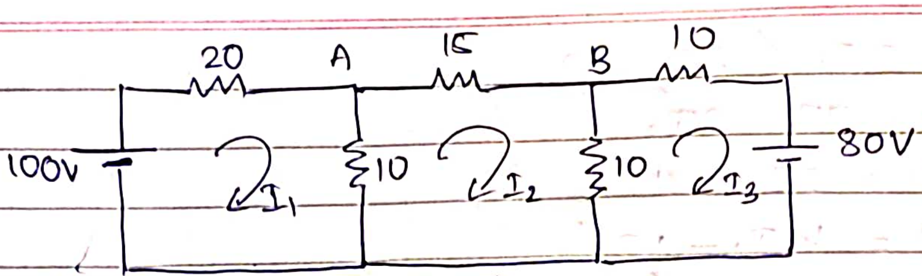
$20 = \cancel{4I_1} + 10I_2 + 6I_3$

$30 = 4I_2 - 4I_3$

$7.5 = I_2 - I_3$

$I_2 = 7.5 + I_3$

Ans: 1.86A.



$I_{AB} = ?$ Using KVL

$100 - 20I_1 - 10(I_1 - I_2) = 0$

$100 - 20I_1 - 10I_1 + 10I_2 = 0$

$100 - 30I_1 + 10I_2 = 0$ —— ①

$-15I_2 - 10(I_2 - I_3) - 10(I_2 - I_1) = 0$

$-15I_2 - 10I_2 + 10I_3 - 10I_2 + 10I_1 = 0$

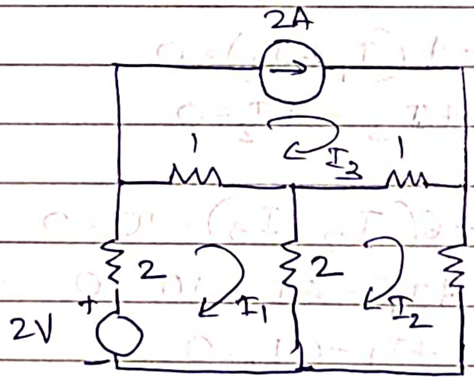
$10I_3 + 10I_1 - 35I_2 = 0$ —— ②

$-10I_3 - 80 - 10(I_3 - I_2) = 0$

$-10I_3 - 80 - 10I_3 + 10I_2 = 0$

$-80 - 20I_3 + 10I_2 = 0$ —— ③

$I_2 = -0.25A$



Case-I

Current source is not common in 2 loops.

loops - 3

$-2I_1 - \cancel{(I_1 - I_3)}\, 2(I_1 - I_2) + 2 = 0$

$\cancel{-5I_1 + 2I_2 + 2 = 0}$ —— ① $\quad -5I_1 + 2I_2 + I_3 + 2 = 0$

$-1I_2 - \cancel{(I_2 - I_3)}\, 2(I_2 - I_1) = 0$

$-4I_2 + 2I_1 = 0$ —— ② $\quad \cancel{I_1 = 2I_2}$

$\cancel{-(I_3 - I_2) - (I_3 - I_1)}$ $\quad I_3 = 2A.$

$-5I_1 + 2I_2 + 4 = 0$

$-10I_2 + 2I_2 + 4 = 0$ $\quad I_2 = 0.5A.$

$-8I_2 + 4 = 0$ $\quad I_1 = 1A.\ 1.25A$

$4 = 8I_2$

$-I_2-(I_2-I_3)-2(I_2-I_1)=0$

$-4I_2+I_3+2I_1=0$

$-4I_2+2I_1+2=0$

$2I_2-5I_1+4=0$

$\cancel{4I_2}-10I_1+8=0$

$-\cancel{4I_2}+2I_1+2=0$

$-8I_1+10=0$

$8I_1=10$

$I_1=\frac{\cancel{10}\,5}{\cancel{8}\,4}$

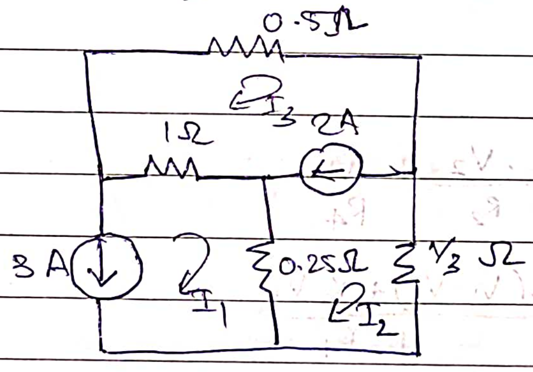
$I_1=1.25\text{ A}.$

$-4I_2+2.5+2=0$

$-4I_2+4.5=0$

$4I_2=4.5$

$I_2=1.125\text{ A}.$

Q. 

$I_1=-3\text{ A}.$

$I_3-I_2=2.$ $\quad I_3=2+I_2$

Removing 2A current source Bigger loop - supermesh

$-0.5I_3-0.33I_2-0.25(I_2-I_1)-(I_3-I_1)=0$

$-0.5I_3-0.33I_2-0.25I_2-0.75-I_3-3=0$

$-1.5I_3+0.58I_2-3.75=0$

$-1.5(2+I_2)+0.58I_2-3.75=0$

$-3-1.5I_2-0.58I_2=3.75$

~~$0.92I_2=0.75$~~ $\quad -2.08I_2=6.75$

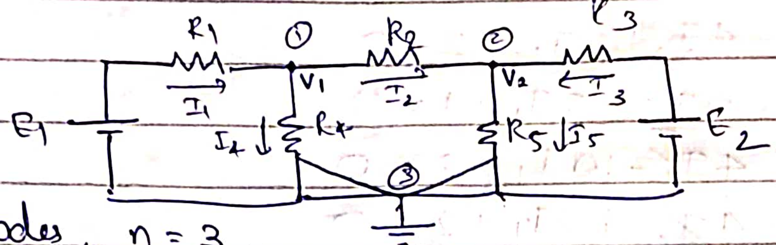
~~$I_2=0.81\text{ A}.$~~ $\quad I_2=-3.24\text{ A}.$

~~$I_3=2+0.81$~~ $\quad I_3=-1.24\text{ A}.$

~~$=2.81\text{ A}.$~~

i) Nodal Analysis

→ Based on KCL



nodes, $n = 3$

No. of eq^{ns} $= n-1 = 2$

∴ One node mark as reference/ datum/ zero potential

At node 1

$$I_1 = I_2 + I_4 \quad — ①$$

$$I_1 R_1 = E_1 - V_1$$

$$I_1 = \frac{E_1 - V_1}{R_1}$$

$$I_2 = \frac{V_1 - V_2}{R_2}$$

$$I_4 = \frac{V_1}{R_4}$$

$$\frac{E_1 - V_1}{R_1} = \frac{V_1 - V_2}{R_2} + \frac{V_1}{R_4}$$

$$\frac{E_1 - V_1}{R_1} = \frac{R_4(V_1 - V_2) + R_2 V_1}{R_2 R_4}$$

$$\frac{R_4(V_1 - V_2) + R_2 V_1}{R_2 R_4} - \frac{E_1 - V_1}{R_1} = 0$$

$$\frac{R_1 R_4(V_1 - V_2) + R_1 R_2 V_1 - R_2 R_4 (E_1 - V_1)}{R_1 R_2 R_4} = 0$$

$$R_1 R_4 (V_1 - V_2) + R_1 R_2 V_1 - R_2 R_4 (E_1 - V_1) = 0$$

$$V_1\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_4}\right) - \frac{V_2}{R_2} - \frac{E_1}{R_1} = 0$$

$\frac{1}{3} + \frac{1}{0.1}$

$\frac{1}{3} + 2$

$= 2.33$

At node 2

$$I_5 = I_2 + I_3 \quad — ②$$

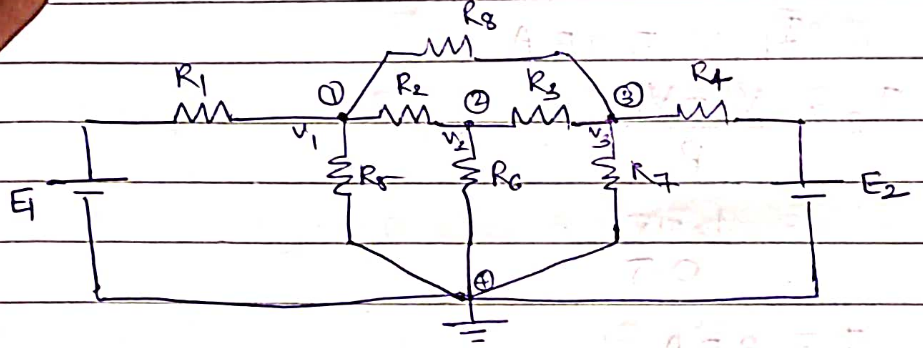
$$I_3 = \frac{E_2 - V_2}{R_3}$$

$$I_5 = \frac{V_2}{R_5}$$

$$\frac{V_2}{R_5} = \frac{V_1 - V_2}{R_2} + \frac{E_2 - V_2}{R_3}$$

$$V_2\left(\frac{-1}{R_2} - \frac{1}{R_3} - \frac{1}{R_5}\right) + \frac{V_1}{R_2} + \frac{E_2}{R_3} = 0.$$

$$V_2\left(\frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_5}\right) - \frac{V_1}{R_2} - \frac{E_2}{R_3} = 0.$$



$n = 4$

$eq^{ns} = 3$

Node 1

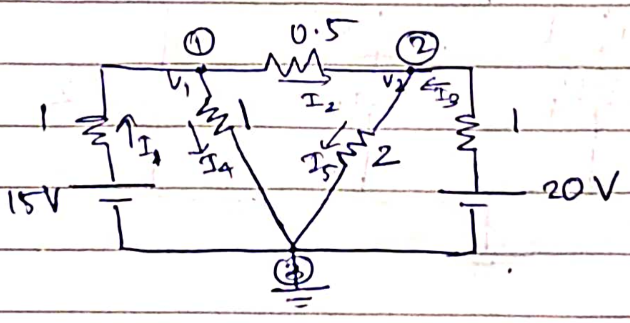
$$V_1\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_5} + \frac{1}{R_8}\right) - \frac{V_2}{R_2} - \frac{E_1}{R_1} - \frac{V_3}{R_8} = 0.$$

Node 2.

$$V_2\left(\frac{1}{R_1} + \frac{1}{R_3} + \frac{1}{R_6}\right) - \frac{V_2}{R_3} - \frac{V_1}{R_2} = 0$$

Node 3

$$V_3\left(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_7} + \frac{1}{R_8}\right) - \frac{V_2}{R_3} - \frac{E_2}{R_4} - \frac{V_1}{R_8} = 0.$$



Calculate total power consumed by all passive elements.

Node 1: $V_1(1 + 1 + 2) - 2V_2 - 15 = 0$

$4V_1 - 2V_2 - 15 = 0$

Node 2: $V_2\left(\frac{1}{1}+\frac{1}{2}+\frac{1}{0.5}\right)-20-2V_1=0$

$V_2(3.5)-20-2V_1=0$

$3.5V_2-2V_1-20=0.$

$V_1=\frac{37}{4}$ $V_2=11$

$I_1=\frac{E_1-V_1}{R_1}=\frac{15-37/4}{1}$

$I_1=5.75A$

$I_2=\frac{V_2-V_1}{R_2}$

$=\frac{1.75}{0.5}$

$I_2=3.5A$

$I_3=\frac{E_2-V_2}{R_4}=\frac{20-11}{1}=9A.$

$I_4=\frac{37}{4}=9.25A$ $I_5=\frac{V_2}{2}=\frac{11}{2}=5.5A.$

$I=33A.$

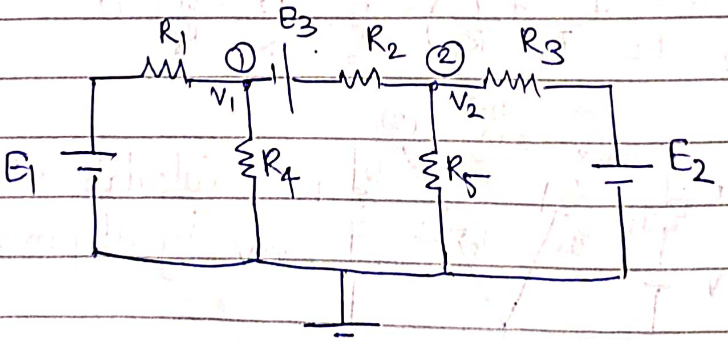
$P=(I_1^2\cdot 1)+I_2^2(0.5)+I_3^2\cdot 1+I_4^2\cdot 1+I_5^2 2$

$=\cancel{12.25+6.125+81+30.25+}$

$=33.0625+6.125+81+85.5625+60.5$

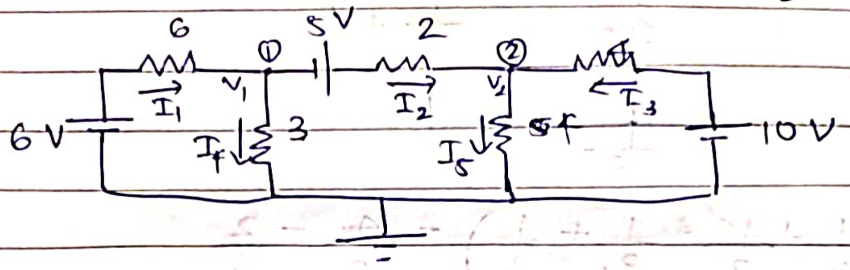
$=\cancel{20\ldots}\ 266.25$

Q.



Node 1: $V_1\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_4}\right)-\frac{V_2}{R_2}-\frac{E_1}{R_1}+\frac{E_3}{R_2}=0$

Node 2: $V_2\left(\frac{1}{R_2}+\frac{1}{R_3}+\frac{1}{R_5}\right)-\frac{V_1}{R_1}-\frac{E_2}{R_3}-\frac{E_3}{R_2}=0.$



Find all branch current.

Node 1: $V_1\left(\frac{1}{6}+\frac{1}{3}+\frac{1}{2}\right)-\frac{V_2}{2}-\frac{6}{6}+\frac{5}{2}=0$

$V_1\left(\frac{1+2+3}{6}\right)-\frac{V_2}{2}-1+2.5=0$

$V_1-0.5V_2+1.5=0$

Node 2: $V_2\left(\frac{1}{2}+\frac{1}{4}+\frac{1}{45}\right)-\frac{V_1}{2}-\frac{10}{4}-\frac{5}{2}=0$

$V_2\left(\frac{10+5+4}{20}\right)-2.5-2.5-\frac{V_1}{2}=0$

$0.95V_2-0.5V_1-5=0$

$-0.5V_1+0.95V_2-5=0.$

$V_1=\frac{43}{28}$ $\quad V_2=\frac{85}{14}$

$V_1=1.53$ $\quad V_2=6.07$ $\quad I_5=1.415A.$

$V_2\left(\frac{2+1+1}{4}\right)-0.5V_1-5=0$

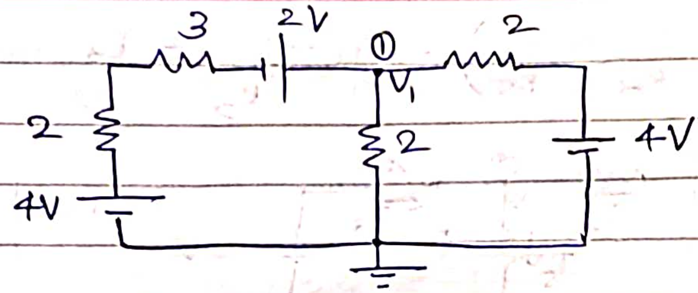
$V_2-0.5V_1-5=0$

$-0.5V_1+V_2-5=0$

$V_1=\frac{4}{3}$ $\quad V_2=\frac{17}{3}$

$I_1=\frac{6-4/3}{6}=\frac{4.67}{6}=0.77A$ $\quad I_3=\frac{10-5.66}{4}=1.085A$

$I_2=\frac{4/3+5-17/3}{2}=0.335A$ $\quad I_4=\frac{4}{9}A.$

Q. 

Find current in 3Ω.

$$V_1\left(\cancel{\frac{1}{2}}+\cancel{\frac{1}{2}}+\frac{1}{3}+\frac{1}{2}\right)-\frac{4}{2}-\frac{2}{3}$$

$$V_1\left(\frac{1}{5}+\frac{1}{2}+\frac{1}{2}\right)-\frac{4}{5}-\frac{2}{5}-\frac{4}{2}=0$$

$$\cancel{V_1\left(\frac{12}{10}\right)-4-\frac{2}{3}=0} \qquad \cancel{\frac{12}{10}V_1-\frac{14}{3}=0}$$

$$\cancel{1.2V_1-4.66=0} \qquad \cancel{\frac{12}{10}V_1=\frac{14}{3}}$$

$$\cancel{V_1=\frac{4.66}{1.2}} \qquad V_1=\frac{\cancel{14}^{7}\times 10}{3\times\cancel{12}_{6}}$$

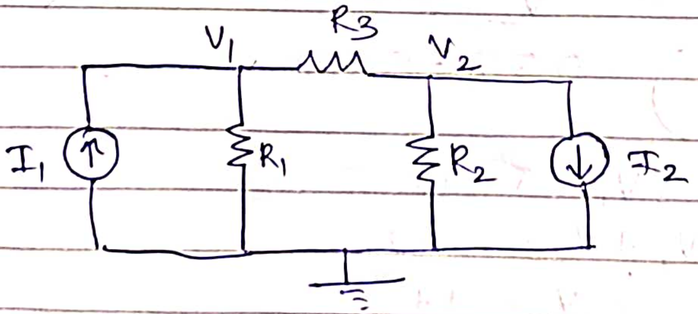
$$V_1=3.88\ V \qquad 0.8-0.6$$

$$1.2V_1-3.2=0$$

$$V_1=\frac{3.2}{1.2}$$

$$V_1=2.66\ V$$

$$I_1=\frac{4+2-2.66}{5}=0.667\ A.$$

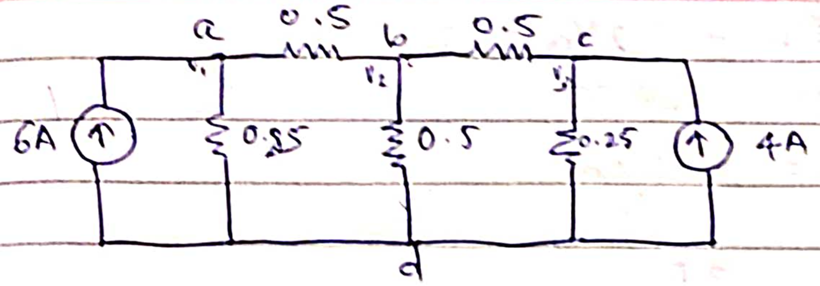
Q. 

Node 1

$$V_1\left(\frac{1}{R_1}+\frac{1}{R_3}\right)-\frac{V_2}{R_3}=I_1$$

Node 2

$$V_2\left(\frac{1}{R_2}+\frac{1}{R_3}\right)-\frac{V_1}{R_3}=-I_2$$



$I_{ab}, I_{bc}, I_{bd} = ?$

$$V_1(2+4) - 2V_2 = 6$$

$$6V_1 - 2V_2 = 6 \quad — ①$$

$$V_2(2+2+2) - 2V_1 - 2V_3 = 0$$

$$6V_2 - 2V_1 - 2V_3 = 0 \quad — ②$$

$$V_3(2+4) - 2V_2 = 4$$

$$6V_3 - 2V_2 = 4 \quad — ③$$

$$V_a = \frac{26}{21} \qquad V_b = \frac{5}{7} \qquad V_c = \frac{19}{21}$$

$$I_{ab} = (V_1 - V_2)2$$

$$= (1.23 - 0.71)2$$

$$I_{ab} = 1.04\text{ A}$$

$$I_{bc} = (V_2 - V_3)2$$

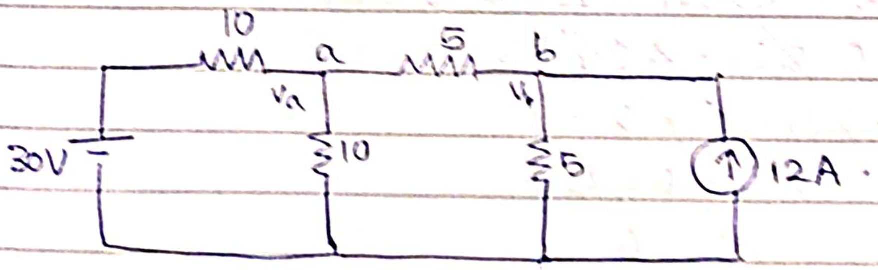
$$= (0.71 - 0.90)2$$

$$I_{bc} = -0.38\text{ A}$$

$$I_{bd} = (V_2)2$$

$$I_{bd} = 1.42\text{ A}$$

Q



$I_{ab} = ?$

$$V_a\left(\frac{1}{10} + \frac{1}{10}\right) - \frac{V_b}{5} \mp \frac{30}{10} = 0$$

$$0.2V_a - 0.2V_b \mp 3 = 0 \quad — ①$$

$$V_b\left(\frac{1}{5} + \frac{1}{5}\right) - \frac{V_a}{5} = 12$$

$$0.4V_b - 0.2V_a = 12$$

$$V_a = 90 \quad V_b = 75$$

$$I_{ab} = \frac{V_a - V_b}{5}$$

$$I_{ab} = 3A$$

$$V_a\left(\frac{1}{10} + \frac{1}{10} + \frac{1}{105}\right) - \frac{V_b}{5} - \frac{30}{10} = 0$$

$$0.3V_a - 0.2V_b - 3 = 0$$

$$0.4V_a - 0.2V_b = 3 \quad \text{— (1)}$$

$$\cancel{V_a = 45} \quad \cancel{V_b = \frac{105}{2} = 52.5}$$

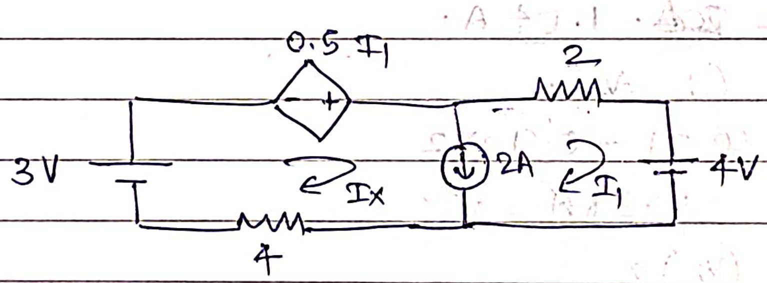
$$\cancel{I_{ab} = \frac{45 - 52.5}{5}}$$

$$\cancel{I_{ab} = -2.25A}$$

$$V_a = 30 \quad V_b = 45$$

$$I_{ab} = -3A.$$

Q.



Calculate ~~usin~~ I_1 using KVL eq^ns.

Sol^n:

$$3 + 0.5I_1 + 2 - 4I_x = 0$$

$$0.5I_1 - 4I_x + 5 = 0 \quad \text{— (1)}$$

$$-2I_1 - 4 - 2 = 0$$

$$-2I_1 - 6 = 0$$

$$-2I_1 = 6$$

$$\boxed{I_1 = -3A}$$

$$0.5(-3) - 4I_x + 5 = 0$$

$$-1.5 + 5 - 4I_x = 0$$

$$3.5 - 4I_x = 0$$

$$I_x = -0.87A.$$

$I_x = I_1 + 2$ $\qquad I_1 - I_x + 2 = 0$ — (1)

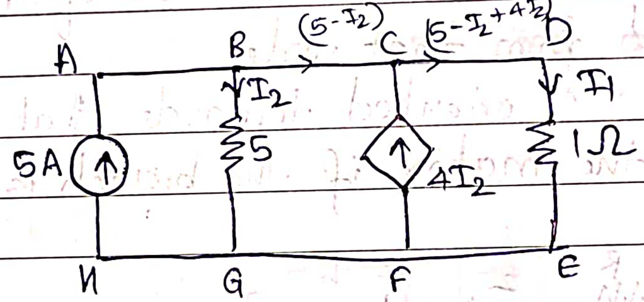
$3 + 0.5I_1 - 2I_1 - 4 - 4I_x = 0$

$-1.5I_1 - 4I_x - 1 = 0$ — (2)

$I_1 = -\frac{18}{11} A = -1.6 A$

$I_x = \frac{4}{11} A.$

$= 0.36 A.$

Q. 

Find I_1 & I_2

Sol^n:

$I_1 = 5 + 3I_2.$ — (1)

$I_1 - 3I_2 = 5$

loop BDEGB.

$-I_1 + 5I_2 = 0$

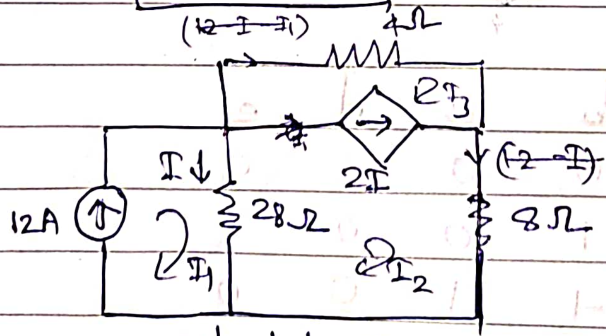
$-(5+3I_2) + 5I_2 = 0$

$2I_2 - 5 = 0$

$\boxed{I_2 = 2.5 A}$

$I_1 = 5 + 3 \times 2.5$

$\boxed{I_1 = 12.5 A}$

Q. 

Calculate I

Sol^n:

~~I (12 - I - I_1 & 12 - I~~

$I_1 = 12A.$ $\qquad I_1 - I_2 = I.$

$I_2 - I_3 = 2I.$ $\qquad 12 - I_2 - I = 0.$

$-4I_3 - 8I_2 + 28I = 0$

$I_2 = -9 A.$ $\quad I_3 = -3$ $\quad I = -3A$

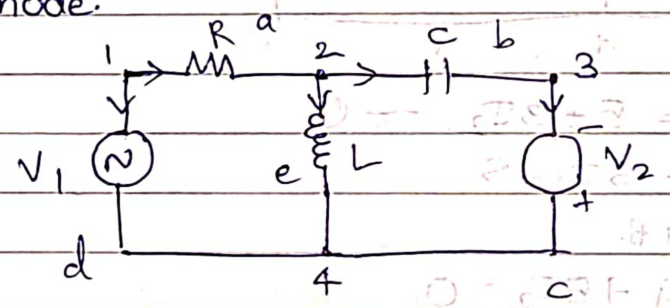
*) Incidence Matrix [Ai]

relation betn no. of branches & no. of nodes from the direction graph.

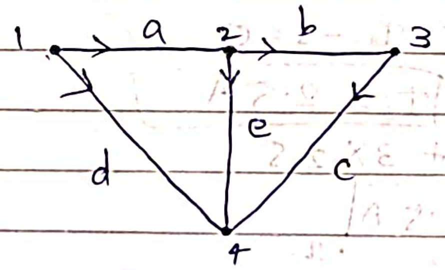
Formation of [Ai]

1. Obtain directed graph of given network.
2. Assign '+1' in the matrix if the arrow of a branch is oriented away from that node.
3. Assign '-1' ... oriented towards that node.
4. Assign '0' in the matrix if the branch is not connected to a node.

N/W



Graph,



nodes ↓ branches →

	a	b	c	d	e
1	1	0	0	1	0
2	-1	1	0	0	1
3	0	-1	1	0	0
4	0	0	-1	-1	-1

check → 1) sum of individual columns is zero.
2) Det. is zero.

Reduced Incidence Matrix $[A_r]$.

$$[A_r] = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 \\ -1 & 1 & 0 & 1 & 0 \\ 0 & -1 & 0 & 0 & 1 \end{bmatrix}$$

obtained by deleting one row from $[A_i]$.

No. of possible trees $\doteq$ det $\{[A_r][A_r]^T\}$.

$$[A_r]^T = \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

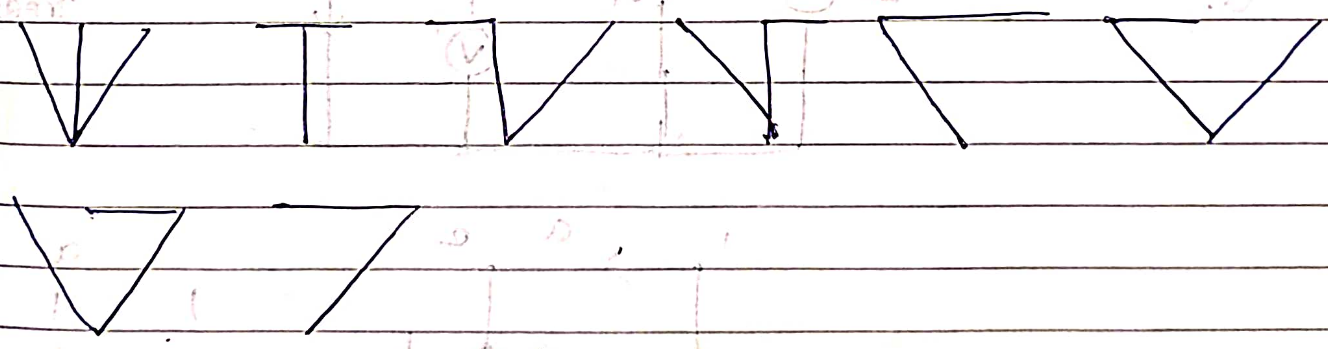
$$[A_r][A_r]^T = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 \\ -1 & 1 & 0 & 1 & 0 \\ 0 & -1 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

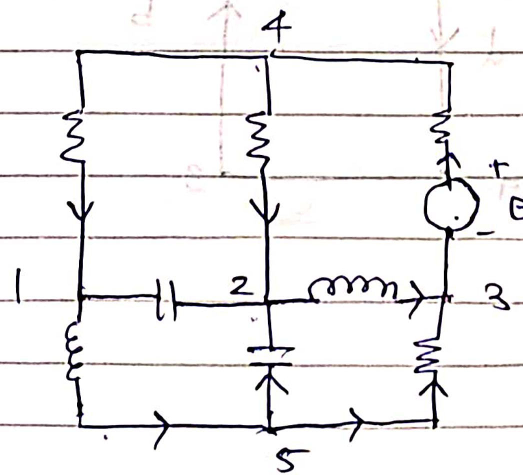
$$= \begin{bmatrix} 2 & -1 & 0 \\ -1 & 3 & -1 \\ 0 & -1 & 2 \end{bmatrix}$$

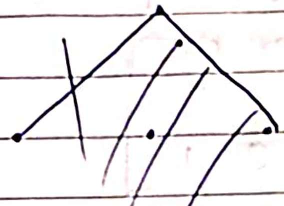
$\text{Det} = 2(5) + 1(-2)$

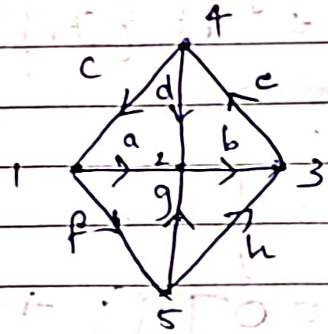
$\text{Det} = 8$

$\therefore$ 8 trees possible.



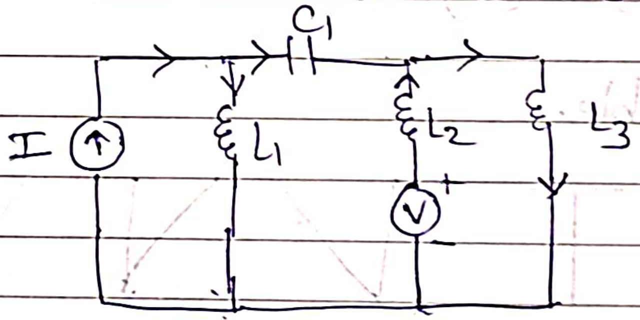




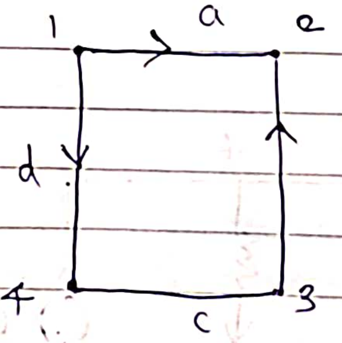


	a	b	c	d	e	f	g	h
1	1	0	-1	0	0	1	0	0
2	-1	1	0	-1	0	0	-1	0
3	0	-1	0	0	1	0	0	-1
4	0	0	1	1	-1	0	0	0
5	0	0	0	0	0	-1	1	1

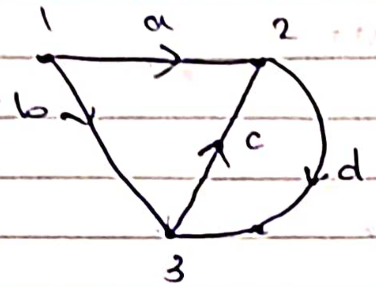
Q.



Possible no. of trees = ?



	a	b	c	d
1	1	0	0	1
2	-1	-1	0	0
3	0	1		
4				



	a	b	c	d
1	1	1	0	0
2	-1	0	-1	1
3	0	-1	1	-1

$$A_r = \begin{bmatrix} 1 & 1 & 0 & 0 \\ -1 & 0 & -1 & 1 \end{bmatrix}$$

$$[A_r]^T = \begin{bmatrix} 1 & -1 \\ 1 & 0 \\ 0 & -1 \\ 0 & 1 \end{bmatrix}$$

$$[A_r]\,[A_r]^T = \begin{bmatrix} 1 & 1 & 0 & 0 \\ -1 & 0 & -1 & 1 \end{bmatrix} \begin{bmatrix} 1 & -1 \\ 1 & 0 \\ 0 & -1 \\ 0 & 1 \end{bmatrix}$$

$$= \begin{bmatrix} 2 & -1 \\ -1 & 3 \end{bmatrix}$$

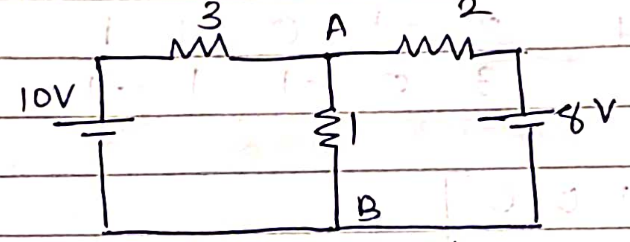
$$\text{Det} = 6 - 1 = 5.$$

29/09/22

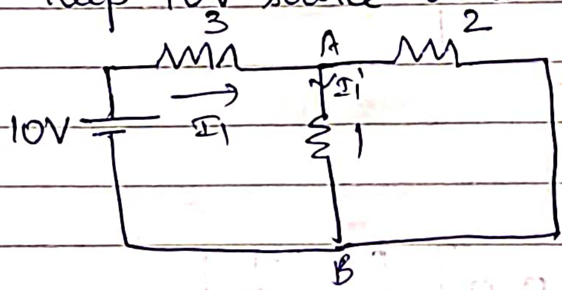
Unit 2

Network Theorems

Superposition Theorem.



Step 1: Keep 10V source alone.



$$1 \parallel 2 = 2/3$$

$$I_1 = \frac{10}{3 + 2/3}$$

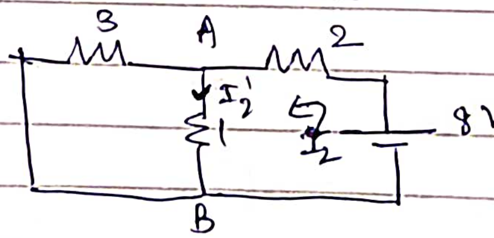
$$= \frac{30}{11}$$

$$I_1 = 2.72 A.$$

$$I_1' = -2.727 \times \frac{2}{2+1}$$

$$= 1.81 A$$

Step 2: Connect 8V source



$$3 \parallel 1 = 3/4$$

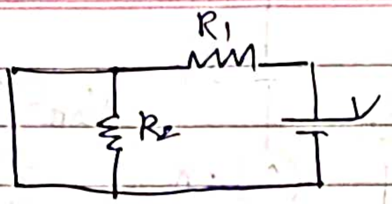
$$I_2 = \frac{8}{2 + 3/4}$$

$$I_2 = 2.909 A.$$

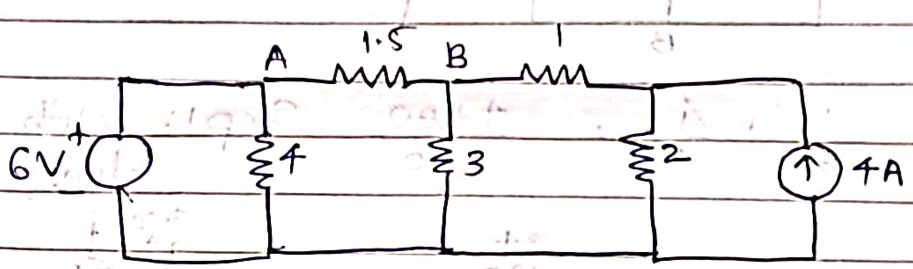
$$I_2' = 2.909 \times \frac{3}{3+1}$$

$$I_2' = 2.181 A \downarrow$$

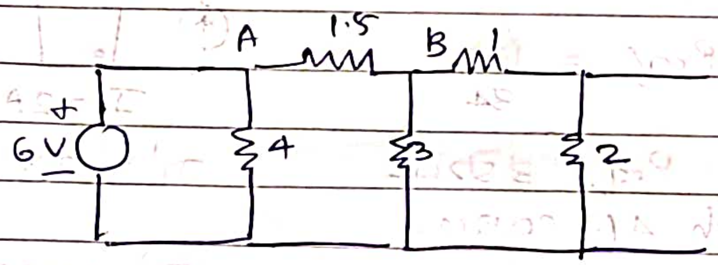
$$\therefore I_{AB} = I_1' + I_2'$$
$$= 1.81 + 2.18$$
$$= 3.99 A.$$



S.C. = Resis = 0.
R_2 = Redundant branch.

Q. 

$I_{AB} = ?$
By superposition Th^m.

Sol^n 

$\frac{1}{3} + \frac{1}{4} \Rightarrow \frac{4+3}{12}$

$\frac{12}{7}$

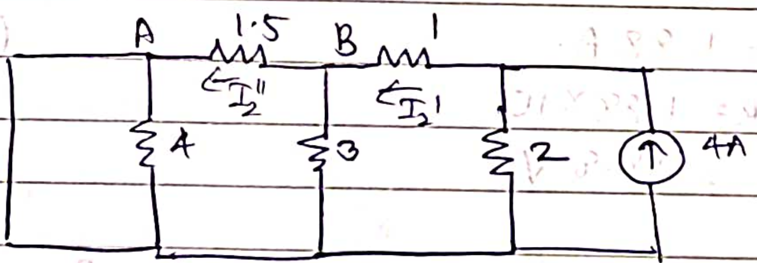
$I_1 = \frac{6}{12/7}$

$= 3.5A.$

$I_1' = 3.5 \times \frac{4}{4+1.5+1.5}$

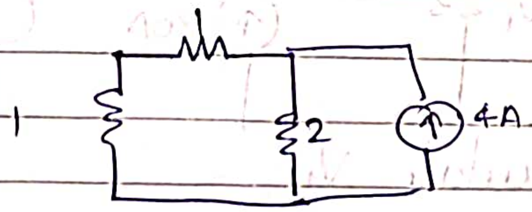
$I_1' = 2A \longrightarrow$

$I_{AB} = 2 - 1.33$
$= 0.66A.$



- 4Ω is redundant.

$3 \parallel 1.5 = 1\Omega$



$I_2 = 4A$

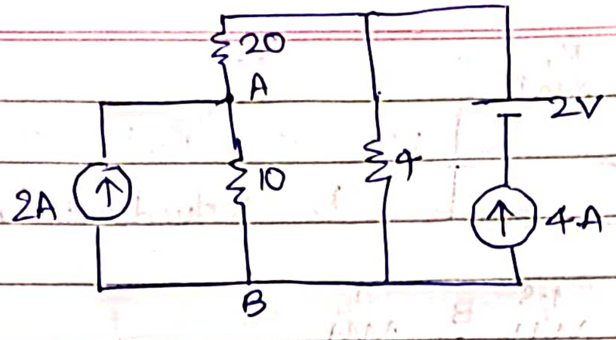
$I_2' = 4 \times \frac{2}{1+1+2}.$

$= 2A.$

$I_2'' = I_2' \times \frac{3}{3+1.5}$

$I_2'' = 1.33A \longleftarrow$

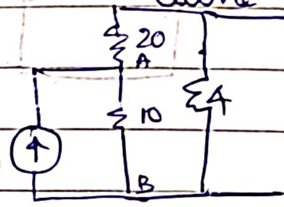
Q.



$V_{AB} = ?$ using superposition theorem.

Soln:

Step 1: With 2A source alone



$I_1 = 2A$

$I_1' = 2 \times \frac{24}{10+20+4}$

$I_1' = 1.41A \downarrow$

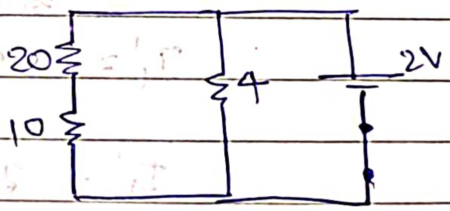
$\frac{1}{30} + \cancel{\frac{1}{4}} = \frac{4+30}{\cancel{120}}$

$= \frac{34}{\cancel{120}}$

$\cancel{Req} = \frac{\cancel{120}}{\cancel{34}}$

$Req = 3.52\,k\Omega$

Step 2: 2V alone



Current = 0

Step 3: with 4A source.

$I_2 = 4A$

$I_2' = 4 \times \frac{4}{10+20+4}$

$I_2' = 0.44A. \downarrow$

$\therefore\ I_{AB} = I_1' + I_2'$

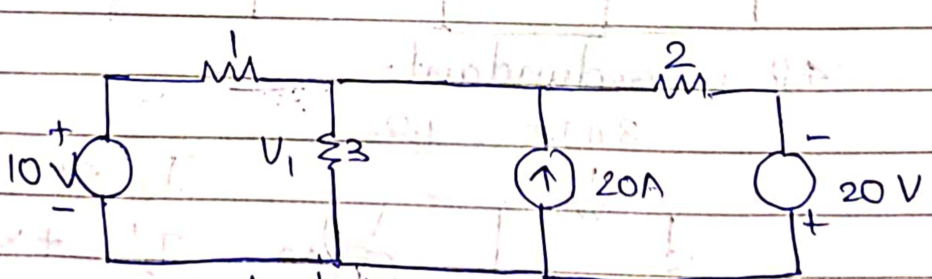
$= 1.41 + 0.44$

$= 1.88\ A.$

$V_{AB} = 1.88 \times 10.$

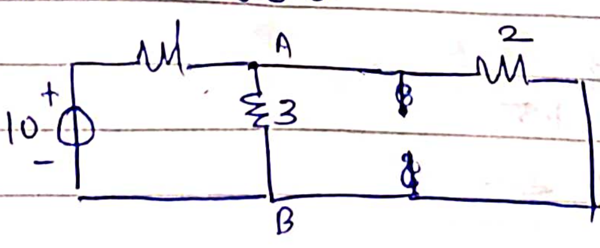
$= 18.8\ V.$

Q.



Calculate V_1

Soln: With 10V alone



$\frac{1}{3} + \frac{1}{2} \Rightarrow \frac{2+3}{6} \Rightarrow \frac{6}{5}$

$\frac{6}{5} + 1 = \frac{11}{5}.$

$I_1 = \frac{10}{11/5}$

$I_1 = \frac{50}{11}$

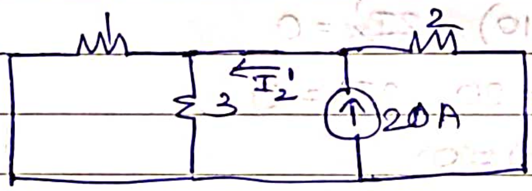
$I_1 = 4.54\ A$

$I_1' = 4.54 \times \frac{2}{3+2}$

$I_1' = 4.54 \times \frac{2}{5}$

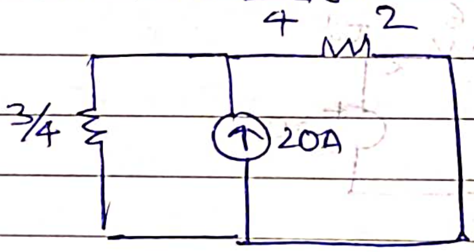
$I_1' = 1.81\ A \downarrow$

With 20A alone



$\cancel{I_2 = 20 \times 2}$

$3 \parallel 1 \Rightarrow \frac{3}{4}\ \Omega$



$I_2 = 20A$

$I_2' = 20 \times \frac{2}{2+3/4}$

$= 14.54\ A.$

$I_2'' = 14.54 \times \frac{1}{1+3}$

$= 3.63\ A \downarrow$

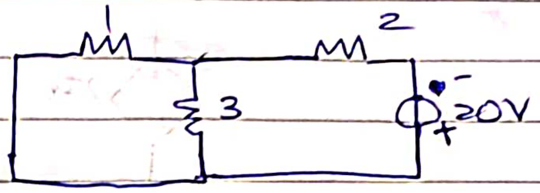
$\cancel{I_{AB} = 1.81 + 3.63 - 6.66}$

$\cancel{= 1.22\ A \uparrow}$

$\cancel{V_{AB} = 1.22 \times 3}$

$\cancel{= 3.66\ A.}$

with 20V alone



$\frac{1}{1} + \frac{1}{3} \Rightarrow \frac{3+1}{3}$

$= \frac{4}{3} = \left(\frac{3}{4}\right)$

$I_3 = \frac{20}{2+3/4}$

$= \frac{80}{3}\ A \cdot 7.27$

$\cancel{I_3' = 26.66 \times \frac{1}{1+3}}$

$\cancel{= 6.66\ A \uparrow}$

$I_3' = 7.27 \times \frac{1}{1+3}$

$= 1.81\ A \uparrow$

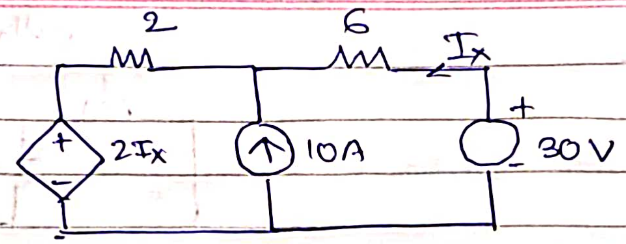
$I_{AB} = 1.81 + 3.63 - 1.81$

$= 3.63\ A.$

$V_{AB} = 3.63 \times 3$

$= 10.89\ V.$

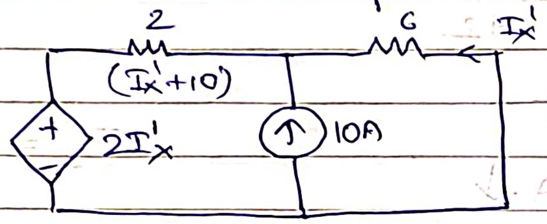
Q.



Find I_x using superposition

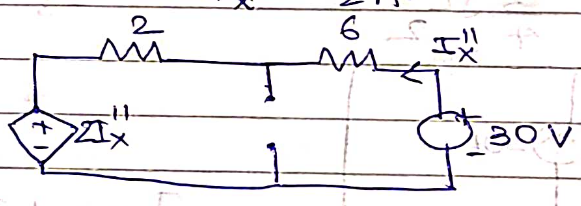
* Dependent sources are kept as it is.

Step 1:



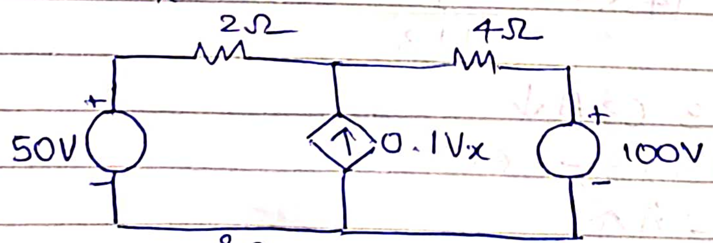
$$-6I_x' - 2(I_x'+10) - 2I_x' = 0$$
$$-6I_x' - 2I_x' - 20 - 2I_x' = 0$$
$$-10I_x' - 20 = 0$$
$$-10I_x' = 20$$
$$I_x' = -2\,A.$$

Step 2:



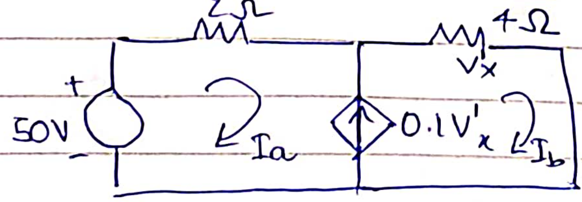
$$-6I_x'' - 2I_x'' - 2I_x'' + 30 = 0$$
$$-10I_x'' = -30$$
$$I_x'' = 3\,A.$$
$$I_x = I_x'' + I_x'$$
$$I_x = 1A$$

Q.



Calculate V_x. Using superposition.

Soln:



$I_b - I_a = 0.1V_x'$ — ①

Writing eq^n for outer loop.

$-2I_a - 4I_b + 50 = 0$

$2I_a + 4I_b = 50$

$I_a + 2I_b = 25$ — ②

$-4I_b = V_x'$ ..... from ckt diag. — ③

$\cancel{I_a}$ $I_b - I_a = 0.1V_x'$

$I_b - I_a = 0.1(-4I_b)$ — ④

$I_b - I_a = -0.4I_b$

$1.4I_b - I_a = 0$

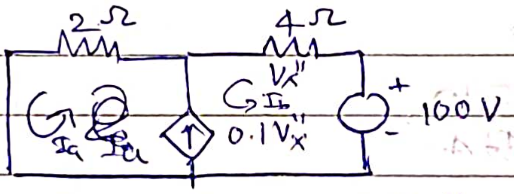
$I_a = 10.29$ $\quad$ $I_b = 7.35$ A.

$V_x' = -4I_b$

$= -4 \times 7.35$

$V_x' = -29.4$ V

Step 2:



$\cancel{I_a + I_b = -0.1V_x''}$

$I_a - I_b = 0.1V_x''$

$-4I_b - 2I_a + 100 = 0$

$2I_a + 4I_b = 100$

$I_a + 2I_b = 50$ — ①

$-4I_b = V_x''$

$I_a - I_b = 0.1(+4I_b)$

$I_a - I_b = 0.4I_b$

$I_a - 1.4I_b = 0$ — ②

$\cancel{I_a = 11.53}$ $\quad$ $I_b = 14.70$

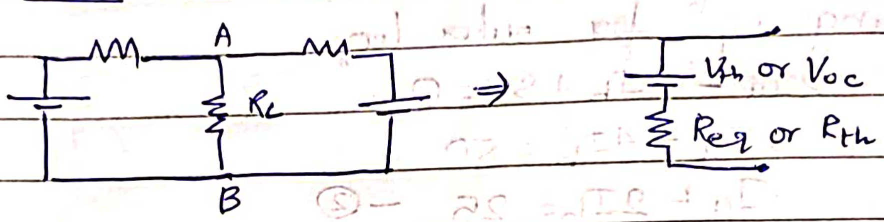
$V_x'' = 4 \times 14.70$

$V_x'' = 58.8$ V

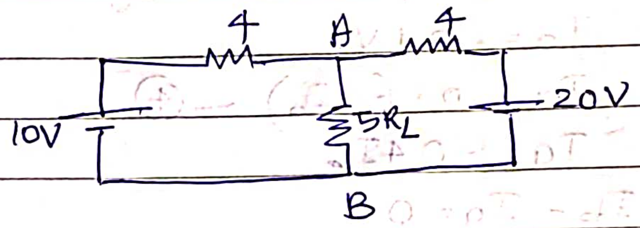
$V_x = V_x' + V_x''$

$= 29.4$ V

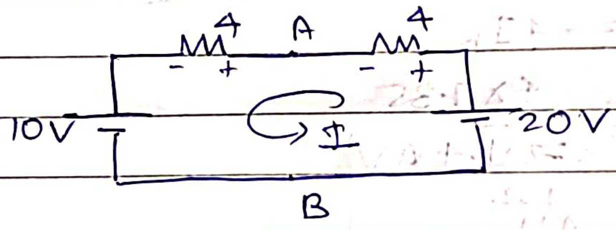
4) Thevenin's Theorem :



Load resistance (R_L).



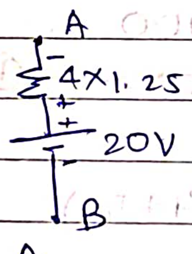
Step 1: Remove R_L.



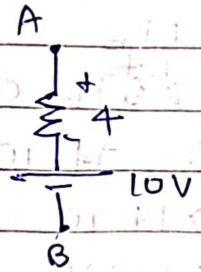
$$I = \frac{20-10}{4+4}$$

$$= \frac{10}{8}$$

$$I = 1.25A.$$



$$V_{th} = 20 - (4 \times 1.25)$$
$$= 15V.$$



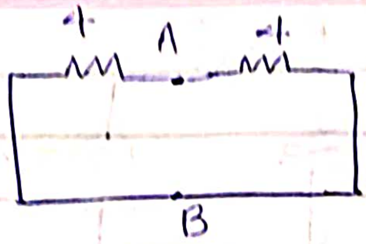
$$V_{th} = 10 + (4 \times 1.25)$$
$$= 15V.$$

$\frac{1}{3} \times \frac{1}{6}$

$\frac{2}{6} \times \frac{1}{6}$

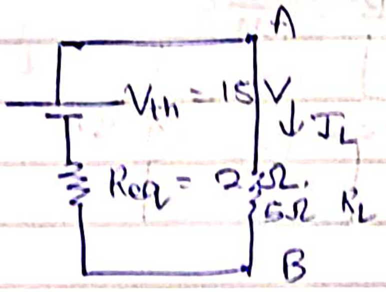
$\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{4}$

Step 2:



$R_{eq} = 4 \| 4 = 2\,\Omega$

Step 3:



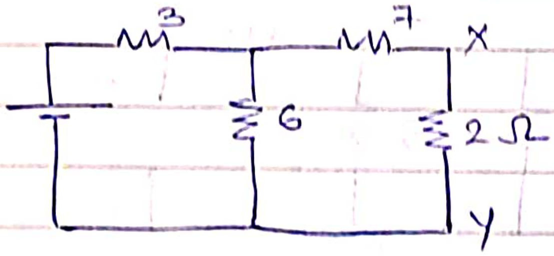
Equivalent Circuit.

$$I_L = \frac{V_{th}}{R_{eq} + R_L}$$

$$= \frac{15}{2+5}$$

$I_L = 2.14$ A.

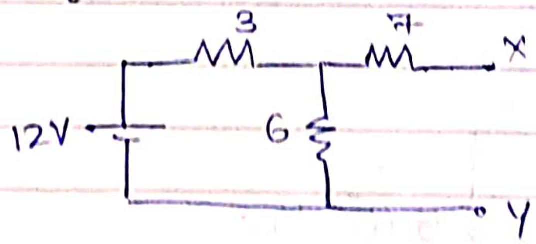
Q.

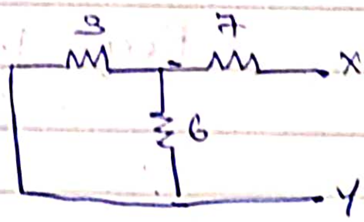


$I_{xy} = ?$ using thevenin's thm.

Sol^n:

$R_L = 2\,\Omega$.





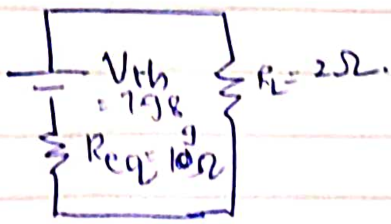
$R_{eq} = \cancel{10}\ 9\,\Omega$

$$I = \frac{12}{3+6}$$

$I = 1.33$ A

$V_{th} = 1.33 \times 6 + 7 \times 0$

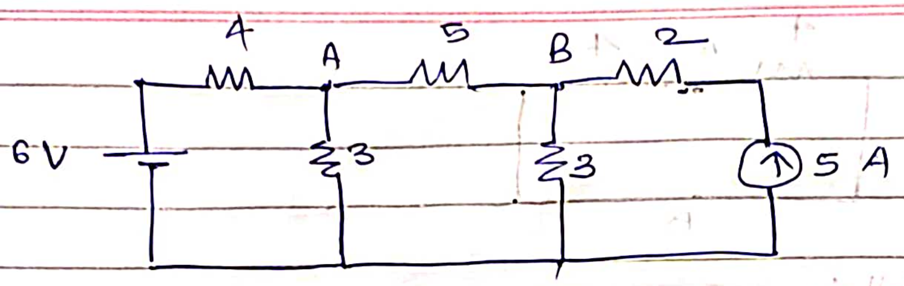
$= 7.98$ V



$$I_{xy} = \frac{7.98}{9 + 2}$$

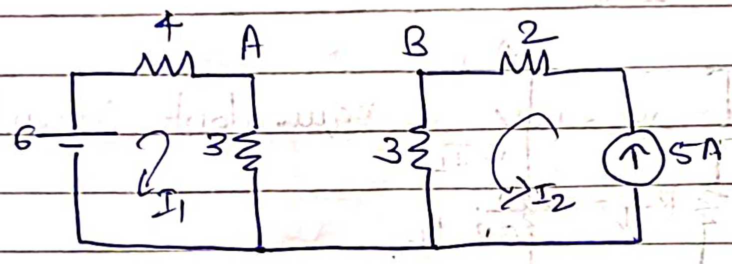
$I_{xy} = 0.72$ A

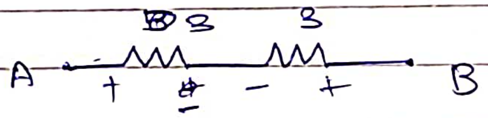
Q.



$I_{AB} = ?$

Soln:





$V_{th} = 3\times5 - 3\times\frac{6}{7}$ $\qquad I = \frac{6}{7}$

$= \cancel{30V}$

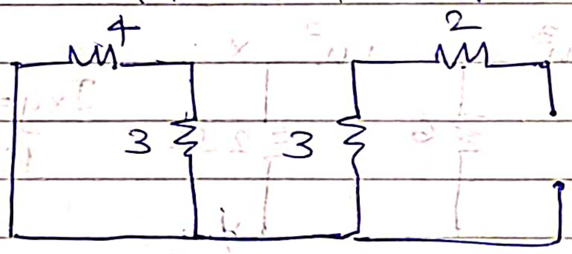
$= 15 - 0.85\times3$

$= \cancel{17.55V}\ 12.45V$

$\frac{1}{4}+\frac{1}{3}$

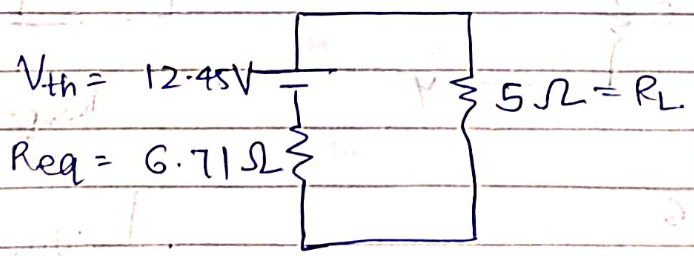
$\frac{4+3}{12}$

$\frac{12}{7}$



$R_{eq} = 1.71 + 3 + 2$

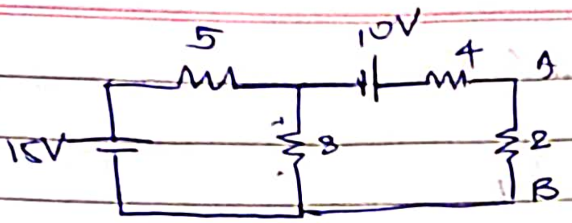
$= 6.71\,\Omega$



$I_{AB} = \frac{12.45}{6.71+5}$

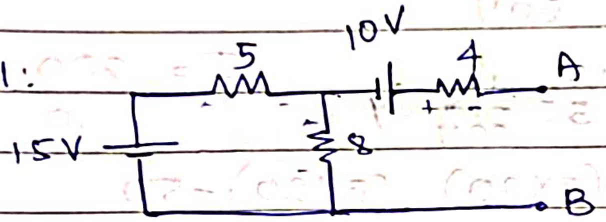
$I_{AB} = 1.06\,A$

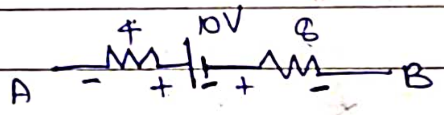
Q.



$I_{AB} = ?$

Soln: Step 1:





$I = \frac{15}{13} = 1.15\,A.$

$V_{th} = 10 + 8 \times 1.15$

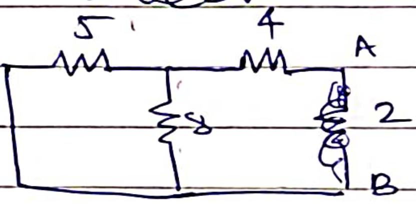
$= 10 + 9.2$

$= 19.224$

$\frac{1}{6} + \frac{1}{8}$

$\Rightarrow \frac{8+6}{48}$

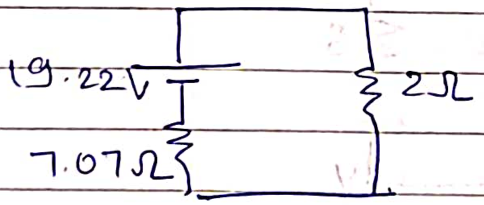
48



$\frac{1}{5} + \frac{1}{8}$

$\Rightarrow \frac{8+5}{40}$

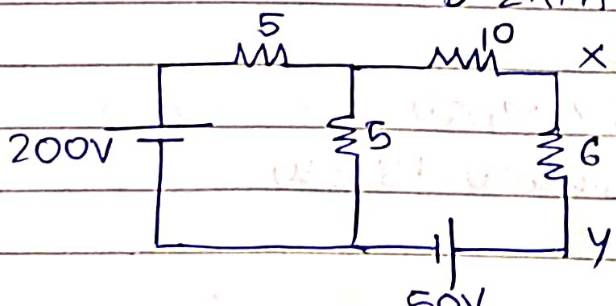
$R_{eq} = 7.07\,\Omega$



$I_{AB} = \frac{19.22}{7.07+2}$

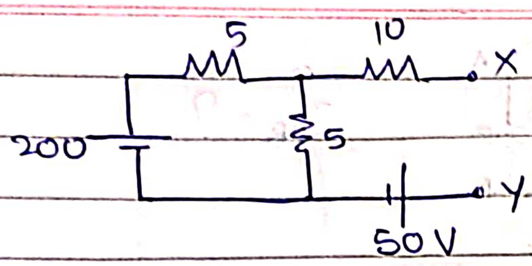
$= 2.11\,A.$

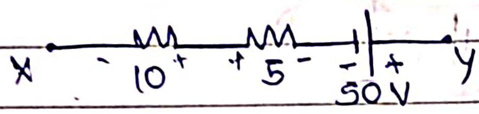
Q.



Calculate power in XY using Thevenin's thm.

Soln:



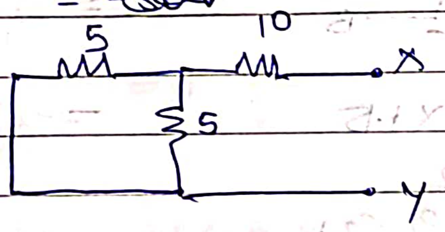


$$I = \frac{200}{10} = 20A.$$

$$V_{th} = \cancel{50 - (5\times20)}\ (5\times20) - 50$$

$$= \cancel{50 - 100}\ \ 50\,V$$

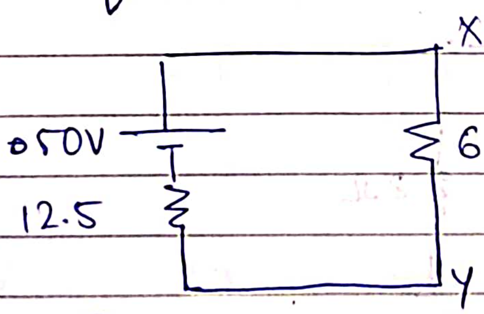
$$= \cancel{-50\,V}$$



$$R_{eq} = 10 + \frac{5}{2}$$

$$= 10 + 2.5$$

$$R_{eq} = 12.5\,\Omega$$



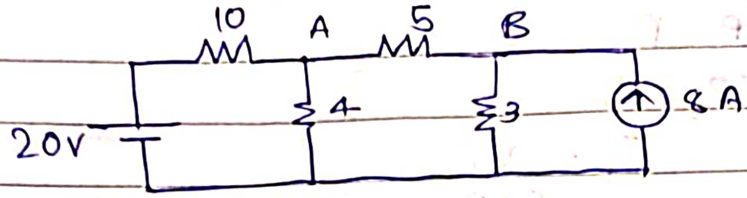
$$I_{xy} = \frac{+50}{12.5+6}$$

$$= 2.702\,A.$$

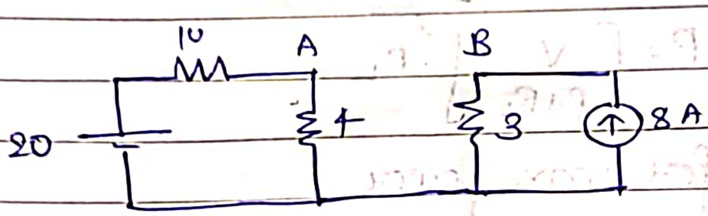
$$\text{Power} = I_{xy}^2 R$$

$$= 7.3 \times 6$$

$$= 43.8\,W$$

Q. 

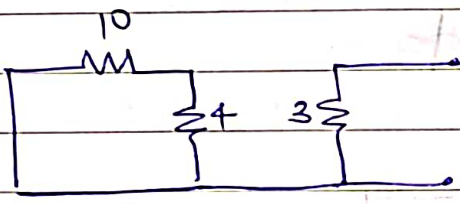
$I_{AB} = ?$

Sol^n: 

$I = \frac{20}{14} = 1.42A$

$V_{th} = 4 \times 1.42 - 24$

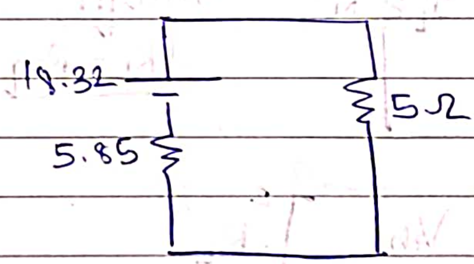
$= -18.32\ V$



$\frac{1}{10} + \frac{1}{4} = \frac{4+10}{40}$

$= \frac{40}{14}$

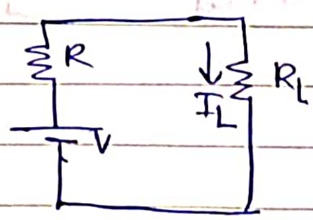
$R_{eq} = 5.85\ \Omega$



$I_{AB} = \frac{18.32}{10.85}$

$= 1.68\ A.$

*) Max. Power transfer theorem.



$$I^2 R = P$$

$$I_L^2 R_L = P_m$$

$$I_L = \frac{V}{R+R_L}$$

$$P = \left[\frac{V}{R+R_L}\right]^2 \cdot R_L$$

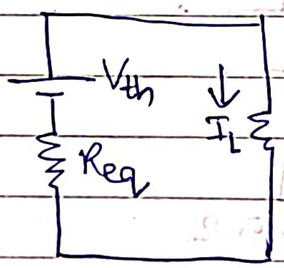
To get condⁿ for max. power

$$\frac{dP}{dR_L} = 0$$

$$\frac{d}{dR_L}\left[\frac{V}{R+R_L}\right]^2 \cdot R_L = 0$$

$$V^2 \frac{d}{dR_L}\left[\frac{R_L}{(R+R_L)^2}\right] = 0$$

$$\boxed{R_L = R.}$$



Condⁿ for max. power transfer,

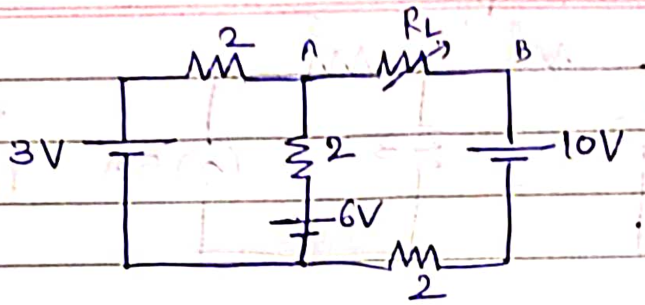
$$\boxed{R_L = R_{eq}}$$

$$P_m = \left[\frac{V_{th}}{R_L + R_{eq}}\right]^2 \cdot R_L$$

P_m will be max at $R_L = R_{eq}$

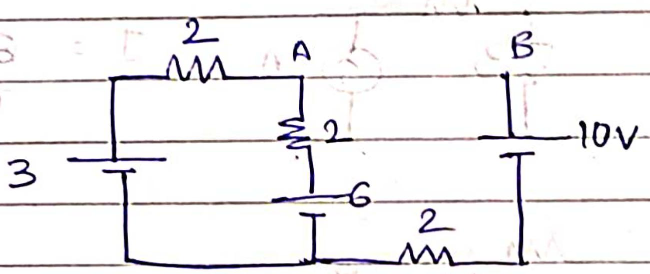
$$P_m = \left[\frac{V_{th}}{2R_{eq}}\right]^2 \cdot R_{eq}$$

$$\boxed{P_m = \frac{V_{th}^2}{4R_{eq}} \text{ watts}}$$

Q. 

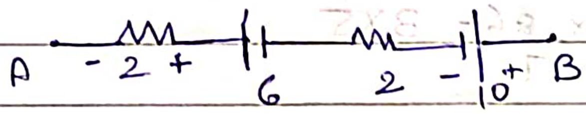
Calculate R_L so the max power is transfered.

Solⁿ:



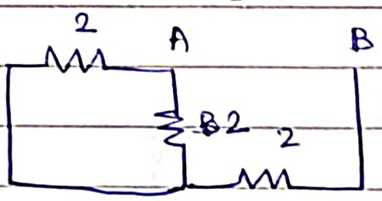
$$I_1 = \frac{6-3}{4} = \frac{3}{4}A$$

$$I_2 = \frac{10}{2} = 5A.$$



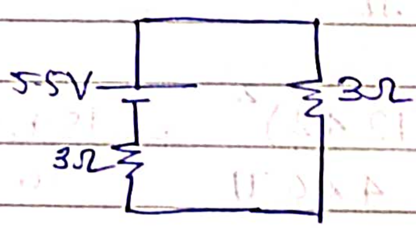
$$V_{th} = 2 \times \frac{3}{4} + 10 - 6$$

$$= 5.5V$$



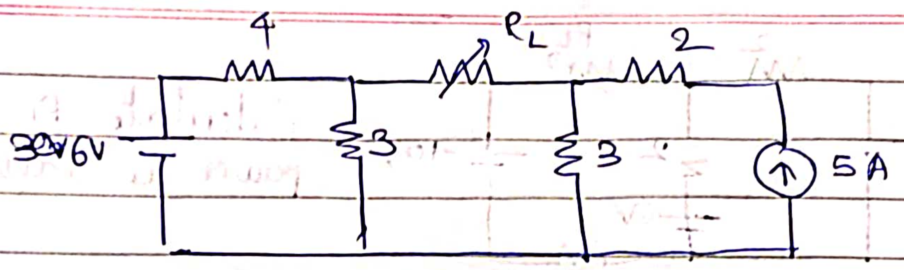
~~Loader~~ $= 1+2 = 3\Omega$

$R_{eq} = 3\Omega \quad \therefore \quad R_L = 3\Omega$



$$P = \frac{(5.5)^2}{4 \times 3} = \frac{30.25}{12} = 2.52W.$$

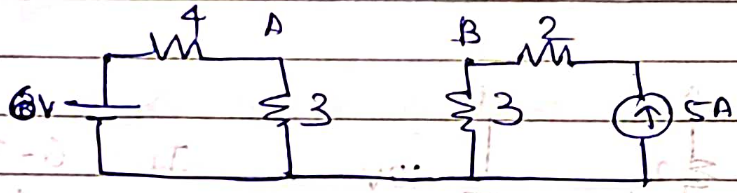
Q.



$R_L = ?$

$P_m = ?$

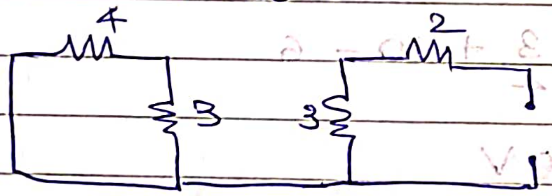
Sol^n:



$I = \frac{8}{7}$

$V_{Th} = 3 \times \frac{8}{7} - 3 \times 5$

$= -12.42\ V$



$\frac{1}{4} + \frac{1}{3} = \frac{3+4}{12}$

$= \frac{12}{7}$

$R_{eq} = \frac{12}{7} + 5$

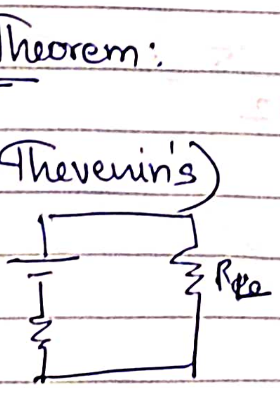
$= 6.71\ \Omega$

$R_L = 6.71\ \Omega$

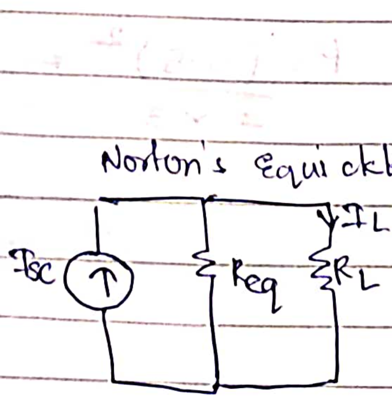
$P_m = \frac{(12.42)^2}{4 \times 6.71} = \frac{154.25}{26.84} = 5.74\ W.$

*) Norton's Theorem:

(Dual of Thevenin's)

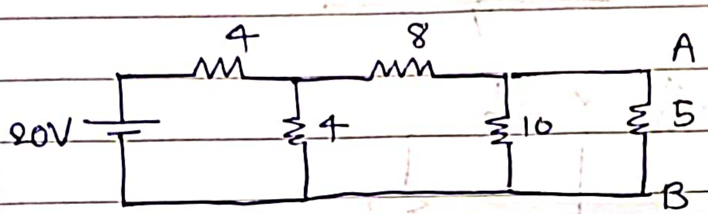


Norton's equi ckt.



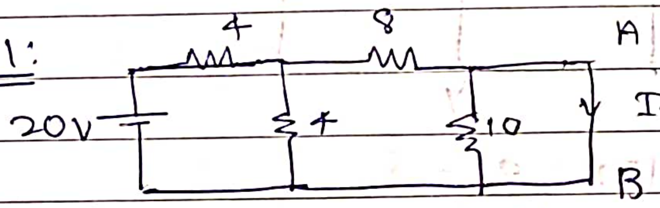
$$I_L = I_{sc} \times \frac{R_{eq}}{R_{eq} + R_L}$$

Q.

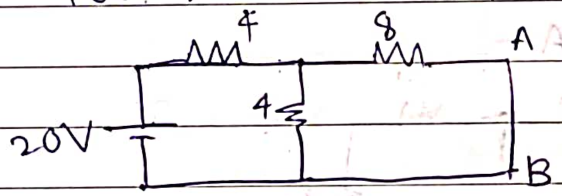


$I_{AB} = ?$

Soln: Step 1:



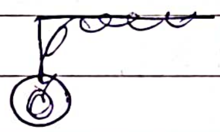
10Ω branch is redundant



$$\frac{8 \times 4}{8+4} = \frac{32}{12} = 2.66\,\Omega$$

$$R_{eq} = 2.66 + 4$$
$$= 6.66\,\Omega$$

~~Isc~~

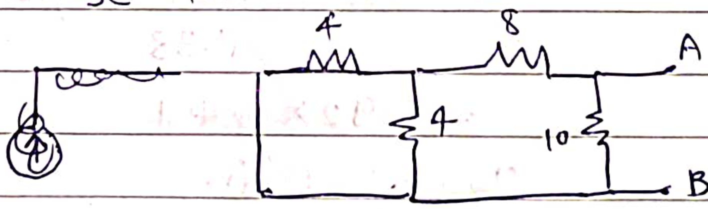


$$I = \frac{20}{6.66}$$

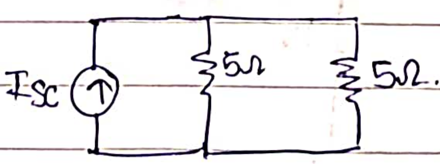
$$I = 3A.$$

$$I_{sc} = 3 \times \frac{4}{4+8}$$

$$I_{sc} = 1A$$

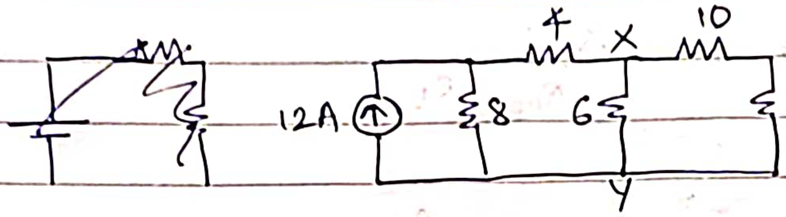


$$R_{eq} = 5\,\Omega.$$



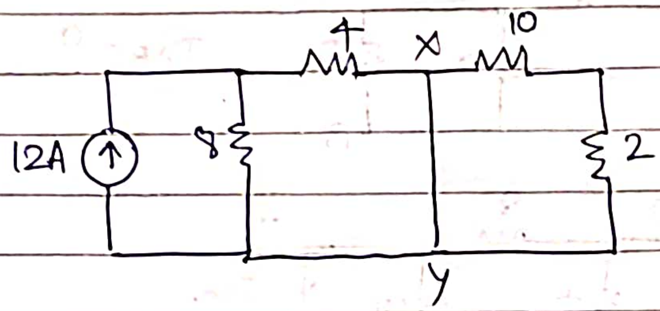
$$I_L = 0.5A.$$

Q.



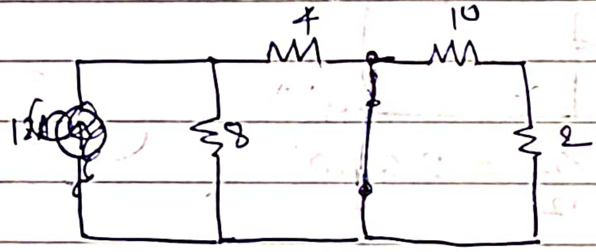
$I_{xy} = ?$

Sol^n:

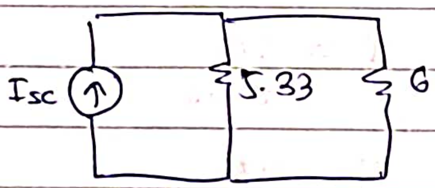


$$I_{sc} = 12 \times \frac{8}{4+8}$$

$$= 7.92\ A$$



$$R_{eq} = \frac{8 \times 16}{8+16} = \frac{128}{24} = 5.33\ \Omega \qquad R_{eq} = 6\Omega$$



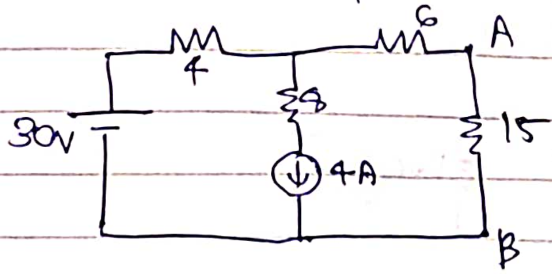
$$I_{xy} = 7.92 \times \frac{5.33}{5.33+6} \qquad 7.92 \times \frac{6}{6+6}$$

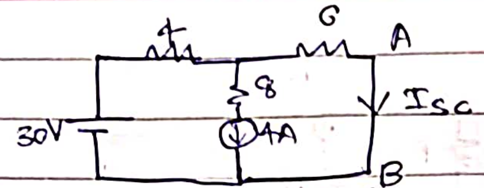
$$= 7.92 \times \frac{5.33}{11.33} \qquad I_{xy} = 3.96\ A.$$

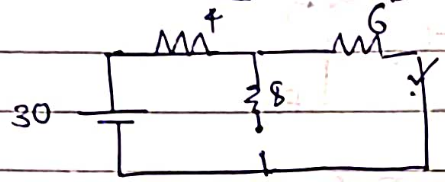
$$= 7.92 \times 0.47$$

$$I_{xy} = 3.72\ A.$$

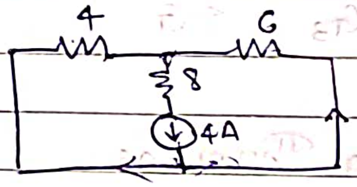
Q.







$I_1 = \frac{30}{10} = 3A.$



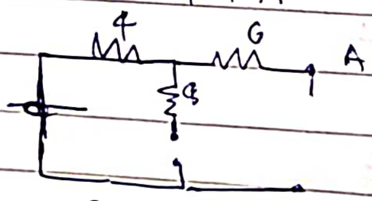
$\frac{4\times 6}{4+6} = \frac{48}{10} = 4.8A.$

$I_2 = 4 \times \frac{8}{6+8}$

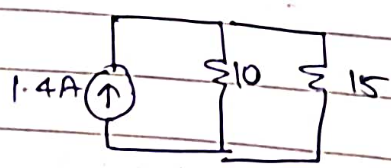
$I_2 = 4 \times \frac{4}{4+6}$

$I_2 = 1.6A.$

$I_{sc} = 3 - 1.6$
$= 1.4A.$



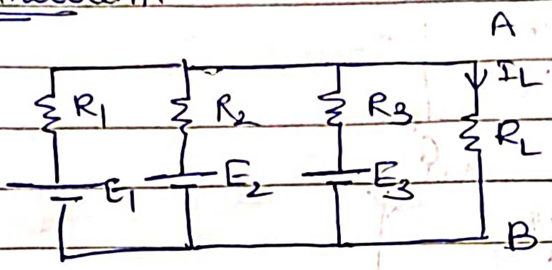
$R_{eq} = 4+6 = 10\Omega.$



$I_L = 1.4 \times \frac{10}{25}$

$I_L = 0.56A.$

*) Millman's Theorem:



$$V_{AB} = \frac{E_1/R_1 + E_2/R_2 + E_3/R_3}{1/R_1 + 1/R_2 + 1/R_3}$$

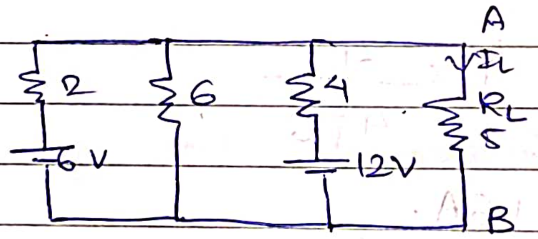
$$V_{AB} = \frac{I_1 + I_2 + I_3}{G_1 + G_2 + G_3} = \frac{\Sigma I}{\Sigma G}$$

$$= V_{th}$$

$R_{eq} \rightarrow$ same way as Thevenin's.

$$I_L = \frac{V_{AB}}{R_{eq} + R_L}$$

Q.



$I_L = ?$

Sol^n:

$$V_{th} = \frac{6/2 + 12/4}{\frac{1}{2} + \frac{1}{6} + \frac{1}{4}}$$

$$= \frac{3+3}{\frac{6+2+3}{12}}$$

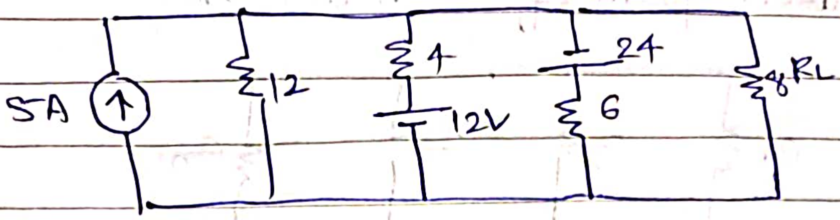
$$= \frac{6 \times 12}{11}$$

$V_{AB} = 6.54$ V.

$$\frac{2 \times 6}{6+2} = \frac{12}{8} = \frac{1.5 \times 4}{1.5+4} = \frac{6}{5.5} = 1.09\Omega.$$

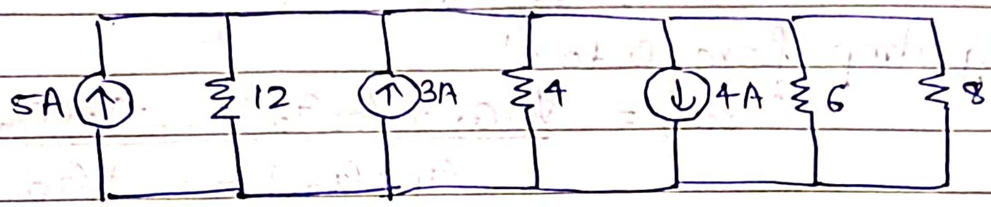
$$I_L = \frac{6.54}{1.09 + 5}$$

$I_L = 1.09$ A

Q. 

V across R_L and I_L.

Sol^n:



$$V_{AB} = \frac{5+3-4}{\frac{1}{12}+\frac{1}{4}+\frac{1}{6}}$$

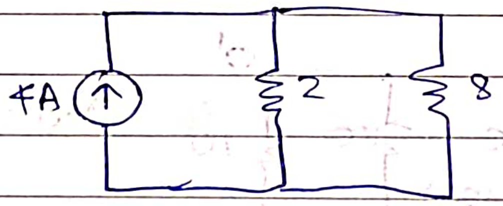
$$= \frac{4}{\frac{1+3+2}{12}}$$

$$= \frac{4 \times \cancel{12}^{2}}{\cancel{6}}$$

$$V_{AB} = 8\,V$$

$$R_{eq} = \frac{12 \times 4}{12+4} = \frac{3 \times 6}{6+3} = \frac{18}{9} = 2\,\Omega.$$

$$I = \frac{8}{2+8} = \frac{8}{10} = \frac{4}{5} = 0.25A.$$



$$I_L = 4 \times \frac{2}{2+8}$$

$$= 0.8A.$$

$$V_L = 0.8 \times 8$$

$$= 6.4V.$$

classmate

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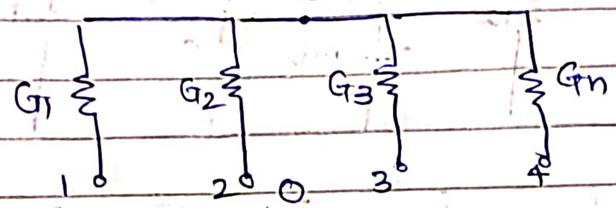
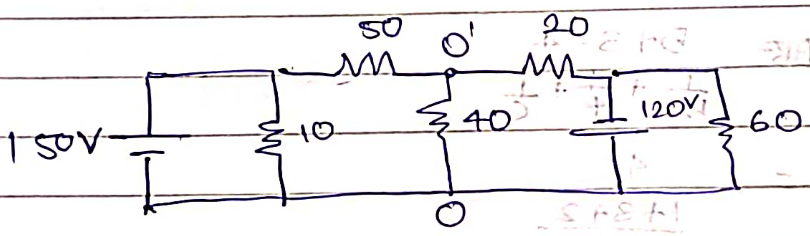
*) Generalised form of Millman's thm:



Vltg. drop from O to O'

$$(V_{oo'}) = \frac{V_{o1}G_1 + V_{o2}G_2 + \dots + V_{on}G_n}{G_1 + G_2 + \dots + G_n}$$

Q.



$V_{oo'} = ?$

Sol^n:

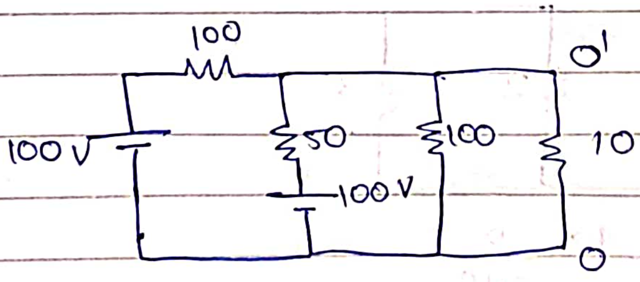
$$V_{oo'} = \frac{\frac{-150}{50} + \frac{120}{20}}{\frac{1}{50} + \frac{1}{40} + \frac{1}{20}}$$

$$= \frac{-3+6}{0.02 + 0.025 + 0.05}$$

$$= \frac{3}{0.095}$$

$V_{oo'} = 31.5V.$

Q.



$V_{oo'} = ?$

Sol^n:

$$V_{oo'} = \frac{\frac{-100}{100} - \frac{100}{50}}{\frac{1}{100} + \frac{1}{50} + \frac{1}{10}}$$

$$= \frac{-1-2}{\frac{1+2+10}{100}}$$

$$= \frac{-3 \times 100}{13} = -21.4V.$$

9/11/22

Unit-3 Analysis of Transient Response in Circuits.

Initial condns:

Time periods 0^- 0 0^+

1. Just before switching ($t = -\infty$ to $t = 0^-$)
2. Just after switching ($t = 0^+$)
3. After switching ($t > 0$).

1. Initial condn for R

$$V = ~~IR~~ \; iR.$$

2. Initial condn for L

$$V = L \cdot \frac{di}{dt}$$

$$i(t) = \frac{1}{L}\int_0^t v(t)\,dt + i(0).$$ $i(0)$ is initial current through L

If no current through L at $t = 0^-$
L will act as O.C.

If current I_0 is flowing through L at $t = 0^-$,
L will act as current source of I_0 A.

3. Capacitor

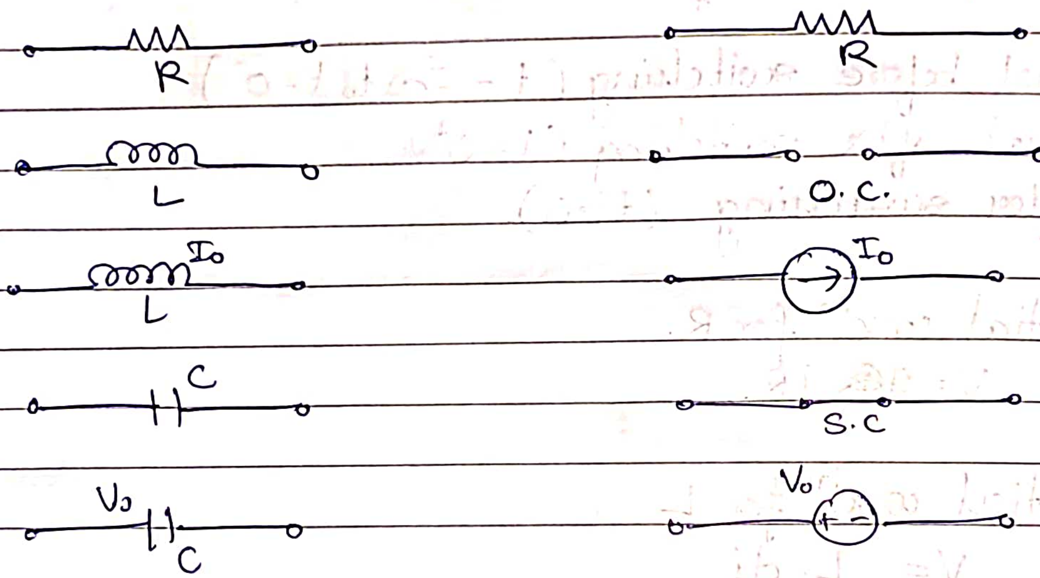
$$V = \frac{1}{C}\int_0^t i(t)\,dt + V(0)$$

$V(0)$ is initial voltage across C.

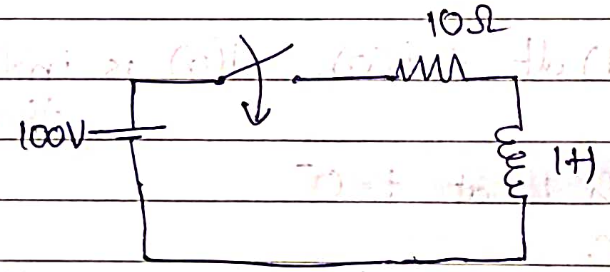
If there is no voltage across cap. at $t = 0^-$
C will act as short circuit.

If initially the capacitor is charged to vltg V_0 at $t = 0^-$
C will act as voltage source of V_0.

Element with initial cond^n	Equi. ckt. at $t=0^+$



Q.

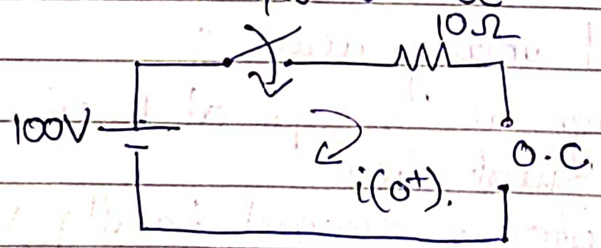


In the given network switch is closed at $t=0$, with 0 current in Inductor, find i, $\frac{di}{dt}$, $\frac{d^2i}{dt^2}$ at $t=0^+$

Sol^n: at $t=0^-$, no current flow through L

$\therefore$ $i(0^-)=0$

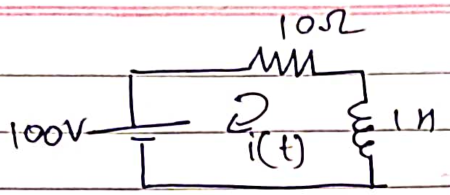
At $t=0^+$ the n/w will be



Inductor acts as O.C.

$\therefore$ $i(0^+)=0.$

~~$\frac{di}{dt}$~~ At $t>0$



$$100 - 10i - 1 \cdot \frac{di}{dt} = 0 \quad \text{--- (1)}$$

$$\frac{di}{dt} = 100 - 10i \quad \text{--- (2)}$$

At $t = 0^+$

$$\frac{di}{dt}(0^+) = 100 - 10\,i(0^+).$$

$$\boxed{\frac{di}{dt}(0^+) = 100 \ \text{A/s}.}$$

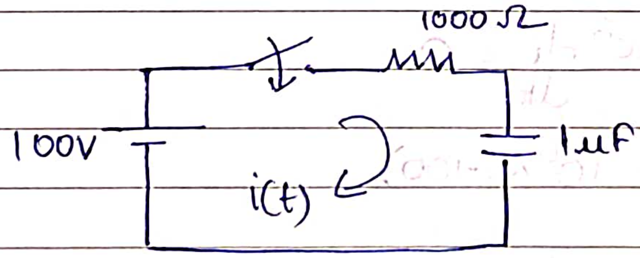
Diff. eq^n (2)

$$\frac{d^2i}{dt^2} = -10\frac{di}{dt}.$$

$$\frac{d^2i}{dt^2}(0^+) = -10\frac{di}{dt}(0^+).$$

$$= -1000 \ \text{A/s}^2.$$

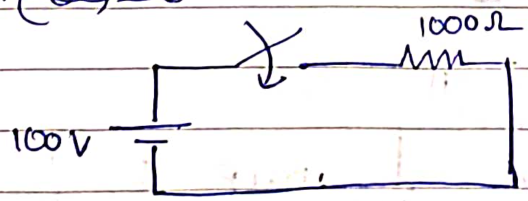
Q.



switch closed at $t = 0$ with capacitor uncharged
$i, \frac{di}{dt}, \frac{d^2i}{dt^2}$ at $t = 0^+$

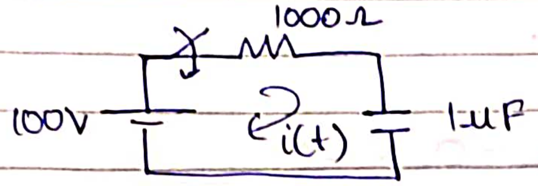
Sol^n: At $t = 0^+$, no ~~curr~~ voltage through C $\quad V(0^-) = 0$

~~$i(0^+) = 0$~~ $\quad \therefore i(0^-) = 0.$



$$i(0^+) = \frac{100}{1000} = 0.1 \ \text{A}.$$

At $t>0$



$$100 - 1000i - 10^6\int_0^t i(t)\,dt = 0$$

$$\cancel{10^6\int_0^t i(t)\,dt = 1000i - 100}$$

$$\cancel{i_0 = 0 - 1000\frac{di}{dt} - 10^6\frac{di}{dt} = 0}$$

At $t=0^+$

$$0 - 1000\frac{di}{dt} - 10^6 i = 0$$

$$\frac{di}{dt} = \frac{10^6 i}{1000}$$

$$= \frac{0.1\times10^6}{1000}$$

$$\frac{di(0^+)}{dt} = -100 \text{ A/s}$$

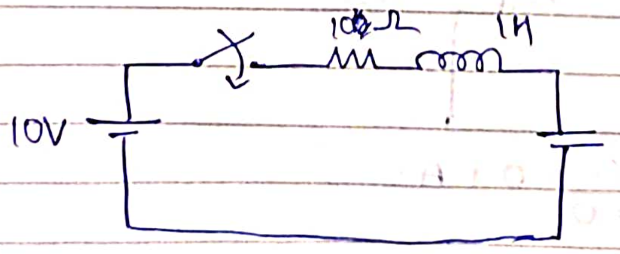
$$-1000\frac{d^2i}{dt} - 10^6\frac{di}{dt} = 0$$

$$-1000\frac{d^2i}{dt^2} = 10^6\times(-100)$$

$$\frac{d^2i}{dt^2} = \frac{10^6\times100}{1000}$$

$$\frac{d^2i}{dt^2} = 10^5 \text{ A}$$

Q.



$i, \frac{di}{dt}, \frac{d^2i}{dt^2}$

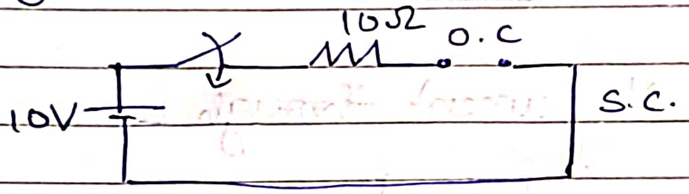
Current is zero & Capacitor is uncharged $t=0^-$

Sol^n: At $t=0^-$

$i_L(0^-)=0$

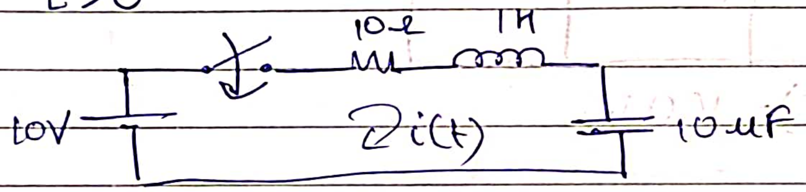
$V_C(0^-)=0$

At $t=0^+$



$i(0^+)=0$

At $t>0$



$$10-10\,i(t)-1\frac{di}{dt}-\frac{1}{10^{-5}}\int_0^t i(t)\,dt=0.$$

$$10-10\,i(t)-\frac{di}{dt}=0 \quad — (1)$$

$$\frac{di}{dt}=10-10\,i(t)$$

At $t=0^+$

$$\frac{di}{dt}(0^+)=10-10\,i(0^+)$$

$$\frac{di}{dt}(0^+)=10\ A/s.$$

At

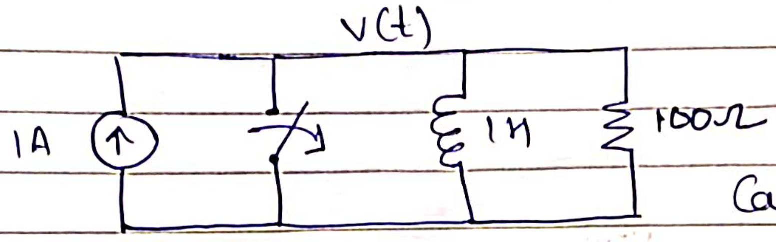
$$\cancel{10}-10\frac{di}{dt}-\frac{d^2i}{dt^2}=0$$

$$\frac{d^2i}{dt^2}=-10\frac{di}{dt}$$

At $t=0^+$

$$\frac{d^2i}{dt^2}(0^+)=-10\times 10$$

$$=-100.$$

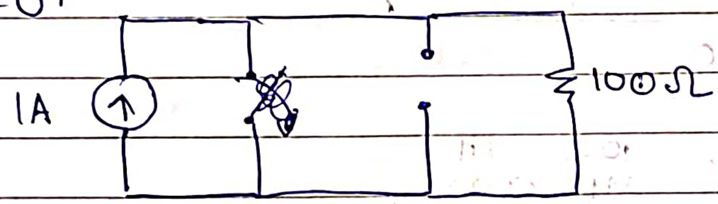
Q. 

At $t=0^-$ switch is closed. Calculate v, $\frac{dv}{dt}$, $\frac{d^2v}{dt^2}$ at $t=0^+$

Soln: At $t=0^-$

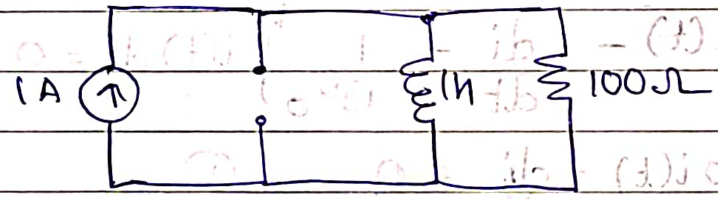
$i_L(0^-) = 0A$. No current through L.

At $t=0^+$



$v(0^+) = 100\,V$.

At $t>0$



$$I_1 = \frac{1}{L}\int v\,dt$$

$$I_2 = \frac{v}{100}$$

$$\frac{1}{L}\int v\,dt + \frac{v}{100} = 1$$

$$\frac{1}{L}v + \frac{1}{100}\frac{dv}{dt} = 0$$

$$\frac{dv}{dt} = -\frac{v}{L} \times 100$$

$$= \frac{-100v}{1}$$

$$\frac{dv}{dt} = -100v$$

At $t=0^+$

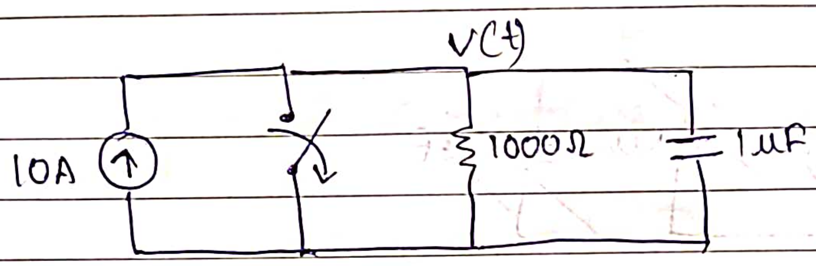
$$\frac{dv}{dt}(0^+) = -10^4 \ V/s.$$

$$\frac{d^2v}{dt^2} = -100\frac{dv}{dt}$$

At $t = 0^+$

$$\frac{d^2v}{dt^2}(0^+) = -100 \times (-10^4)$$
$$= 10^6 \ V/s^2$$

Q.

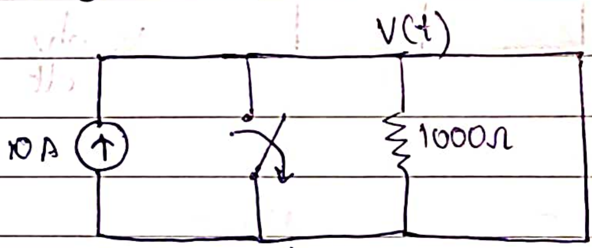


Switch opened at $t=0$
$v, \frac{dv}{dt}, \frac{d^2v}{dt^2}$ at $t=0^+$

Sol^n: At $t=0^-$

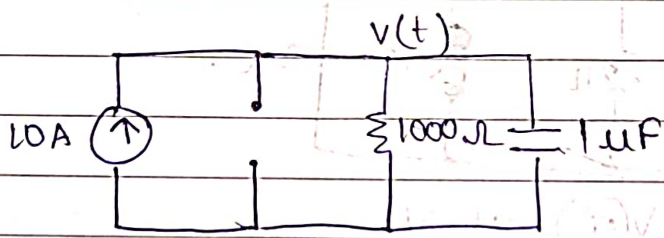
$$v(0^-) = 0$$

At $t=0^+$



$$v(0^+) = \cancel{10^4 V}\ 0V.$$

At $t>0$



$$\frac{v}{1000} + C\frac{dv}{dt} = 10$$

$$C\frac{dv}{dt} = 10 - \frac{v}{1000}$$

$$\frac{dv}{dt} = \cancel{10000}\ \frac{10}{10^{-6}}$$
$$= 10^7 \ V/s$$

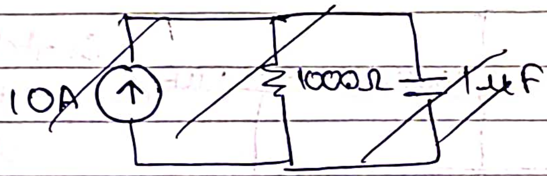
$$\frac{1}{1000}\frac{dv}{dt} + C\frac{d^2v}{dt^2} = 0$$

$$10^4 + 10^{-6}\frac{d^2v}{dt^2} = 0$$

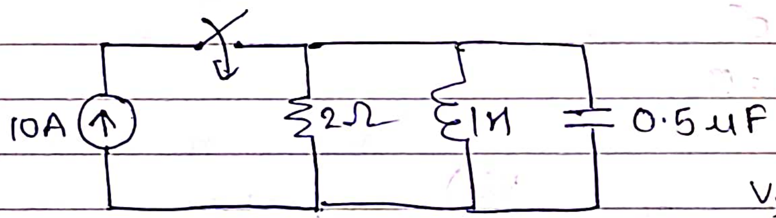
$$10^{-6}\frac{d^2v}{dt^2} = -10^4$$

$$\frac{d^2v}{dt^2} = -10^{10}\ V/s^2.$$

~~Q.~~



Q.



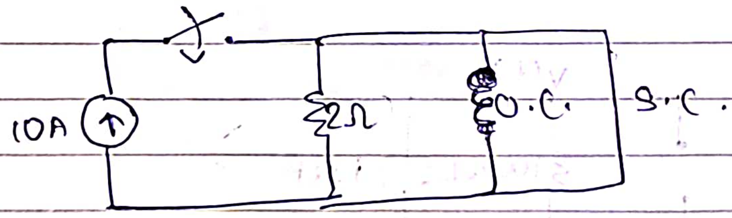
Switch is closed at $t=0$

$v, \frac{dv}{dt}, \frac{d^2v}{dt^2}$ at $t=0^+$

Soln: At $t=0^-$

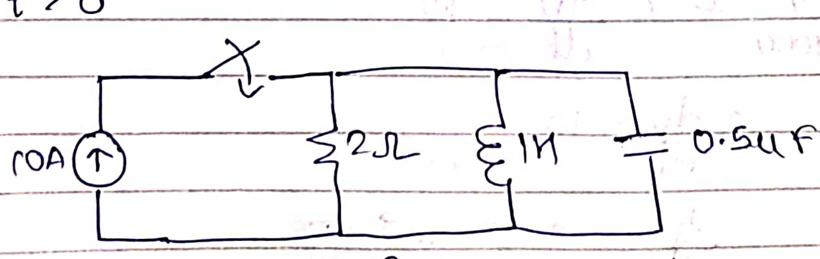
$v(0^-)=0$

At $t=0^+$



$V(0^+) = 0\ V.$

At $t>0$



$$\frac{v}{2} + \frac{1}{L}\int v\,dt + C\frac{dv}{dt} = 10$$

At $t=0^+$

$$\frac{v(0^+)}{2} + \frac{1}{L}\int v(0^+)\,dt + C\frac{dv}{dt} = 10$$

$$\frac{dv}{dt} = \frac{10}{0.5\times10^{-6}}$$

$$\frac{dv}{dt} = 2\times10^{7} \text{ V/s}$$

$$\frac{1}{2}\frac{dv}{dt} + \frac{1}{L}v + C\frac{d^2v}{dt} = 0$$

$$\frac{1}{2}2\times10^{7} + \frac{1}{L}v(0^+) + 0.5\times10^{-6}\frac{d^2v}{dt^2} = 0$$

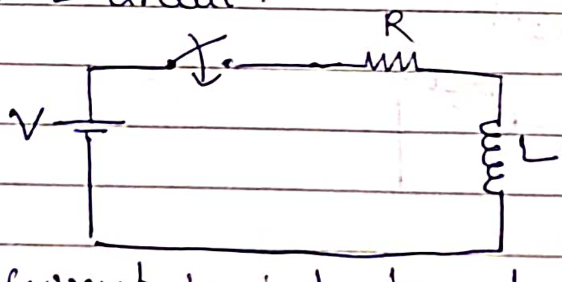
$$10^{7} + 0.5\times10^{-6}\frac{d^2v}{dt^2} = 0$$

$$0.5\times10^{-6}\frac{d^2v}{dt^2} = -10^{7}$$

$$\frac{d^2v}{dt^2} = -2\times10^{13} \text{ V/s}^2$$

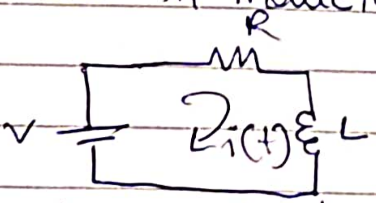
Transient Response:

- R-L circuit:



Switch is closed at $t=0$.

$\therefore$ Current in inductor at $t=0^- = 0$.



$t>0$

KVL eq^n at $t>0$

$$V - Ri(t) - L\frac{di}{dt} = 0 \quad - \text{ Linear D.E. order 1.}$$

if variables are separated

$$(V - Ri)\,dt = L\,di$$

$$\frac{L}{V - Ri}\,di = dt.$$

Integrating both sides

$$-\frac{L}{R}\ln(V - Ri) = t + k \quad \text{--- ①}$$

to get value of k, at $t = 0$, $i = 0$

$$-\frac{L}{R}\ln V = k. \quad \text{--- ②}$$

Put ② in eq^n ①

$$-\frac{L}{R}(\ln V - Ri) = t - \frac{L}{R}\ln V.$$

$\cancel{t = Ri}$ $\cancel{t = \ln(Ri)}$

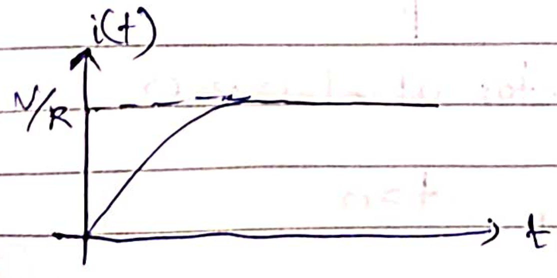
$\cancel{V = Ri}$

$$= -\frac{L}{R}\left[\ln(V - Ri) - \ln(V)\right] = t$$

$$\frac{V - Ri}{V} = e^{-R/L\, t}$$

$$V - Ri = V \cdot e^{-R/L \cdot t}$$

$$\boxed{i = \frac{V}{R} - \frac{V}{R}e^{-\frac{R}{L}t}}$$



Voltage across R

$$V_R = Ri = R \times \frac{V}{R}\left(1 - e^{-R/L \cdot t}\right)$$

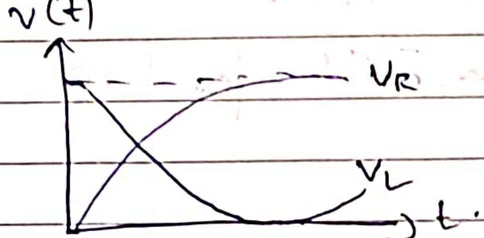
$$V_R = V\left(1 - e^{-R/L \cdot t}\right) \quad \text{for } t > 0$$

Voltage across L

$$V_L = L \cdot \frac{di}{dt}$$

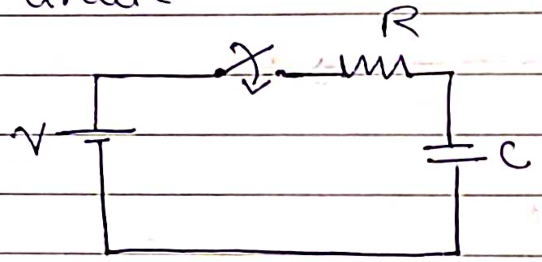
$$= L \cdot \frac{V}{R} \frac{d}{dt}\left(1 - e^{-R/L \cdot t}\right)$$

$$V_L = V \cdot e^{-R/L \cdot t} \quad \text{for } t > 0.$$



$\frac{L}{R} \rightarrow$ time constant of R-L circuit.

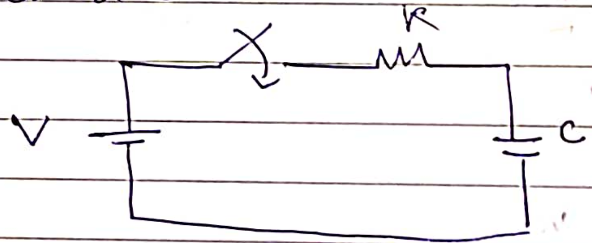
- R-C circuit.



At $t=0$ switch is closed

$\therefore$ Capacitor is uncharged initially

for $t>0$



$$V - Ri - \frac{1}{C}\int_0^t i\,dt = 0$$

$$0 - R\frac{di}{dt} - \frac{i}{C} = 0$$

$$\frac{di}{dt} + \frac{1}{RC} i = 0.$$

$$\frac{di}{i} = \frac{-dt}{RC}$$

Int. both sides.

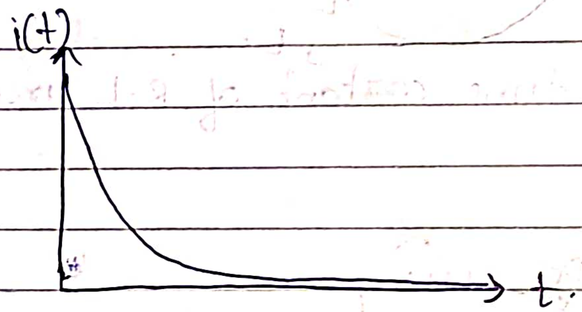
$$\ln i = \frac{-1}{RC} t + K.$$

At $t=0^{+}$ $i = V/R$.

$\therefore \ln\left(\frac{V}{R}\right) = K.$

$$\therefore \ln i = \frac{-t}{RC} + \ln\left(\frac{V}{R}\right).$$

$$i = \frac{V}{R} \cdot e^{-t/RC} \quad \text{for } t>0.$$



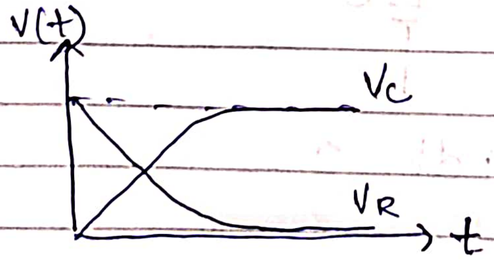
Voltage across R.

$$V_R = V \cdot e^{-t/RC}$$

Voltage across C

$$V_C = \frac{1}{C}\int_0^t \frac{V}{R} e^{-t/RC}\, dt.$$

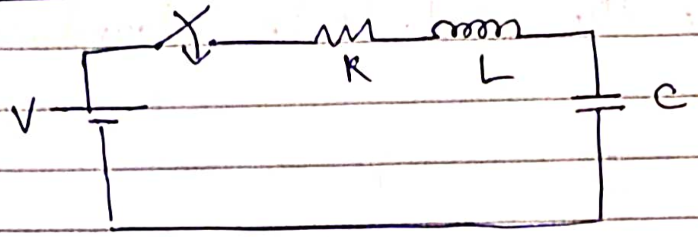
$$V_C = -V e^{-t/RC}$$



RC → time constant of RC ckt. (T).

Date
Page

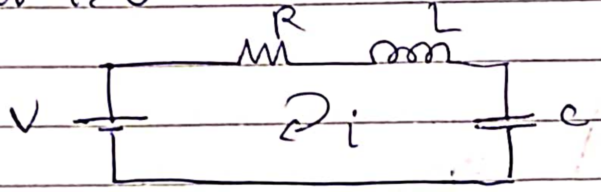
*) RLC - Circuit:



switch is closed at $t=0$.

Inductor current $\}$ $=0$.
Capacitor voltage $\}$

For $t \geq 0$



$$V - Ri - L\frac{di}{dt} - \frac{1}{C}\int_0^t i\,dt = 0.$$

Differentiate

$$0 - R\frac{di}{dt} - L\frac{d^2i}{dt^2} - \frac{i}{C} = 0.$$

$$\frac{d^2i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{i}{LC} = 0.$$

2nd order D.E.

$$s^2 + \frac{R}{L}s + \frac{1}{LC} = 0$$

$$S_1, S_2 = \frac{-R/L \pm \sqrt{\left(\frac{R}{L}\right)^2 - 4\left(\frac{1}{LC}\right)}}{2}$$

$$S_1 = -\frac{R}{2L} + \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

$$S_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2}$$
$$= -\alpha + \beta$$
$$S_2 = -\alpha - \beta$$

$\alpha = \frac{R}{2L}$

$\beta = \sqrt{\alpha^2 - \omega_0^2}$

$\omega_0 = \frac{1}{\sqrt{LC}}$

$$i(t) = k_1 e^{s_1 t} + k_2 e^{s_2 t}$$

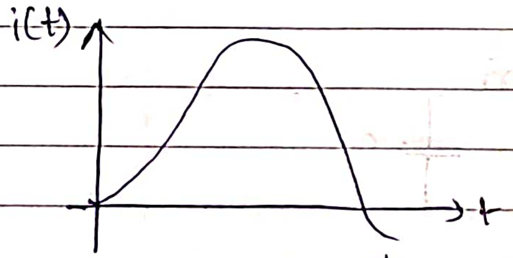
k_1, k_2 are the const. to be determined.

I] $\alpha > \omega_0$

i.e. $\frac{R}{2L} > \frac{1}{\sqrt{LC}}$

Roots are real & unequal.

Overdamped cond^n.



sol^n is $i = e^{-\alpha t}(k_1 e^{\beta t} + k_2 e^{-\beta t})$

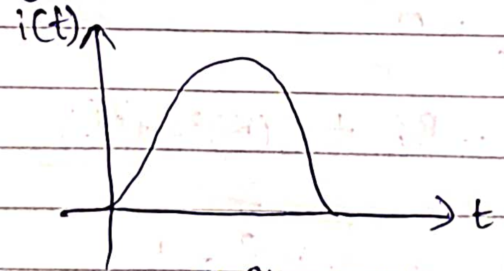
Or $i = k_1 e^{s_1 t} + k_2 e^{s_2 t} \Big|_{t>0}$

II] $\alpha = \omega_0$

i.e. $\frac{R}{2L} = \frac{1}{\sqrt{LC}}$

Roots are real & equal.

Critically damped.

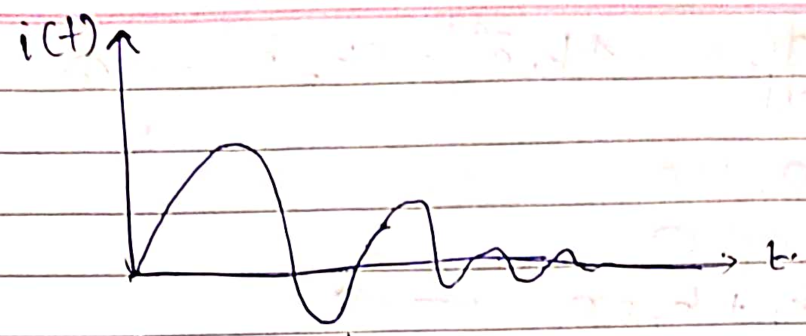


sol^n is $i = e^{-\alpha t}(k_1 + k_2 t)$ $t > 0$

III] $\alpha < \omega_0$

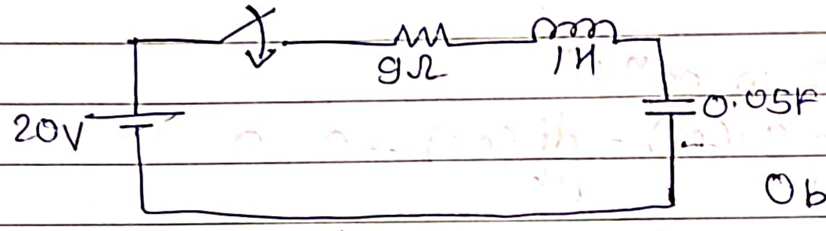
Roots are complex conjugate

Underdamped.



$i = k_1 e^{s_1 t} + k_2 e^{s_2 t}$.

Q.



Switch is closed at $t=0$.

Obtain $i(t)$ at $t>0$.

Soln: Inductor current } = 0. $i(0^-) = 0$

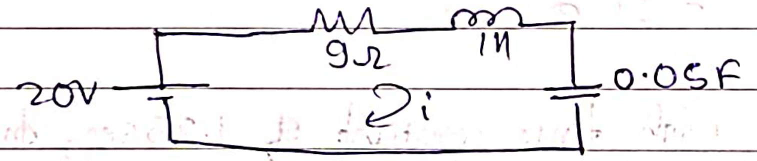
Capacitor voltage } $V_c(0^-) = 0$.

At ~~t=0~~ $t = 0^+$

$i = 0$

$V_c = 0$

At $t>0$



$$20 - 9i - 1\frac{di}{dt} - \frac{1}{0.05}\int i\,dt = 0 \quad \text{—} (1)$$

$$-9\frac{di}{dt} - \frac{d^2 i}{dt^2} - 20\, i = 0$$

$$\frac{d^2 i}{dt^2} + 9\frac{di}{dt} + 20 i = 0$$

$$s^2 + 9s + 20 = 0.$$

$$s_1 = -4 \qquad s_2 = -5$$

$$i = k_1 e^{-4t} + k_2 e^{-5t} \quad \text{—} (2)$$

~~$k_1 + k_2 = 0$~~. Diff eqn (2)

$$\frac{di}{dt} = -4k_1 e^{-4t} - 5k_2 e^{-5t} \quad — ③$$

At $t=0$, $i=0$

from eq^n ②

$$k_1 + k_2 = 0 \quad — ④$$

from eq^n ③

$$-4k_1 - 5k_2 = \frac{di}{dt}(0^+).$$

Put $t=0$ in eq^n ①

$$20 - 9i(0^+) - \frac{di}{dt}(0^+) - 0 = 0$$

$$\frac{di(0^+)}{dt} = 20 \text{ A/s}$$

$$-4k_1 - 5k_2 = 20$$

$$-4k_1 + 5k_1 = 20$$

$$k_1 = 20.$$

$$k_2 = -20.$$

$$\therefore i = 20e^{-4t} - 20e^{-5t}$$

Q. In a R-L circuit with time constant of 1.25 sec, Inductor current increases from the initial value of zero to final value 1.2A.

a) Inductor current at $t=0.4$ s, $t=0.8$, $t=2$.

b) Find a time at which the current reaches 0.3 A, 0.6A, 0.9A

Sol^n:

$$i_L = \frac{V}{R}(1 - e^{-R/L\, t})$$

$$T = 1.25$$

$$\frac{L}{R} = 1.25$$

$$\frac{R}{L} = 0.8$$

$i_L = 1.2(1 - e^{-0.8\times0.4})$

$= 1.2(1 - e^{-0.32})$

$i_L = 1.2(1-0.726)$

$= 1.2 \times 0.274$

$i_L = 0.32$ at $t = 0.4$ s.

$i_L = 1.2(1 - e^{-0.8\times0.8})$

$= 1.2(1 - e^{-0.64})$

$= 1.2(1-0.527)$

$= 1.2 \times 0.473$

$i_L = 0.567$ at $t = 0.8$ s.

$i_L = 1.2(1 - e^{-0.8\times2})$

$= 1.2(1 - e^{-1.6})$

$= 1.2(1-0.201)$

$= 1.2(0.799)$

$i_L = 0.958$ at $t = 2$ s.

$0.3 = 1.2(1 - e^{-0.8t})$

$0.3 = 1.2 - 1.2e^{-0.8t}$

$1.2e^{-0.8t} = 1.2 - 0.3$

$1.2e^{-0.8t} = 0.9$

$e^{-0.8t} = 0.75$

$-0.8t = -0.28$

$t = 0.35$ s when $i = 0.3$ A.

$0.6 = 1.2 - 1.2e^{-0.8t}$

$1.2e^{-0.8t} = 0.6$

$e^{-0.8t} = 0.5$

$-0.8t = -0.693$

$t = 0.866$ s when $i = 0.6$A

$0.9 = 1.2 - 1.2e^{-0.8t}$

$1.2e^{-0.8t} = 0.3$

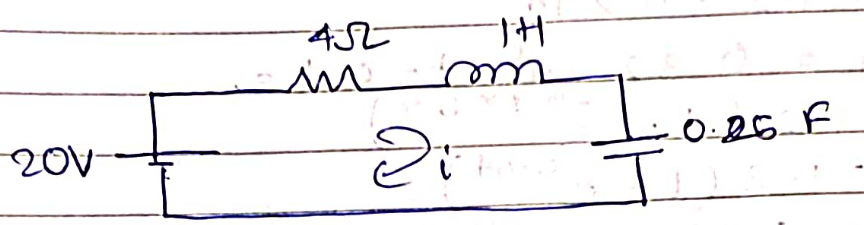
$e^{-0.8t} = 0.25$

$-0.8t = -1.386$

$t = 1.73$ s when $i = 0.9$A.

Q. Find exp. for current in series RLC ckt fed by a DC voltage of 20V with $R = 4\Omega$, $L = 1H$, $C = \frac{1}{4}F$. Assume initial cond^ns to be zero.

Sol^n:



$$20 - 4i - \frac{di}{dt} - 4\int_0^t i\,dt = 0$$

$$-4\frac{di}{dt} - \frac{d^2i}{dt^2} - 4i = 0$$

$$s^2 + 4s + 4 = 0$$

$$s_1, s_2 = -2$$

$$i = k_1 e^{-2t} + k_2 e^{-2t} t$$

At $t=0$, $i=0$

$\cancel{k_1 + k_2 = 0}$ $\quad k_1 = 0$

$$20 - 4i(0^+) - \frac{di}{dt}(0^+) - 0 = 0$$

$$20 - \frac{di}{dt}(0^+) = 0$$

$$\frac{di}{dt}(0^+) = 20 \text{ A/s}$$

$$\cancel{\frac{di}{dt} = -2k_1 e^{-2t} - 2k_2 e^{-2t}}$$

$$\cancel{20 = -2(k_1 + k_2)} \quad 20 =$$

$$\cancel{-10 = k_1 + k_2}$$

$$\cancel{-10 = k_1}$$

$$\cancel{20 = -2k_1 +}$$

$$\frac{di}{dt} = -2k_1 e^{-2t} + k_2\left(t(-2)e^{-2t} + e^{-2t}\right)$$

$$20 = k_2 \cancel{e^{-2t}}$$

$\therefore \quad i = 20 e^{-2t} t.$

*) Analysis of Transient Response in ckt. using Laplace T.

Integro D.E. → Laplace Transform → Algebraic eqn → Algeb. operations → Inverse Laplace T. → soln.

Properties of L.T.

1. Linearity

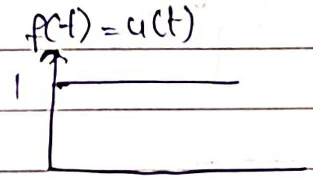
$$L\{f_1(t) + f_2(t) + \dots f_n(t)\} = F_1(s) + F_2(s) + \dots + F_n(s).$$

$$L\{a_1 f_1(t) + a_2 f_2(t) + \dots\} = a_1 F_1(s) + a_2 F_2(s) + \dots$$

$a_1, a_2 \rightarrow$ const.

Step funcn

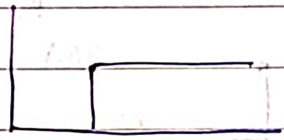
$$u(t) = 1 \quad \text{for } t \geq 0$$
$$= 0 \quad \text{for } t < 0$$



$$L\{u(t)\} = \frac{1}{s}$$

if step is shifted by T

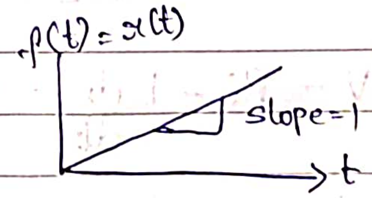
$$f(t) = u(t-T).$$



$$L\{u(t-T)\} = \frac{e^{-Ts}}{s}$$

Ramp funcn

$$r(t) = t \quad \text{for } t \geq 0$$
$$= 0 \quad \text{for } t < 0$$

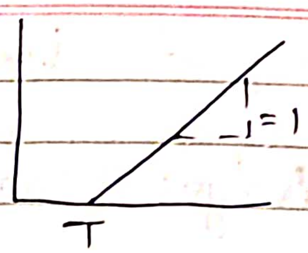


$$L\{t\,u(t)\} = \frac{1}{s^2}$$

if slope is A

$$= \frac{A}{s^2}$$

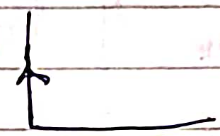
$$L\{x(t-T)\} = \frac{e^{-Ts}}{s^2}$$



Impulse

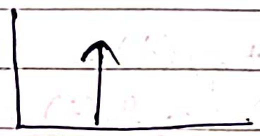
$\delta(t) = 1$ for $t=0$

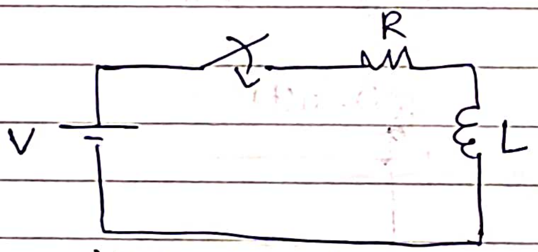
$\quad = 0$ for $t \neq 0$



$L\{\delta(t)\} = 1$

$L\{\delta(t-T)\} = e^{-Ts}$



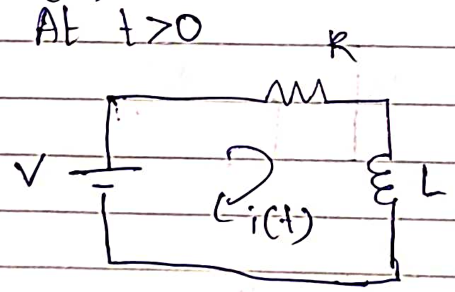
Q. 

Switch is closed $t=0$. Find the eqn of i.

Soln: $i(0^-) = 0 = i_L$

$i(0^+) = 0$

At $t>0$



$V - Ri - L\frac{di}{dt} = 0.$ where $i = i(t)$.

$V =$ const as it is dc

$V = Ri(t) + L\frac{di(t)}{dt}$

Taking L.T. of above eqn.

$i(0^-) =$

$$I_sR + L[s.I_s - i(0^-)] = \frac{V}{s}$$

$$I_sR + L[sI_s] - L[i(0^-)] = \frac{V}{s}$$

$$I_s[R+sL] = \frac{V}{s}$$

$$I_s = \frac{V}{s(R+sL)}$$

$$I_s = \frac{V/L}{s(s+R/L)}$$

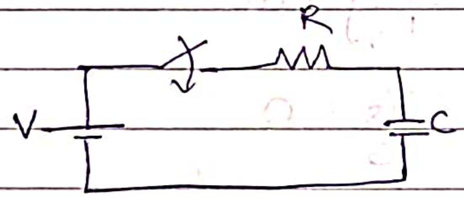
$$L^{-1}[I_s] = \frac{V}{L}\, L^{-1}\left[\frac{1}{s(s+R/L)}\right]$$

$$= \frac{V}{L}\, L^{-1}\left[\frac{s+R/L-s}{s(s+R/L)}\right] \times \frac{L}{R}$$

$$= \frac{V}{R}\, L^{-1}\left[\frac{1}{s} - \frac{1}{s+R/L}\right]$$

$$= \frac{V}{R}\left[1 - e^{-R/L\,t}\right]$$

R-C



$$V - Ri - \frac{1}{C}\int_0^t i\,dt = 0$$

$$V = Ri + \frac{1}{C}\int_0^t i\,dt.$$

Taking Laplace

$$\frac{V}{s} = I_sR + \frac{1}{C}\frac{I_s}{s}$$

$$\frac{V}{s} = I_s\left(R + \frac{1}{Cs}\right)$$

$$I_s = \frac{VC\cancel{s}}{(RCs+1)\cancel{s}}$$

$ax+1$
$as+1.$

$$I_s = \frac{VC}{RCs+1}$$

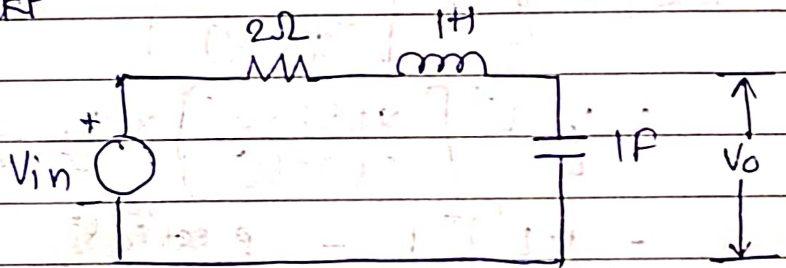
$$\frac{VC}{RCs+1} \neq \frac{A}{RCs+1}$$

$$I_s = \frac{V\cancel{C}}{R\cancel{C}\left(\frac{1}{RC}+s\right)}$$

Taking Lap. Inv

$$i(t) = \frac{V}{R} e^{-\frac{t}{RC}}$$

* RLC Ckt



Determine the response in time domain for unit impulse input.

Sol^n:

$$V_{in} - 2i - 1.\frac{di}{dt} - \frac{1}{1}\int_0^t i\,dt = 0$$

$$V_{in(s)} - 2I_s - sI_s - \frac{I_s}{s} = 0$$

$$I_s\left[-2 - s - \frac{1}{s}\right] = -V$$

$$I_s = \frac{V}{\left(-2-s-\frac{1}{s}\right)}$$

$$= \frac{V}{\left(\frac{-2s-s^2-1}{s}\right)}$$

$$I_s = \frac{Vs}{-2s-s^2-1}$$

$$I_s = \frac{-Vs}{2s+s^2+1}$$

while, o/p voltage

$$V_o(s) = \frac{I_s}{s}$$

$$I(s) = s \cdot V_o(s).$$

$$s \cdot V_o(s)\left(\frac{s^2+2s+1}{s}\right) = V_{in}(s)$$

$$\frac{V_o(s)}{V_{in}(s)} = \frac{1}{s^2+2s+1} = \frac{1}{(s+1)^2}$$

Input is unit impulse

$$V_{in}(s) = L[\delta(t)] = 1$$

$$V_o(s) = \frac{1}{(s+1)^2}$$

$$\cancel{\text{Vote}} \quad 1 = \frac{A}{(s+1)^2} + \frac{B}{(s+1)}$$

$$1 = A + B(s+1)$$

$\cancel{S=0}$ $\quad$ $\cancel{B} =$: $1 = A + Bs + B$

$\cancel{A=1}$ $\quad$ $A + B = 1$ $\quad$ $Bs = 0$

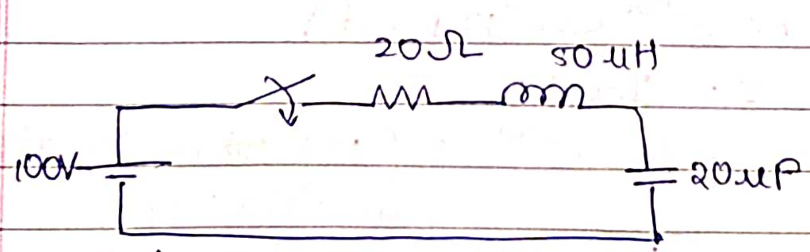
$A = 1$ $\quad$ $B = 0$

Taking L. Inv.

$$V_o(t) = L^{-1}\left[\frac{1}{(s+1)^2}\right]$$

$$= t.e^{-t}.$$

Q.



i at $t>0$

V_L for $t>0$

Sol^n:

$i(0^-) = 0$

$v(0^-) = 0$

$$100 - 20i - 50\times10^{-6}\frac{di}{dt} - \frac{1}{20\times10^{-6}}\int_0^{t} i\,dt = 0$$

$$\frac{100}{s} - 20I_s - 50\times10^{-6}[sI_s] - \frac{1}{20\times10^{-6}} \times \frac{I_s}{s} = 0$$

$s^2 + 400s + (200)^2$

400000.

10^6.

$\frac{1}{(s+a)^2} = e^{-t}$

f^n $\frac{1}{s^2} = t$

$$\frac{100}{s} = 20 I_s + 50\times10^{-3} s I_s + 0.05\times10^6 \frac{I_s}{s}$$

$$\frac{100}{s} = I_s\left[20 + 50\times10^{-3} s + \frac{5\times10^4}{s}\right]$$

$$\frac{100}{\cancel{s}} = I_s\left[\frac{20s + 50\times10^{-3}s^2 + 5\times10^4}{\cancel{s}}\right]$$

$$I_s = \frac{100}{20s + \overset{0.05}{\cancel{50\times10^{-3}}}s^2 + 5\times10^4}$$

$$I_s = \frac{100}{0.05s^2 + 20s + 5\times10^4}$$

$$I_s = \frac{2000}{s^2 + 400s + 10^6}$$

$$\frac{2000}{s^2+400s+10^6} = \frac{As+B}{s^2+400s+10^6}$$

$$As + B = 2000$$

$$B = 2000 \quad A = 0.$$

$$I_s = \frac{2000}{s^2 + 400s + 10^6}$$

$$I_s = \frac{2000}{(s+200)^2 + (979.79)^2}$$

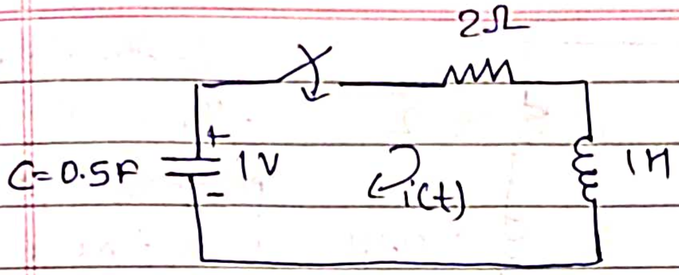
$$I_s = \frac{2000}{(s+200)^2} + \frac{2000}{979.79}$$

$$i(t) = 2.04\, e^{-200t} \sin(979.79t).$$

$$V_L(s) = I(s) L s$$

$$= 100\, e^{-200t}\cos(979.79t) - 20.41\, e^{-200t} \sin(979.79t).$$

Q.



Cap. is charged to 1V initially.
Find i(t)

Soln:

$i(0^-) = 0$

$v(0^-) = 0$

$i(0^+) = 0$

$V(0^+) = 1V$

At $t > 0$

$$-2i - 1\frac{di}{dt} - 2\int i\,dt = 0$$

$$1 - 2I_s - sI_s - \frac{2I_s}{s} = 0$$

$$\cancel{I_s\left[-2 - s - \frac{2}{s}\right] = -1}$$

$$I_s = \frac{s}{2s + s^2 + 2}$$

$$= \cancel{\frac{s}{s^2+2s+4}} \quad \cancel{\frac{s}{(s+2)^2-2}}$$

$$\cancel{I_s = e^{-2t}}$$

$$\frac{1}{s} - 2I_s - sI_s - \frac{2I_s}{s} = 0$$

$$I_s\left(2 + s + \frac{1}{s}\right) = \frac{1}{s}$$

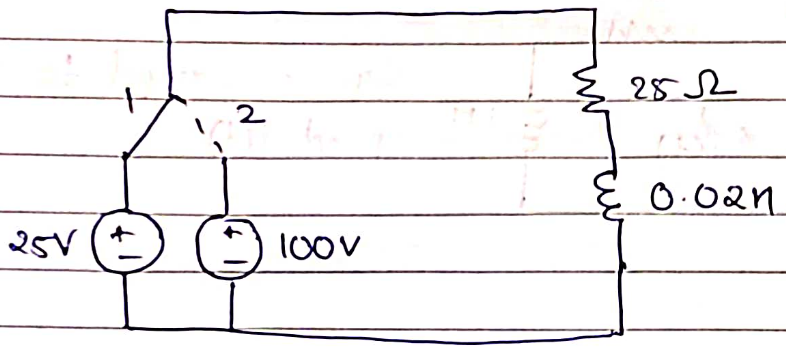
$$I_s\left(\frac{2s + s^2 + 1}{s}\right) = \frac{1}{s}$$

$$I_s = \frac{1}{2s + s^2 + 2}$$

$$I_s = \frac{1}{(s+1)^2 + 1}$$

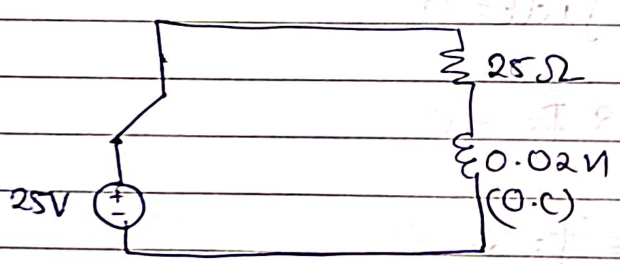
Taking laplace

$$i(t) = e^{-t}\sin t.$$

Q. 

In the ckt shown the switch is in position 1 for a long time enough to establish a steady state condn. At t=0 the switch is thrown to position 2.

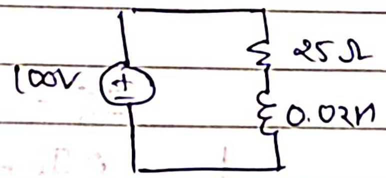
Soln: At $t=0^-$



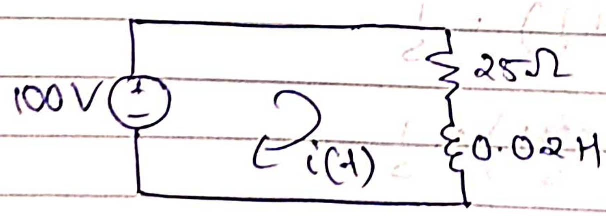
$i = \frac{25}{25} = 1A.$ $V = 25V$

At $t=0^+$

$i = \frac{100}{25} = 4A$ $V = 100V$



At $t>0$



$$100 - 25i - 0.02\frac{di}{dt} = 0$$

$$\frac{100}{s} - 25I_s - 0.02sI_s = 0$$

$$I_s(25 + 0.02s) = \frac{100}{s}$$

$$I_s = \frac{100}{s(25 + 0.02s)}$$

$$I_s = \frac{100}{0.02s^2 + 25}$$

$$100 - 25i = 0.02\frac{di}{dt}$$

$$\frac{100 - 25i}{0.02} = \frac{di}{dt}$$

$$5000 - 1250i \, dt = di$$

Integrating

$$5000i - \underline{1250i^2}$$

$$0.02sI_s - 0.02i(0^-) + 25I(s) = \frac{100}{s}$$

$$I(s) = \frac{100 + 0.02s}{s(25 + 0.02s)}$$

$$= \frac{s + 5000}{s(s + 1250)}$$

$$= \frac{A}{s} + \frac{B}{s + 1250}$$

$$s + 5000 = A(s + 1250) + B(s)$$

$A + B = 1$ $\quad$ $1250A = 5000$

$B = -3$ $\quad$ $A = 4$

$$I_s = \frac{4}{s} - \frac{3}{s + 1250}$$

Taking $i(t)$.

$$i(t) = 4 - 3e^{-1250t}.$$