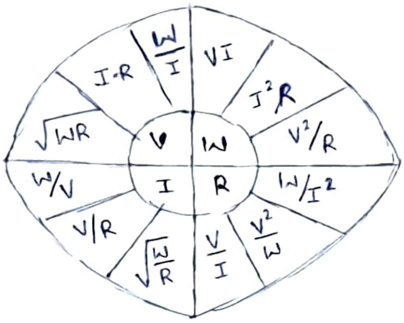
EEE

OHM'S LAW :

* The voltage across any specified conduction is directly proportional to the current flowing through it, when temperature remains same. $\therefore V \propto I$

$\boxed{V = IR}$



(Imp)

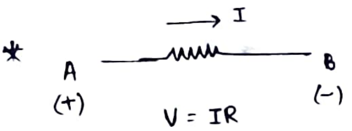
FORMULAE

KIRCHOFF'S LAWS :

→ KCL : The algebraic sum of all the currents meeting at a point / junction is zero. $\therefore \sum I = 0$

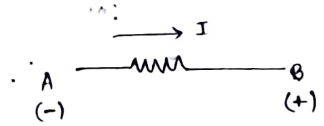
→ KVL : In a closed circuit, the sum of the potential drops is equal to the sum of the potential rises

DETERMINATION OF SIGNS FOR RESISTORS AND SOURCE :

* 

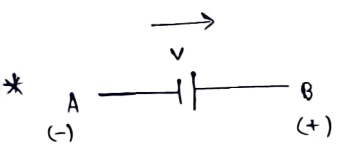
$V = IR$

[-ve]

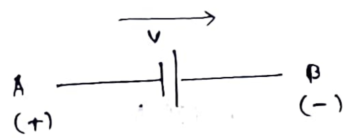


$V = IR$

[+ve]

* 

Rise in voltage

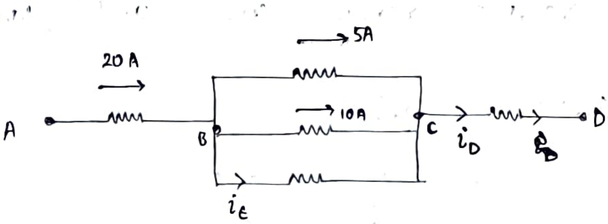


Fall / drop in voltage.

* DC ⟶ I , V
* AC ⟶ i , v

} Representation

⇒ Find current i_E & i_D ?



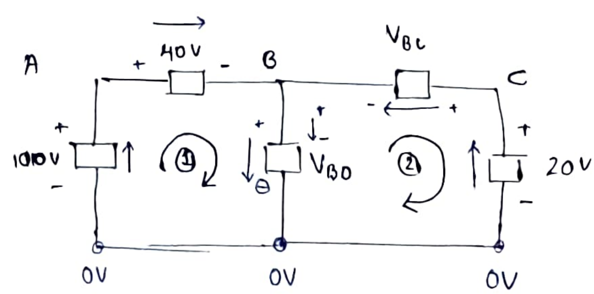
Sol^n)

KCL : $20 = 5 + 10 + i_E$

$i_E = 5\,A$

KCL : $i_D = 5 + 10 + 5 = 20\,A$

⇒ Determine the missing voltage across the circuit :



Sol^n) Assume '0' v down

∵ they are at same junction.

Ans ⟶ blue pen.

∴ Loop - 1 : [KVL]

$+100 - 40 - V_{BO} = 0$

$V_{BO} = 60\,V$

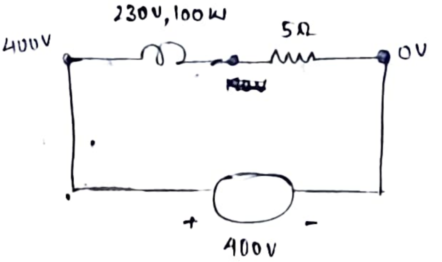
Loop - 2 : [KVL]

$-20 + V_{BC} + V_{BO} = 0$

$V_{BC} = 40\,V$

⇒ Determine the current i.e, flowing through 5Ω resistor ?

Sol^n/ $\cancel{400 - 230} = 170V$



$\because \cancel{V = iR}$

$\cancel{i = \frac{170}{5} = 34\ A}$

$P = Vi$

$i = \frac{P}{V} = \frac{100}{230} = 0.435\ A$

⇒ An electric bulb is rated to 230V, 60W. Determine the current ~~when current~~ through the bulb & cost of energy for 30 days. If the bulb is switched on for 6 hrs per day. Assume electric energy cost 0.35/- /Kwhr. (1 Kw hr = 1 unit)

Sol^n/. $P = Vi$

$i = \frac{60}{230} = \frac{6}{23}\ A$

$W = Pt$

$W = (60)(6\ hr) = 360\ W\ hr.$

$W = (360)(30) = 10800\ W/hr$

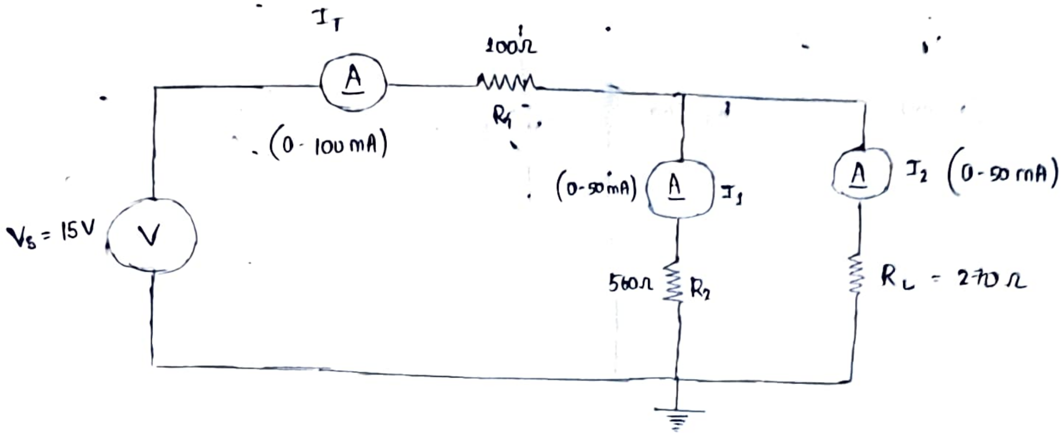
$\therefore$ cost $= 10800 \times \frac{35}{100}\ W/hr$

$= 3780\ W/hr$

cost $= 3.7\ Kw/hr$ (Ans)

⇒ VERIFICATION OF KIRCHOFF'S LAW :

→ KCL :

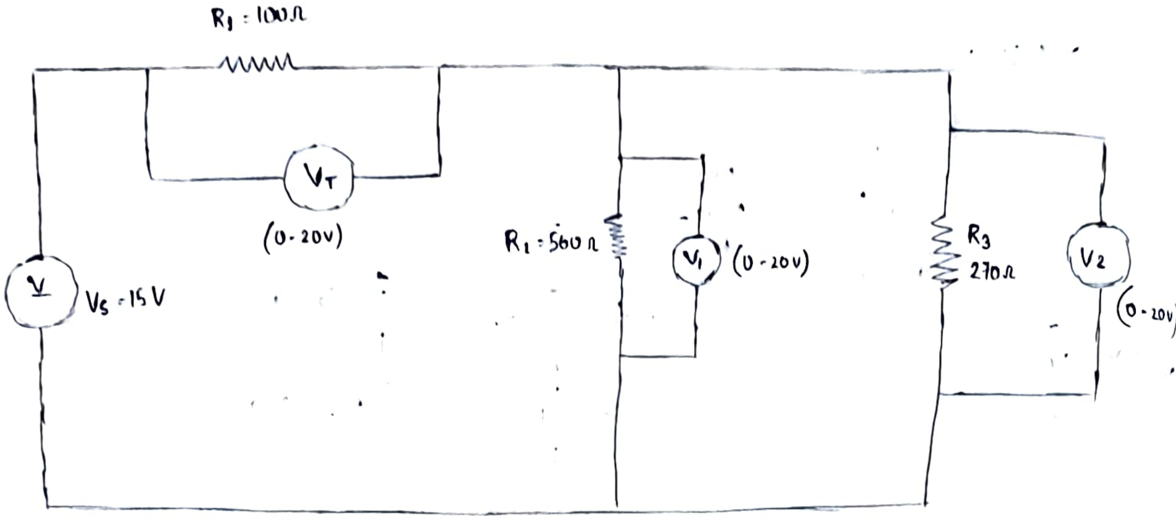


TABULES COLUMN :

V_S		I_T		I_1		I_2	
Theory	Practical	Theory	Practical	Theory	Practical	Theory	Practical
15 V			54.2		17.6		36.6.
20V			71.2		48.4		22.8

O/P
verified
B
Rekha.

→ KVL :

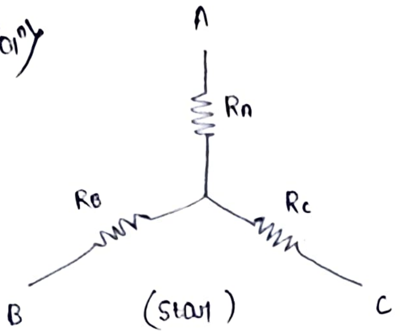


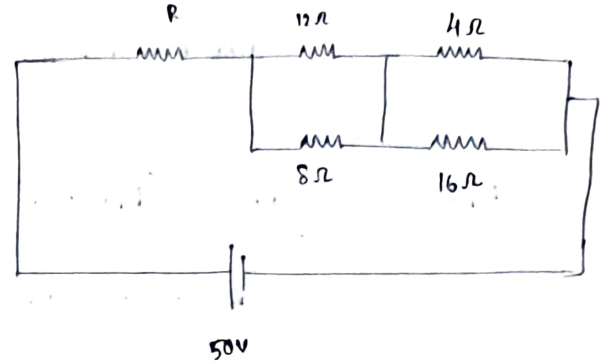
V_S	V_T		V_1		V_2	
	Theory	Practical	Theory	Practical	Theory	Practical
15V		4V		10V		10V
20V		6V		13V		13V

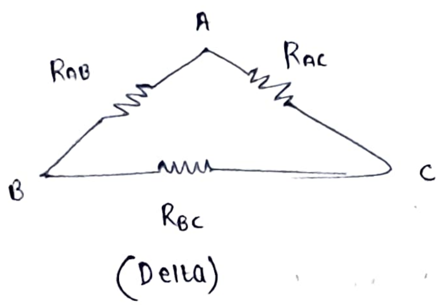
O/p verified

⇒ Find the unknown resistance & current flowing through the circuit. Assume total power = 20W

Sol^n







Δ to ~~star, Y, (wye)~~

~~$R_A =$~~

* Derivation delta to star, Y, (wye).

$$R_A + R_B = \frac{R_{AB} R_{CA} + R_{AB} R_{BC}}{R_{AB} + R_{BC} + R_{CA}}$$

$$R_A + R_B = \frac{R_{AB} (R_{CA} + R_{BC})}{R_{AB} + R_{BC} + R_{CA}} \rightarrow (1)$$

$$R_B + R_C = \frac{R_{BC}(R_{AB} + R_{CA})}{R_{AB} + R_{AC} + R_{BC}} \rightarrow (2)$$

$$R_C + R_A = \frac{R_{CA} (R_{AB} + R_{BC})}{R_{AB} + R_{AC} + R_{BC}} \rightarrow (3)$$

(3) - (2)

$$R_A - R_B = \frac{R_{AB} R_{CA} - R_{AB} R_{BC}}{R_{AB} + R_{BC} + R_{AC}} \rightarrow (4)$$

(1) + (4)

$$R_A = \frac{R_{AB} R_{CA}}{R_{AB} + R_{BC} + R_{AC}}$$

similarly

$$R_B = \frac{R_{AB} R_{BC}}{R_{AB} + R_{BC} + R_{AC}}, \quad R_C = \frac{R_{AC} R_{BC}}{R_{AB} + R_{BC} + R_{AC}}$$

* Start to Delta:

$$R_A R_B = \frac{(R_{AB})^2 (R_{CA} R_{BC})}{(R_{AB} + R_{BC} + R_{CA})^2}$$

$$R_B R_C = \frac{(R_{BC})^2 (R_{AB} R_{CA})}{(R_{AB} + R_{AC} + R_{BC})^2}$$

$$R_C R_A = \frac{(R_{CA})^2 (R_{AB} R_{BC})}{(R_{AB} + R_{BC} + R_{AC})^2}$$

$$R_A R_B + R_B R_C + R_A R_C = \frac{R_{AB} R_{BC} R_{CA} (R_{AB} + R_{BC} + R_{CA})}{(R_{AB} + R_{BC} + R_{CA})^2}$$

$$R_A R_B + R_B R_C + R_A R_C = \frac{R_{AB} R_{BC} R_{CA}}{(R_{AB} + R_{BC} + R_{CA})}$$

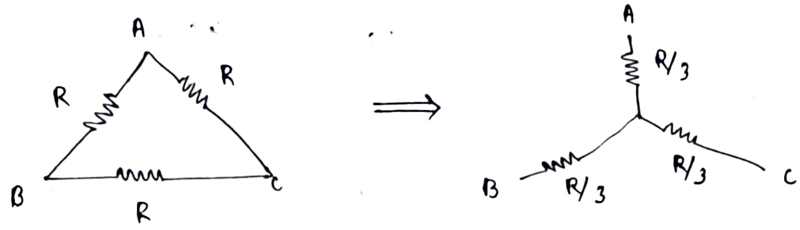
$$R_A R_B + R_B R_C + R_C R_A = R_{AB} \cdot R_C$$

imp $$R_{AB} = \frac{R_A R_B + R_B R_C + R_A R_C}{R_C}$$

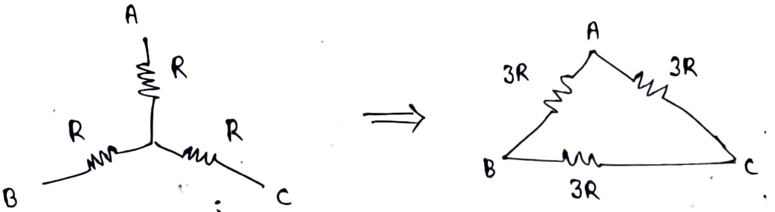
imp $$R_{BC} = \frac{R_A R_B + R_B R_C + R_A R_C}{R_A}$$

imp $$R_{AC} = \frac{R_A R_B + R_B R_C + R_A R_C}{R_B}$$

→ If all $R_{AB} = R_{BC} = R_{AC} = R$.

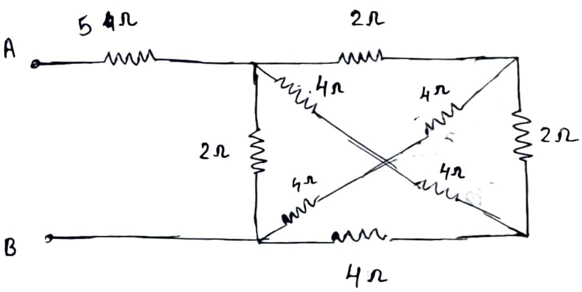


→ Case - 2 : $Y \Rightarrow \Delta$, $R_A = R_B = R_C = R$.



⇒ Use Δ to Y : find equivalent resistance b/w A & B.

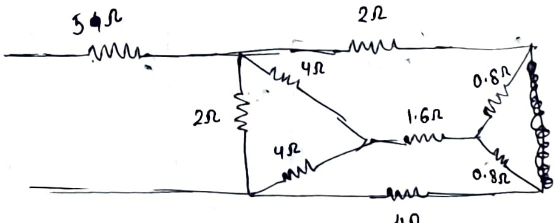
Sol^n



$R_1 = \frac{(4)(4)}{4+4+2} = \frac{16}{10} = 1.6\,\Omega$

$R_2 = \frac{(2)(4)}{10} = 0.8\,\Omega$

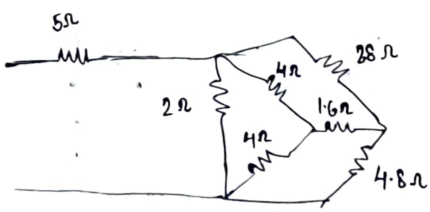
$R_3 = \frac{(2)(4)}{10} = 0.8\,\Omega$



4Ω , 1.6Ω , 4Ω

are Y to Δ connected

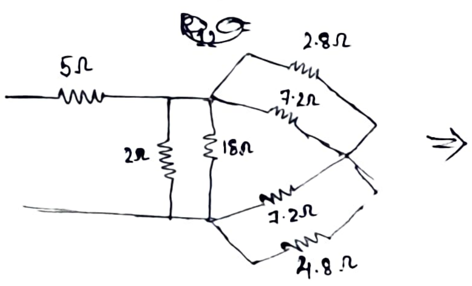
$R_1 = \frac{(4)(1.6) + (4)(1.6) + (4\times4)}{4}$

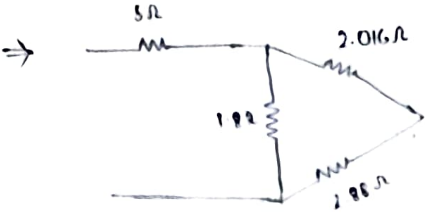


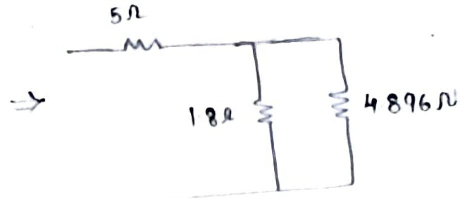
$R_1 = 7.2\,\Omega$

$R_2 = 7.2\,\Omega$

$R_3 = 18\,\Omega$.

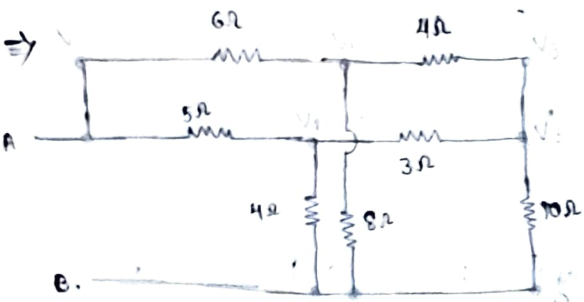


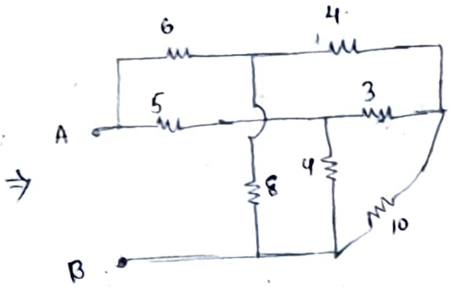


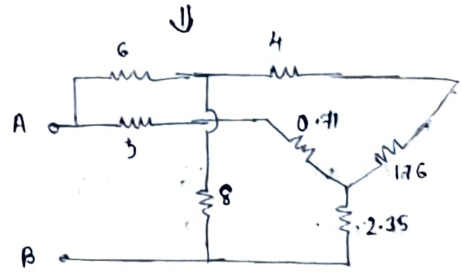


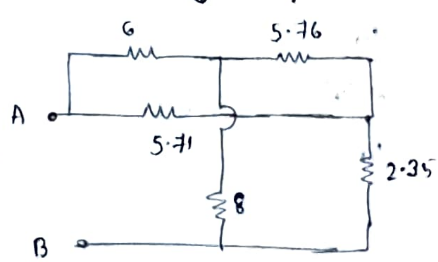
$$R_{eq} = 5 + \frac{(1.8)(4.896)}{(1.8) + (4.896)} = 6.316\,\Omega$$

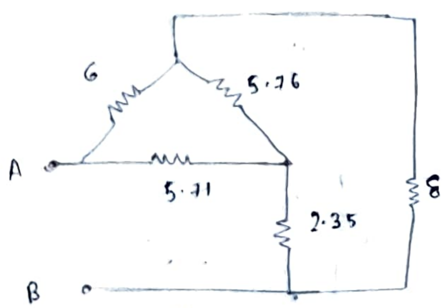
(Ans)

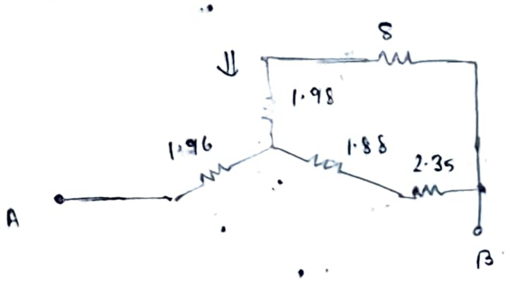


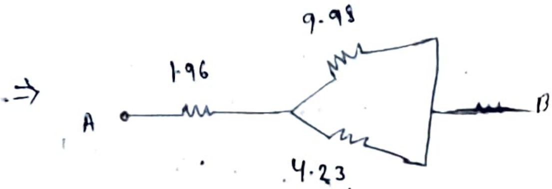


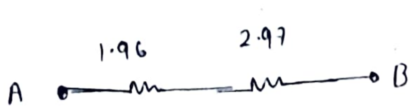








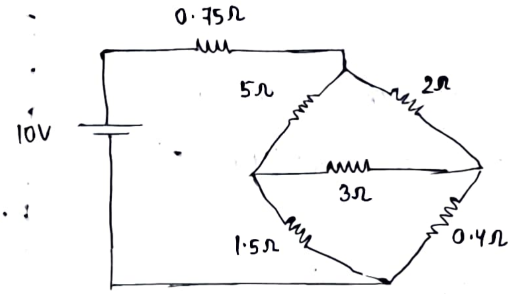




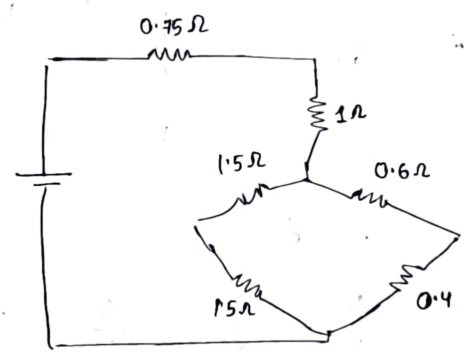
$$R_{eq} = 4.93\,\Omega$$

⇒ In the wheatstone bridge circuit shown in fig. Find the effective resistance b/w P & Q. Find the current supplied by 10V battery connected to PQ terminal.

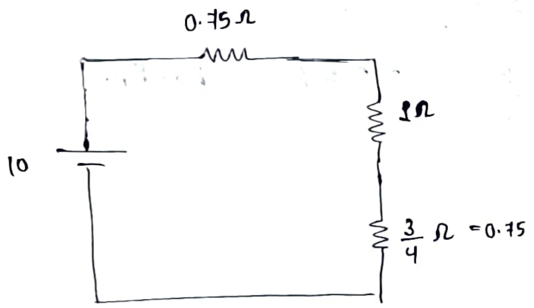
Sol^n



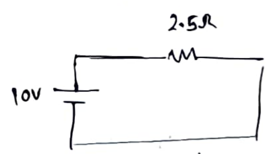
⇓



⇐



⇓



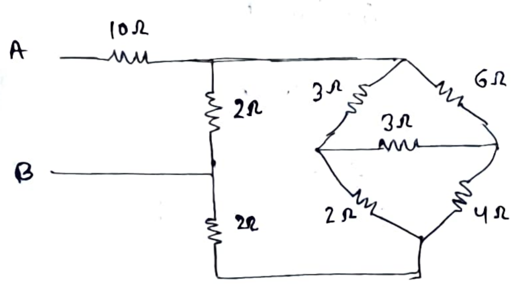
$$i = \frac{10}{2.5} = \frac{100}{25} = 4A$$

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

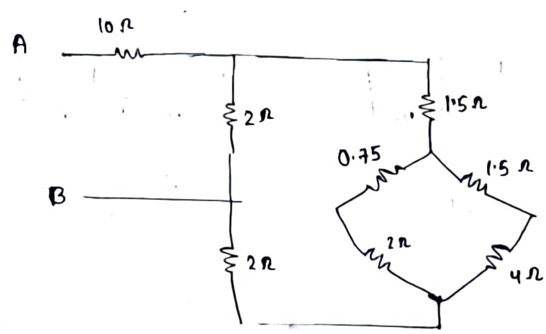
⇒ Find equ^v resistance b/w A & B of :

$\frac{18\ 6\ 3}{12\ 4\ 2}$

$\frac{9\ 3}{12\ 4}$



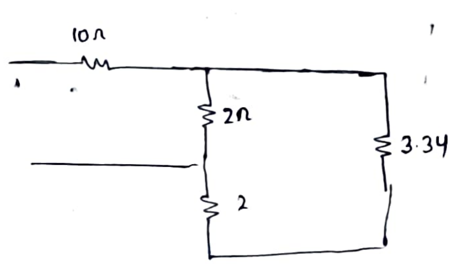
⇒



⇓

$\frac{2.75 \times 6}{8.75}$

1.89
1.50
3.39

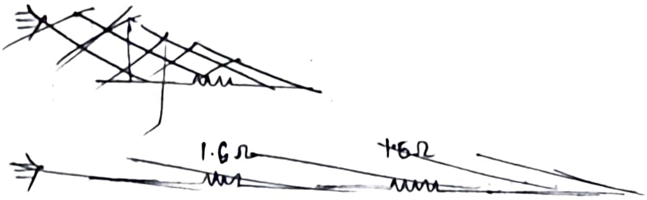


⇐

⇓

11.46Ω

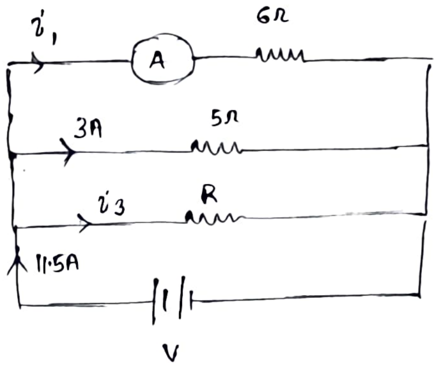
5.34
2



⇒ Determine :

i) The reading on ammeter

ii) The value of resistor (R)



Soln) $11.5 = i_1 + 3 + i_3$

$i_1 + i_3 = 8.5$

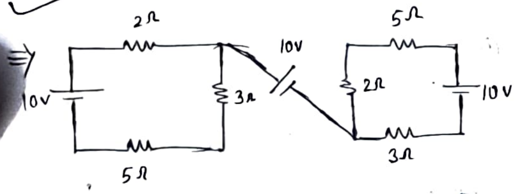
$i_3 = 6A$

$V = 3 \times 5 = 15V$

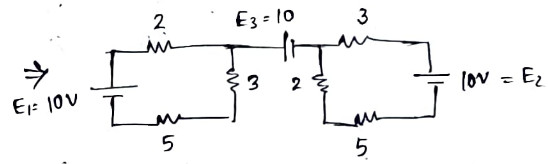
$i_1 = \frac{15}{6} = 2.5A$ (Reading)

ii) $R = \frac{V}{i_3} = \frac{15}{6} = \frac{5}{2} = 2.5\Omega$

imp

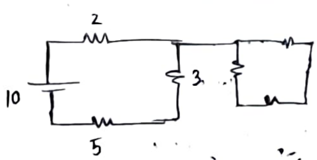


⇒



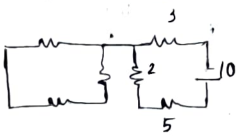
Soln)

Consider E_1



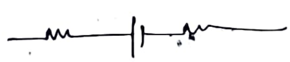
$i = \frac{10}{10} = 1A$

Consider E_2



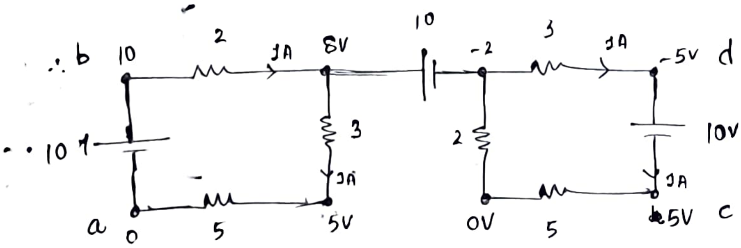
$i = \frac{10}{10} = 1A$

Consider E_3



$i = 0$

cause no loop

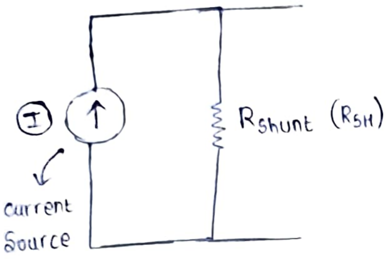


$\therefore V_{ad} = V_a - V_d = 0 - (-5) = 5V$

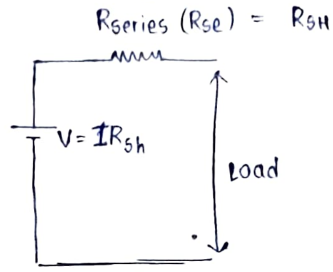
$V_{bc} = V_b - V_c = 10 - 5 = 5V$

Source Transformation :

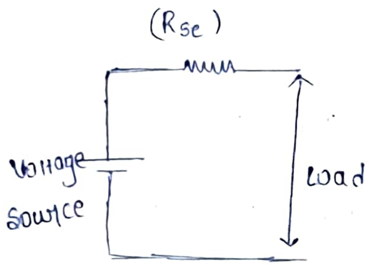
→ Current Source to Voltage Source :



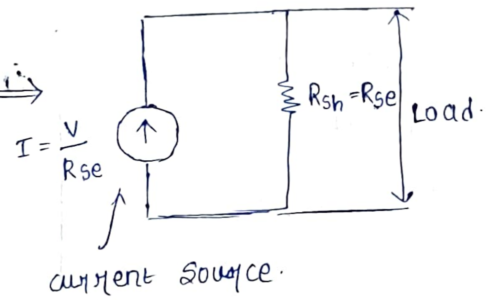
⇒



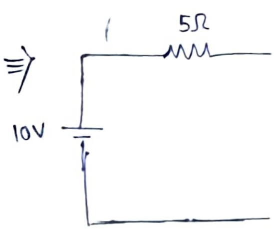
→ Voltage Source to Current Source :

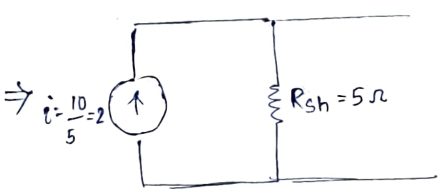


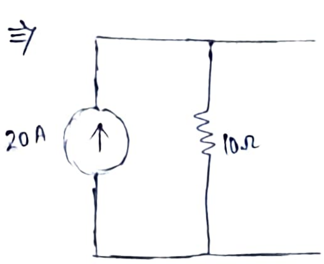
⇒

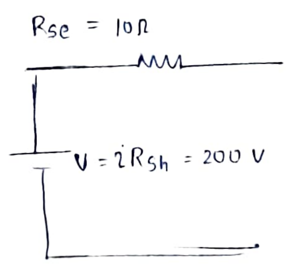


→ Example :



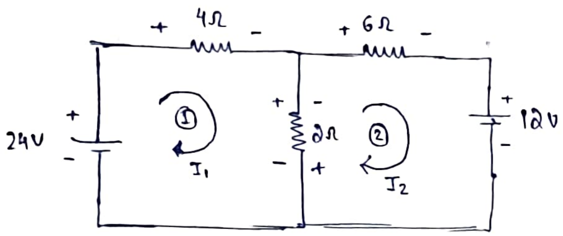






MESH / LOOP CURRENT METHOD :

⇒ Determine the current through various resistors using the concept of mesh current method ?



Sorry Always take dir^n of loop same.

then take sign on resistors. according to dir^n of i

① ⟶ $24 - 4I_1 - 2I_1 = 0$

$I_1 = 4A$

② ⟶ $-6I_2 - 12 - 2I_2 = 0$

$8I_2 = -12$

$I_2 = \frac{-3}{2} = \underline{-1.5\ A}$

(wrong method).

① ⟶ $24 - 4I_1 - 2(I_1 - I_2) = 0$

$24 - 4I_1 - 2I_1 + 2I_2 = 0$

$24 = 6I_1 - 2I_2$

② ⟶ $-6I_2 - 12 - 2(I_2 - I_1) = 0$

$-6I_2 - 12 - 2I_2 + 2I_1 = 0$

$2I_1 = 8I_2 + 12$

(correct method).

∴ $8 = 2I_1 - \frac{2}{3}I_2$

$\frac{24 - 2}{3}$

$2I_1 = 8I_2 + 12$

⇒ $8 = 8I_2 + 12 - \frac{2}{3}I_2$

⇒ $-4 = \frac{22}{3}I_2$

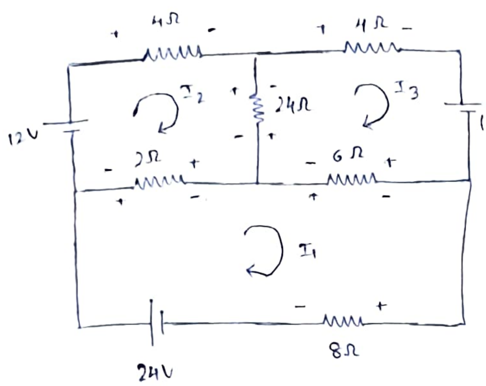
⇒ $I_2 = \frac{-12}{22} = \underline{\underline{\frac{-6}{11}\ A}}$.

$I_1 = 4I_2 + 6$

$= \frac{-24}{11} + 6 = \underline{\underline{\frac{42}{11}\ A}}$

⇒ ~~In the~~

⇒ Determine the current in 8Ω resistor ?



$x = I_1$
$y = I_2$
$z = I_3$

Sol^n (2) $\longrightarrow -4I_2 - (I_2 - I_3)\,24 - 2(I_2 - I_1) + 12 = 0.$

$-4I_2 - 24I_2 + 24I_3 - 2I_2 + 2I_1 + 12 = 0$

$-30I_2 + 24I_3 + 2I_1 + 12 = 0.$

(3) $\longrightarrow -4I_3 - 10 - 6(I_3 - I_1) - 24(I_3 - I_2) = 0$

$-34I_3 + 6I_1 + 24I_2 - 10 = 0.$

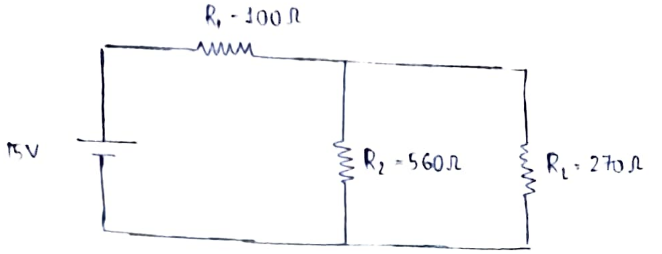
(1) $\longrightarrow 24 - 2(I_1 - I_2) - 6(I_1 - I_3) - 8I_1 = 0.$

$24 - 16I_1 + 2I_2 + 6I_3 = 0.$

$\therefore\ i_1 = \underline{\underline{2.06\ A}}$ $\quad i_2 = \underline{\underline{1.36}}$ $\quad i_3 = \underline{\underline{1.03}}$ A.

MAXIMUM POWER TRANSFER THEOREM :

→ Thevenin's Theorem :



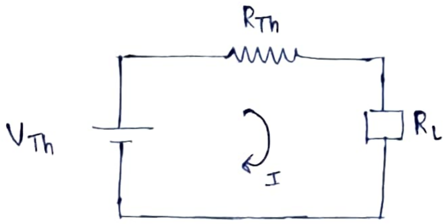
← Circuit diagram.

To solve this type of circuit :

* Step-1 : i) Find $V_{Th} = V_{OC}$
  ii) Remove 'R_L' & find voltage across 'R_L'

* Step-2 : i) Find R_{Th}
  ii) Voltage source if present → Short circuit
  Current source if present → Open circuit
  iii) View from 'R_L' side & reduce the network & find R_{Th}

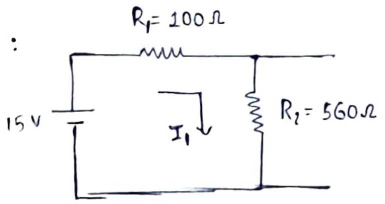
* Step-3 : Draw equivalent circuit diagram



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

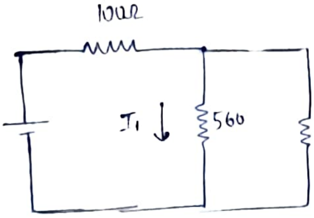
ex: Above circuit diagram. Solve using Thevenin's Theorem?

Sol^n) Step-1 :



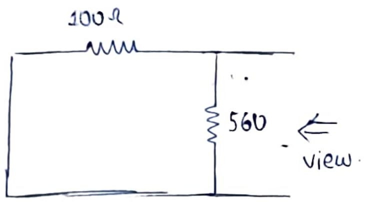
$$\therefore I_1 = \frac{V}{R_T} = \frac{15}{660} = 0.0227 \text{ A}$$

Now put this I_1 in main circuit to get V_{Th}



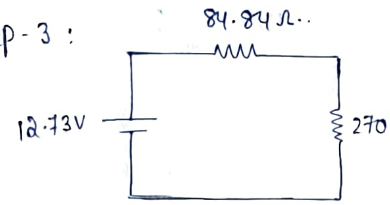
$V_{Th} = (0.0227)(560) = 12.73\,V$

Step-2: Short circuit voltage source.



$\Rightarrow R_{Th} = \frac{(100)(560)}{660} = 84.84\,\Omega$

Step-3:

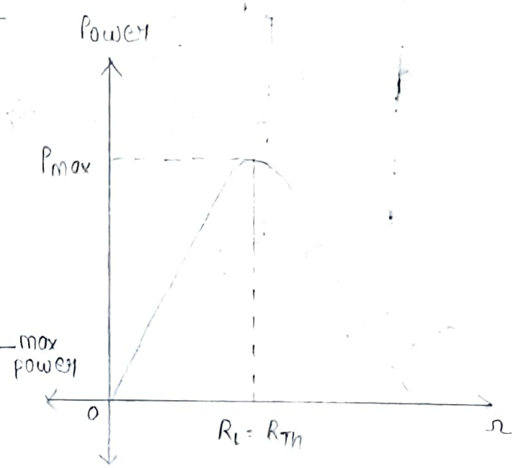


$\Rightarrow i = \frac{V_{Th}}{R_{Th} + R_L} = \frac{12.73}{270 + 84.84} = 0.0359\,A$

Assumed

S.No	R_L	R_{Th}	I_L	$P = I_L^2 R_L$
1	40	84.84	0.10196	0.4158
2	60	84.84	0.08788	0.4633
3	[illegible]	84.84	0.08[illegible]	0.4729
4	[illegible]	84.84	0.07122	0.4770 ← max power
5	[illegible]	84.84	0.07501	0.4773
6	100	84.84	0.0668	0.4733
7	[illegible]	84.84	0.06219	0.4637
8	[illegible]	84.84	0.05[illegible]	0.4468

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

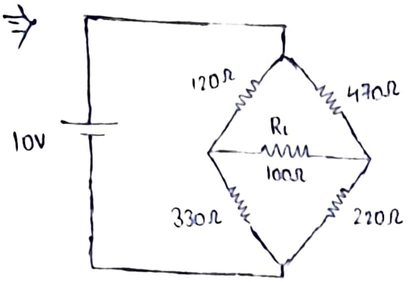


$P_{max} \Rightarrow R_L = R_{Th}$

↑

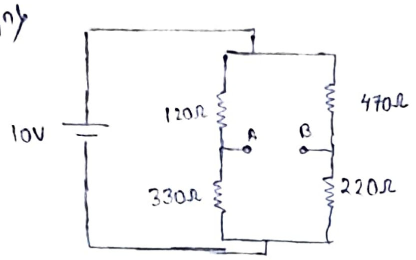
Condition

⇒



Find max^m power ?

Sol^n



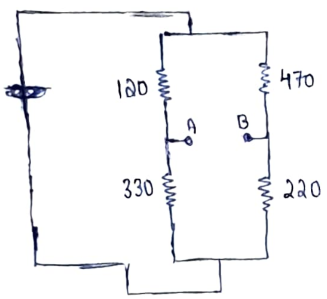
Step-1

voltage division.

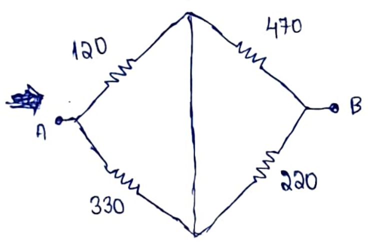
$$\Rightarrow V_A = \left[\frac{330}{120+330}\right] \times 10 = 7.33\,V$$

$$\Rightarrow V_B = \left[\frac{220}{470+220}\right] \times 10 = 3.188\,V.$$

$$\therefore V_{Th} = 7.33 - 3.188 = 4.1415\,V$$



⇒



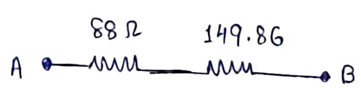
Step-2

⇓

$$R_{left} = \frac{330 \times 120}{330+120} = \frac{39600}{450} = 88\,\Omega$$

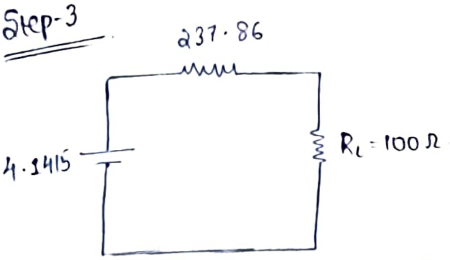
$$R_{right} = \frac{470 \times 220}{470+220} = \frac{103400}{690} = 149.86\,\Omega$$

⇓



$$R_{Th} = 237.86\,\Omega$$

Step-3



$$\Rightarrow i = \frac{4 \cdot 1415}{337 \cdot 86} = 0.012 \text{ A}$$

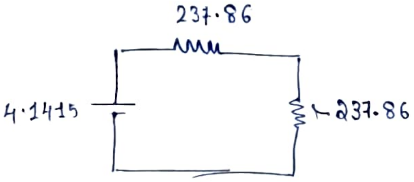
imp

$$\therefore P_{max} = \frac{V_{Th}^2}{4 \cdot R_{Th}} = \frac{(4 \cdot 1415)^2}{4\,(237 \cdot 86)} = 0.01803 \text{ W}$$

(or to find P_{max})

$$P_{max} = \frac{V^2}{4R}$$

P_{max}, when $R_{Th} = R_L$.



$$\Rightarrow i = \frac{4 \cdot 1415}{237 \cdot 86 + 237 \cdot 86} = 8 \cdot 7 \times 10^{-3} \text{ A}$$

$$\therefore P_{max} = Vi = (4 \cdot 1415)(8 \cdot 7 \times 10^{-3}) = 0.03603 \text{ W}$$

This is for both resistors.

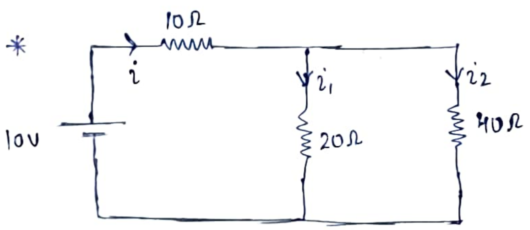
$$\therefore \text{for only } R_L = \frac{0.3603}{2} = \cancel{8.7 \times 10^{-3}} \text{ W} \quad 0.01803 \text{ W}$$

(or else) use, $P_{max} = \frac{i^2 R}{B}$ = $(4 \cdot 1415)^2 (237 \cdot 86) = \cancel{8.7 \times 10^{-3}}$ W

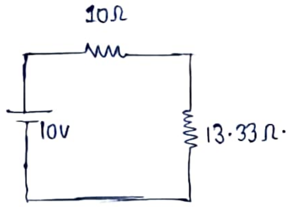
↳ 0.01803 W

Network Reduction Method :

*



⇒



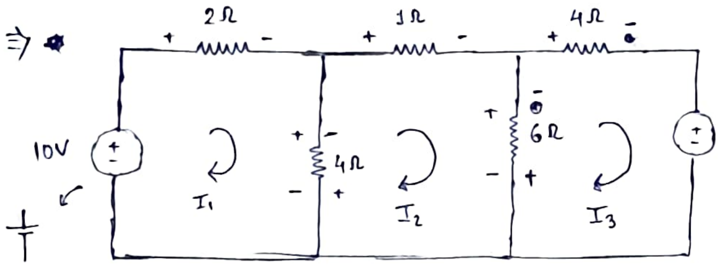
⇓

$$i = \frac{V}{R} = 0.428 \text{ A}$$

$$i_1 = \frac{i R_2}{R_1 + R_2} = \frac{(0.428)(40)}{60} = 0.2857 \text{ A}$$

$$i_2 = \frac{i R_1}{R_1 + R_2} = \frac{(0.428)(20)}{60} = 0.1428 \text{ A}$$

Loop ANALYSIS. [USING CREMERS RULE]

⇒ 

Find current in 6Ω ?

Sol^n

$\cancel{-2I_1 - 4I_1 + 10 = 0}$ $\qquad -2I_1 - 4(I_1 - I_2) + 10 = 0$

$\cancel{-1I_2 - 6I_2 - 4I_2 = 0}$ $\qquad -1I_2 - 6(I_2 - I_3) - 4(I_2 - I_1) = 0$

$\cancel{-4I_3 - 20 - 6I_3 = 0}$ $\qquad -4I_3 - 20 - 6(I_3 - I_2) = 0$

Use determinant method to solve ;

$$\Delta = \begin{array}{ccc} I_1 & I_2 & I_3 \\ \end{array}$$
$$\Delta = \begin{bmatrix} 6 & -4 & 0 \\ 4 & -11 & 6 \\ 0 & 6 & -10 \end{bmatrix} \begin{bmatrix} 10 \\ 0 \\ 20 \end{bmatrix}$$

~~AX = B.~~

$\therefore x = \frac{D_1}{D}$, $y = \frac{D_2}{D}$, $z = \frac{D_3}{D}$ } use this

$$\Delta = 6[110 - 36] + 4[-40 - 0] + 0[-] =$$

$\therefore I_1 = 0.92\,A$

$I_2 = -1.13\,A$

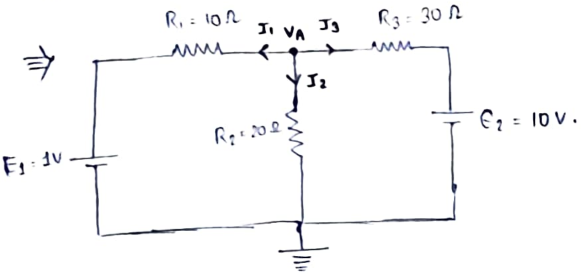
$I_3 = -2.68\,A.$

$\therefore i_{6\Omega} = I_2 - I_3 = -1.1267 - (-2.676)$

$= \underline{\underline{1.5493\ A.}}$

NODAL ANALYSIS :

⇒



Ans with black pen.

Sol^n $\quad I_1 = \dfrac{V_A - 1}{10}$, $\quad I_2 = \dfrac{V_A - 0}{20}$, $\quad I_3 = \dfrac{V_A - 10}{30}$.

using KCL :

$$I_1 + I_2 + I_3 = 0.$$

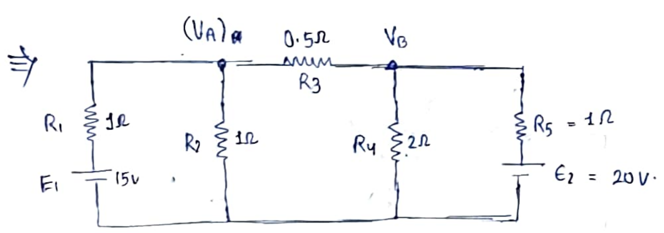
$$\frac{V_A - 1}{10} + \frac{V_A}{20} + \frac{V_A - 10}{30} = 0$$

$$6V_A - 6 + 3V_A + 2V_A - 20 = 0.$$

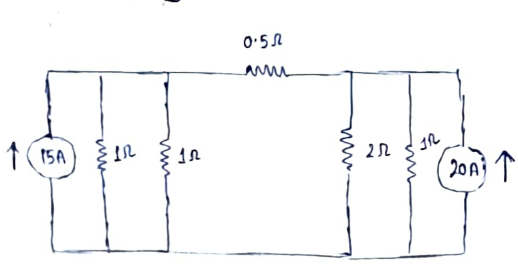
$$11 V_A = 26$$

$$V_A = \frac{26}{11} = 2.36$$

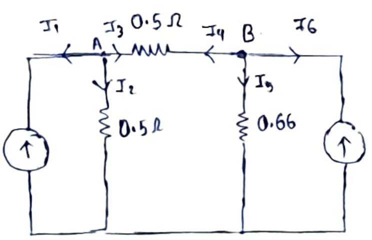
⇒



Sol^n converting v source to i source.



⇒



$I_4 = \dfrac{V_B - V_A}{0.5}$, $\quad I_5 = \dfrac{V_B}{0.66}$, $\quad I_6 = -20.$

$I_1 = -15$ A.

$I_2 = \dfrac{V_A}{0.5}$, $\quad I_3 = \dfrac{V_A - V_B}{0.5}$

$$\frac{V_B}{0.5} - \frac{V_A}{0.5} + \frac{V_B}{0.66} - 20 = 0$$

KCL $= -15 + \dfrac{V_A}{0.5} + \dfrac{V_A - V_B}{0.5} = 0.$

$$2V_A - 3.5 V_B = -20.$$

$$2V_A - V_B = 7.5$$

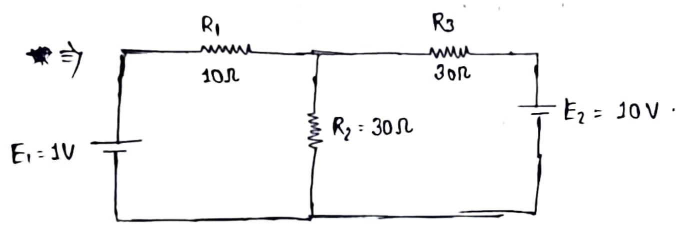
$$4V_A - 2V_B = 15$$

$\therefore V_A = 9.25$ V

$V_B = 11$ V. // (Ans)

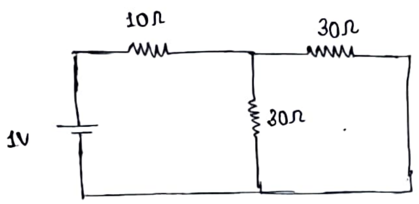
SUPERPOSITION THEOREM :

$\Rightarrow$

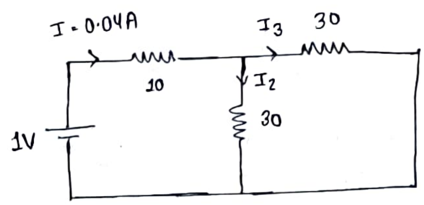


Find the current through R_2.

Sol^{n}) Case - 1 : [considering E_1]



$\Rightarrow$

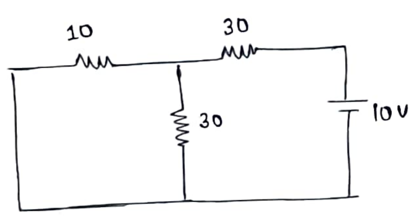


$\Rightarrow I = \frac{1}{25} = 0.04\text{ A}$

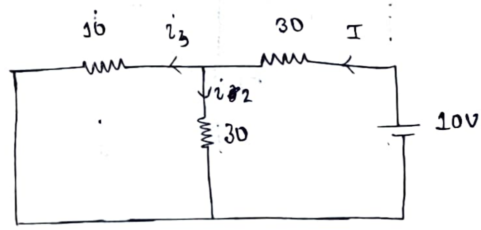
$\therefore i_2 = (0.04)\left(\frac{30}{30+30}\right) = 0.02\text{A}.$

$i_3 = 0.02\text{A}$

Case - 2 : [Considering E_2].



$\Rightarrow$



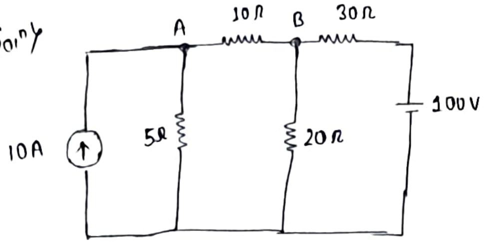
$\Rightarrow i = \frac{10}{37.5} = 0.267\text{ A}$

$i_2 = (0.267)\left(\frac{10}{40}\right) = 0.067\text{A}$

$\therefore$ i through R_2 = $0.02 + 0.067 = 0.087\text{ A}$

⇒ Find i through the branch A & B, using superposition theorem?

Sol^n/

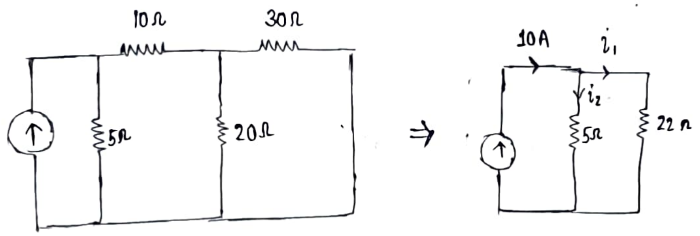


$I_{AB} = 1.85185\ A$

$I_{BA} = 1.48148$

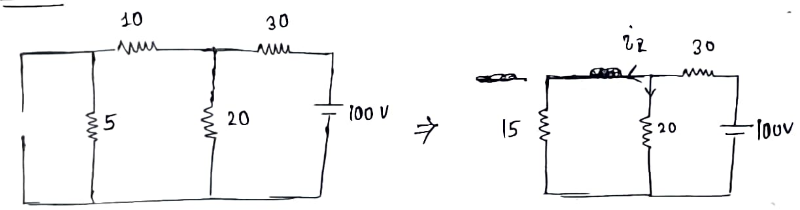
$I_T = 0.3703$

Case - 1 [considering current source].



$\therefore i_1 = (10)\left[\frac{5}{27}\right] = 1.85185\ A$

Case - 2



$i = 38.5714\ A.$

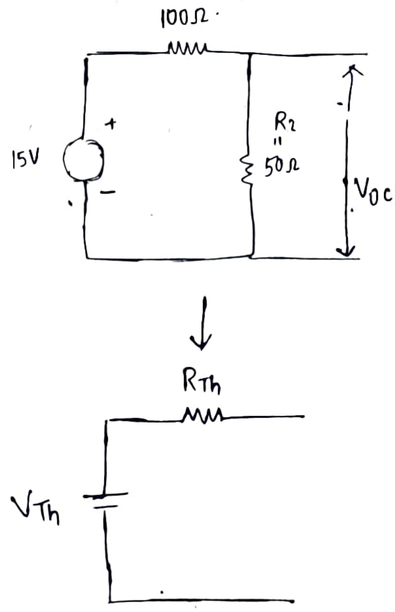
$\therefore i_2 = (38.5714)\left[\frac{20}{20+15}\right] = 1.48148\ A.$

$\therefore i_{AB} = i_1 - i_2 = 1.85185 - 1.48148 = 0.37037\ A.$

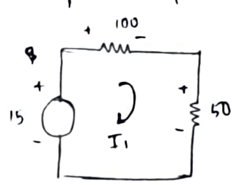
⇒ Find V_{Th}, R_{Th} & draw equi. circuit.

Sol^n/ Voltage div. method.

$V_{R_2} = \left[\frac{50}{100+50}\right][15] = 5V.$



loop current method.



$15 - 100 I_1 - 50 I_1 = 0$

$I_1 = 0.1A$; $V_{R_2} = 5V$ (Ans)

MAXIMUM POWER THEOREM

Voltage	V_{Th}		R_{Th}		I	
	Theo	Prac	Theo	Pract.	Theo	Prac
15 V	12.73 V	12.60 V	84.80 Ω	84.50 Ω	35.9 mA	36.5 mA

R_L (Ω)	R_{Th} (Ω)	I_L (mA)	$P = I_L^2 R_L$.
50	84.5	94.7	448 W
60	84.5	88.1	465.69 W
70	84.5	82.3	474.13 W
80	84.5	77.1	475.55 W
84.5	84.5	75.6	482.94 W
90	84.5	72.6	474.36 W
100	84.5	69.5	469.22 W
110	84.5	65.7	464.21 W
120	84.5	62.3	465.75 W
130	84.5	59.5	460.23 W