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# Chapter # 4

Q.no.1: Find The determenent:

(a)
$$\begin{vmatrix} 2 & 1 \\ -4 & 3 \end{vmatrix}$$

let
$$A = \begin{vmatrix} 2 & 1 \\ -4 & 3 \end{vmatrix}$$

$$|A| = (2 \times 3) - (-4 \times 1)$$

$$|A| = 6 - (-4) = 6+4$$

$$\boxed{|A| = 10}$$

(b)
$$\begin{vmatrix} 0 & 2 & 11 \\ 6 & 4 & 1 \\ 3 & -1 & 5 \end{vmatrix}$$

let
$$B' = \begin{vmatrix} 0 & 2 & 11 \\ 6 & 4 & 1 \\ 3 & -1 & 5 \end{vmatrix}$$

(2)

$$|B| = \begin{vmatrix} 0 & 2 & 11 \\ 6 & 4 & 1 \\ 3 & -1 & 5 \end{vmatrix}$$

Expending Row1:

$$|B| = 0\begin{vmatrix} 4 & 1 \\ -1 & 5 \end{vmatrix} - 2\begin{vmatrix} 6 & 1 \\ 3 & 5 \end{vmatrix} + 11\begin{vmatrix} 6 & 4 \\ 3 & -1 \end{vmatrix}$$

$$= 0 - 2(30-3) + 11(-6-12)$$

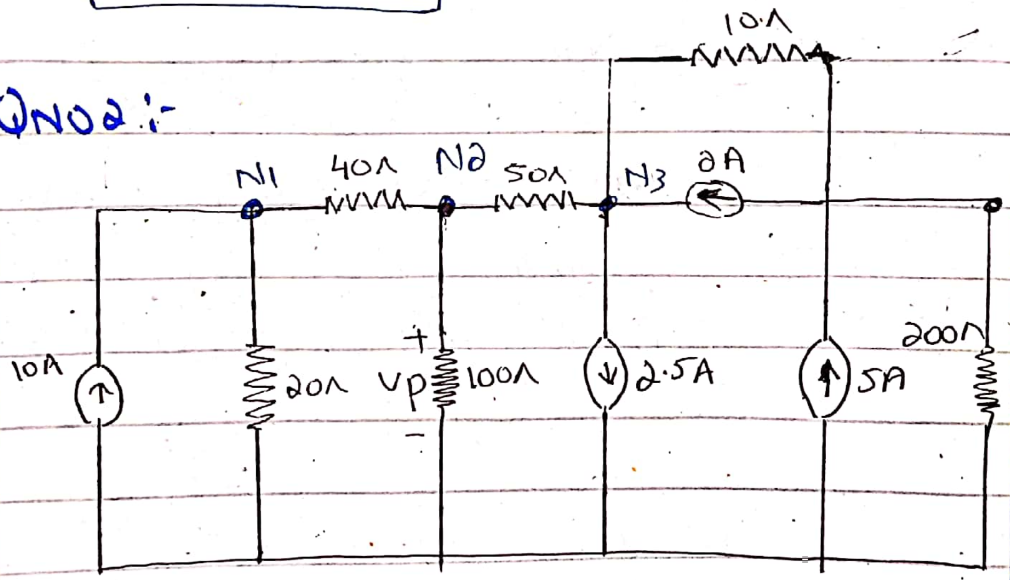
$$= -2(27) + 11(-18)$$

$$= -54 - 198$$

$$252$$

$$\boxed{|B| = 252}$$

QNo2:-




Find Vp Through Nodal analysis.

(3)

Applying KCL on Node 1

$I_{20\Omega} + I_{40\Omega} = I_s \quad ; \; I = V/R$

$\cancel{\frac{V_1}{20} + \frac{V_1 - V_2}{40} = 10A}$

$$\frac{V_1}{20} + \frac{V_1 - V_2}{40} = 10$$

$$\frac{V_1}{20} + \frac{V_1 - V_2}{40} = 10$$

$$\frac{2V_1 + V_1 - V_2}{40} = 10$$

$$3V_1 - V_2 = 400 \rightarrow (1)$$

at Node (2)

$$\frac{V_2 - V_1}{40} + \frac{V_2}{100} + \frac{V_2 - V_3}{50} = 0$$

$$\frac{5V_2 - 5V_1 + 2V_2 + 4V_2 - 4V_3}{200} = 0$$

$$-5V_1 + 11V_2 - 4V_3 = 0 \rightarrow (2)$$

At Node 3:

$$\frac{V_3 - V_2}{50} + \frac{V_3 - V_4}{10} = 2 - 2.5$$

$$\frac{V_3 - V_2 + 5V_3 - 5V_4}{50} = -0.5$$

$$-V_2 + 6V_3 - 5V_4 = -25 \rightarrow (3)$$

(4)

at Node (4).

$$\frac{V_3 - V_2}{10} + \frac{V_3}{200} = 5 - 2$$

$$\frac{20V_3 - 20V_2 + V_3}{200} = 3$$

$$\frac{-20V_2 + 21V_3}{200} = 3$$

$$-20V_2 + 21V_3 = 600 \rightarrow (4)$$

by ~~solving~~ eqv (1), (2), (3) & (4)

~~we get~~

$$\begin{bmatrix} 3 & -1 & 0 & 0 \\ -5 & 11 & -4 & 0 \\ 0 & -1 & 6 & -5 \\ 0 & -20 & 21 & 0 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \\ V_4 \end{bmatrix} = \begin{bmatrix} 400 \\ 0 \\ -25 \\ 600 \end{bmatrix}$$

by solving matrix we get

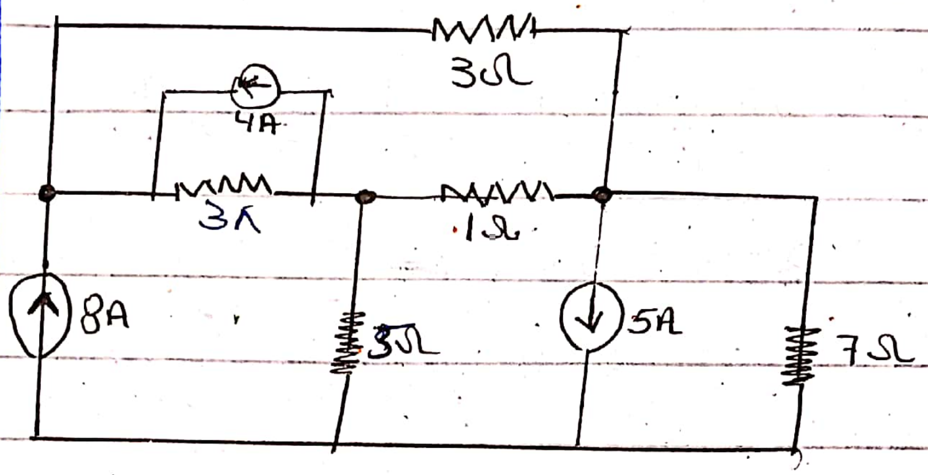
$V_1 = 18.46\,V$, $V_2 = 141.3\,V$

$V_3 = 163.2\,V$ $V_4 = 172.5\,V$

from Fig $V_2 = V_P$

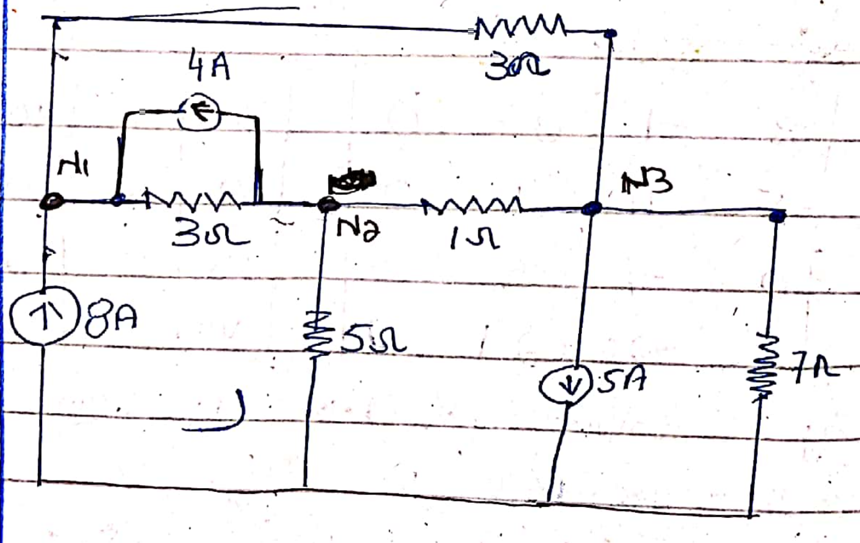
Hence $\boxed{V_P = 141.3\,V} \rightarrow$ ANS.

QNO3:-




Find voltage across 3Ω & power dissipated by 7Ω.

Re draw circuit & Identify Nodes




At Node 1 (N1) Apply KCL

$$\cancel{\frac{V_3 - V_2}{1}} + \frac{V_3 - V_1}{3}$$

Next page.

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$$\frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{3} = 8 + 4$$

$$\frac{V_1 - V_2 + V_1 - V_3}{3} = 12$$

$$2V_1 - V_2 - V_3 = 12 \times 3$$

$$2V_1 - V_2 - V_3 = 36 \rightarrow (1)$$

at $N_2$ :-

$$\frac{V_2 - V_1}{3} + \frac{V_2}{5} + \frac{V_2 - V_3}{1} = -4$$

$$\frac{5V_2 - 5V_1 + 3V_2 + 15V_2 - 15V_3}{15} = -4$$

$$-5V_1 + 23V_2 - 15V_3 = -60 \rightarrow (2)$$

at Node 3:-

$$\frac{V_3 - V_2}{1} + \frac{V_3 - V_1}{3} + \frac{V_3}{7} = -5$$

$$\frac{21V_3 - 21V_2 + 7V_3 - 7V_1 + 4V_3}{21} = -5$$

$$-7V_1 - 21V_2 + 31V_3 = -105$$

(7)

write 3 eq. in form of matric

$$\begin{bmatrix} 2 & -1 & -1 \\ -5 & 2 & -10 \\ -7 & -21 & 31 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 86 \\ 4 \\ 105 \end{bmatrix}$$

A $\quad$ x $\quad$ B

$$AX = B$$

$$A^{-1}AX = A^{-1}B$$

$$IX = A^{-1}B$$

$$X = A^{-1}B \quad -\ast$$

by sloving above matix by inversion method we get

$$\begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} 26.7 \\ 8.8 \\ 8.6 \end{bmatrix}$$

Here $V_{5\Omega} = V_2$

voltage across $5\Omega = 8.8V$

$$\boxed{V_{5\Omega} = 8.8V} \rightarrow \text{AWS}$$

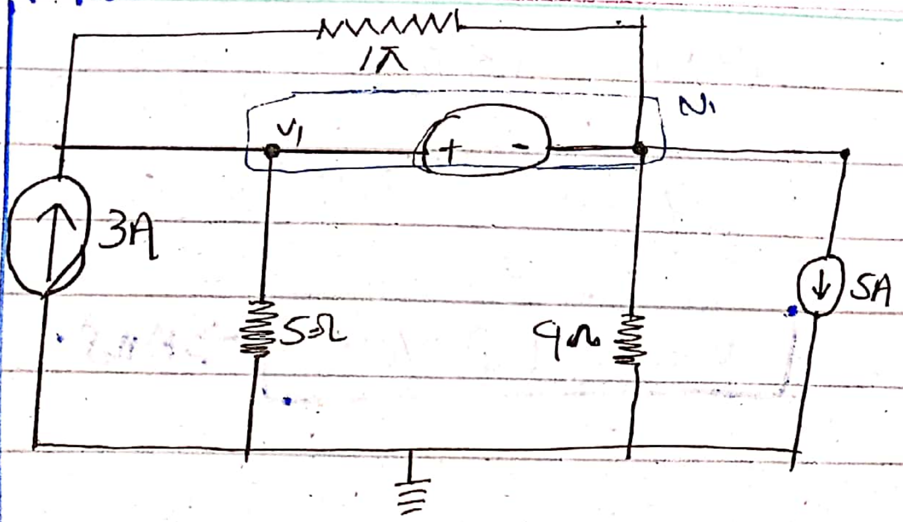
Now

$$P_{7\Omega} = V_3^2/R$$

$$= \frac{(8.6)^2}{7} = \frac{74.8}{7}$$

$$\boxed{P_{7\Omega} = 10.64} \rightarrow \text{Ans.}$$

Q4:- (8)




Find $V_1$.

Apply KCL on ~~...~~ supernode

$$\frac{(V_1 - V_2)}{1} + \frac{V_1}{5} + \frac{V_2 - V_1}{1} + \frac{V_2}{9} = 3 - 5$$

$$\frac{\cancel{45V_1} - \cancel{45V_2} + 9V_1 + \cancel{45V_2} - \cancel{45V_1} + 5V_2}{45} = -2$$

$$9V_1 + 5V_2 = -90 \rightarrow (1)$$

Here

$$V_1 - V_2 = 9 \quad -(ii)$$

multiply 5 eq (2) & Add eq (1)

$$\begin{aligned} 9V_1 + 5\cancel{V_2} &= -90 \\ +5V_1 - \cancel{5V_2} &= +40 \\ \hline 14V_1 &= 130 \end{aligned}$$

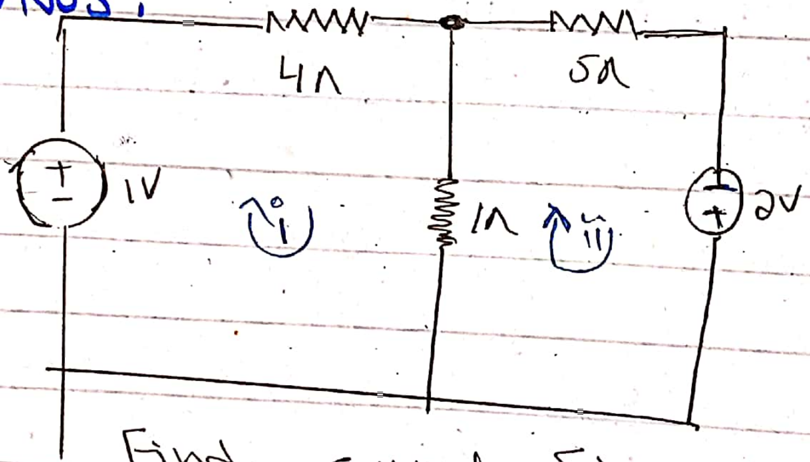
$V_1$

$$14V_1 = 130$$

$$V_1 = 130/14$$

$$\boxed{V_1 = 9.2 \text{ Volt}} \rightarrow \text{Ans.}$$

Q NO 5:-




Find current Flowing out from +ive terminal of each voltage source.

by mesh analysis

Apply KVL on loop 1

$$1V - 4i_1 - (i_1 - i_2) = 0$$

$$1 = 4i_1 + i_1 - i_2$$

$$5i_1 - i_2 = 1 \rightarrow (1)$$

at loop (2)

$$1(i_2 - i_1) + 5i_2 = 2$$

$$6i_2 - i_1 = 2 \quad \text{—(ii)}$$

$$-i_1 + 6i_2 = 2 \quad \text{—(ii)}$$

multiply 5 by eq (ii) & Add with eq (1)

$$\cancel{5i_1} + 30i_2 = 10$$
$$\cancel{5i_1} - i_2 = 1$$

$$29i_2 = 11$$

$$i_2 = 11/29$$

$$\boxed{i_2 = 0.37A} \rightarrow \text{Ans-}$$

put value of $i_2$ in eq (1)

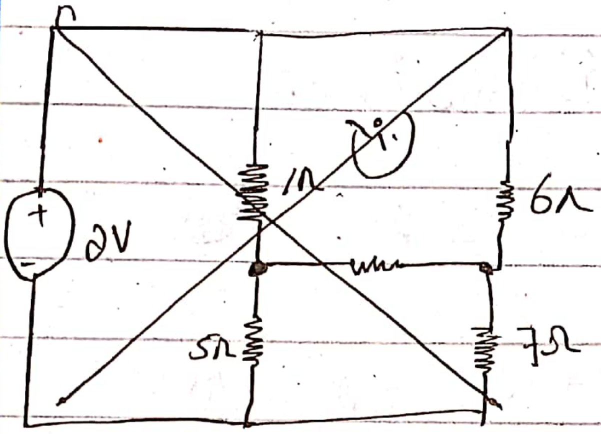
$$5i_1 - 0.37 = 1$$

$$5i_1 = 1 + 0.37$$

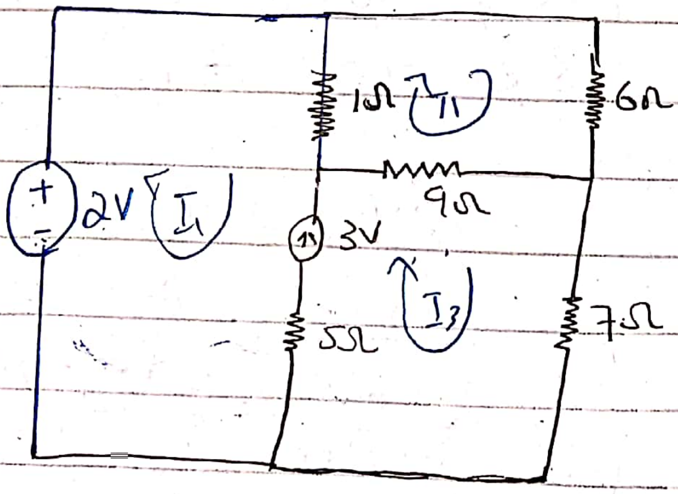
$$\boxed{i_1 = 0.27A} \rightarrow \text{Ans}$$

(11)

Q NO 6 :-




Q NO 6 :-




From loop I :-

$$-2 + 1(i_1 - I_2) - 3 + 5(i_1 - I_3) = 0$$

$$6i_1 - i_2 - 5i_3 = 5 \quad \rightarrow (i)$$

From loop (ii)

$$1(i_2 - i_1) + 6i_2 + 9(i_2 - i_3) = 0$$

$$-i_1 + 16i_2 - 9i_3 = 0 \quad \rightarrow (ii)$$

(12)

from loop 3:-

$5(i_3 - i_2) + 9(i_3 - i_2) + 7i_3 = -3$

$-5i_1 - 9i_2 + 21i_3 = -3 \rightarrow (iii)$

From eqv (1) (2) & (3)

$$\underbrace{\begin{bmatrix} 6 & -1 & -5 \\ -1 & 16 & -9 \\ -5 & -9 & 21 \end{bmatrix}}_{A} \begin{bmatrix} i_1 \\ i_2 \\ i_3 \end{bmatrix} = \begin{bmatrix} 5 \\ 0 \\ -3 \end{bmatrix}$$

solve by cramer's rule.

$$|A| = \begin{vmatrix} 6 & -1 & -5 \\ -1 & 16 & -9 \\ -5 & -9 & 21 \end{vmatrix}$$

Futher simplification

$|A| = 1015$

Now

$$A_x = \begin{vmatrix} 5 & -1 & -5 \\ 0 & 16 & -9 \\ -3 & -9 & 21 \end{vmatrix}$$

$|A_x| = 1008$

$$A_y = \begin{vmatrix} 6 & 5 & -5 \\ -1 & 0 & -9 \\ -5 & -3 & 21 \end{vmatrix}$$

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$|A_y| = 153$

$$A_2 = \begin{vmatrix} 6 & -1 & 5 \\ -1 & 16 & 0 \\ -5 & -9 & -3 \end{vmatrix}$$

$|A_2| = 730$

Now $i_1 = \frac{|A_x|}{|A|} = \frac{1008}{1015}$

$$\boxed{i_1 = 0.9\,A}$$

$i_2 = \frac{|A_y|}{|A|} = \frac{153}{1015}$

$$\boxed{i_2 = 0.150\,A}$$

$i_3 = \frac{|A_2|}{|A|} = \frac{730}{1015}$

$$\boxed{i_3 = 0.71\,A}$$

$$\boxed{\begin{aligned} i_1 &= 0.9A \\ i_2 &= 0.15A \\ i_3 &= 0.71A \end{aligned}} \rightarrow \text{Ans.}$$

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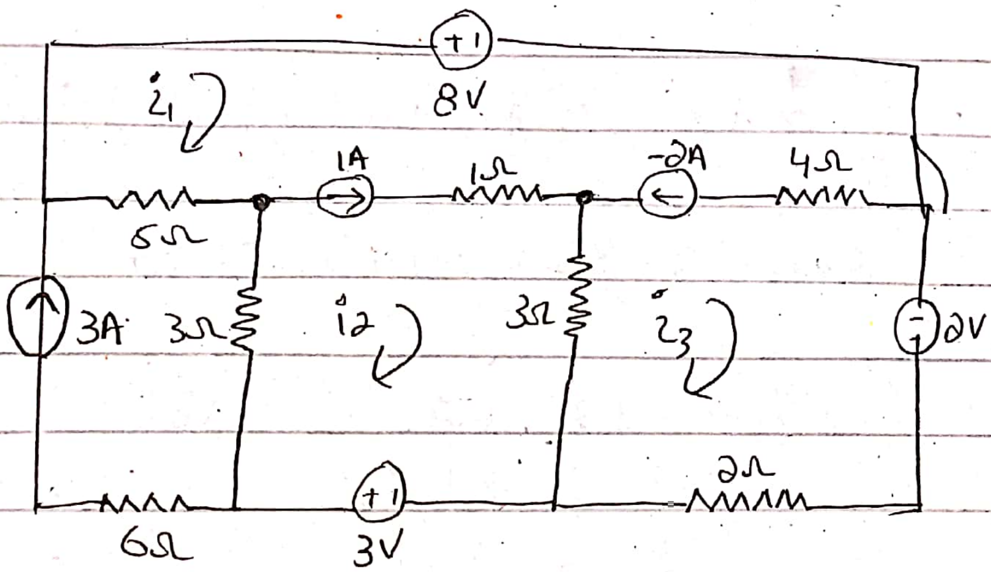
(14)

Q NO 7 :-




let $i_1, i_2$ & $i_3$ As a supernode and Apply KCL to it.

$$5(i_1-3)+3(i_2-3)+2i_3=3+2-8$$

$$5i_1-15+3i_2-9+2i_3=-3$$

$$5i_1+3i_2+2i_3=-3+15+9$$

$$5i_1+3i_2+2i_3=21 \rightarrow (1)$$

We know that

$$i_2-i_1=1$$

where $i_2=1+i_1 \rightarrow (ii)$

$$\cancel{i_1-i_3}\ i_2-i_1=-2$$

$$-i_2\ i=-2\ \bar{+}\ i_1$$

$$\cancel{i_3=2+i_1 \ \text{—(iii)}}$$

$$i_3=2+i_1 \quad \text{—(iii)}$$

(15)

put eq (ii) & (iii) in (1)

$$5i_1 + 3(1+i_1) + 2(2+i_1) = 12$$

$$\cancel{5i_1 + 3 + 3i_2 + 4 + 2i_1 = 12}$$

$$5i_1 + 3 + 3i + 2i + 4 = 12$$

$$10i_1 = 21/10$$

$$\boxed{i_1 = 2.1A}$$

put vale of $i_1$ in eq (2) & (3)

$$i_2 = 1 + 2.1$$

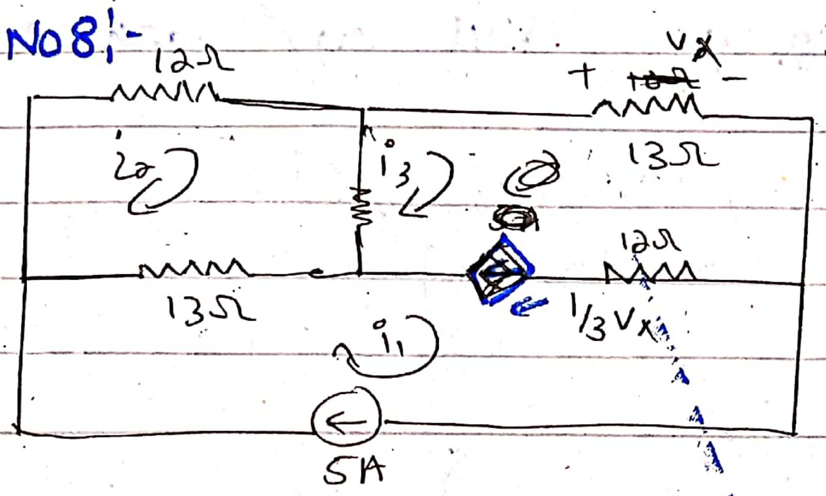
$$\boxed{i_2 = 3.1A}$$

$$i_3 = 2 + 2.1$$

$$\boxed{i_3 = 4.1A}$$

$$\boxed{\begin{aligned} i_1 &= 2.1A \\ i_2 &= 3.1A \\ i_3 &= 4.1A \end{aligned}} \rightarrow \text{Ans.}$$

Q No 8:-




from the fig
we know that
5A current flowing through $i_1$

$\boxed{i_1 = 5A}$

Now These is dependent source b/w $i_2$ & $i_3$

$$i_2 - i_3 = \frac{1}{3}V_x$$

$\therefore V_x = 13 i_3$

$$-i_3 = \frac{13 i_3}{3} + 5$$

$\boxed{i_3 = 1.5A}$

Now on $i_2$:-

(17)

$$13(i_2-i_1)+11(i_2-i_3)+12i_2=0$$

$$13i_2-13i_1+11i_2-11i_3+12i_2=0$$

$$36i_2-13(5)-11(-1.5)=0$$

$$36i_2-65+16.5=0$$

$$36i_2=65-16.5$$

$$i_2=\frac{48.5}{36}$$

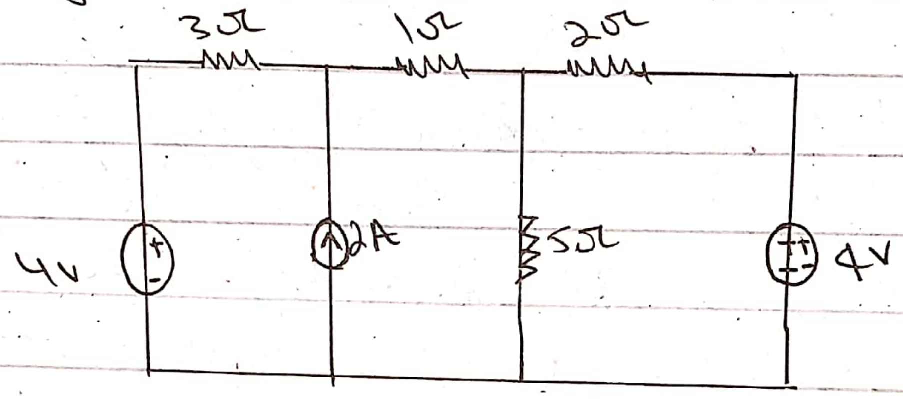
$$\boxed{i_2=1.37A}$$

x ———— x ~~~~ x ———— x

# Chapter # 5:-

## QNo 1:-

Figure:-




**Solution**

Since there are three sources $v_1, v_2, v_3$

$$v_x = v_1 + v_2 + v_3$$

where $v_1, v_2$ and $v_3$ are the contribution due to ~~all~~ the left 4v voltage source - 2A current source and the right 4voltage source respectively.

To obtain $v_1$ we set the 2A and the right 4V source to zero as shown below -

apply mesh analysis to the two meshes 1 and 2, we obtain the following matrix equation.

$$\begin{bmatrix} 3+1+5 & -5 \\ -5 & 5+2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 4 \\ 0 \end{bmatrix}$$

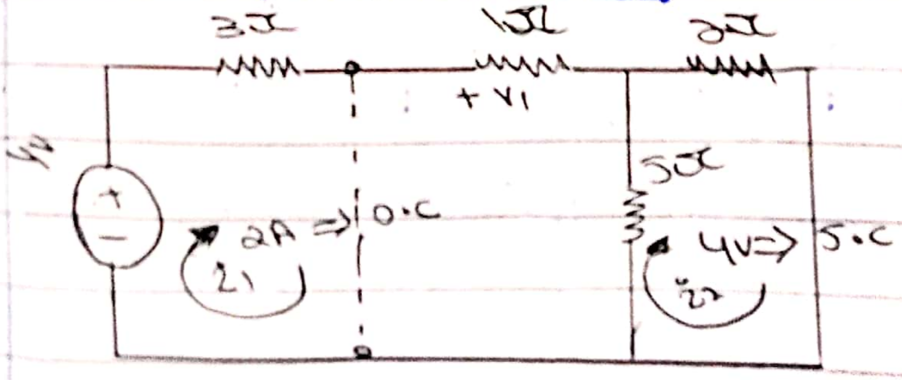
we find

$$i = \frac{14}{19} A$$

for 1Ω resistor, ohm's law gives

$$V_1 = 1 \cdot i_1 = \frac{14}{19} V \approx 736.84 mV$$

$$\boxed{V_1 = 736.84 mV}$$




To obtain v2 we set the two 4v source to zero as shown below. apply nodal analysis to

The two node va an vb we obtain the following matrix equation -

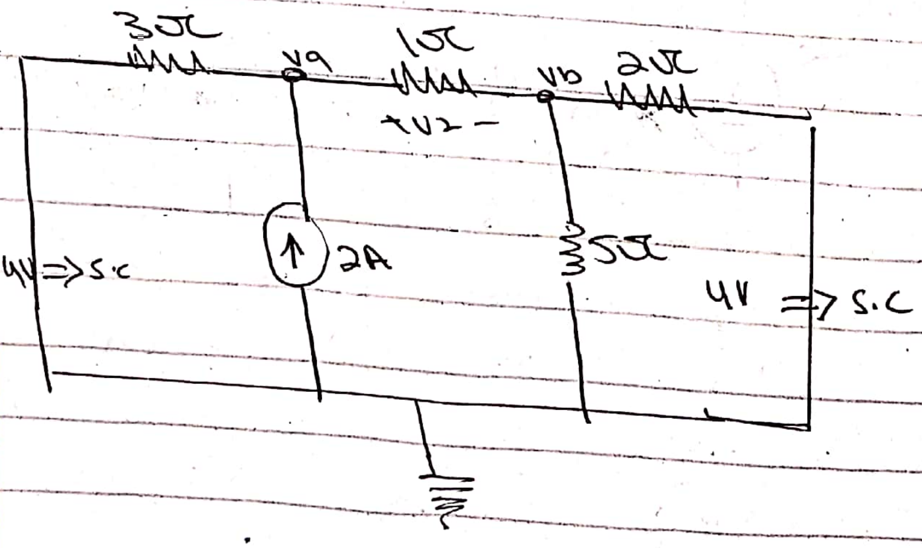
$$\begin{bmatrix} \frac{1}{3}+1 & -1 \\ -1 & 1+\frac{1}{3}+\frac{1}{2} \end{bmatrix} \begin{bmatrix} va \\ vb \end{bmatrix} = \begin{bmatrix} 2 \\ 9 \end{bmatrix}$$

matrix equation we find $Va = \frac{51}{19}$ v and $Vb = \frac{21}{19}$ v

By inspection it is clear that.

$$V2 = Va - Vb = \frac{51}{19} - \frac{30}{19} = \frac{21}{19}$$

$$\boxed{V2 = 1.105 V}$$



To obtain V3 we set the 2A and the left 4V source to zero as shown below. Apply mesh analysis to the two meshes 1 and 2 we obtain the following matrix equation-

$$\begin{bmatrix} 3+1+5 & -5 \\ -5 & 5+2 \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix} = \begin{bmatrix} 6 \\ 4 \end{bmatrix}$$

The matrix equation we find

$$i_1 = \frac{-10}{19} A$$

For the 1 ohm resistor ohm's law gives:-

$$V_3 = 1 \cdot i_1 = \frac{-10}{19} V$$

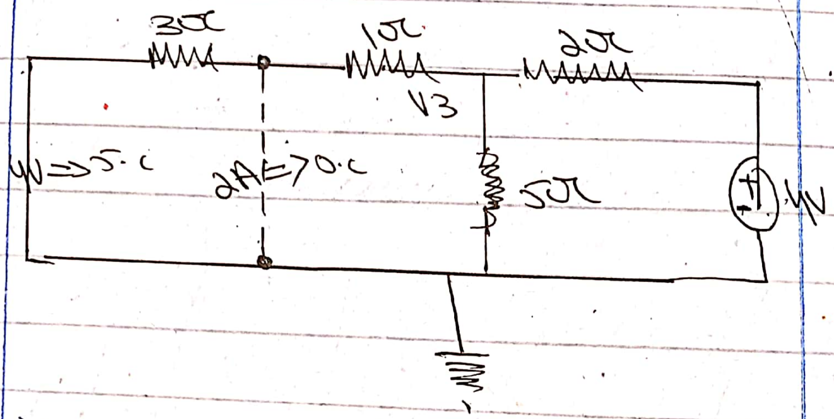
$$\boxed{V_3 = -526.32 mV}$$

Therefore

$$V_n = V_1 + V_2 + V_3$$

$Vx = 736.84mV + 1.105V - 526.32mV$

$$\boxed{Vx = 1.316V}$$




it is required to evaluate the values of the current source that results in reducing the Vx value by 10%. let the new values of Vx is Vx'. the current source values affects only its contribution which is V2. let the new values of V2 is V2'.

$V'_x = 0.9 \cdot V_x = 0.9 \cdot 1.316V$

$V_x = 1.1844V$

and

$V_2' - V_x' - (V_1 + V_3) = 1.1844V - 173.684\,mV$

$- 526.32\,mV = 9.7388\,mV.$

Apply nodal analysis to the two nodes va and vb in the circuit shown below gives.

$$I_{cs} = \left(1 + \frac{1}{3}\right) v_a - v_b \quad —— ①$$

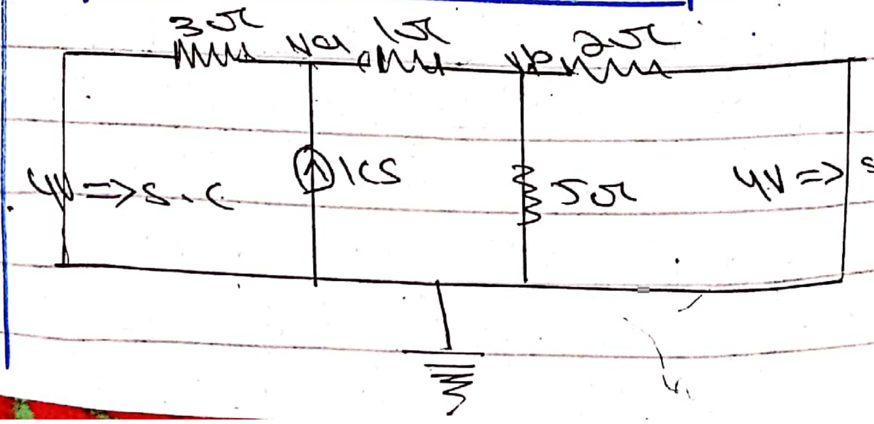
$$0 = -v_a + \left(1 + \frac{1}{5} + \frac{1}{2}\right) v_b \quad —— ②$$

we have

$$v_a - v_b = V_2' = 973.88\,mV \quad —— ③$$

Solving the three equation ①, ② and ③ we have

$$\boxed{I_{cs} = 1.7622A}$$



we verify our results in part (a) using pspice as shown below we obtain:-

$$V_x = 6.053 - 4.737$$

$$= \boxed{1.316V}$$

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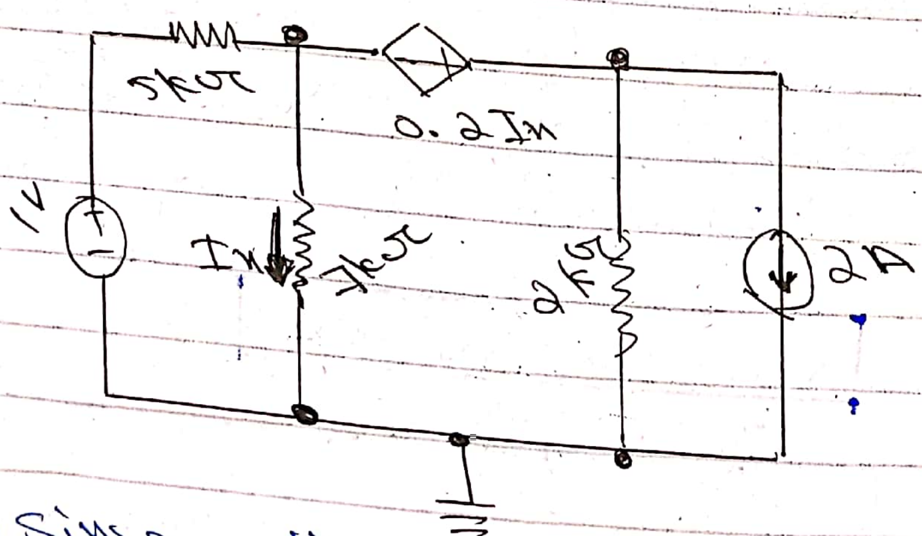
Q No 2:-

employ superposition principles to obtain a values for the current $I_n$ as labeled.




Since there are two independent sources - let where $I_{n1}$ and

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$I_{x2}$ are the contribution due $I_v$ voltage source and 2A current source respectively.

To obtain $i_{x1}$ we set the 2A current source to zero (replacing it with an open circuit) as shown below.

Apply KCL to the super-position X gives.

$$\frac{V_1 - I}{5000} + \frac{V_1}{7000} + \frac{V_2}{2000} = 0$$

But

$$V_2 = V_1 + 0.2 I_{x1}^{\circ} \text{ here}$$

$$\frac{V_1 - 1}{5000} + \frac{V}{7000} + \frac{V_1 + 0.2 I \times 1}{2000} = 0$$

But

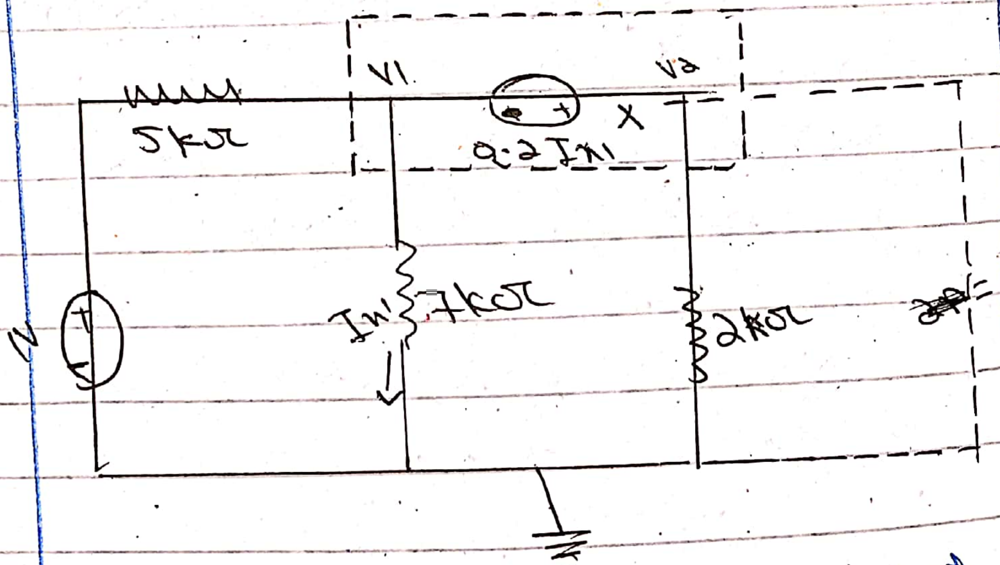
$$V_1 = 7000 I_{x1}^{\circ} \text{ hence}$$

$$\frac{7000 I_{N1} - 2}{5000} + \frac{7000 I_{N1}}{7000}$$

$$+ \frac{7000 I_{N1} + 0.2 I_{x1}}{2000} = 0$$

Then

$$\boxed{I_{N1} = 32.9 \mu A}$$




To obtain $I_{N2}$ we set the (V) voltage source to zero as shown below. Apply KCL to the super node Y given

$$\frac{V_1}{5000} + \frac{V_1}{7000} + \frac{V_2}{2000} = -2$$

But

$V_1 = 7000 I_{N2}$ hence

$$\frac{7000 I_{n2}}{5000} + \frac{7000 I_{n2}}{7000} + \frac{7000 I_{n2}}{2000} + 0.2 I_{n}$$

$$= -2$$

Thus

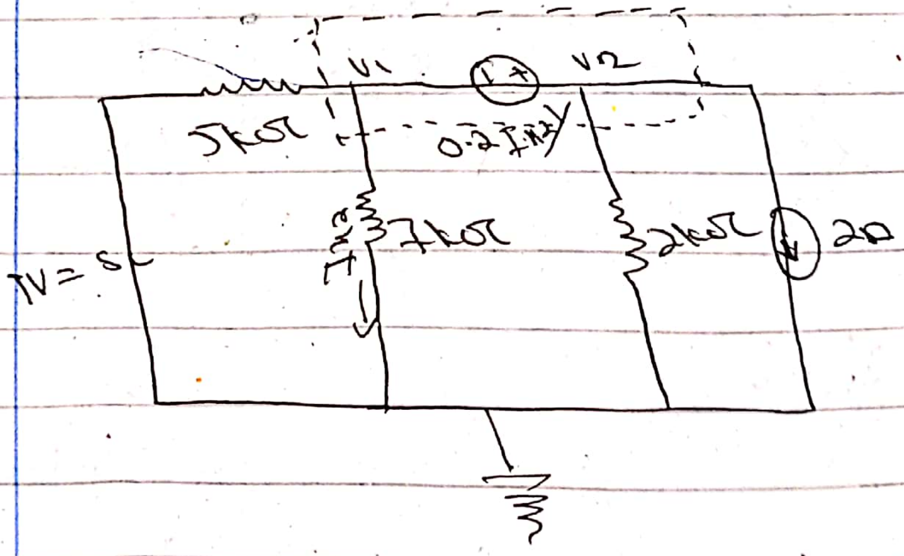
$$\boxed{I_{n2} = -338.98 \text{ mA}}$$

Therefore,

$$I_n = I_{n1} + I_{n2}$$

$$= 33.9 \mu A + (-338.8 \text{ mA})$$

$$\boxed{I_n = -338.95 \text{ mA}}$$



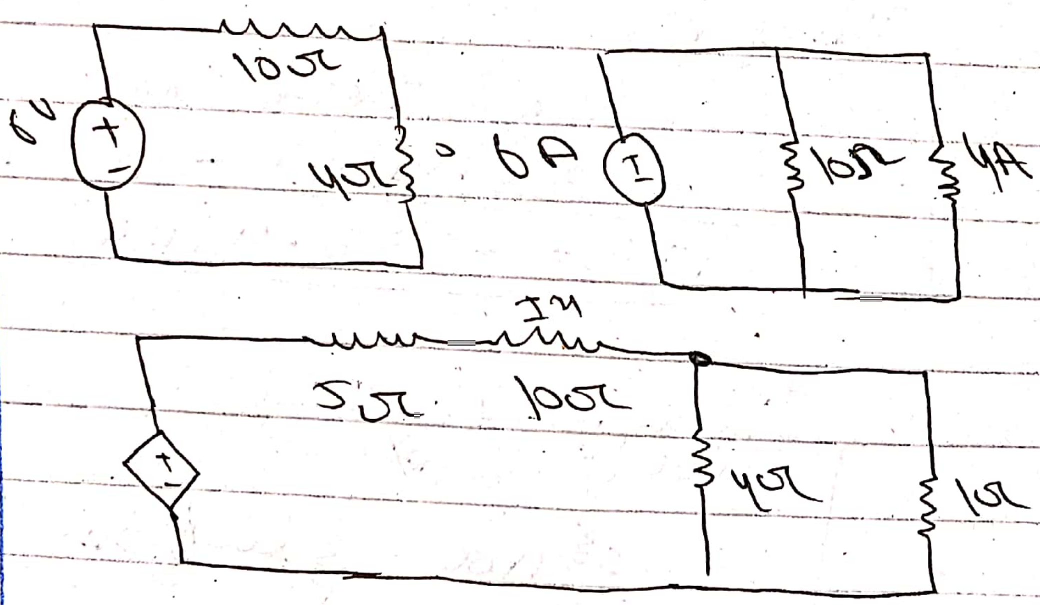

Result

$$I_n = -338.95 \text{ mA}$$

* —— * —— *

QNO3:-

perform an apperopriate source transformation on each of the circuit depicted in 5.58, taking care to retain 40Ω resistor in each final circuit.




Solution

To get the value of the new source we use-

$I \; V/R$

$I = 6/10$

$\boxed{I = 0.6A}$

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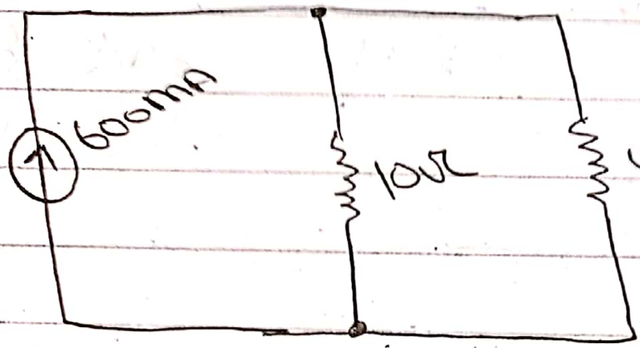
And

we can draw the circuit as:



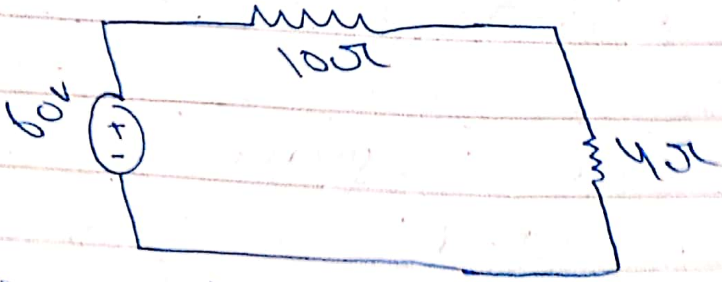

The new voltage source will have the of:

$V = 10 \cdot 6$

$\boxed{V = 60V}$

And

we draw it as:

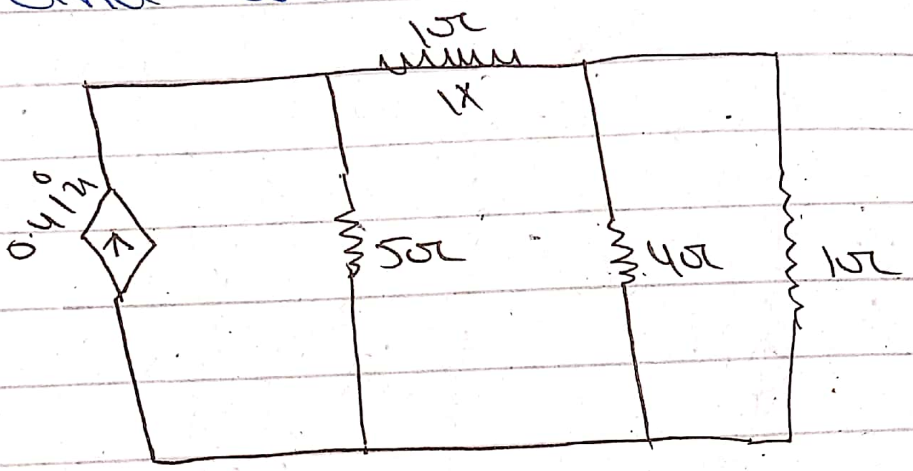



To get the value of the new current source we use

$I = \frac{2i_x}{5}$

$I = 0.4 i_x$

and we draw it as:




Results:-

(a) we replace the ~~100Ω~~ 10Ω resistor and the voltage source with a 600 mA current source in parallel with a 100Ω resistor.

(b) we replace the 10Ω resistor and a current source with a sixty voltage (60v) source in series with a 10Ω resistor.

(c) we replace the 5Ω resistor and the

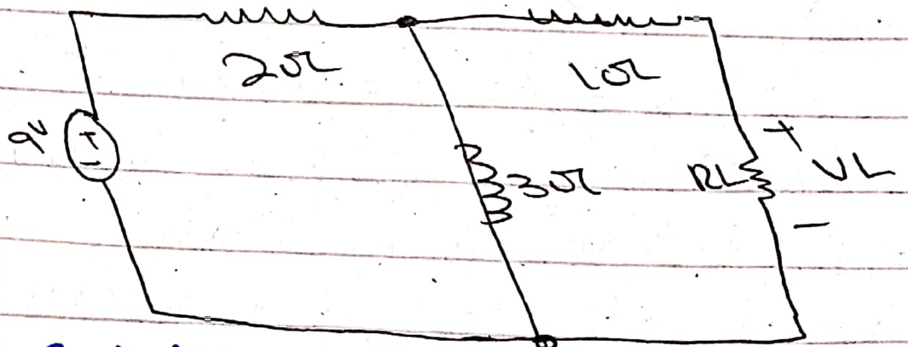
dependent voltage source with a dependent current source labeled $0.4 i_x$ in parallel with a $5\Omega$ resistor

* ——— * ——— * ———*

Q No 4:-

(a) Determine the Thevenin equivalent of the network to RL.

(b) Determine VL for RL = $1\Omega$, $3.5\Omega$, $6.2537\Omega$ and $9.8\Omega$




Solution :-

To get VTh we disconnect RL and find the voltage b/w the two disconnected point - As we can see. This voltage is the one in the $3\Omega$

$V_{Th} = 9V \cdot \frac{3}{5}$

$$\boxed{V_{Th} = 5.4V}$$

We can calculate $R_{Th}$ as:-

$R_{Th} = 1 + 3 \parallel 2$

$R_{Th} = 2.2\Omega$

Then

we calculate $V_L$ as:

$V_L = V_{Th} \cdot \frac{R_L}{R_L + R_{Th}}$

for each value of $R_L$ we get

$R_L = 1\Omega \Rightarrow V_L = 1.688V$

$R_L = 3.5\Omega \Rightarrow V_L = 3.316V$

$R_L = 9.8\Omega \Rightarrow V_L = 4.41V$

$R_L = 6.2570\Omega \Rightarrow V_L = 3.995V$

Result:-

$V_{Th} = 5.4V$, $R_{Th} = 2.2\Omega$

$V_L = 1.688V$, $3.316V$, $3.995V$ and $4.41V$

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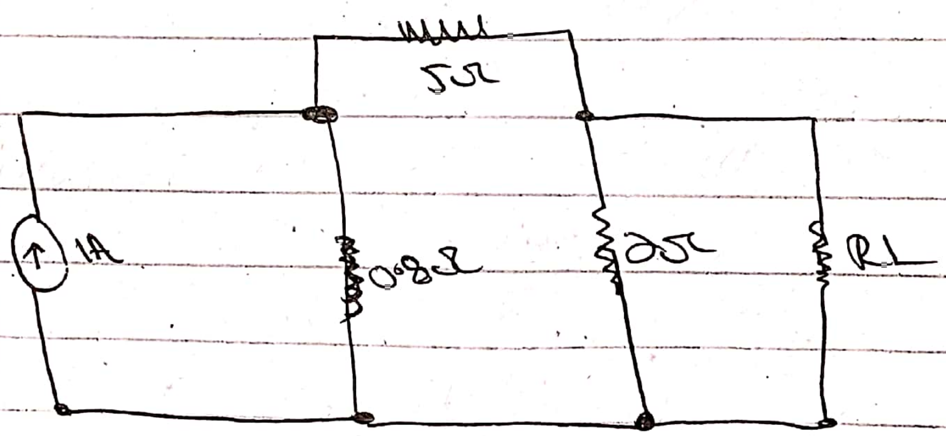
Q.No5:-

(a) obtain the norton equivalent of the network connected to RL

(b) obtain Tho'evnin equivalent of the same network.

(c) Use either to calculate it for RL = 0Ω, 1Ω, 4.923Ω and 8.107Ω.




## Solution

(a) we calculate RN as:

$RN = (0.8 + 5 \parallel 50) \parallel 2$

$RN = 3.3 \parallel 2$

$RN = 1.245\Omega$

(34)

For $i_N$ we have:

$$i_N = \frac{0.8}{0.8 + 2.5}$$

$$i_N = 0.242A$$

(b)

Now we can $V_{Th}$ as;

$$V_{Th} = i_N \cdot R_N$$

$$V_{Th} = 0.302V$$

(c)

Using Thevenin equivalent we get.

$$i_L = \frac{V_{Th}}{R_{Th} + R_L}$$

For each calue of $R_L$ giving as

(1) $R_L = 0\Omega \Rightarrow i_L = 0.243A$

(2) $R_L = 1\Omega \Rightarrow i_L = 0.135A$

(3) $R_L = 4.923\Omega \Rightarrow i_L = 0.049A$

(35)

(4) $RL = 8.107\Omega \Rightarrow i_L = 0.032A$.

Result:-

(a)

$I_N = 0.242A$, $R_N = 1.245\Omega$

(b)

$V_{Th} = 0.302V$, $R_{Th} = 1.245V$

(c)

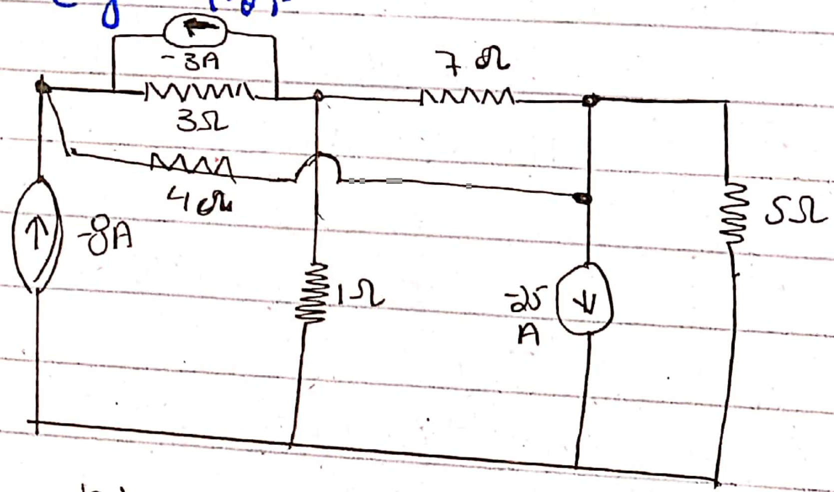
$i_L = 0.243A$, $0.135A$, $0.049A$
$0.032A$.

* ——— * ———— *

Question No2:-

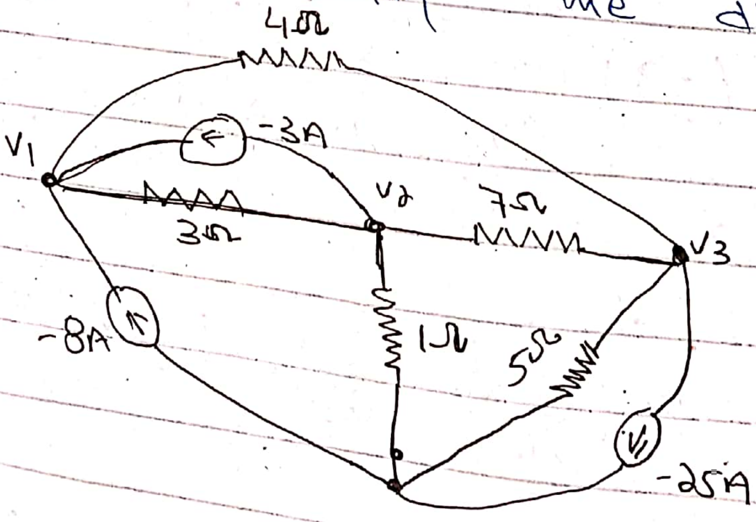
Part 1:

E.g 4.21-




determine the Nodal voltage For the circuit as refferenced to the bottom node.

by Simplifying the diagram.



Now Apply KCL at $V_1$ :-

$$-8-3 = \frac{V_1 - V_2}{3} + \frac{V_1 - V_3}{4}$$

$$-11 = \frac{4V_1 - 4V_2 + 3V_1 - 3V_3}{12}$$

$$\frac{7V_1 - 4V_2 - 3V_3}{12} = -11$$

$$\frac{7}{12}V_1 - \frac{4}{12}V_2 - \frac{3}{12}V_3 = -11$$

$$0.58V_1 - 0.33 - 0.25V_3 = -11 \rightarrow (I)$$

at $V_2$ :-

$$-(-3) = \frac{V_2 - V_1}{3} + \frac{V_2}{1} + \frac{V_2 - V_3}{7}$$

$$3 = \frac{7V_2 - 7V_1 + 21V_2 + 3V_2 - 3V_3}{21}$$

$$\frac{31}{21}V_2 - \frac{7}{21}V_1 - \frac{3}{21}V_3 = 3$$

$$-0.25V_1 + 1.4V_2 - 0.14V_3 = 3 \rightarrow (II)$$

at V3 :-

$$-(-25) = \frac{V_3}{5} + \frac{V_3 - V_2}{7} + \frac{V_3 - V_1}{4}$$

$= \cancel{025}$

$\Rightarrow -0.25V_1 - 0.14V_2 + 0.59V_3 = 25 \rightarrow (3)$

write eq (1) (2) (3) in matrix form.

$$\begin{bmatrix} 0.58 & -0.33 & -0.25 \\ -0.25 & 1.47 & -0.14 \\ -0.25 & -0.14 & 0.59 \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} -11 \\ 3 \\ 25 \end{bmatrix}$$

A

$$\text{now } |A| \begin{vmatrix} 0.58 & -0.33 & -0.25 \\ -0.25 & 1.47 & -0.14 \\ 0.25 & -0.14 & 0.59 \end{vmatrix}$$

$|A| = 0.316$

$$Ax_1 = \begin{vmatrix} -11 & -0.33 & -0.25 \\ 3 & 1.47 & -0.14 \\ 25 & -0.14 & 0.59 \end{vmatrix}$$

$|Ax_1| = 1.714$

$$A_y = \begin{bmatrix} 0.58 & -11 & -0.25 \\ -0.33 & 3 & -0.25 \\ -0.25 & 25 & 0.09 \end{bmatrix}$$

$$|A_y| = 2.4$$

$$|A_z| = \begin{bmatrix} 0.58 & -0.33 & -11 \\ -0.33 & 1.47 & 3 \\ -0.25 & -0.14 & 25 \end{bmatrix}$$

$$|A_z| = 14.6$$

Now

from Cramer's Rule

$$V_1 = \frac{|A_x|}{|A|} = \frac{1.714}{0.316} = 5.41$$

$$\boxed{V_1 = 5.41V}$$

$$V_2 = \frac{|A_y|}{|A|} = \frac{2.4}{0.316} = 7.73V$$

$$\boxed{V_2 = 7.73V}$$

$$V_3 = \frac{|A_z|}{|A|} = \frac{14.6}{0.316} = 46.3V$$

$$\boxed{V_3 = 46.3V}$$

Result

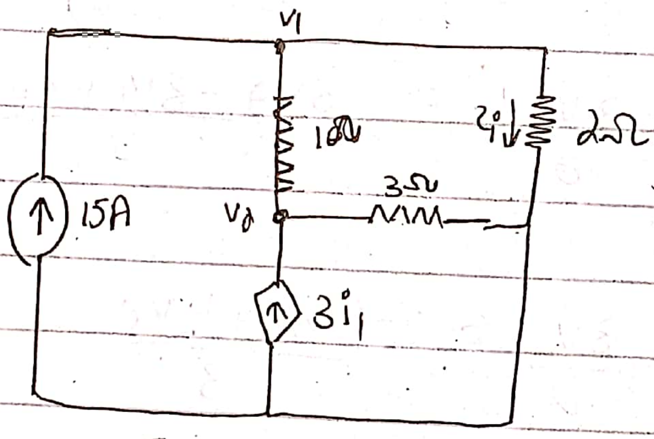
$V_1 = 5.41\,V$

$V_2 = 7.73\,V$

$V_3 = 46.3\,V$

x ~~~ x ~~~ x ~~~ x

Example: 4.3:-




Find power supply by dependent source.

Apply KCL at $V_1$

$$15 = \frac{V_1 - V_2}{1} + \frac{V_1 - 0}{2}$$

$$15 = \frac{2V_1 - 2V_2 + V_1}{2}$$

$$15 = 3V_1 - 2V_2 \longrightarrow (1)$$

at $v_2$:-

$$3i_1 = \frac{v_2 - v_1}{1} + \frac{v_2}{3}$$

$$3i_1 = \frac{3v_2 - 3v_1 + v_2}{3} \rightarrow (u)$$

$$3i_1 = 3$$

we know that

$i_1$ is current pass through $2\Omega$ resistor

$i_1 = v_1/2$ put in eq (u)

$$\frac{3v_1}{2} = \frac{3v_2 - 3v_1 + v_2}{3}$$

$$\frac{3v_1}{2} = \frac{-3v_1 + 4v_2}{3}$$

$$9v_1 = -6v_1 + 8v_2$$

$$8v_2 = 9v_1 + 6v_1$$

$$8v_2 = 15v_1$$

$$-15v_1 + 8v_2 = 0 \rightarrow (3)$$

now

multiply 5 by eq (1)

& ~~subtract from~~ Add with (iii)

(42)

$5(3V_1 - 2V_2 = 15)$ — ①

②

$15V_1 - 10V_2 = \cancel{30}\ 75$

$-15V_1 + 8V_2 = 0$

$-2V_2 = \cancel{30}75$

~~$V_2 = -15$~~

$$\boxed{V_2 = -37.5\ V}$$

put $V_2 = -37.5V$ in ③

$-15V_1 + (8 \times -37.5) = 0$

$-15V_1 - 300 = 0$

$-15V_1 = 300$

$-V_1 = 20$

$$\boxed{V_1 = -20V}$$

Now we know that

$I_1 = V_1/2$

$I_1 = \frac{-37.5}{2}$

$$\boxed{I_1 = 18.5}$$

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Power ~~dissipated~~ supplied by variable source.

$$P = I \cdot V$$

$$P = (3I_1)(-37.5)$$

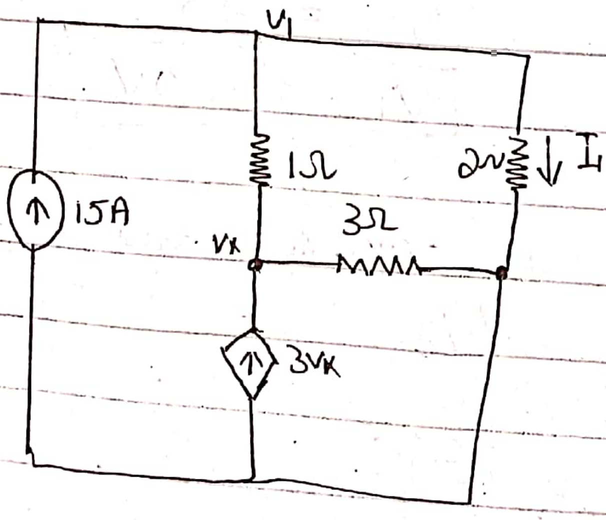
$$= (3(18.5)) \times -37.5$$

$$56.2 \times -37.5$$

$$\boxed{P = 2.1\,kW}$$

x ~ x ~ x ~ x

Ex 4.4:-




Find Power supplied by dependent source

Apply KCL at $(V_2)$

$$15 = \frac{V_1 - V_2}{1} + \frac{V_1}{2}$$

$$15 = \frac{2V_1 - 2V_2 + V_1}{2}$$

$$3V_1 - 2V_2 = 30 \rightarrow (1)$$

at $V_1$!

$$3V_x = \frac{V_2 - V_1}{1} + \frac{V_2}{3}$$

$$3V_x = \frac{3V_2 - 3V_1 + V_2}{3} \rightarrow (1)$$

We know that

$$V_x = \frac{V_2}{3} \text{ put (ii)}$$

$$3\frac{V_2}{\cancel{3}} = \frac{3V_2 - 3V_1 + V_2}{\cancel{3}}$$

$$3V_2 = 4V_2 - 3V_1$$

$$V_2 - 3V_1 = 0 \rightarrow (3)$$

(45)

Add eq (1) & 3

$$3V_1 - 2V_2 = 30$$
$$-3V_1 + V_2 = 0$$

$$V_2 = 30$$

here $V_2 = V_x$

Power

supply

$\cancel{P = V^2/R \quad (30)^2}$

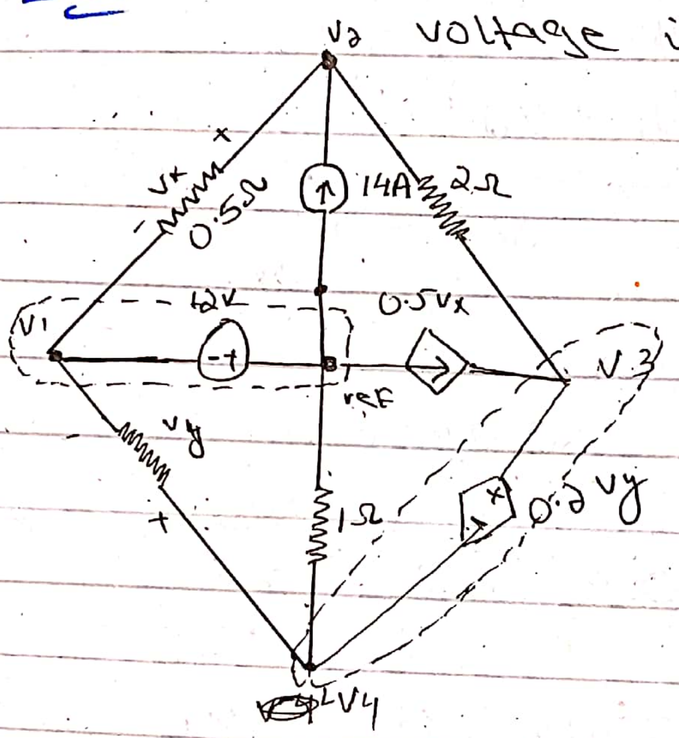
$$\text{Power} = (3V_x)(V_x)$$

$$= (3 \times 30)(30)$$

$$P = 90 \times 30$$

$$\boxed{P = 8\,kW}$$

Ex 4.6:- Determine the Node-to-reffer voltage in the circuit.




As from Fig

$V_1 = 12V$

Apply KCL at $V_2$

$$\frac{V_2 - V_1}{0.5} + \frac{V_2 - V_3}{2} = 14$$

$$\frac{4V_2 - 4V_1 + V_2 - V_3}{2} = 14$$

$$\Rightarrow \cancel{-4V_1 + 5V_2 - V_3 = 28 \rightarrow 1}$$

$$-2V_1 + 2.5V_2 - 0.5V_3 = 14 \rightarrow (1)$$

(47)

at Supper node $V_3$ & $V_4$

$$0.5V_x = \frac{V_3 - V_2}{2} + \frac{V_4 - V_1}{2.5} + \frac{V_4}{1}$$

$$0.5x = \frac{5V_3 - 5V_2 + 4V_4 - 4V_1 + 10V_4}{10}$$

$$\cancel{0.5V_x = \frac{-4V_1 - 5V_2 + 5V_3 + 14V_4}{10} \rightarrow (ii)}$$

$0.$

From Fig

$$0.5V_x = 0.5(V_2 - V_1) \quad \text{put (ii)}$$

$$0.5(V_2 - V_1) = \frac{-4V_1 - 5V_2 + 5V_3 + 14V_4}{10}$$

$$\cancel{5V_2 - 5V_1 = -4V_1 - 5V_2 + 5V_3 + 14V_4}$$

$$\cancel{-9V_1 - 10V_2 + 5V_3 + 14V_4 = 0 \rightarrow (iii)}$$

$$0.1V_1 - V_2 + 0.5V_3 + 1.4V_4 = 0 \rightarrow (iii)$$

Now we have

$$-2V_1 - 2.5V_2 - 0.5V_3 = 14 \rightarrow (a)$$

$$0.1V_1 - V_2 + 0.5V_3 + 1.4V_4 = 0 \rightarrow (b)$$

$$V_1 = 12 \rightarrow (c)$$

$$0.2V_1 + V_3 - 1.2V_4 = 0 \rightarrow (e)$$

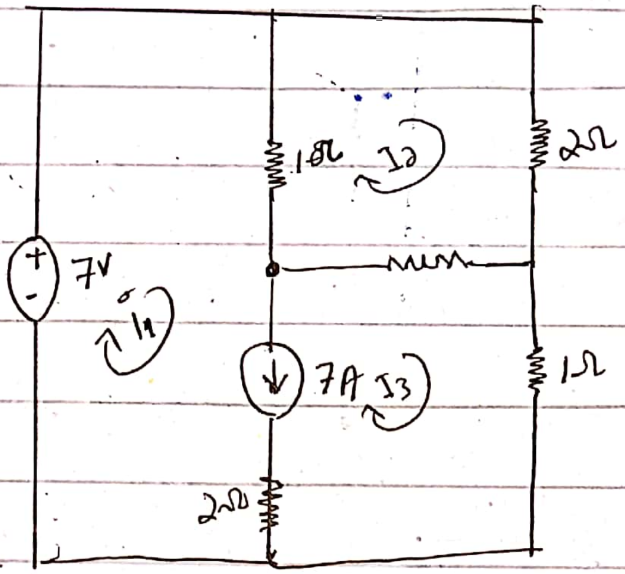
by solving These equation.

$$\boxed{\begin{aligned} V_1 &= 12V \\ V_2 &= -4V \\ V_3 &= 24V \\ V_4 &= 1 \end{aligned}}$$

x ~ x ~ x ~ x

Example 4.11 :-

Next - page -




Determine the mesh current.

From Fig

The 7A indepent current source is common b/w to mesh so it will consider as super mesh.

~~& Apply KVL to it.~~

at mesh 2:-

$$1(I_2 - I_1) + 3(I_2 - I_3) + 2I_2 = 0$$

$$I_2 - I_1 + 3I_2 - 3I_3 + 2I_2 =$$

$$-I_1 + 6I_2 - 3I_3 = 0 \rightarrow (1)$$

at ~~mesh (2)~~ super mesh.

$\cancel{(I_2 - I_1)}$

$$-7 + 1(I_1 - I_2) + 3(I_3 - I_2) + 1I_3 = 0$$

$$\Rightarrow \cancel{I_1 - 4I_3}$$

$$I_1 - I_2 + 3I_3 - 3I_2 + I_3 = 7$$

$$\cancel{I_1 + 6I_2 - 3I_3 =}$$

$$I_1 - 4I_2 + 4I_3 = 7 \rightarrow (ii)$$

& From Fig its clear

$$I_1 - I_3 = 7 \quad (iii)$$

Now write (3) eq in matrix.

$$\begin{bmatrix} 1 & -4 & 4 \\ -1 & 6 & -3 \\ 1 & 0 & -1 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 7 \\ 0 \\ 7 \end{bmatrix}$$

$$|A| = \begin{vmatrix} 1 & -4 & 4 \\ -1 & 6 & -3 \\ 1 & 0 & -1 \end{vmatrix}$$

$$1(-6-0) - (-4)[1-(-3)] + 4[0-6]$$

$$= -6 + 4(1+3) + 4(-6)$$

$$-6 + 16 - 24$$

(57)

$|A| = -30 + 16$

$\boxed{|A| = -14}$

$$|Ax| = \begin{vmatrix} 7 & -4 & 4 \\ 0 & 6 & -3 \\ 7 & 0 & -1 \end{vmatrix}$$ Expend colowmn 1

~~by c1~~

$= 7(-6-0) + 0 + 7(12-24)$

$-42 + 0 - 84$

$\boxed{|Ax| = -126}$

$$|Ay| = \begin{vmatrix} 1 & 7 & 4 \\ -1 & 0 & -3 \\ 0 & 7 & -1 \end{vmatrix}$$

$1(0-(-21)) - 1[-7-28] + 0$

$|Ay| = 21 - 1(-35)$

$= 21 + 35$

$\boxed{|Ay| = 56}$

$$|A_2| = \begin{vmatrix} 1 & -4 & 7 \\ -1 & 6 & 0 \\ 0 & 0 & 7 \end{vmatrix}$$

$$|A_2| = 1(42) - (-1)28 + 0$$

$$|A_2| = 42 - 28$$

$$\boxed{|A_2| = 14}$$

NOW

$$I_1 = \frac{|A_1|}{|A|} = \frac{+126}{+14}$$

$$\boxed{I_1 = 9A}$$

$$I_2 = \frac{|A_1|}{|A|} = \frac{+56}{+14} = 2.5A$$

$$\boxed{I_2 = 2.5A}$$

$$I_3 = \frac{14}{-14} = -1$$

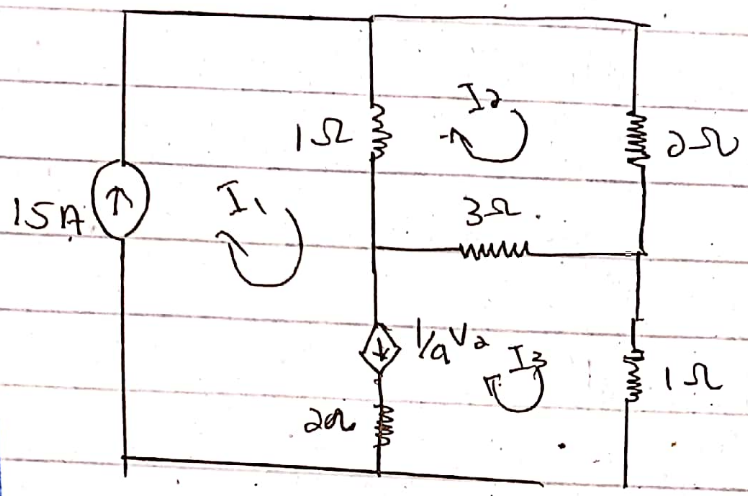
$$\boxed{I_3 = -1}$$

$$\boxed{\begin{aligned} I_1 &= 9A \\ I_2 &= 2.5A \\ I_3 &= -1A \end{aligned}}$$

Example: (53)

4.12 :-

Find unknow element of circuit.




It is clear from circuit

$I_1 = 15A$

&

~~Now Apply KVL at $I_3$~~

$$\frac{V_x}{9} = \frac{I_3 - I_1}{1} = \frac{3(I_3 - I_2)}{9}$$

$$I_1 + \frac{1}{9} V_x = I_3$$

$$I_1 + \frac{\cancel{3}\, I_3 - I_2}{\cancel{9}\, 3} = I_3$$

$$I_1 + \frac{I_3 - I_2}{3} = I_3$$

$$\frac{1}{3} I_2 - I_3 \frac{1}{3} - i_1 + I_3 = 0$$

$$-I_1 + \frac{1}{3} I_2 + \frac{2}{3} I_3 = 0$$

As $I_1 = 15$

$$-15 + \frac{1}{3} I_2 + \frac{2}{3} I_3 = 0$$

$$\frac{1}{3} I_2 + \frac{2}{3} I_3 = 15$$

$$\Rightarrow I_2 + 2 I_3 = 45 \rightarrow (1)$$

Apply KVL at mesh 2.

$$1(I_2 - I_1) + 2 I_2 + 3(I_2 - I_3) = 0$$

$$I_2 - I_1 + 2I_2 + 3I_2 - 3I_3 = 0$$

$$6 I_2 - I_1 - 3 I_3 = 0$$

$$6 I_2 - 15 - 3 I_3 = 0$$

$$6 I_2 - 3 I_3 = 15 \rightarrow (ii)$$

$$I_2 + 2I_3 = 45 \rightarrow (I)$$

$$6I_2 - 3I_3 = 15 \rightarrow (II)$$

multiply 6 by eq (I)
& subtract from 2

$$\begin{aligned} \cancel{6I_2} + 12I_3 &= 270 \\ \cancel{6I_2} - 3I_3 &= -15 \\ \hline 15I_3 &= 255 \end{aligned}$$

$$\boxed{I_3 = 17A}$$

put $I_3 = 17$ in eq (I)

$$I_2 + 3(I_3) = 45$$

$$I_2 + (17 \times 3) = 45$$

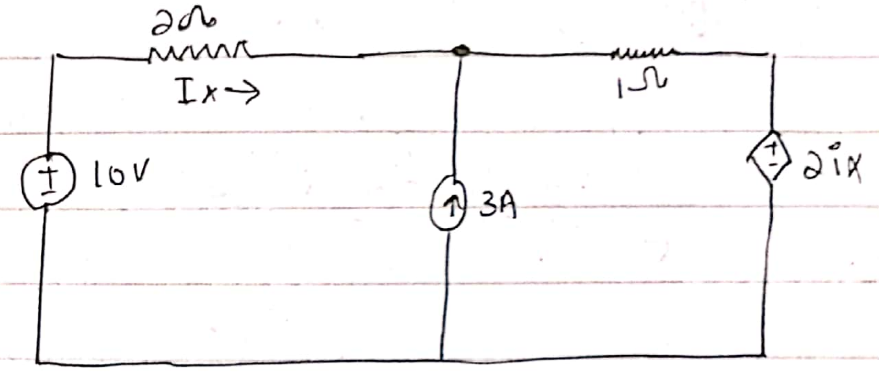
$$I_2 = 45 - 51$$

$$\boxed{I_2 = -6A}$$

$$\boxed{\begin{aligned} I_1 &= 15A \\ I_2 &= 17A \\ I_3 &= -6A \end{aligned}}$$

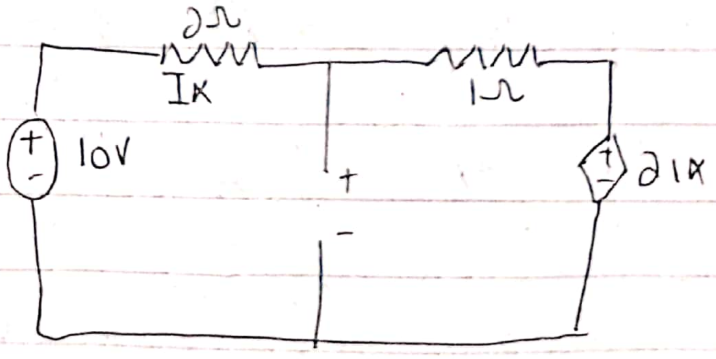
## Example 5.31:-

Use super position theorem to determine the value of $I_x$.




Solution:-

First we remove current source make it open circuit




Now aply KVL

$\cancel{2I_x +}$

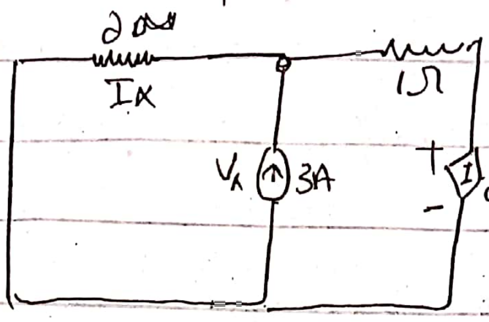
$$-10 + 2I_x' + 1I_x' + 2I_x' = 0$$

$$2I_x' + I_x' + 2I_x' = 10$$

$$5I_x' = 10$$

$$\boxed{I_x' = 2A}$$

NOW we will remove voltage source by short circuit




$$\frac{Vx''}{2} + \frac{Vx'' - 2Ix''}{1} = 3$$

$$\frac{Vx + 2x - 4Ix''}{2} = 3$$

$$3Vx - 4Ix'' = 6 \rightarrow (1)$$

NOW

$$Vx = 2(-Ix'') \quad \text{put in } (1)$$

$$\cancel{Vx = 2(-2}$$

$$3(2 - Ix'') - 4Ix'' = 6$$

$$-6Ix'' - 4Ix'' = 6$$

$$-10Ix'' = 6$$

$$Ix'' = 6/10$$

$$\boxed{Ix'' = -0.6}$$

Now

$$I_x = I_x' + I_x''$$

$$= 2 + (-0.6)$$

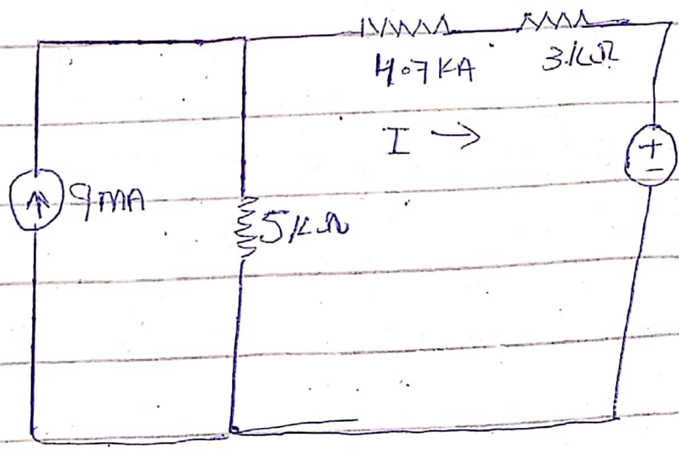
$$= 2 - 0.6$$

$$\boxed{I_x = 1.4A} \rightarrow \text{Ans}$$

x ———— x ———— x —— x

## Example (5.4)

Find the current through 4.7 kΩ after transforming the 9mA source in to the equivalent voltage source.




Solution:

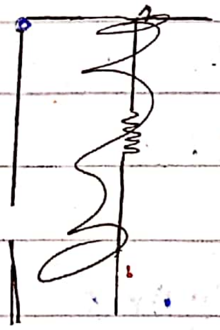
We know that

$$V = IR$$

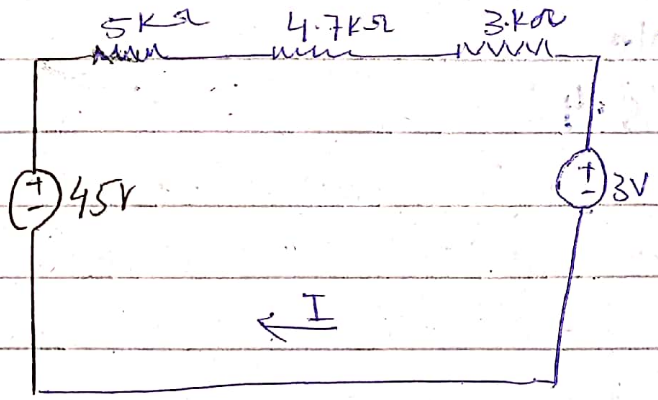
$$V = (9\times10^{-3})(5\times10^{3})$$

$$V = \cancel{35}\ 45\ \text{Volt}$$

~~Now remove current source by open circuit.~~



Now replace 9A source with 45 V source & redraw circuit.




As = $V = IR$

apply KVL

$$-45 + 5\times10^{3}I + 4.7\times10^{3} + 3\times10^{3}I + 3 = 0$$

$$5\times10^{3}I + 4.7\times10^{3}I + 3\times10^{3}I = 45 - 3$$

$$(5 + 4.7 + 3)\times10^{3}I = 42$$

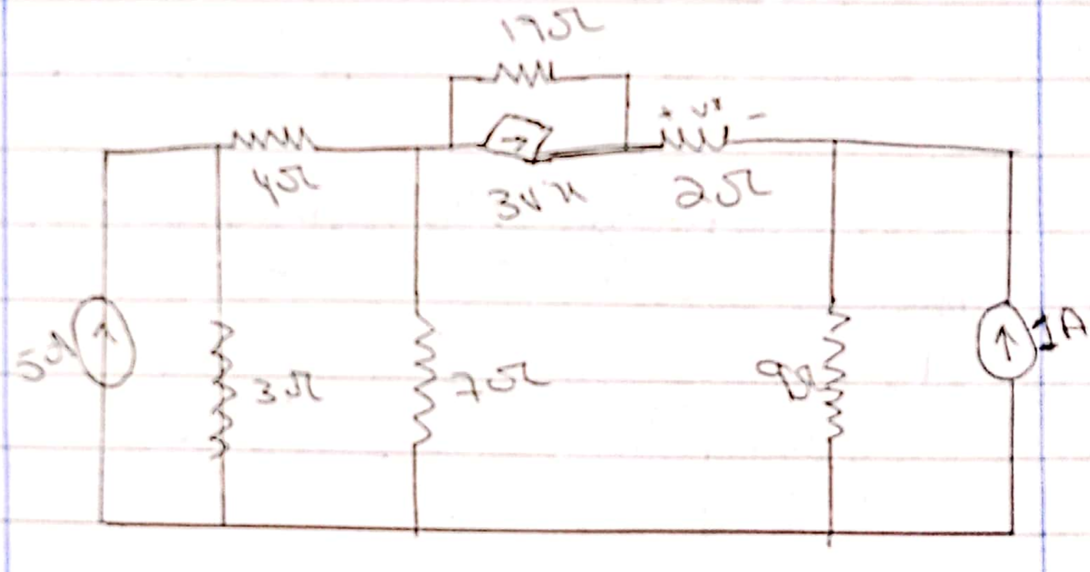
$$12.7\times10^{3}I = 42$$

$$12700\,I = 42$$

$$\boxed{I = 0.0033A} \rightarrow \text{Ans.}$$

Example 4.5:-

calculate the current through the 2Ω resistor by making use of source transformation to first simplify the current.




$V = IR$

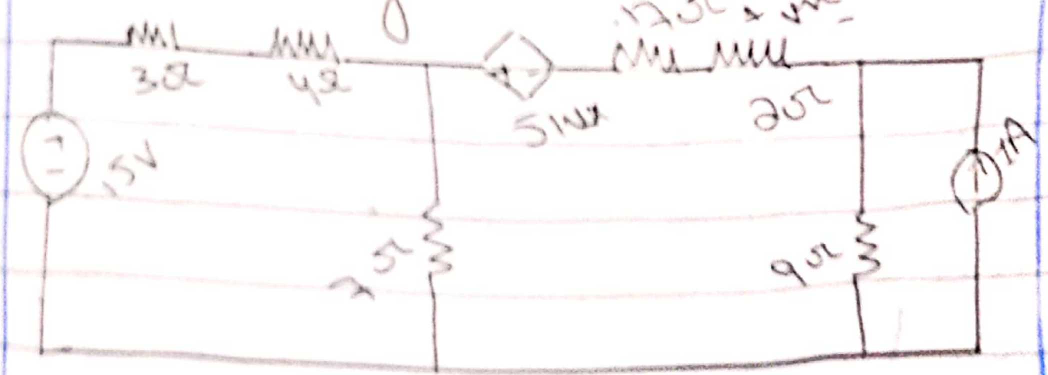
$V = 5(3)$

$V = 15V$

$V_x = 3(17)$

$V_x = 51$

Re-drawing a circuit



$R = 3+4$

$R = 7\Omega$

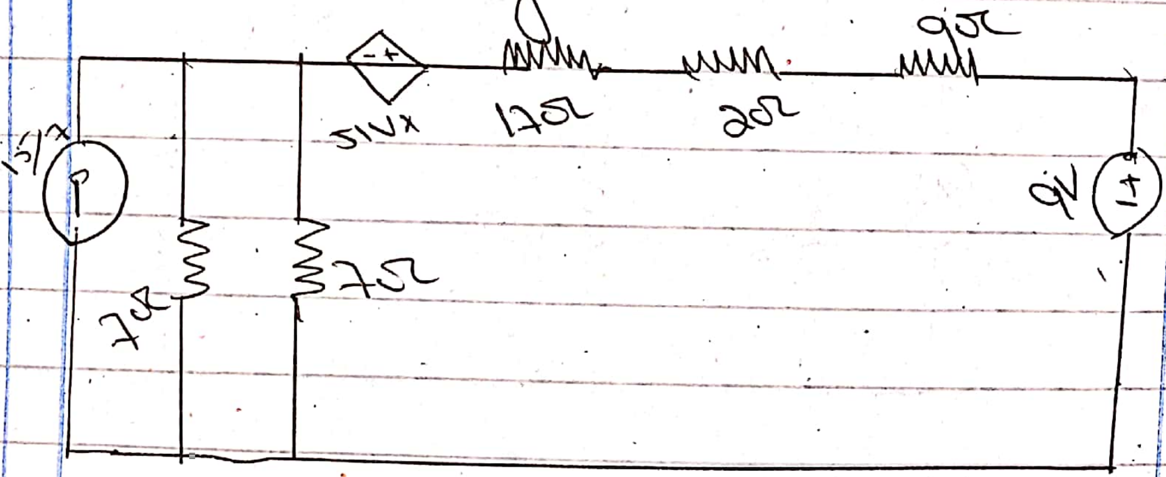
$I = \frac{V}{R} = \frac{15}{2} = 7.5$

$V = IR$

$V = 9(1)$

$V = 9$

Re-drawing a circuit.



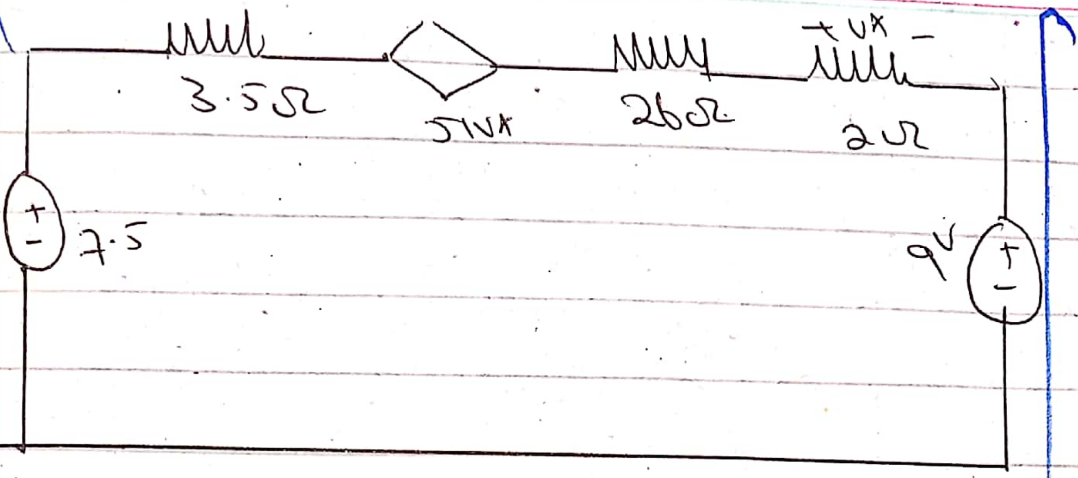

$V = IR = \left(\frac{5}{17}\right)(7)$

$V = 7.5$

But

$R = 17+9$

$R = 26\Omega$




Applying KVL on mesh i

$$3.5i - 51V + 28i = 7.5 - 9$$

$$V_x = 21$$

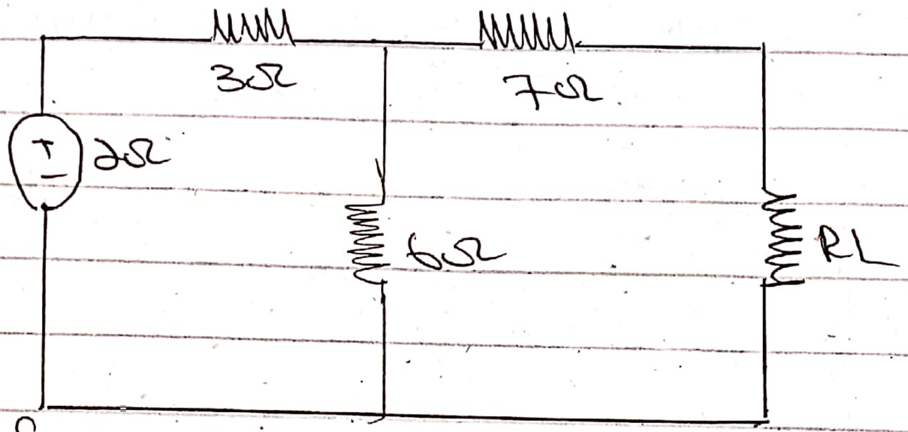
$$3.5i - 51(22)i + 28i = -1.5$$

$$i = -1.5 / -10395$$

$$\Rightarrow \boxed{i = 0.0014A}$$

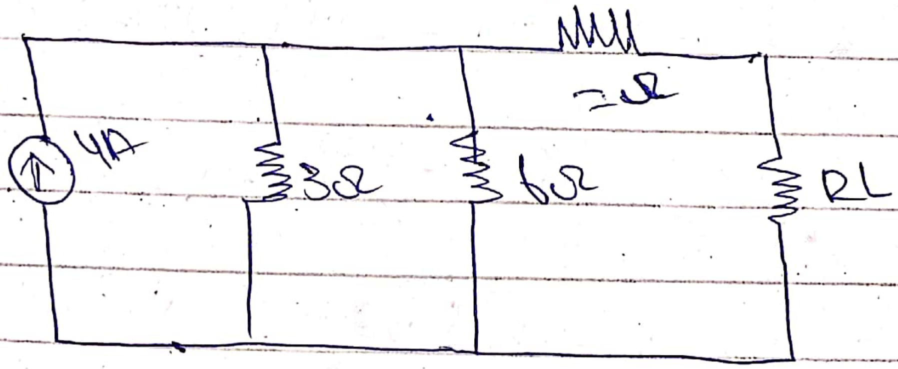
**Example 5.6:-**

consider a circuit shown in figure. Determine the thevenin equivalent of network A, and compute the power delivered to the load resistor RL.

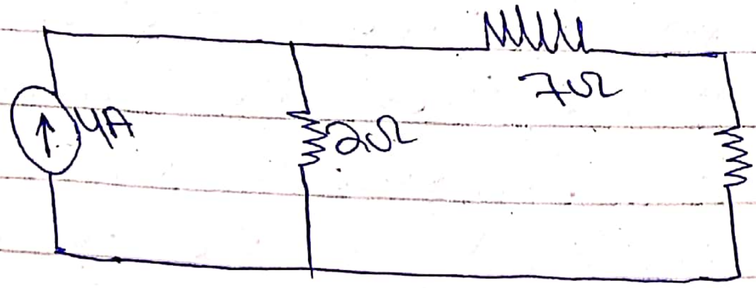



**Solution**

$$I = \frac{V}{R} = \frac{12}{3} = 4A$$

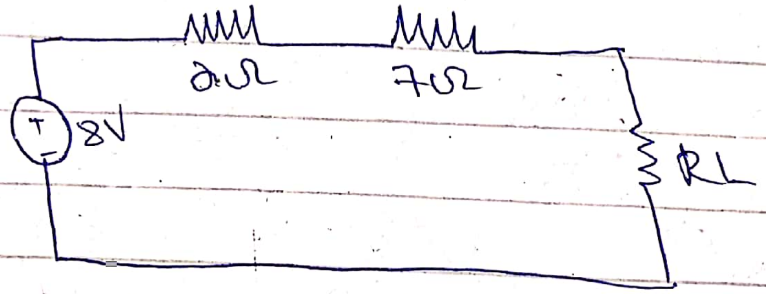



$$R_{eq} = \frac{3 \times 6}{3 + 6} = \frac{18}{9} = 2\Omega$$

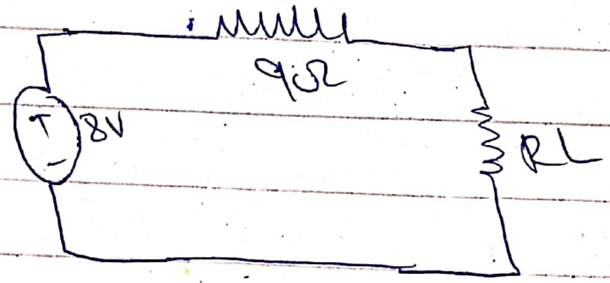



$$V = IR = 4(2)$$

$$V = 8V$$




$R = 2 + 7 = 9\Omega$




$V_{Th} = 8V$

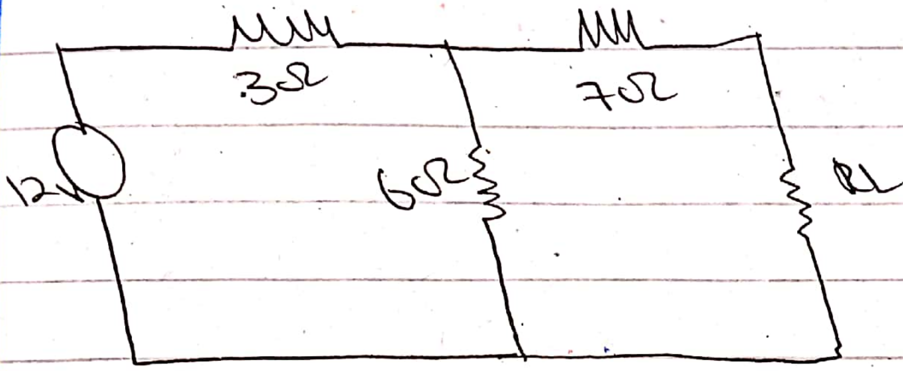
$R_{Th} = 9\Omega$

$R_{op} = \left(\frac{8}{7+R_L}\right)^2 R_L$

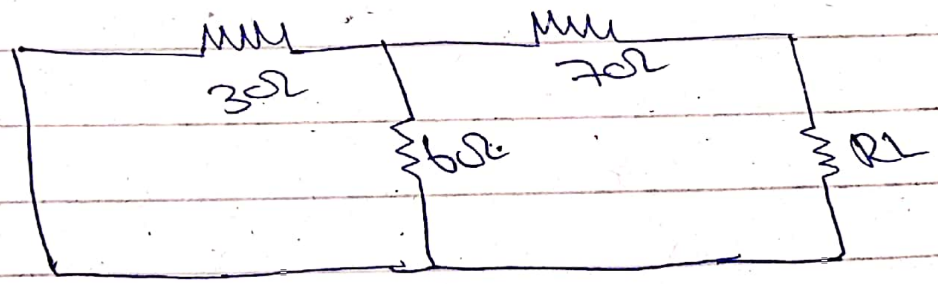
For any value of RL with have different solution.

## Example 5.7:-

Use Thevenin's Theorem determine the Thevenin equivalent for that part of the circuit in to the left of RL.




For finding RTh we will remove voltage source and make it is a short circuit.



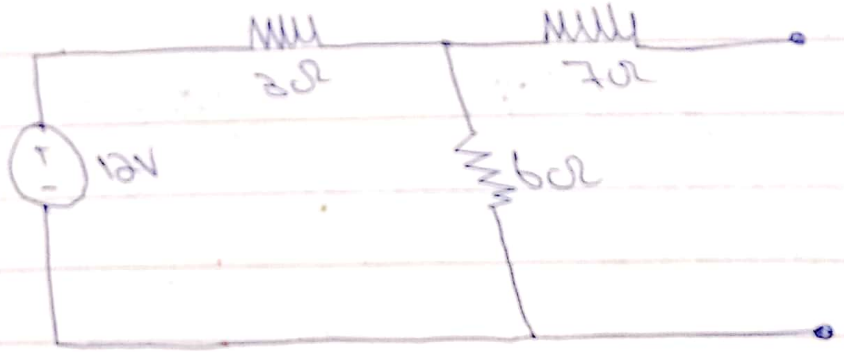

For RTh we will add all the resistor except RL.

$$R_{Th} = 3 \parallel 6 + 7$$

$$= \frac{18}{2} + 7$$

$$R_{Th} = 9$$

For Voc we will remove RL and make it's an open circuit.



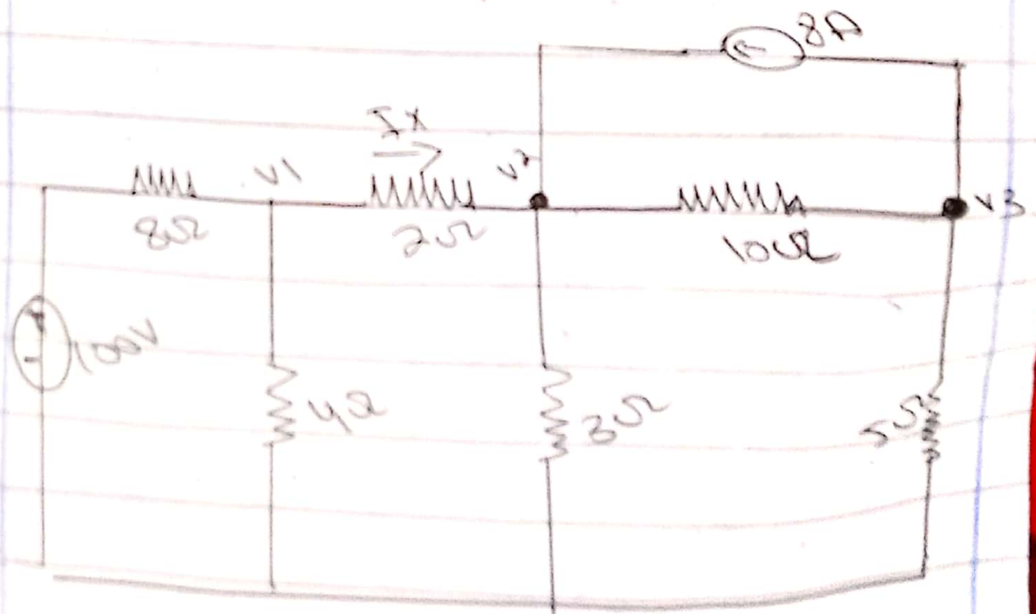

$$V_{oc} = 12\left(\frac{6}{3+6}\right)$$

$$V_{oc} = 8V$$

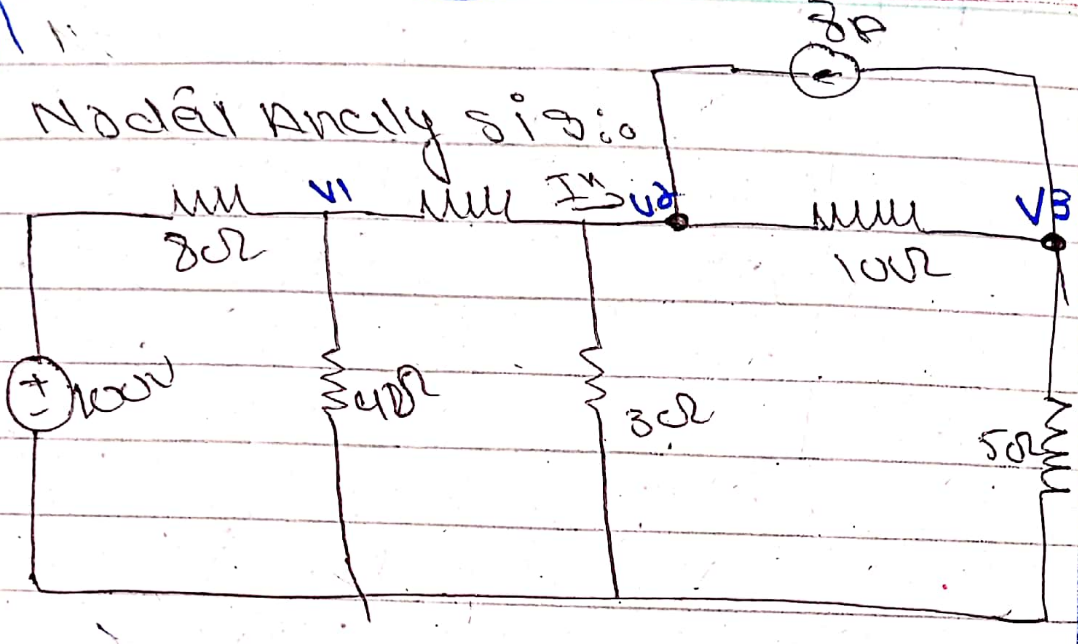
* ——— * ——— *

Q No 3:-

Find the value of $I_x$ for the circuit using nodal analysis, mesh analysis and superposition Theorem.



Nodal Analysis:




Solution:-

(1) Apply nodal analysis (KCL) on node 1 (V1).

$$\frac{V1-100}{8}+\frac{V1}{4}+\frac{V1-V2}{2}=0$$

$$\frac{V1-100+2V1+4V1-4V2}{8}=0$$

$$7V1-4V2=100 \quad \text{———} (1)$$

Apply KCL on node 2 i-e V2.

$$\frac{V2-V1}{2}+\frac{V2}{3}+\frac{V2-V3}{18}=8$$

$$\frac{30V2-30V1+20V2+3V2+3V3}{60}=8$$

$V = I R$

$I$

(08) $P = I \cdot V$

$-30V_1 + 53V_1 - 3V_3 = 480$ —— (ii)

Apply KCL on node 3 i-e $V_3$:-

$$\frac{V_3 - V_2}{10} + \frac{V_3}{5} = -8$$

$$\frac{V_3 - V_2 + 2V_3}{10} = -8$$

$$\frac{-V_2 + 3V_3}{10} = -8$$

$-V_2 + 3V_3 = -80$ —— (iii)

Taking eq (i)

$7V_1 - 4V_2 = 100$

$V_1 = \frac{4V_2 + 100}{7}$ ---(a)

Taking eq (iii)

$-V_2 + 3V_3 = -80$

$V_3 = \frac{V_2 - 80}{3}$ —— (b)

putting eq (a) and (b) in eq (ii)

$-30(0.57V_2 + 14.28) + 53V_2$
$-3(0.33V_2 - 26.67) = 480$

$-17.1V_2 - 428.4 + 53V_2 - 0.99V_2 + 80.01 = 480$

$34.91V_2 = 828.39$

$V_2 = \frac{828.39}{34.91}$

$\boxed{V_2 = 20.31}$

Putting on eq (2)

$V_2 = \frac{4(20.31)+100}{7}$

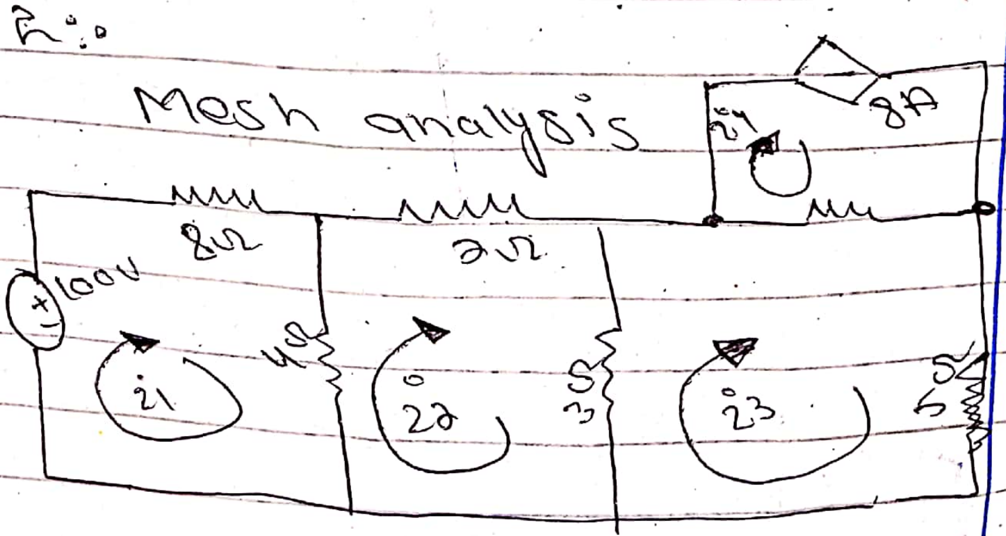
$V_2 = 25.89$

$i_x = \frac{V_1 - V_2}{2} = \frac{25.89 - 20.31}{2}$

$\boxed{i_x = 2.79A}$

Q:

Mesh analysis



Apply KVL on loop I:-

$8i_1 + 4(i_2 + i_2) = 100$

$8i_1 + 4i_2 - 4i_2 = 100$

$12i_2 - 4i_2 = 100$ —— (1)

Apply KVL on loop 2:-

$2i_2 + 4(i_2 - i_2) + 3(i_3 - i_2) = 0$

$2i_2 + 4i_2 - 4i_2 + 3i_3 - 3i_2 = 0$

$-4i_2 + 9i_2 - 3i_3 = 0$ —— (2)

Apply KVL on loop 3:-

$3(i_3 - i_2) + 10(i_3 - i_4) + 5i_3 = 0$

$3i_3 - 3i_2 + 10i_3 - 10i_4 + 5i_3 = 0$

As $i_4 = 8$

$-3i_2 + 18i_3 = -80$ —— (3)

Taking eq (1)

$i_1 = \frac{4i_2 - 100}{12}$ —— (a)

Taking eq (3)

$-3i_2 + 18i_3 = -80$

$i_3 = \frac{-3i_2 + 80}{18}$ —— (b)

Putting eq (a) and (b) in eq (2)

$-4(0.33i_2 - 8.33) + 9i_2 - 3(0.16i_2 + 4.44) = 0$

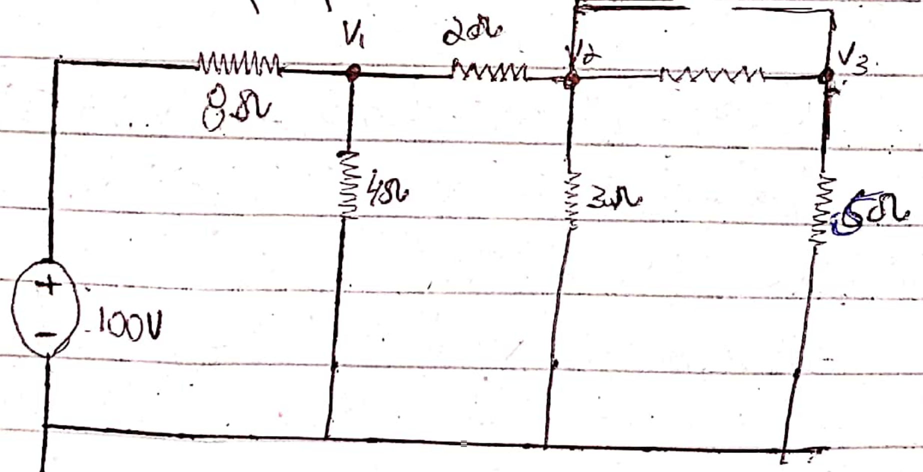
$\Rightarrow -1.32i_2 + 33.32 + 9i_2 - 0.48i_2 - 13.21 = 0$

$7.2i_2 = +20$

$i_2 = \frac{20}{7.2} \Rightarrow i_2 = i_x$

$i_2 = 2.79A \longrightarrow \boxed{i_x\ 2.79A}$

3:- Superposition Theorem.




~~Rem~~: redraw ~~a~~ circuit by remove current source by open circuit.

Apply KCL on Node 1 $V_1$:

$$\frac{-100 + V_1}{8} + \frac{V_1 - V_2}{2} + \frac{V_1}{4} = 0$$

$$\frac{V_1 - 100 + 4V_1 - 4V_2 + 2V_1}{8} = 0$$

$$7V_1 - 4V_2 = 100 \longrightarrow (i)$$

Apply KCL on Node 2:

$$\frac{V_2 - V_1}{2} + \frac{V_2}{3} + \frac{V_2 - V_3}{10} = 0$$

$$\cancel{\frac{5V_2 - 5V_1}{10}}$$

$$\frac{15V_2 - 15V_1 + 10V_2 + 3V_2 - 3V_3}{30} = 0$$

$$-15V_1 + 23V_2 - 3V_3 = 0 \longrightarrow (ii)$$

at Node 3:-

$$\frac{V_3 - V_2}{10} + \frac{V_3}{5} = 0$$

$$\cancel{\frac{2V_3 - 2V_2}{10}}$$

$$\frac{V_3 - V_2 + 2V_3}{10} = 0$$

$$-V_2 + 3V_3 = 0 \longrightarrow (iii)$$

(73)

Now From eq(1) &

$$7V_1 - 4V_2 = 100$$

$$7V_1 = 100 + 4V_2$$

$$V_1 = \frac{100 + 4V_2}{7}$$

$$\boxed{V_1 = \frac{100 + 4V_2}{7}} \rightarrow (a)$$

From eq (2):

$$-V_2 + 3V_3 = 0$$

$$+V_2 = +3V_3$$

$$\boxed{V_3 = \frac{1}{3} V_2}$$

Put in eq (4)

$$-15V_1 + 23V_2 - 3V_3 = 0$$

$$-15\left(\frac{100 + 4V_2}{7}\right) + 23V_2 - \cancel{3}\left(\frac{1}{\cancel{3}}V_2\right) = 0$$

$$-15(14.2 + 0.5V_2) + 23V_2 - V_2 = 0$$

$$-213 - 7.5V_2 + 22V_2$$

$-7.5V_2 + 22V_2 = 213$

$14.5V_2 = 213$

$$\boxed{V_2 = 14.6\text{ V}}$$

put in $V_2 = 14.6\text{V}$

$V_3 = \frac{1}{3} V_2$

$V_3 = \frac{14.6}{3}$

$$\boxed{V_3 = 4.8\text{V}}$$

$V_1 = \frac{100 + 4(14.6)}{7}$

$\frac{100 + 58.4}{7}$

$V_1 = 22.6$ volt.

Now from figure

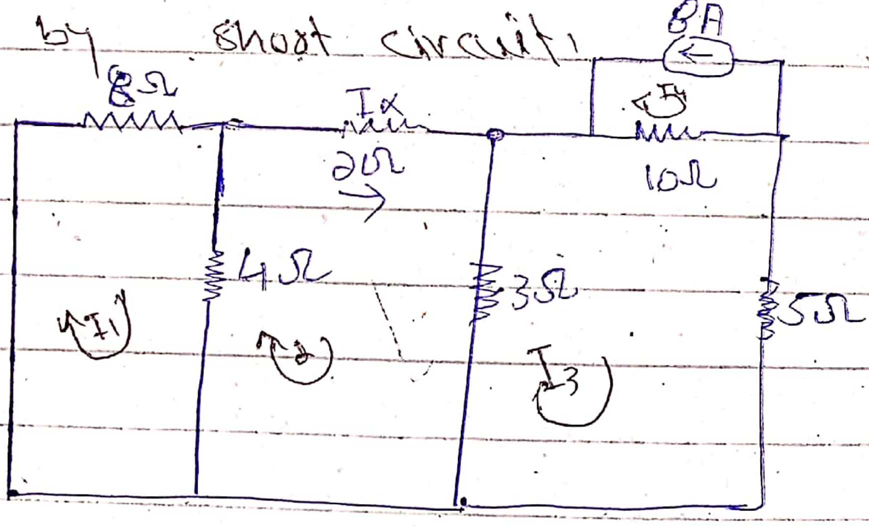
$$I_x' = \frac{V_1 - V_2}{2}$$

$$= \frac{22.6 - 14.6}{2}$$

$$8/2$$

$$\boxed{I_x' = 4A} \rightarrow A$$

Now remove voltage source by short circuit.




~~Here~~

$$I_4 = 8A$$

Apply KVL at loop1

$$8I_1 + 4(I_1 - I_2) = 0$$

$$8I_1 + 4I_1 - 4I_2 = 0$$

$$12I_1 - 4I_2 = 0$$

$$3I_1 - I_2 = 0 \quad \rightarrow (i)$$

at loop 2:

$$2I_2 + 3(I_2 - I_3) + 4(I_2 - I_1) = 0$$

$$2I_2 + 3I_2 - 3I_3 + 4I_2 - 4I_1 = 0$$

$$-4I_1 + 9I_2 - 3I_3 = 0 \rightarrow (ii)$$

at loop 3:-

$$10(I_3 - I_4) + 5I_3 + 3(I_3 - I_2) = 0$$

$$10I_3 - 10(8) + 5I_3 + 3I_3 - 3I_2 =$$

$$10I_3 - 80 + 5I_3 + 3I_3 - 3I_2 = 0$$

$$-3I_2 + 18I_3 = 80 \rightarrow (iii)$$

From eq (1)

$$3I_1 - I_2 = 0$$

$$\boxed{I_1 = 1/3\, I_2 \quad — a}$$

From eqv ③

$$-3I_2 + 18I_3 = -80$$

$$\boxed{I_3 = \frac{3I_2 - 80}{18}} \rightarrow (b)$$

put ⓐ & ⓑ in eq ②

$$-4\left(\tfrac{1}{3}I_2\right) + 9I_2 - 3\left(\frac{3I_2 - 80}{18}\right) = 0$$

$$-\tfrac{4}{3}I_2 + 9I_2 - 3\left(\tfrac{1}{6}I_2 - 4.4\right) = 0$$

$$-1.3I_2 + 9I_2 - 0.5I_2 + 13.2 = 0$$

$$7.2I_2 = +13.2$$

$$\boxed{I_2 = +1.8A}$$

Now

$$I_1 = -\tfrac{1}{3}I_2$$

$$\boxed{I_1 = +0.6}$$

Now

$$I_x'' = I_1 + I_2$$

$$I_x'' = +0.6018$$

$$\cancel{I_x'' = 2.411} \rightarrow **$$

$$\boxed{I_x'' = -1.21} \rightarrow **$$

From * & **

$$I_x = I_x' + I_x''$$

$$\cancel{= 4 + (2.411)}$$

$$= 4 - 1.21$$

$$\boxed{I_x = 2.79} \rightarrow \text{Ans}$$

x —— x —— x —— x —— x —

Q3 Part 2:-

Compair numbers of steps & easiness in above 3 method -

(1) Nodal Analysis:-

in nodal analysis we apply KCL on each Node (i-e 3 Node) which give us three equation. ~~whic~~ by sloving these three equation we find $I_x$. Nodal analysis completed more than 5 steps and its ~~qual quait~~ quit deficult to indentify Nodes For such complex circuit and slove these complicated equation by This method the question become to lengthy and deficult.

mesh analysis:-

by mesh analysis also the question became to deficult b/c in this method we apply KVL on 4 loop & that give us ~~more~~ 4 equation by sloving these 4 equation we get requir result. it also too lengthy and dificult.

Superposition theorem:-

Superposition theorem quite easy way to slove such complicated circuit ~~b/ut~~ b/c in ~~the~~ this method we not take current source and voltage source simultaneously. we remove ~~first~~ one source & slove the circuit and then other due to ~~the~~ this the circuit became to eassy. and it's not too lengthy like other method.

x —— x —— x —— x —— x

END