S. No.	Date	Title	Page No.	Teacher's Sign

Current divider formula

→ When 1 current (i_t) divides btw 2 resistors (R_1 & R_2) in parallel

Current across $R_1 = i_{R_1} = i_t \left(\frac{R_2}{R_1 + R_2} \right)$

→ When 1 current (i_t) divides btw 3 resistors (R_1, R_2, R_3) in parallel:

Current across $R_1 = i_{R_1} = i_t \left[\frac{1/R_2}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}} \right]$

Voltage divider formula:

→ When voltage (v_t) divides across 2 resistors R_1 & R_2 in series

Voltage across $R_2 = v_2 = v_t \left(\frac{R_2}{R_1 + R_2} \right)$

→ When voltage (v_t) divides across 3 resistors R_1, R_2 & R_3 in series.

Voltage across $R_2 = v_2 = v_t \left(\frac{R_2}{R_1 + R_2 + R_3} \right)$

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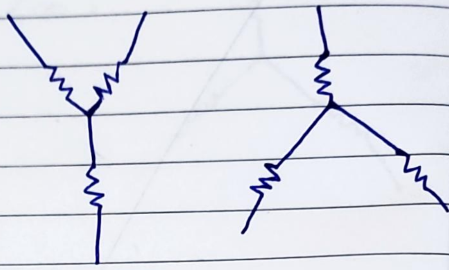
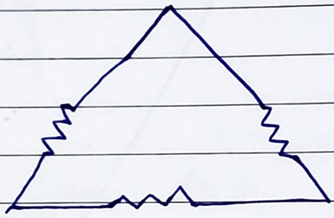
Converting Star → delta
delta → Star.

Star :→

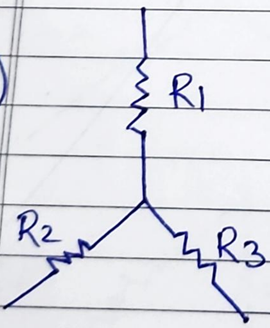


delta :→



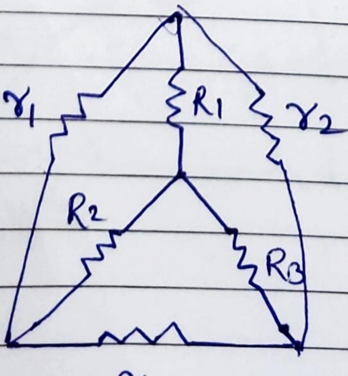
Q) Convert Star → delta

Q)



{Formula}

(ans)

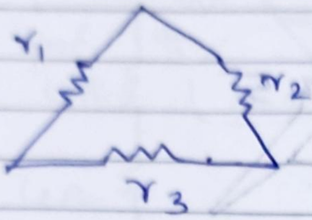


$r_1 = R_1 + R_2 + \frac{R_1 R_2}{R_3}$

$r_2 = R_1 + R_3 + \frac{R_1 R_3}{R_2}$

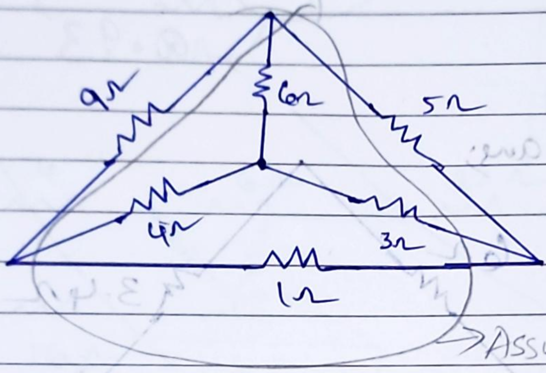
$r_3 = R_3 + R_2 + \frac{R_3 R_2}{R_1}$

ans) ⇒

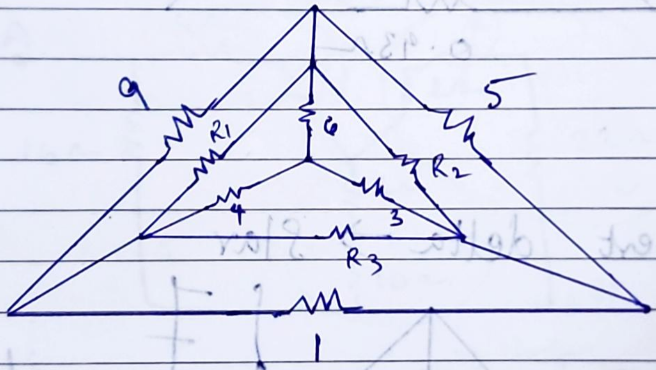


→ Delta transformatⁿ

Q)



→ Assume Δ here

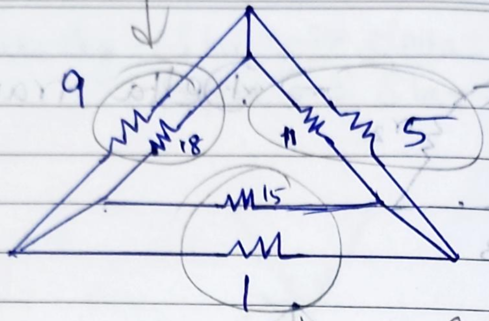


$$R_1 = 6 + 4 + \frac{6 \times 4}{3} = 18\,\Omega$$

$$R_2 = 6 + 3 + \frac{6 \times 3}{4} = 15\,\Omega$$

$$R_3 = 4 + 3 + \frac{4 \times 3}{6} = 11\,\Omega$$

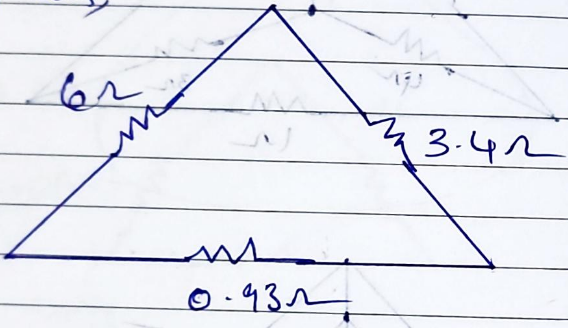
Rpnet = 6



3.4

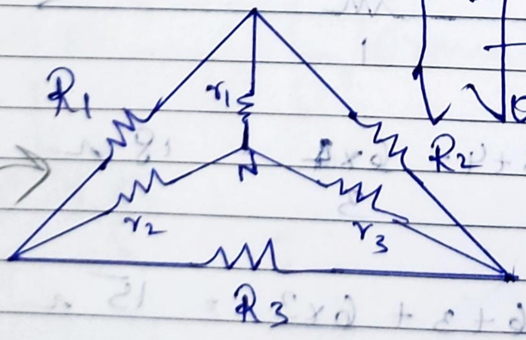
0.93

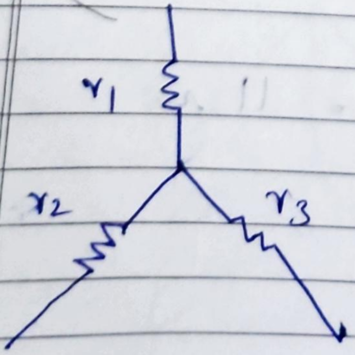
Req ans:



Q) Convert delta → star.

{ Formula }





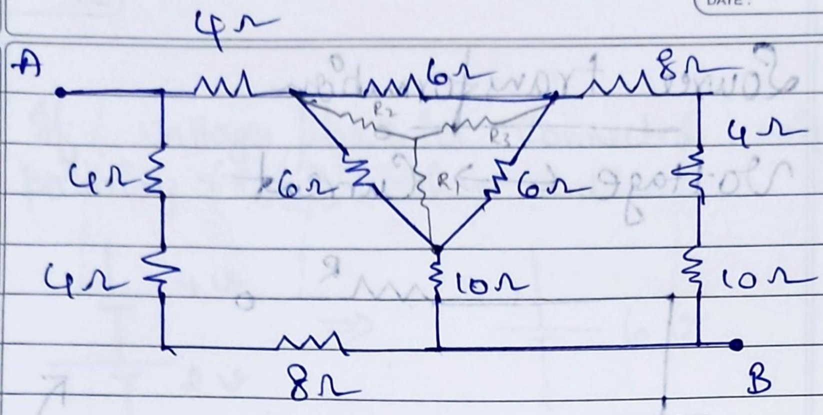
$$r_1 = \frac{R_1 \times R_2}{R_1 + R_2 + R_3}$$

$$r_2 = \frac{R_1 \times R_3}{R_1 + R_2 + R_3}$$

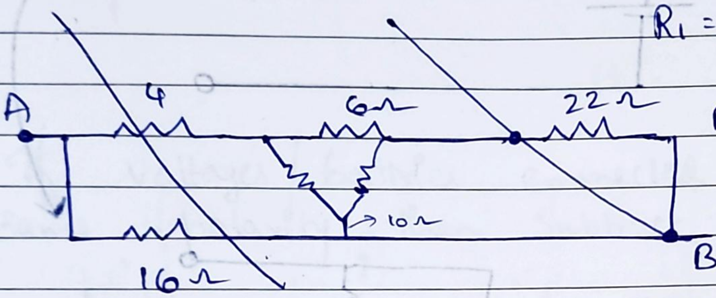
$$r_3 = \frac{R_2 \times R_3}{R_1 + R_2 + R_3}$$

Find R_{net} btw A & B.

Eg;

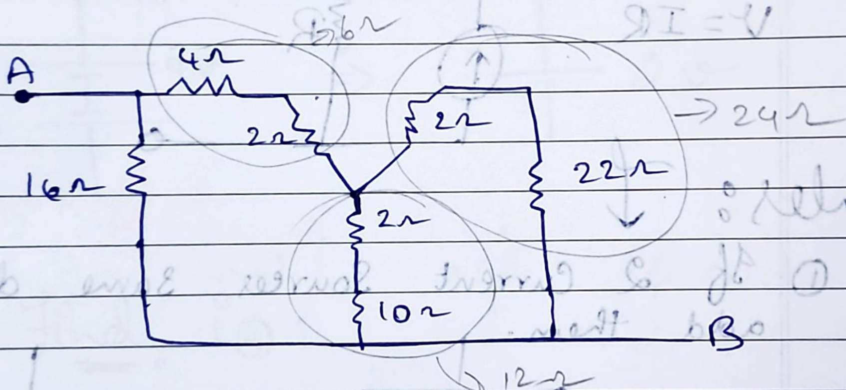


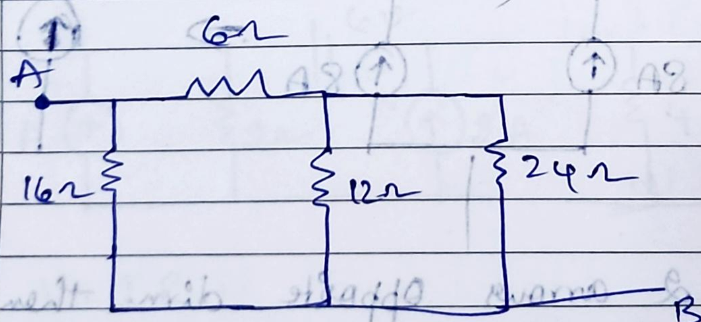
$R_1 = \frac{6\times 6}{18} = 2$



$R_2 = \frac{6\times 6}{18} = 2$

$R_3 = \frac{6\times 6}{6+6+6} = 2$





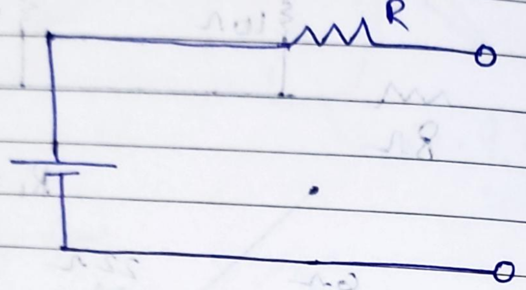
$\frac{1}{R_P} = \frac{1}{12} + \frac{1}{24}$, $R_P = 8$

$8 + 6 \Rightarrow 14\Omega$

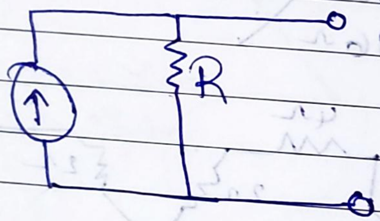
$\frac{1}{R_{net}} = \frac{1}{14} + \frac{1}{16} = \frac{112}{15} = 4.6\Omega$

Source transformation

Voltage ⟷ Current.

① 

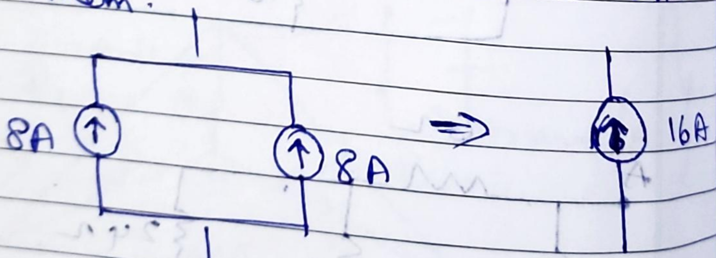
$V = IR$



Rules:

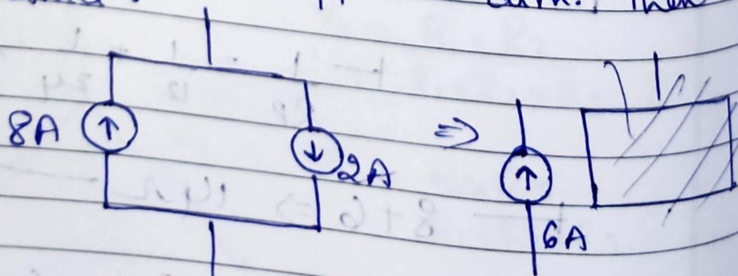
① If 2 current sources same dirn. add them.

Eg;



② If 2 arrows opposite dirn. then Subtract.

Eg;



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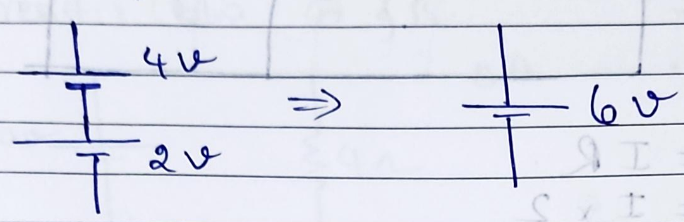
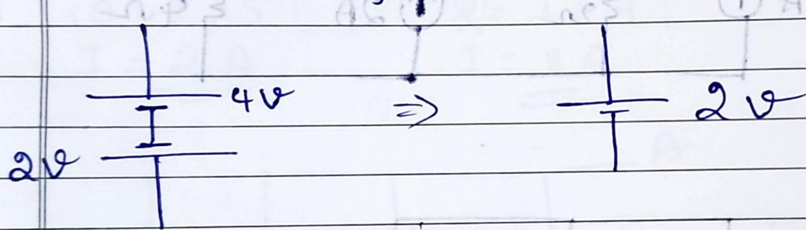
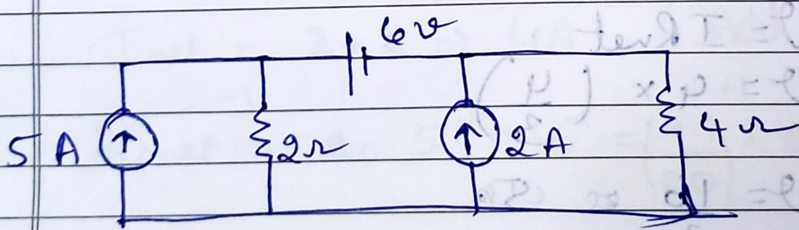
(3) If voltages / battries connected with opp polarity (+ -) then add.



(4) If voltages / battries connected with same polarity then subtract.

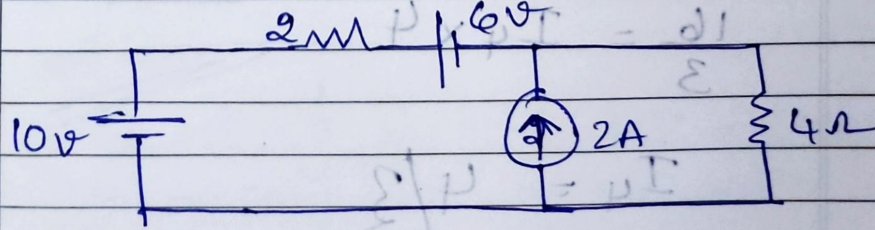


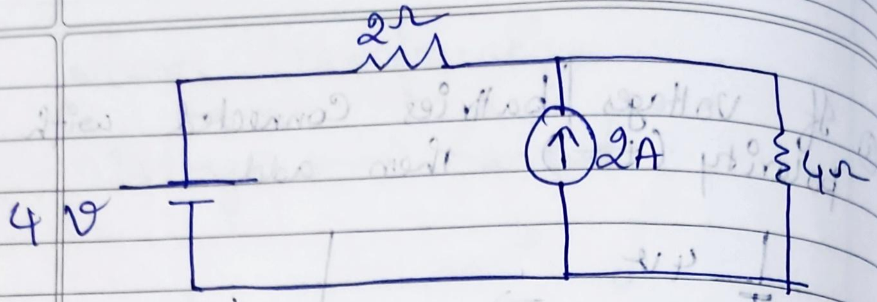
Q) Find $i_{(4)}$:



$V = IR$.

$V = 5 \times 2 \Rightarrow 10$

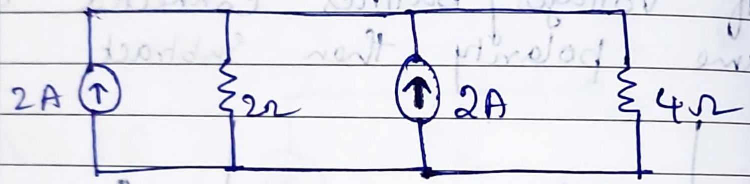


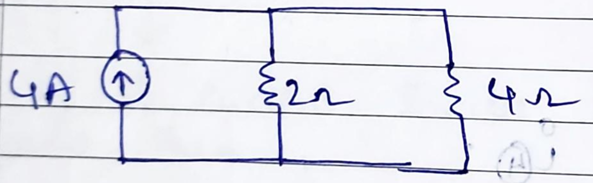


$V = IR$

$4 = I \times 2$

$I = 2\,A$





$V = I R_{net}$

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

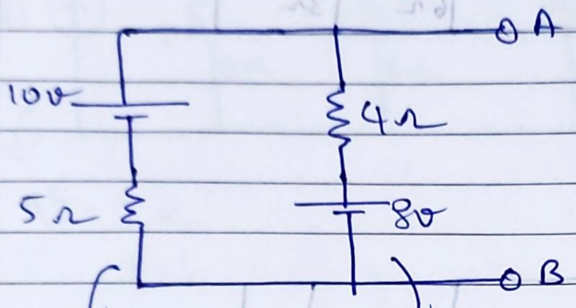
$V = \frac{16}{3} \approx 5.6$

$V_4 = I_4 R$

$\frac{16}{3} = I_4 \times 4$

$I_4 = \underline{4/3}$

Q) Convert the given ckt into a single current source in parallel with single resist. b/w A & B.



$V = IR$

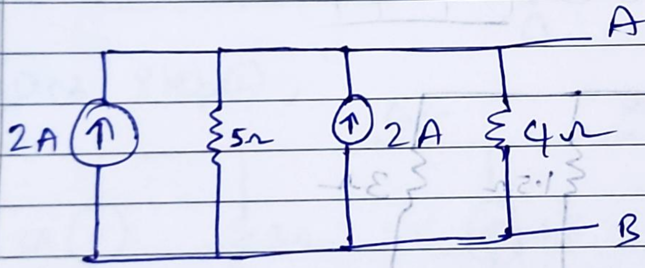
$V = IR$

Ans) $10 = I \times 5$

$8 = I \times 4$

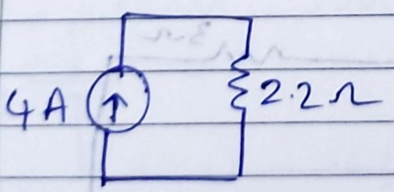
$I = 2A$

$I = 2A$



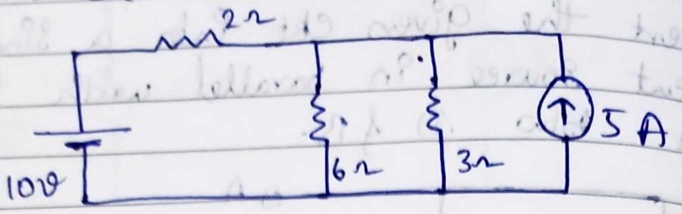
$I_{net} = 2 + 2 \Rightarrow 4A$ (Add ∵ same dirⁿ)

$R_{pnet}^{-1} = 5^{-1} + 4^{-1} = \left(\frac{9}{20}\right) = 2.2\Omega$



Find I_3

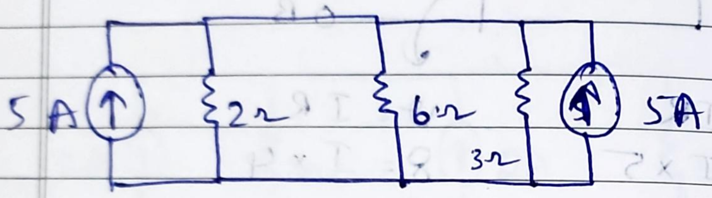
Q)



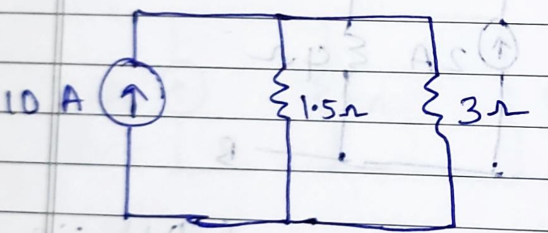
$V = IR$

$10 = I \times 2$

$I = 5\ A$



$I_{net} = (5 + 5 = 10\ A)$



~~$V = IR$~~

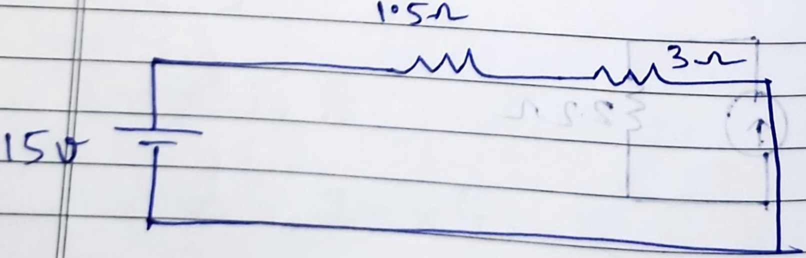
~~$V = 10 \times 1.5$~~

~~$\Rightarrow 15\ V$~~

$V = IR$

$\Rightarrow 10 \times 1.5$

$\Rightarrow 15\ V$



$V = I R_{net}$

$15 = I \times 4.5$

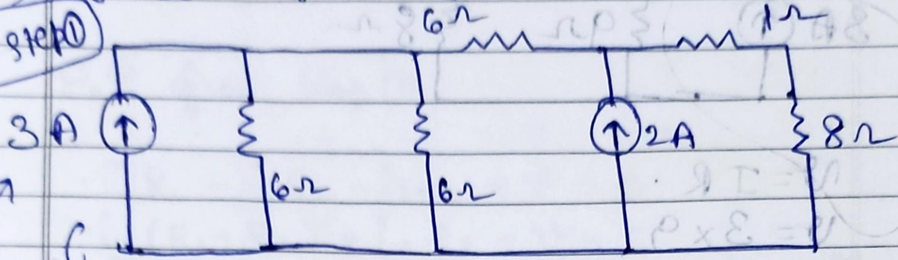
$I = 3.33\ A$

$\because$ In series current same;

$I_3 = 3.33\ A$

Q) Find I_8 .

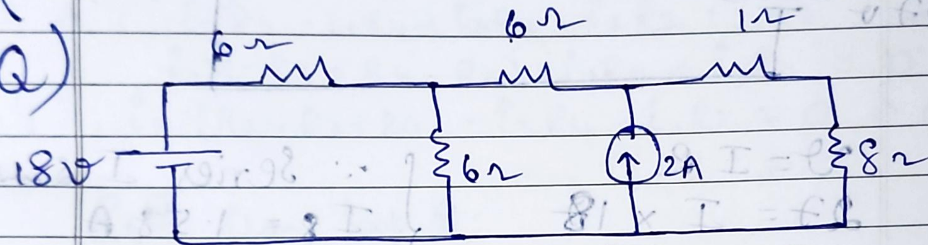
ans step①



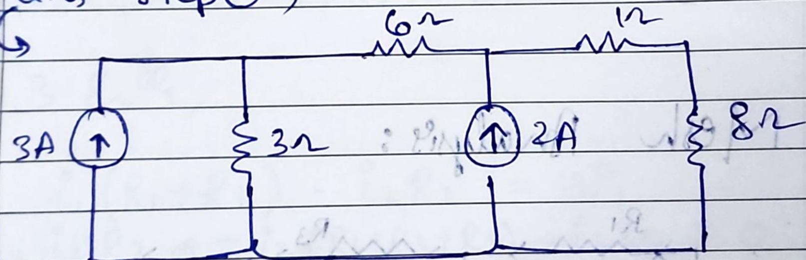
$v = IR$

$v = 3 \times 6 \Rightarrow 18$

Q)

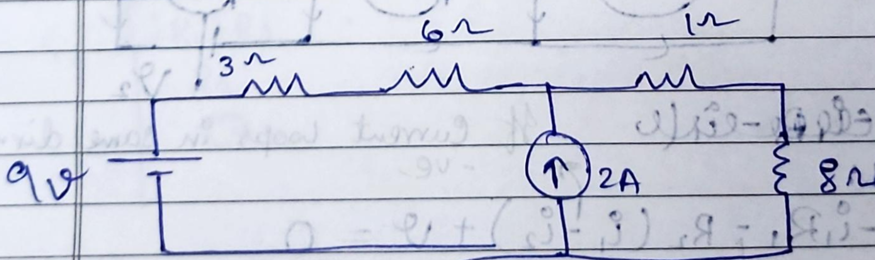


ans step② ;



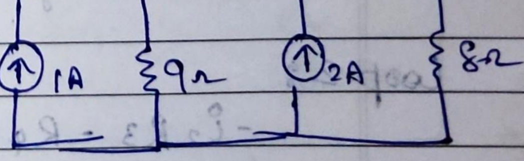
$v = IR$

$v = 3 \times 3 \Rightarrow 9Av$

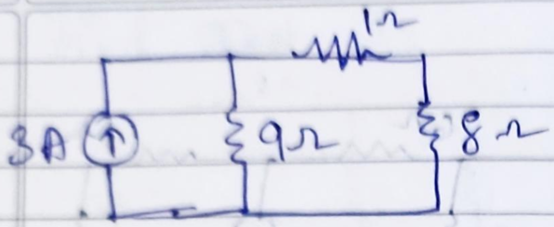


$v = IR$

$9 = I \times (6+3) \Rightarrow$



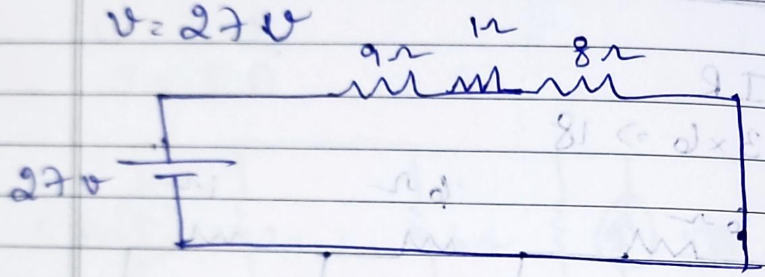
$I = 1A$



$v = IR$

$v = 3 \times 9$

$v = 27\,v$



$v = IR$

$27 = I \times 18$

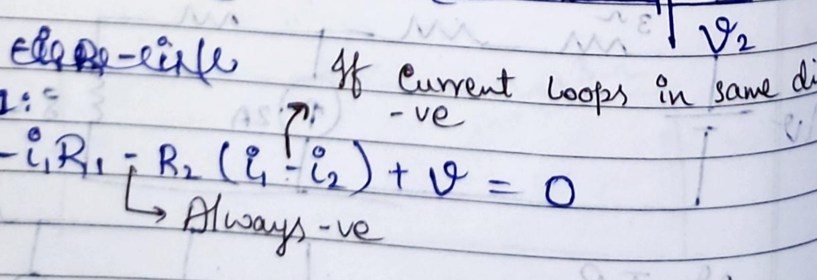
$I_8 = 1.58\,A$

∵ Series I same

$I_8 = 1.58\,A$

Mesh Analysis:

Q)



ele-circle

Loop 1:

If current loops in same dirn -ve

$-i_1R_1 - R_2(i_1 - i_2) + v = 0$

↳ Always -ve

Loop 2:

$-i_2R_3 - R_4(i_2 - i_3) - R_2(i_2 - i_1) = 0$

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Loop 3;

$$-i_3 R_5 - V_2 - (i_3 - i_2) R_4 = 0$$

Eq ① from loop ①;

$$-i_1 R_1 - i_1 R_2 + i_2 R_2 + V = 0$$
$$-i_1 (R_1 + R_2) + i_2 R_2 + V = 0$$
$$i_1 (R_1 + R_2) - i_2 R_2 - V = 0 \Rightarrow ①$$

Eq ② from loop ②;

$$-i_2 R_3 - i_2 R_4 + i_3 R_4 - i_2 R_2 + i_1 R_2 = 0$$
$$i_2 (-R_3 - R_4 - R_2) + i_3 R_4 + i_1 R_2 = 0$$
$$i_2 (R_2 + R_3 + R_4) - i_3 R_4 - i_1 R_2 = 0 \Rightarrow ②$$

Eq ③ from loop ③;

$$-i_3 R_5 - V_2 - i_3 R_4 + i_2 R_4 = 0$$
$$i_2 R_4 - i_3 (R_4 + R_5) - V_2 = 0 \Rightarrow ③$$

3 Eqs;

$$i_1 (R_1 + R_2) - i_2 R_2 = V_1$$
$$i_1 R_2 - i_2 (R_2 + R_3 + R_4) + i_3 R_4 = 0$$
$$i_2 R_4 - i_3 (R_4 + R_5) = V_2$$

$$\begin{bmatrix} R_1 + R_2 & -R_2 & 0 \\ R_2 & -(R_2 + R_3 + R_4) & R_4 \\ 0 & R_4 & -(R_4 + R_5) \end{bmatrix}$$

$$D_{i_1} \Rightarrow \begin{bmatrix} V_1 & -R_2 & 0 \\ 0 & -(R_2 + R_3 + R_4) & R_4 \\ V_2 & R_4 & -(R_4 + R_5) \end{bmatrix}$$

" in D_{i_2} — $V_1, 0, V_2$

in D_{i_3} — $V_1, 0, V_2$

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Now Gen shortcut formula...

$$\begin{bmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

↓ Main det. D

↓ Sub. this in 1st, 2nd & 3rd col. for D_x, D_y & D_z

Value of unkown ↓

$$\frac{D_x}{D \to (\text{main det})}$$

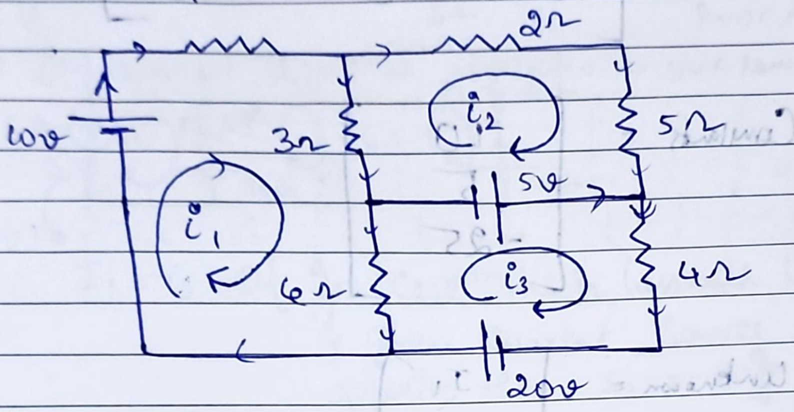
For sign of matrix elements see dirn. of loops. If dirn. of 2 loops say 1 & 2 is same (clockwise) then R_{12} & R_{21} is -ve

If loop dirn. of 1st & 3rd loop is opp. then R_{13} & R_{31} is +ve

(*) Applicable only if using this direct matrix shortcut method

If loops in Same dirn then give -ve sign

Q) Find value of current through 5Ω resistor.



for Mesh ① ;

$10\cancel{0} - i_1(1) - (i_1 - i_2)3 - (i_1 - i_3)6 = 0$

$10\cancel{0} - i_1 - 3i_1 + 3i_2 - 6i_1 + 6i_3 = 0$

$10\cancel{0} - 10i_1 + 3i_2 + 6i_3 = 0$

$10i_1 - 3i_2 - 6i_3 = 10\cancel{0} \Rightarrow$ ①

for Mesh 2 ;

$-i_2(2) - i_2(5) - 5 - (i_2 - i_1)3 = 0$

$-2i_2 - 5i_2 - 5 - 3i_2 + 3i_1 = 0$

$-10i_2 - 5 + 3i_1 = 0$

$3i_1 - 10i_2 = 5 \cancel{00} \Rightarrow$ ②

for Mesh ③

$5 - i_3 4 + 20 - (i_3 - i_1)6 = 0$

$5 - 4i_3 + 20 - 6i_3 + 6i_1 = 0$

$25 - 10i_3 + 6i_1 = 0$

$6i_1 - 10i_3 = -25$

If loops in same dirn then give -ve sign.

If you take (-) common from both rows it becomes +ve & whatever is inside becomes of normal

$$D = \begin{bmatrix} 10 & -3 & -6 \\ 3 & -10 & 0 \\ 6 & 0 & -10 \end{bmatrix}$$

$$\text{Constants} = \begin{bmatrix} 10 \\ 5 \\ -25 \end{bmatrix}$$ ∴ Earn form

$$\text{unknown} = \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix}$$

$$I_1 \Rightarrow \frac{\begin{bmatrix} 10 & -3 & -6 \\ 5 & -10 & 0 \\ -25 & 0 & -10 \end{bmatrix}}{\begin{bmatrix} 10 \\ 5 \\ -25 \end{bmatrix}}$$

ly find I_2 & I_3

& current in 5Ω resistor $= I_2$

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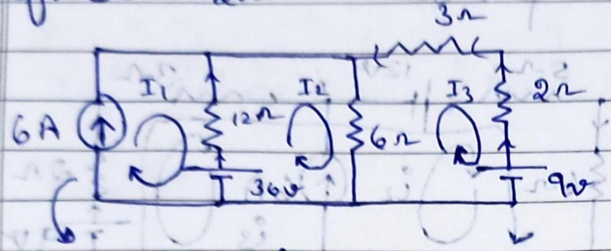
2) Mesh Analysis with Current Source

find $I_{2\Omega}$.



$I_1 = 6 \Rightarrow ①$ { In case mesh (assumed loop) dirn & given current source dirn is opposite then $I_1 = -6$ }

Mesh: 2;

$-(i_2 - i_1)12 - (i_2 - i_3)6 + 36 = 0$

$\Rightarrow -12i_1 + 18i_2 - 6i_3 = 36$

$\Rightarrow 2i_1 - 3i_2 + i_3 = -6 \Rightarrow ①$

Given $i_1 = 6$

$\Rightarrow 3i_2 - i_3 = 6 + 12$

$\Rightarrow 3i_2 - i_3 = 18 \Rightarrow ①$

$\Rightarrow 3i_2 - 18 = i_3$

Mesh 3;

$i_3(2) + i_3(3) + (i_3 - i_2)6 - 9 = 0$

$2i_3 + 3i_3 - 6i_3 + 6i_2 - 9 = 0$

$-i_3 + 6i_2 - 9 = 0$

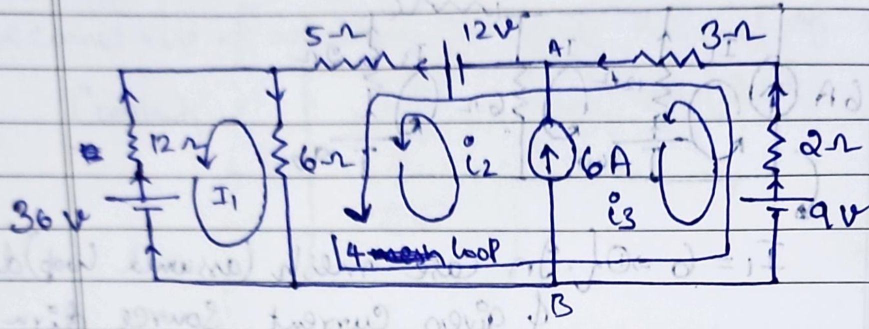
$6i_2 - i_3 = +9$

$6I_2 - 11i_3 = 9 \Rightarrow ②$

Solve Both Eq^(n) & get the Req ans

3) Super Mesh Analysis:

Find $I_{5\Omega}$ & $I_{6\Omega}$



For mesh ①;

$$+i_1(12) + (i_1 - i_2)6 + 36 = 0$$
$$12i_1 - 6i_1 + 6i_2 + 36 = 0$$
$$6i_1 + 6i_2 + 36 = 0$$
$$i_1 + i_2 + 6 = 0$$

⇒ Mesh 2 & 3 will form a supermesh as it shares common current source

Writing Eq^n for supermesh:

$$+i_2 - i_3 = 6$$
$$+i_2 - i_3 = 6$$

* { If i is in dir^n of current source take those i's as +ve & the ones in opp. dir^n of current source they are -ve

(*) After writing supermesh Eq^n ignore the complete problem making current source wire AB in this case & take a single loop that covers both mesh 2 & 3. (Single loop is loop 4 this case) write current corresponding to that loop.

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$$+9-2(i_3)-3(i_3)+12-5(i_2)-(i_2-i_1)6=0$$

$$9-2i_3-3i_3+12-5i_2-6i_2+6i_1=0$$
$$21-5i_3-11i_2+6i_1=0$$
$$6i_1-11i_2-5i_3+21=0.$$

3 Eqns;

$6i_1+6i_2+?$

$$i_1+i_2+0i_3=-6$$
$$0i_1+i_2-i_3=+6$$
$$6i_1-11i_2-5i_3=-21$$

find i_1, i_2, i_3.

$$I_{5\Omega}=i_2$$

$$I_{6\Omega}=|i_2-i_1|$$

→ Modulus.

}

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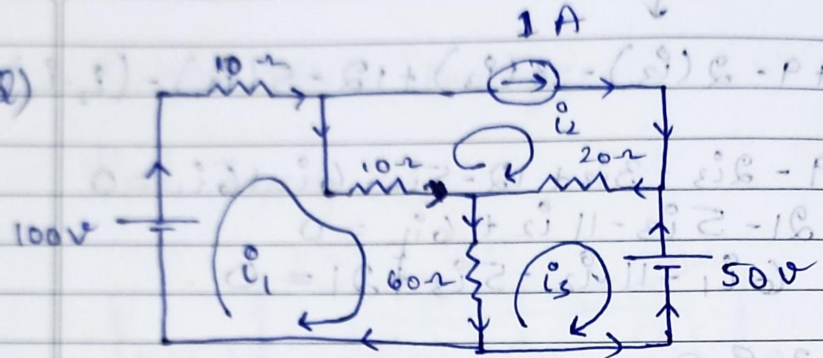
(Q)



find $I_{60\Omega}$

In Mesh (1);

$$100 - 10i_1 - (i_1 - i_2)10 - (i_1 - i_3)60 = 0$$
$$100 - 10i_1 - 10i_1 + 10i_2 - i_1 + 60i_3 = 0$$
$$-11i_1 + 100 + 10i_2 + 60i_3 = 0$$
$$11i_1 - 10i_2 - 60i_3 = 100 \quad \Rightarrow (1)$$

In Mesh 2;

$$i_2 = 1A \quad \Rightarrow (2)$$

(2) in (1);

$$11i_1 - 10 - 60i_3 = 100$$
$$11i_1 - 60i_3 = 110 \quad \Rightarrow (a)$$

Mesh (3);

$\cancel{-50 + 60i_3}$

$$-50 - (i_3 - i_1)60 - (i_3 - i_2)(20) = 0$$

$$-50 - 60i_3 + 60i_1 - 20i_3 + 20i_2 = 0$$
$$-50 - 80i_3 + 60i_1 + 20i_2 = 0$$

$\because i_2 = 1$

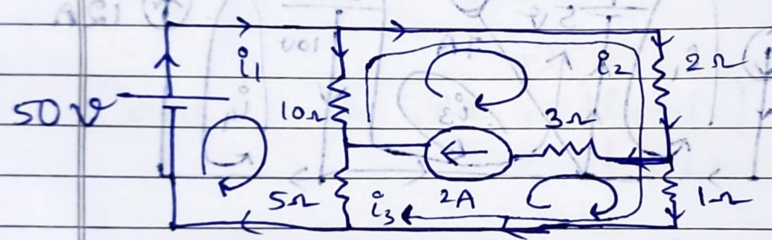
$60i_1 - 80i_3 + 20 - 50 = 0$

$60i_1 - 80i_3 = 30 \Rightarrow (b)$

from (a) & (b);

find I_1 & I_3 then subtract both to get $I_{60\Omega}$

(*) Supermesh with current & resistor



Find $I_{5\Omega}$;

Mesh (1);

$50 - (i_1 - i_2)10 - (i_1 - i_3)5 = 0$

$50 - 10i_1 + 10i_2 - 5i_1 + 5i_3 = 0$

$50 - 15i_1 + 10i_2 + 5i_3 = 0$

$10 - 3i_1 + 2i_2 + i_3 = 0$

$3i_1 - 2i_2 - i_3 = 10 \Rightarrow (1)$

Mesh (2);

Supermesh eq (1); $0i_1 + i_2 - i_3 = 2 \Rightarrow (2)$

Mesh (2 & 3):

$-i_2 2 - i_3(1) - (i_3 - i_1)5 - (i_2 - i_1)10 = 0$

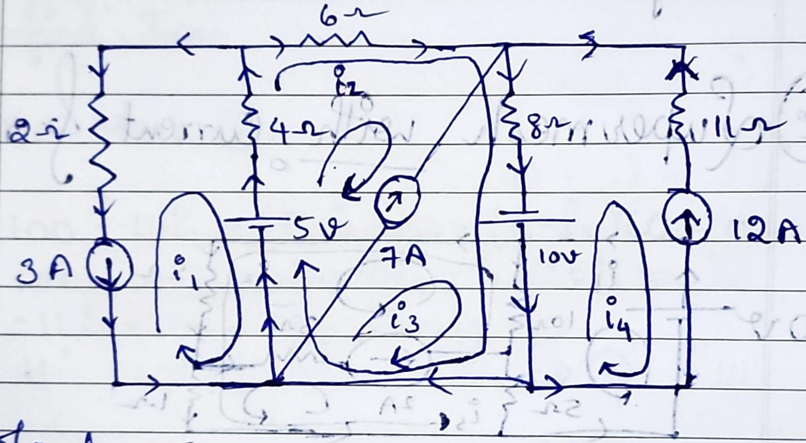
$-5i_1 + 4i_2 + 2i_3 = 0$

$5i_1 - 4i_2 - 2i_3 = 0$

from ①, ②, ③ get i_1, i_2, i_3

To get $I_{5\Omega}$; $|I_3 - I_1|$

(Q)



Find $I_{8\Omega}$

In Mesh ①;

$i_1 = -3A$ ((-) ∵ current dirⁿ opp to loop dirⁿ)

$i_4 = -12A$ ((-) ")

Supermesh ε_2 ② ↓;

$i_3 - i_2 = 7 \Rightarrow i_2 - i_3 = -7$

Big Mesh;

$-i_2 6 - (i_3 - i_4)8 + 10 + 5 - (i_2 - i_1)4 = 0$

$-6i_2 - 8i_3 + 8i_4 + 10 + 5 - 4i_2 + 4i_1 = 0$

$4i_1 - 10i_2 - 8i_3 + 8i_4 + 15 = 0$

$\therefore\ i_1 = -3$

$i_4 = -12$

$-12 - 10i_2 - 8i_3 - 96 + 15 = 0$

$10i_2 + 8i_3 = -93$

$i_2 = -8.27$

$i_3 = -1.27$

~~Current via 8Ω = $|i_2 - i_3|$~~

$\Rightarrow$

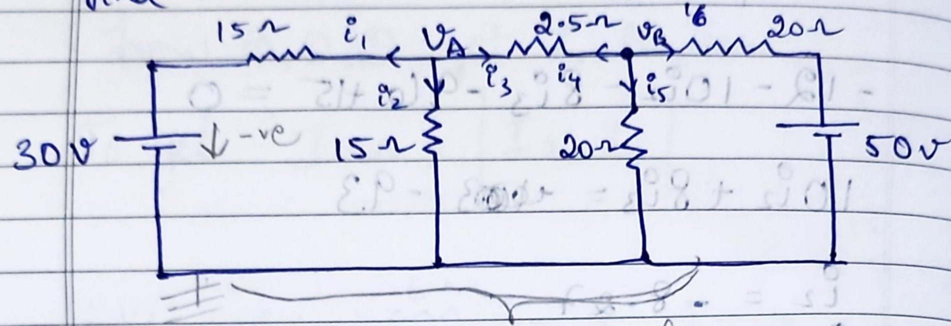
Current via 8Ω $= |i_4 - i_3|$

$= |-1.27 - (-12)|$

$\Rightarrow \underline{10.73A}$

Nodal Analysis

find current btn V_A & V_B



① ∴ No Component here Assume Ground

② Throw out current from all nodes

③ Use below formula

Node V_A:

$$I_1 + I_2 + I_3 = 0$$

$$\frac{V_A - 30}{15} + \frac{V_A - 0}{15} + \frac{V_A - V_B}{2.5} = 0$$

-ve 30, As battery + → - (KVL)

$$\frac{V_A - 30 + V_A + 6V_A - 6V_B}{15} = 0$$

$$8V_A - 6V_B = 30$$

$$4V_A - 3V_B = 15 \Rightarrow ①$$

Node V_B;

-ve as.....

$$I_4 + I_5 + I_6 = 0$$

$$\frac{V_B - V_A}{2.5} + \frac{V_B - 0}{20} + \frac{V_B - 50}{20} = 0$$

Solve 2 above Eq;

$V_A = 18.75$

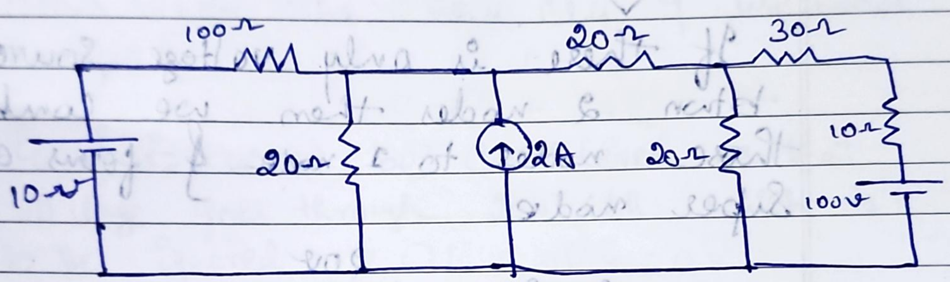
$V_B = 20$

Current b/w V_A & V_B = I_3

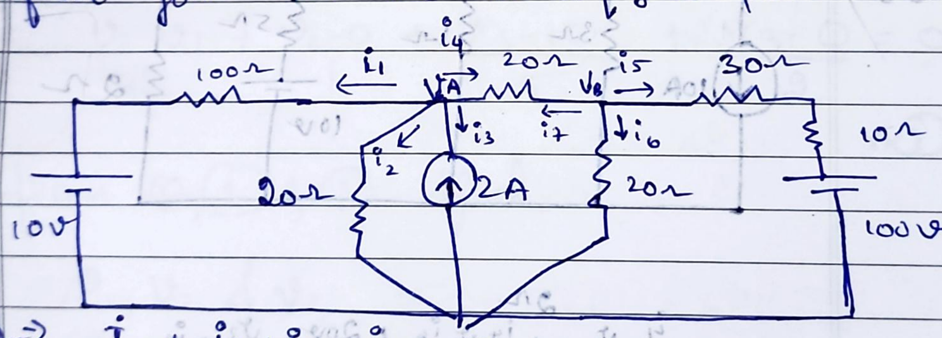
$$I_3 = \frac{V_A - V_B}{2.5} \approx -0.5A$$

(*) Nodal Analysis with current source.

Q)



first join all the null / zero potential wires



@ $V_A \Rightarrow$ $i_1 + i_2 + i_3 + i_4 = 0$

$$\frac{V_A - 10}{100} + \frac{V_A - 0}{20} - 2 + \frac{V_A - V_B}{20} = 0 \quad \Rightarrow (1)$$

{-ve ∵ i_3 dirn & source current dirn is opposite, if same dirn then its +ve}

@ $V_B \Rightarrow$ $i_5 + i_6 + i_7 = 0$

$$\frac{V_B - 100}{30+10} + \frac{V_B - 0}{20} + \frac{V_B - V_A}{20} = 0 \quad \Rightarrow (2)$$

Rnet ← 30+10

Solve (1) & (2) to get;

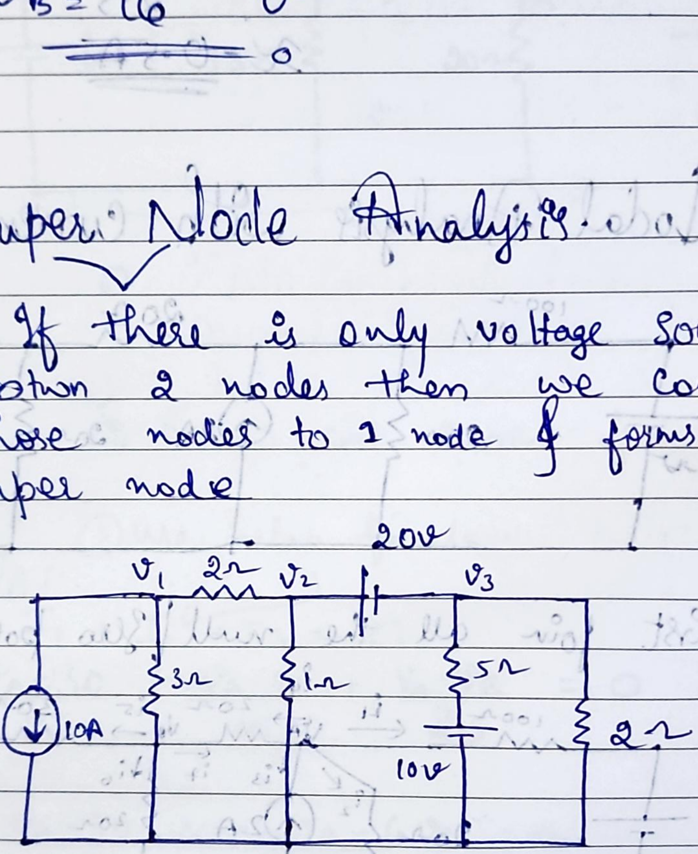
$v_A = -10\ v$

$v_B = 16\ v$

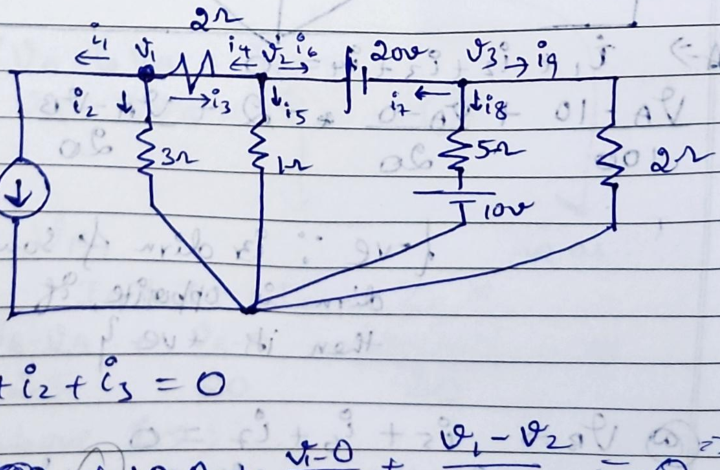
Super Node Analysis

If there is only voltage source btwn 2 nodes then we combine those nodes to 1 node & forms a Super node

Q)



ans)



(a) $V_1 \Rightarrow i_1 + i_2 + i_3 = 0$

$$+10A + \frac{v_1 - 0}{3} + \frac{v_1 - v_2}{2} = 0 \Rightarrow (1)$$

∵ i_1 dirn & source dirn same

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Now, v_2 & v_3 has voltage source
So, this has to be made into super node
Supernode eq ⓦ & then ignore that volt source

$$+v_2 - v_3 = 20 \Rightarrow (2)$$

↳ volt. value

↳ ∵ -ve terminal points @ v_3

↳ ∵ +ve terminal of 20 v cell points @ v_2

Now ignore the 20 v cell & use nodal analysis.

i_6 & i_7 wont be considered as that voltage goes through 20 v cell which is to be ignored.

So, $i_4 + i_5 + i_8 + i_9 = 0$

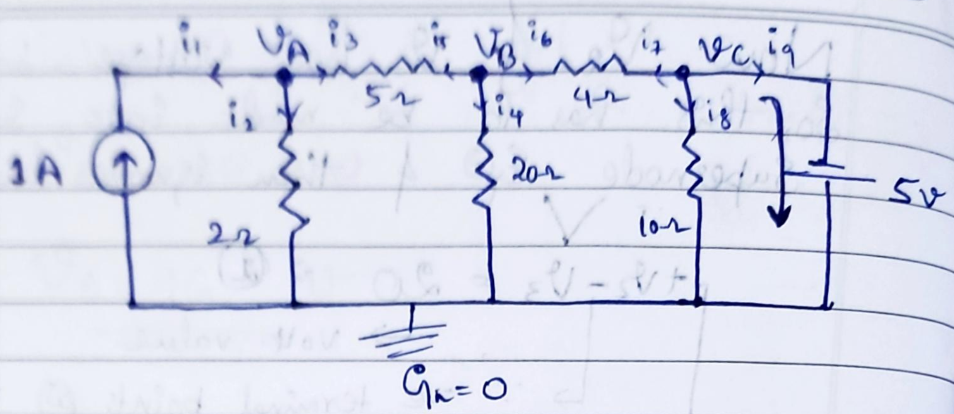
$$\frac{v_2 - v_1}{2} + \frac{v_2 - 0}{1} + \frac{v_3 - 10}{5} + \frac{v_3 - 0}{2} = 0 \Rightarrow (3)$$

from (1), (2) & (3) find

v_1, v_2 & v_3

* here voltage source directly connected to node

Q)



In V_A;

$$i_1 + i_2 + i_3 = 0$$

$$-1 + \frac{V_A}{2} + \frac{V_A - V_B}{5} = 0$$

opp dirn

$$7V_A - 2V_B = 10 \Rightarrow (1)$$

In V_B;

$$i_5 + i_4 + i_6 = 0$$

$$\frac{V_B - V_A}{5} + \frac{V_B}{20} + \frac{V_B - V_C}{4} = 0$$

$$-4V_A + 10V_B - 5V_C = 0$$

$$4V_A - 10V_B + 5V_C = 0 \Rightarrow (2)$$

* Now in node V_C.
node directly connected to ~~current~~ volt-source

write voltage Eq for V_C.

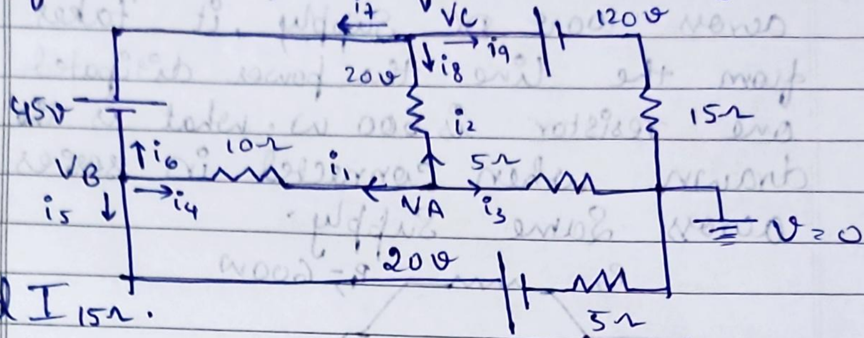
$V_C + 5 = 0$ (+ve 5, as i_9 flows from -ve end of battery) → +ve

$\Rightarrow V_C = -5 \Rightarrow (3)$

Use I.

from ①, ② & ③ find V_A, V_B & V_C

Q)



find $I_{15\Omega}$.

$i_1 + i_2 + i_3 = 0$

$$\frac{V_A - V_B}{10} + \frac{V_A - V_C}{20} + \frac{V_A}{5} = 0$$

$7V_A - 2V_B - V_C = 0 \Rightarrow$ ①

∵ There is a voltage source (45V) b/w 2 nodes it's a super node.
(here 45V is b/w V_C & V_B)

⇒ write Supernode Eqn :

$V_C - V_B = 45$ (∵ +ve side of cell → V_C, −ve " " " → V_B)
⇒ ②

Eq

i_6 & i_7 won't be considered, ∵ that current passes through 45V cell (to be ignored)

$i_4 + i_5 + i_8 + i_9 = 0$

$$\frac{V_B - V_A}{10} + \frac{V_B - 20}{5} + \frac{V_C - V_A}{20} + \frac{V_C - 120}{15} = 0$$

→ +ve

$9V_A - 18V_B - 7V_C = -720$ ⇒ ③

Use calci find V_A, V_B & V_C

$I_{15\Omega} = I_9 = \frac{V_C - 120}{15} = -3.54\,A$

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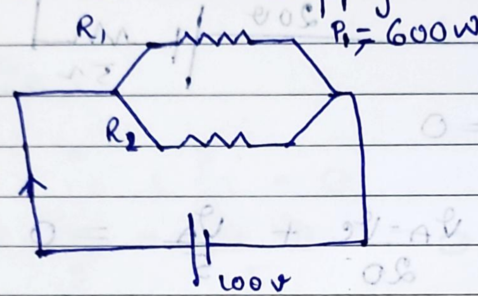
Q) 2 resistors are connected in parallel across 100V DC supply, it takes 10 A from the line the power dissipated in one resistor is 600 W. What is the current drawn when connected in series across same supply.



$$\cancel{P_1 = \frac{V^2}{R} \Rightarrow \frac{100\times100}{600} = \frac{50}{3} \approx 16.66\,\Omega}$$

$$P_1 = \frac{V^2}{R}$$

$$R = \frac{V^2}{P} = \frac{100^2}{600} = 16.66\,\Omega$$

$$V = I R_{net}$$

$$100 = 10 \times \left(\frac{16.66 \times R}{16.66 + R}\right) = 25.05$$

$$R_2 = 25.01\,\Omega$$

$$R_{series} = 41.66\,\Omega$$

$$I_{series} = \frac{V}{R_{series}} = \frac{100}{41.66} = 2.40$$

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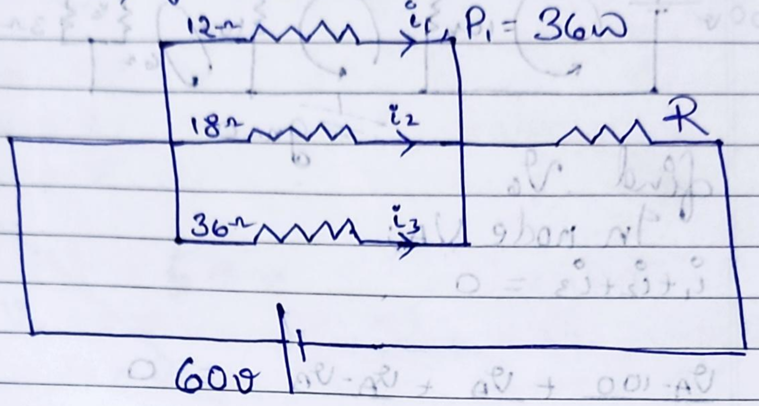
Q) Find R, if $P_{12} = 36W$



$P = I^2 R$

$36 = I_1^2 \times 12$

$3 = I_1^2$

$I_1 = \sqrt{3} = 1.7A$

$P = \frac{v^2}{R}$ volt accross first box

$36 = v^2/12$

$\Rightarrow v = 12\sqrt{3}\ v$

$R_p = \left(\frac{1}{12} + \frac{1}{18} + \frac{1}{36}\right)^{-1} = 6\Omega$

$v = I_2 \times R_3$

$12\sqrt{3} = I_2 \times 18$

$I_2 = 1.15\ A$

$v = I_3 \times R_3$

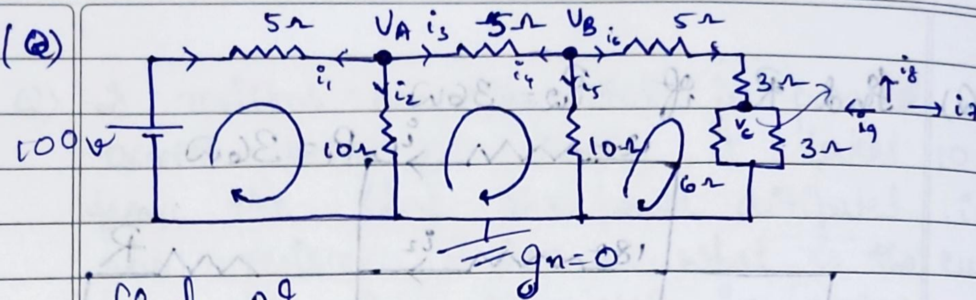
$I_3 = \frac{12\sqrt{3}}{36} = 0.57A$

$v = I R_{net}$

$\Rightarrow 60 = (1.7 + 1.15 + 0.57)(6 + R)$

$\Rightarrow R = 11.54\Omega$

(Q)



find V_6

In node V_A;

$i_1 + i_2 + i_3 = 0$

$$\frac{V_A - 100}{5} + \frac{V_A}{10} + \frac{V_A - V_B}{5} = 0$$

$2V_A - 200 + V_A + 2V_A - 2V_B = 0$

$\Rightarrow 5V_A - 2V_B = 200 \Rightarrow (1)$

In node V_B

$i_4 + i_5 + i_6 = 0$

$$\frac{V_B - V_A}{5} + \frac{V_B}{10} + \frac{V_B}{(5+3+2)} = 0$$

$2V_B - 2V_A + V_B + V_B = 0$

$4V_B - 2V_A = 0$

$2V_B = V_A \Rightarrow (2)$

In node V_C

$i_7 + i_8 + i_9 = 0$

$$\frac{V_c}{3} + \frac{V_c - V_B}{8} + \frac{V_c}{6} = 0$$

$8V_c + 3V_c - 3V_B + 4V_c = 0$

$15V_c - 3V_B = 0$

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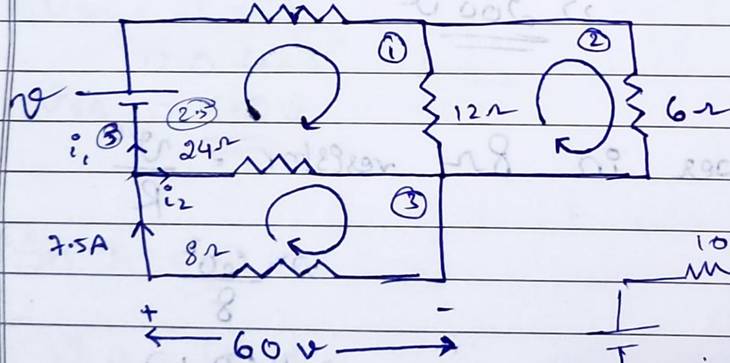
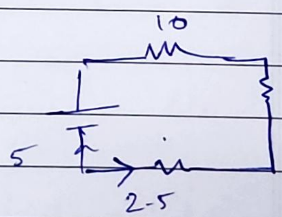
$5V_C = V_B \Rightarrow (3)$

$V_A = 50\ V$
$V_B = 25\ V$
$V_C = 5\ V$

$\therefore$ ~~$V_C = 5\ V$~~ $\because$ In parrallel
~~$V_6 = 5\ V$~~ $V_{6\Omega} = V_C = 5\ V$
~~$V_6 = I_6 \times 6$~~
~~$5 =$~~

Q) find voltage source value of power in 8Ω resistor



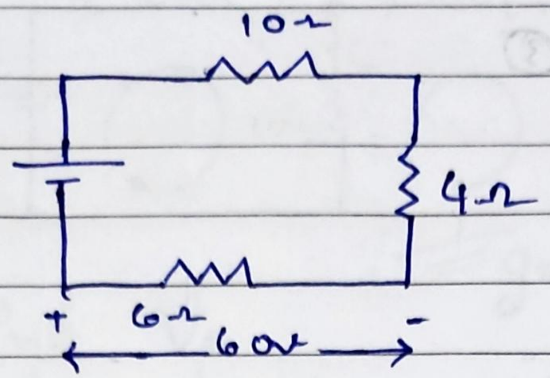


~~In mesh 3;~~
~~$V = 60\ V$~~
~~$R = 8\ \Omega$~~
~~$I = \frac{V}{R} = 7.5\ A$~~

$20 \Rightarrow R$
$I = 7.5$
$V = 150$

$$\frac{1}{R_{p1}} = \frac{1}{24} + \frac{1}{8} \Rightarrow 6 = R_p$$

||| ly $R_{p2} = 4\ \Omega$



$V = IR$

$60 = I \times 6$

$I = 10\ A$

$\therefore$ Series ckt $I_{ckt} = 10\ A$

$V_{net} = I_{ckt} \times R_{net}$

$\Rightarrow 10 \times (10+4+6)$

$\Rightarrow 10 \times (20)$

$\Rightarrow 200\ V$

Power in 8Ω resistor $= \dfrac{V^2}{R}$

$\Rightarrow \dfrac{60^2}{8}$

$\Rightarrow 450\ W$

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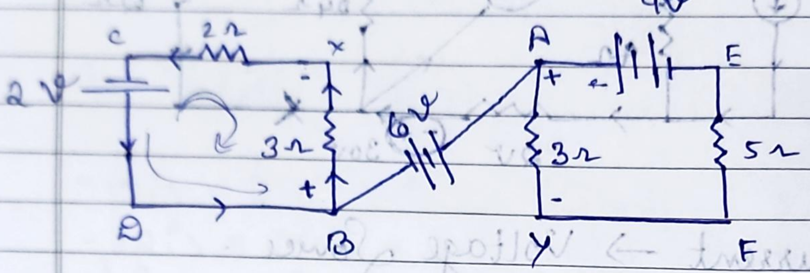
Q) Find the potential diff b/w x & y in the below fig.



$V_{xy} = V_{xB} + V_{BA} + V_{Ay}$

In CxBDC

$V_{net} = I R_{net}$

$2 = I \times 5$

$I = 0.4A$

$V_{3\Omega} = I \times 3$

$\Rightarrow 0.4 \times 3$

$V_{xB} \Rightarrow 1.2V$

In AEFYA;

$V_{net} = I R_{net}$

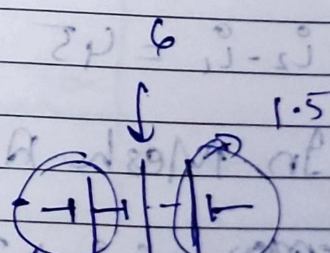
$4 = I \times 8$

$I = 0.5 A$

$V_{3\Omega} = I \times 3$

$\Rightarrow 0.5 \times 3$

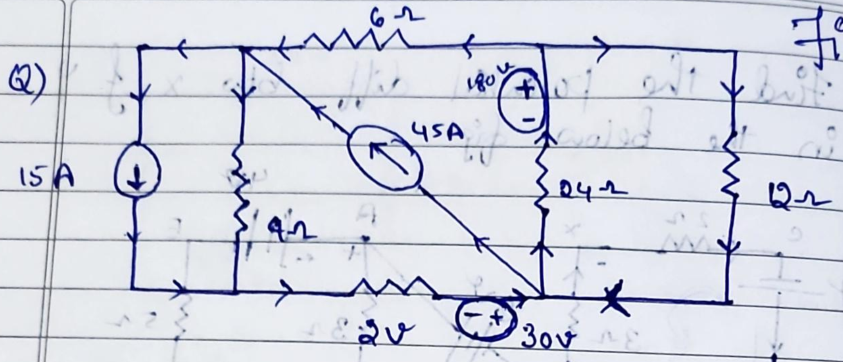
$V_{Ay} \Rightarrow 1.5 V$



$\therefore V_{xy} = 1.2 + 6 - 1.5$

$\Rightarrow 5.7 V$

Q2) Find i_1, i_2

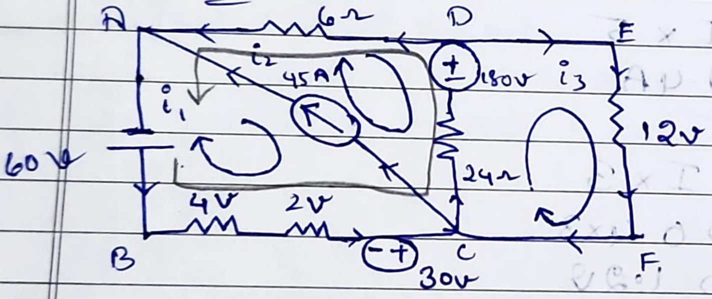


Current → Voltage Source.

$V = IR$

$\Rightarrow 15 \times 4$

$\Rightarrow \underline{60\ V}$



~~In mesh ABCA?~~

~~4/60?~~

Super mesh Eq^n,

$i_2 - i_1 = 45 \quad \Rightarrow (1)$

In Mesh ABCDA:

$(2)\ -6i_1 + 30 - 24(i_2 - i_3) + 180 - 6i_2 = 0$

$-6i_1 + 30 + 24i_3 - 24i_2 + 180 - 6i_2 = 0$

$\cancel{-i_1 + 5 + 8i_3 = i}$

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$-i_1 + 5 + 4i_3 - 4i_2 + 30 - i_2 = 0$

$i_1 + 5i_2 - 4i_3 = 35 \rightarrow (2)$

In Mesh DEFCD;

$-12i_3 - 24(i_3 - i_2) + 180 = 0$

$-12i_3 - 24i_3 + 24i_2 + 180 = 0$

$-i_3 - 2i_3 + 2i_2 + 15 = 0$

$2i_2 c + e3$

$2i_2 - 3i_3 + 15 = 0 \rightarrow (3)$

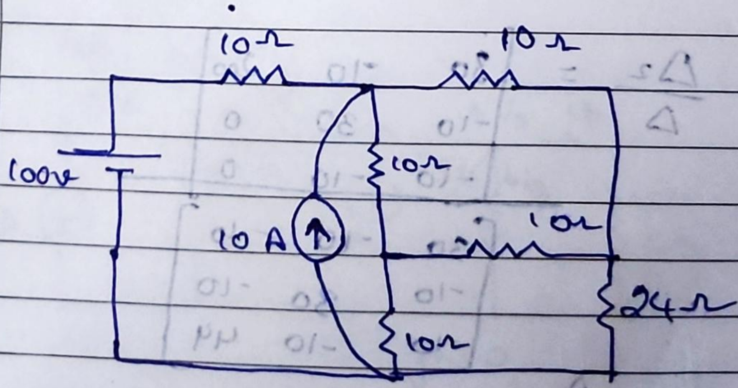
$i_1 = -15$

$i_2 = 30$

$i_3 = 25$

$i_{12} = i_3 = \underline{25\,A}$

(3) Use Mesh current Analysis to find $I_{24\Omega}$.



$I = \frac{V}{R} = \frac{100}{10} = \underline{10\,A}$

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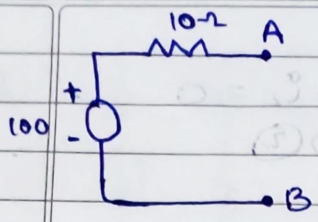
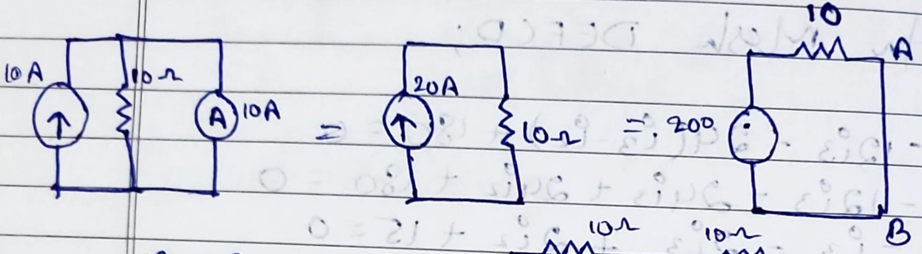


$$I = \frac{V}{R} = \frac{100}{10}$$

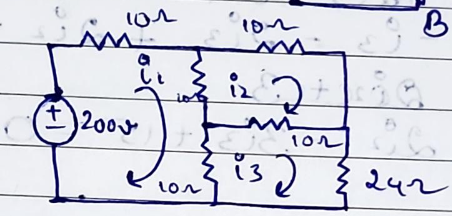
$\Rightarrow \underline{10A}$



$V = IR$

$= 20 \times 10$

$= \underline{200V}$



$$\begin{bmatrix} R_{11} & R_{12} & R_{13} \\ R_{21} & R_{22} & R_{23} \\ R_{31} & R_{32} & R_{33} \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix}$$

$$\begin{bmatrix} 30 & -10 & -10 \\ -10 & 30 & -10 \\ -10 & -10 & 44 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 200 \\ 0 \\ 0 \end{bmatrix}$$

$$I_2 = \frac{\Delta_2}{\Delta} = \frac{\begin{vmatrix} 30 & -10 & 200 \\ -10 & 30 & 0 \\ -10 & -10 & 0 \end{vmatrix}}{\begin{vmatrix} 30 & -10 & -10 \\ -10 & 30 & -10 \\ -10 & -10 & 44 \end{vmatrix}}$$

$= \underline{2.94A}$

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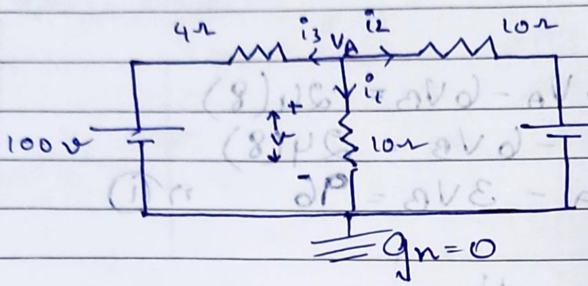
Q) Find the voltage v shown in the figure.



$v_A = 0$
At node v_A;

$i_1 + i_2 + i_3 = 0$

$$\frac{v_A - 100}{4} + \frac{v_A}{10} + \frac{v_A - 180}{10} = 0$$

$$10v_A - 1000 + 4v_A + 4v_A - 720 = 0$$

$$18v_A - 1720 = 0$$

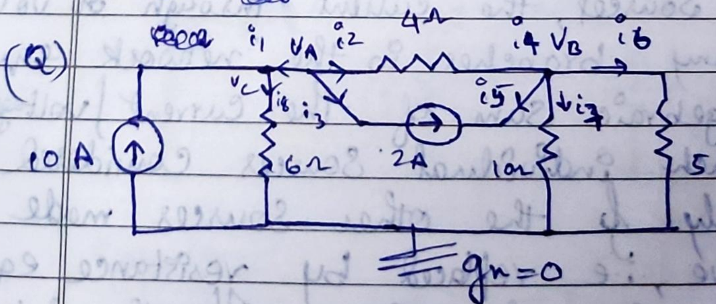
$$v_A = 95.5\,v$$

$$v = \cancel{v_g}\; v_A - g_n$$

$$\Rightarrow 95.5 - 0$$

$$\Rightarrow 95.5\,v$$

(Q)



In node V_A:

$i_8 + i_1 + i_2 + i_3 = 0$,

$$-10 + \frac{V_A - 0}{6} + 2 + \frac{V_A - V_B}{4} = 0$$

$$\frac{V_A}{6} + \frac{V_A - V_B}{4} = 8$$

$$4V_A + 6V_A - 6V_B = 24(8)$$
$$10V_A - 6V_B = 24(8)$$
$$5V_A - 3V_B = 96 \quad \Rightarrow (1)$$

At node V_B.

$$i_4 + i_5 + i_6 + i_7 = 0$$
$$\frac{V_B - V_A}{2} + (-2) + \frac{V_B}{10} + \frac{V_B}{5} = 0$$

$$5V_B - 5V_A + V_B + 2V_B = 20$$
$$8V_B - 5V_A = 20 \quad \Rightarrow (2)$$

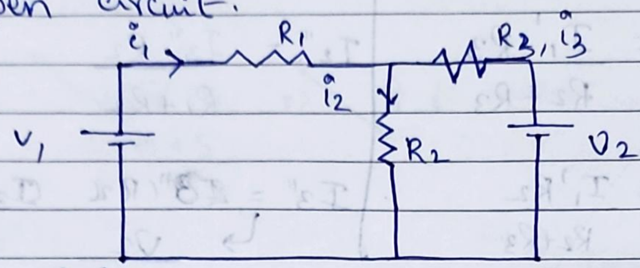
$V_A = 33.12V$
$V_B = 23.2V$.

* No. of Sources (volt/current) + 1 steps used in solving problem
* Every step should have 1 Source
* Volt → Short ckt.
  Current → open ckt.

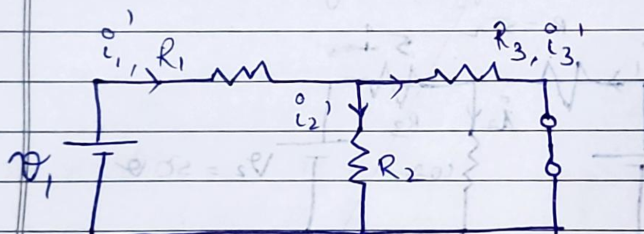
Superposition Theorem

In a linear bilateral network containing several sources, the current through or voltage across any branches in the network equals the algebraic sum of the current/voltages of each individual sources considered seperately & the other sources made in operative, i.e replaced by resistance equal to their internal resistance. If the internal resistances of the sources are not known then voltage source should be replaced by short circuit & current source by open circuit.

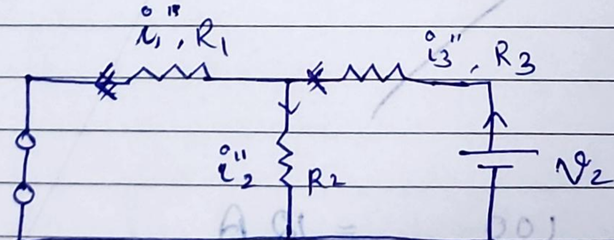
Eg;



Step 1; V_1 is considered, V_2 is replaced by short circuit.



Step: 2; V_2 is considered V_1 is replaced by short circuit.



Step: 3;

$$I_1 = I_1' - I_1''$$

$$I_2 = I_2' + I_2''$$

$$I_3 = I_3' - I_3''$$

↳ sign seeing dirn of I_3' & I_3'' in fig1 & fig2 ; If dir opp. minus (−)

$$I_1' = \frac{v_1}{R_1 + (R_2 \| R_3)}$$

$$I_3'' = \frac{V_2}{R_3 + (R_1 \| R_2)}$$

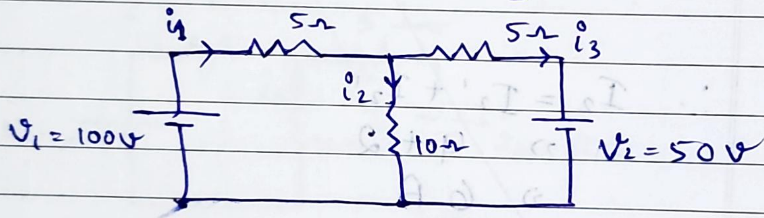
$$I_2' = \frac{I_1' R_3}{R_2 + R_3}$$

$$I_2'' = \frac{I_3'' R_2}{R_1 + R_2}$$

$$I_3' = \frac{I_1' R_2}{R_2 + R_3}$$

$$I_1'' = \frac{I_3'' R_2}{R_1 + R_2}$$

Compute the current in 10Ω resistor as shown in fig using superpost^n theorem.



$$i_1' = \frac{100}{5 + \left(\frac{1}{10} + \frac{1}{5}\right)^{-1}}$$

$$= 12\,A$$

$$i_2' = \frac{12 \times 5}{10 + 5}$$

$$\Rightarrow \frac{60}{15}$$

$$\Rightarrow 4\,A$$

$$i_3'' = \frac{50}{5 + \left(\frac{1}{5} + \frac{1}{10}\right)^{-1}}$$

$$\Rightarrow \underline{6 \text{ A}}$$

$$i_2'' = \frac{6 \times 10}{5 + 10}$$

$$\Rightarrow \frac{60}{15}$$

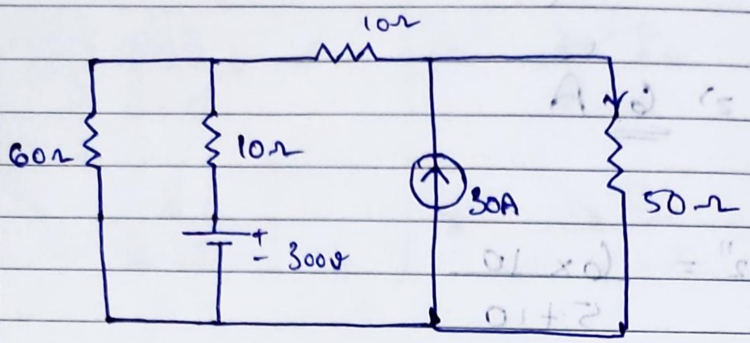
$$\Rightarrow \underline{4 \text{ A}}$$

$$I_2 = I_2' + I_2''$$

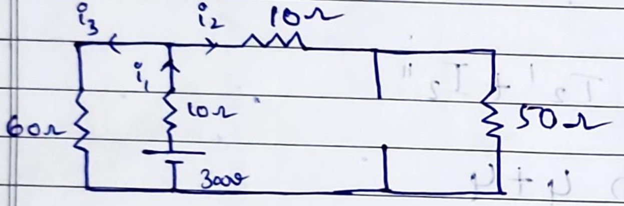
$$\Rightarrow 4 + 4$$

$$\Rightarrow \underline{8 \text{ A}}$$

Q) Find the current in the 50 Ω Resistor shown in figure using superpostⁿ theorem.



Step 1;
Consider 300 v source, replace 30 A current source by open circuit.

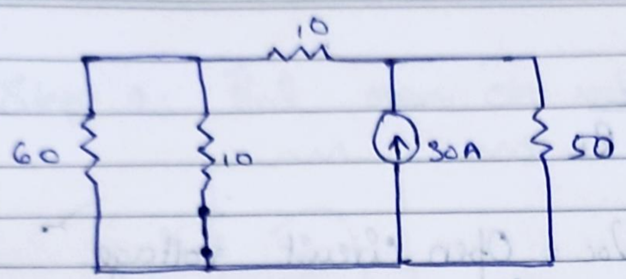


$$R_{net} = \left(\frac{1}{60} + \frac{1}{60}\right)^{-1} + 10 \Rightarrow \underline{\underline{40\,\Omega}}$$

$$I = \frac{V}{R} = \frac{300}{40} = \underline{\underline{7.5\,A}}$$

$$I'_{50\Omega} = 7.5\left(\frac{60}{60+60}\right) \Rightarrow \underline{\underline{3.75\,A}}$$

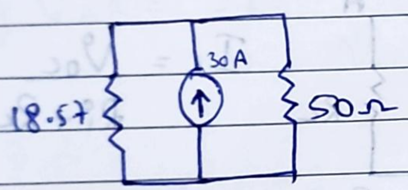
Step: 2;
Consider 30 A source & replace 300v by short circuit.



$R_{eq} = 8.57 + 10 \ \& \ 150$ (parallel

$\Rightarrow \left(\frac{1}{18.57} + \frac{1}{50}\right)^{-1} \Rightarrow \underline{\underline{18.57\,\Omega}}$

$\Rightarrow \cancel{13.54\,\Omega}$



$I'_{50} = 30\left(\frac{18.57}{18.57+50}\right)$

$\Rightarrow \underline{\underline{8.125\ A}}$

Step 3; $I_{50\Omega} = I'_{50} + I''_{50}$

$\Rightarrow 3.75 + 8.125$

$\Rightarrow \underline{\underline{11.875}}$

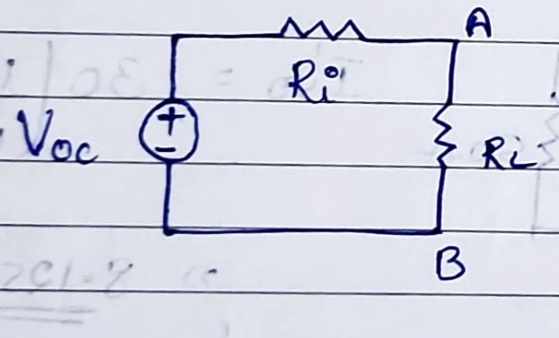
* Thevnin's Theorem;

Current through the load resistance (R_L) Connected across 2 terminals, A & B of a linear bilateral network is given by the relation. I_L

$$I_L = \frac{V_{oc}}{R_i + R_L}$$

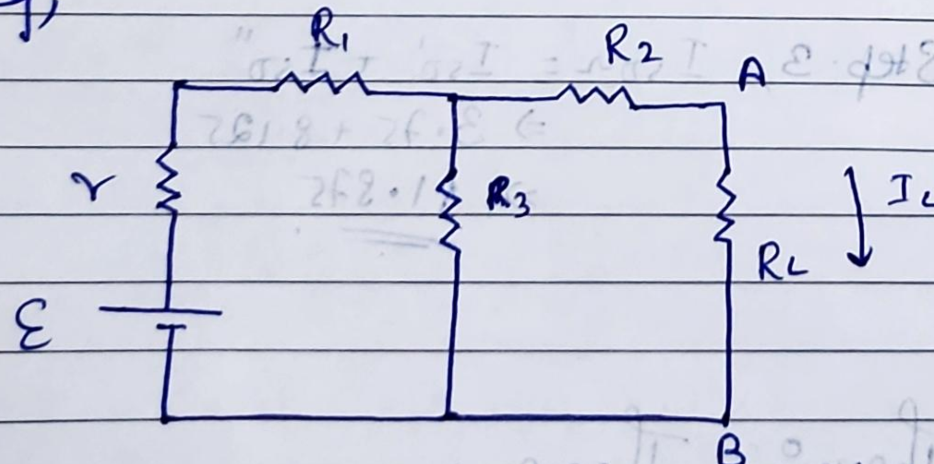
where, V_{oc} = Open circuit voltage
(i.e. voltage across terminal AB when R_L is removed)

R_i = Internal restance of network as veiwed back into the open circuit end network from terminal A & B deactivating all the independent sources



$$I_L = \frac{V_{oc}}{R_i + R_L}$$

Eg;



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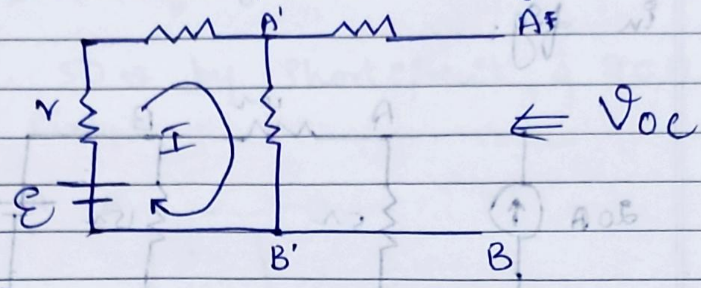
Step: 1; Find open ckt voltage. (V_{oc})



$$I = \frac{\varepsilon}{r + R_1 + R_3}$$

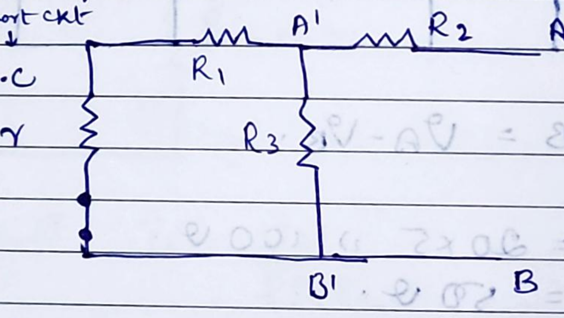
$\because V_{A'B'} = V_{AB} = V_{oc}$.

& $V_{A'B'} = IR_3$.

$\Rightarrow V_{oc} = IR_3$.

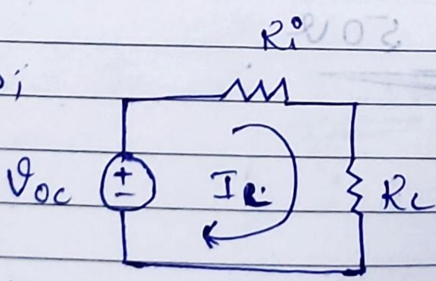
Step 2; Find internal resistance (R_i)

Replace volt → S.C (short ckt)
current → O.C (open ckt)



$$R_i = \left((r + R_1) \parallel R_3 \right) + R_2$$

Step: 3;



$$I_L = \frac{V_{oc}}{R_i + R_L} \Rightarrow \frac{IR_3}{((r + R_1) \parallel R_3) + R_2 + R_L}$$

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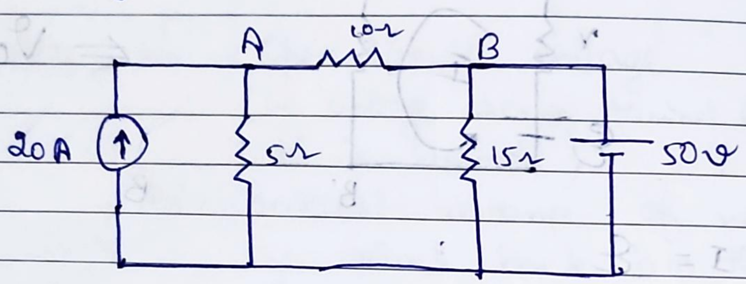
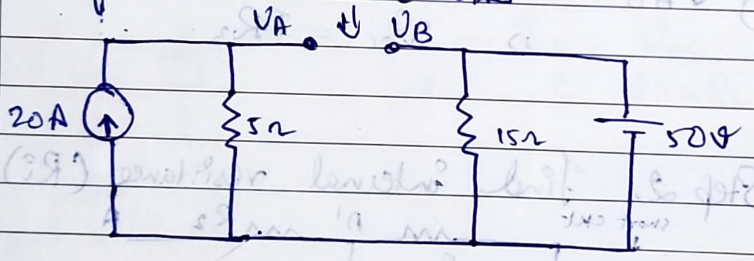
Q) Find current through 10 Ω resistor shown in fig.



Step: 1;

To find V_{oc}. $V_{oc} = V_{AB}$



$$V_{AB} = V_A - V_B.$$

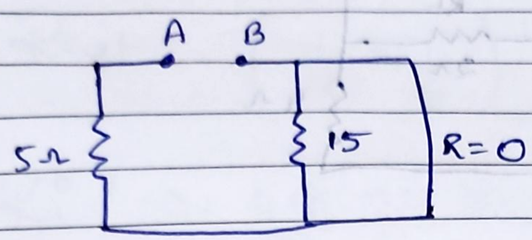
$$V_A = 20 \times 5 \Rightarrow 100\,V.$$
$$V_B = 50\,V.$$

$$\therefore V_{AB} = 100 - 50 \Rightarrow 50\,V$$

$$\therefore V_{oc} = 50\,V$$

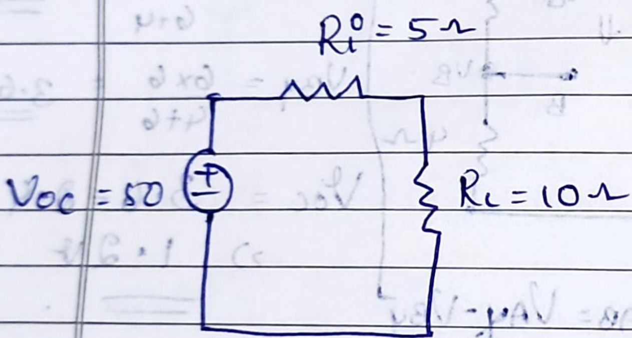
Step: 2 ; to find R_i;

Replace 50 V by short circuit & 20 A by open circuit.



$R_{net} = 5\Omega = R_i$

↳ ∵ All current flows through B to A (without 15Ω) ∵ we shorted circuit.

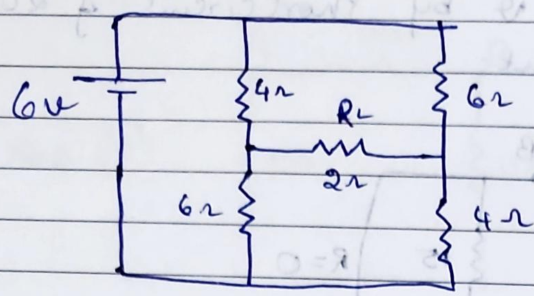


~~$V_{oc} = IR_T$~~ $\quad I_L = \dfrac{V_{oc}}{R_i + R_L}$

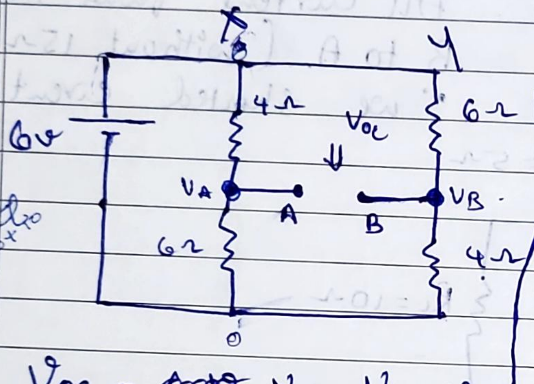
$\Rightarrow \dfrac{50}{15}$

$I_{10} = I_L \Rightarrow \underline{\underline{3.33\,A}}$

Q) Find the current through 2Ω resistor using thevine theorem.



Step 1; find V_{oc}



$V_{Ax} = \frac{6 \times 4}{6+4} = 2.4\,V$

$V_{By} = \frac{6 \times 6}{4+6} = 3.6\,V$

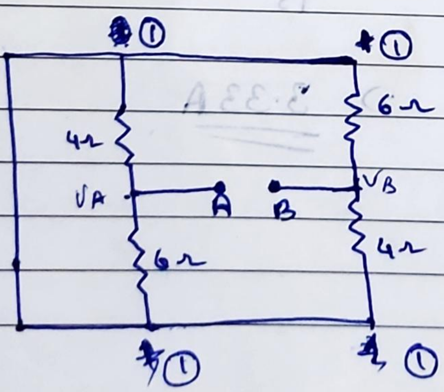
$V_{oc} = 3.6 - 2.4$

$\Rightarrow \boxed{1.2\,V}$

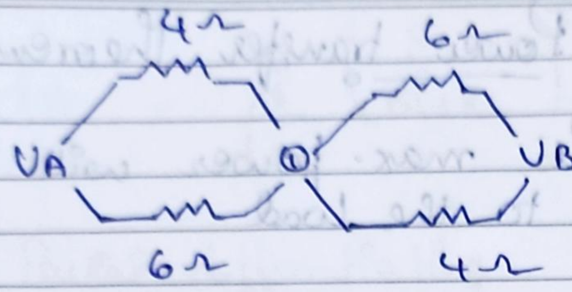
$V_{oc} = V_{AB} = V_{Ax} - V_{By}$

Step : 2; find R_i

Replace 6v by shortcircuit,

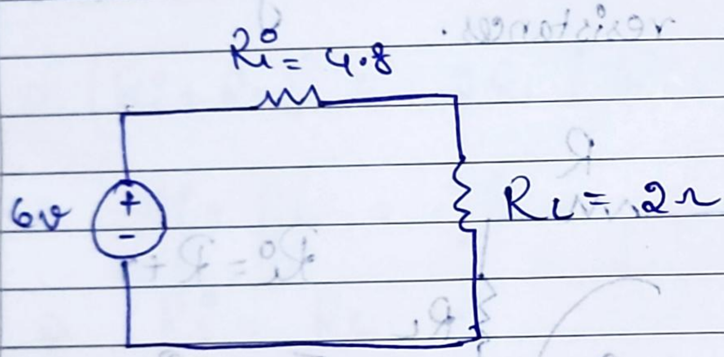


VA , VB



$$R_{net} = \left(\frac{1}{4} + \frac{1}{6}\right)^{-1} + \left(\frac{1}{4} + \frac{1}{6}\right)^{-1}$$

$R_i \Rightarrow \underline{4.8\,\Omega}$



Current through 2Ω = Current in ckt.

$\Rightarrow V = I R_{net}$

$$\Rightarrow I_L = \frac{V_{oc}}{R_i + R_L}$$

$$\Rightarrow I_L = \frac{1.2}{4.8+2} \Rightarrow \frac{1.26}{6.8} =$$

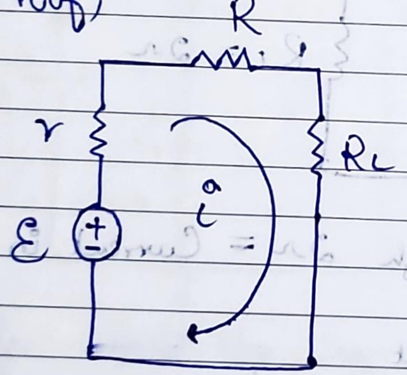
$\hookrightarrow \underline{0.17}$ A

Maximum Power transfer Theorem

(*) Iff $R_i = R_L$ max. power will be transfered to the load.

Statement: A resistive load abstracts max power from a network when the load resistance equals the internal resistance of the network as veiwed from the output terminals with all energy sources removed leaving behind their internal resistances.

Proof;



$$R_i = R + r$$

$$I = \frac{\mathcal{E}}{R_i + R_L}$$

$$P_{R_L} = I^2 R_L$$

$$P_{R_L} \Rightarrow \left(\frac{\mathcal{E}}{R_i + R_L}\right)^2 R_L$$

Maxima;

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

$$\Rightarrow \frac{d}{dR_L}\left(\frac{\mathcal{E}}{R_i + R_L}\right) = 0$$

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$$\frac{dP_L}{dR_L} = \frac{d}{dR_L}\left(\frac{\mathcal{E}}{R_i+R_L}\right)^2 R_L = 0$$

Partial differentiating.

$$\mathcal{E}^2\left[\frac{(R_i+R_L)^2(1) - R_L(2)(R_i+R_L)(1)}{((R_i+R_L)^2)^2}\right]$$

$$\Rightarrow (R_i+R_L)^2 - 2R_L(R_i+R_L) = 0$$

$$\Rightarrow (R_i+R_L)^2 = 2R_L(R_i+R_L)$$

$$\Rightarrow R_i+R_L = 2R_L$$

$$\Rightarrow R_i = R_L$$

Magnitude of Max power @ $R_i = R_L$.

$$\Rightarrow P_{max} = \left(\frac{\mathcal{E}}{R_L+R_L}\right)^2 R_L$$

$$P_{max} \Rightarrow \frac{\mathcal{E}^2}{4R_L}$$

$$\text{Effiency } (\eta) = \frac{\text{Output power}}{\text{input power}} \times 100$$

$$= \frac{P_{max}}{\mathcal{E} \times I}$$

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$$\eta = \frac{P_{max}}{\mathcal{E} \times \left(\frac{\mathcal{E}}{R_i + R_L}\right)}$$

$$\eta = \frac{P_{max}}{\mathcal{E}^2} \times R_i + R_L$$

$$\eta = \frac{\mathcal{E}^2}{4R_L \times \mathcal{E}^2} \times R_i + R_L$$

$$\eta = \frac{R_i + R_L}{4R_L}$$

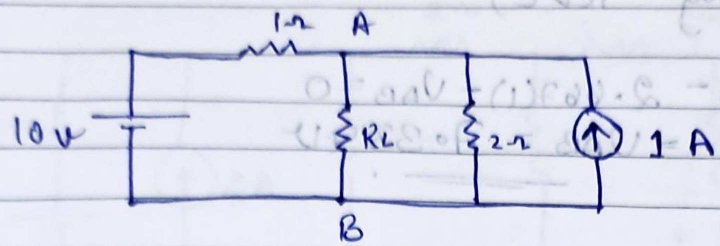
$$\eta = \frac{R_i}{4R_L} + \frac{1}{4}$$

$$\because R_i = R_L$$

$$\eta = \frac{1}{4} + \frac{1}{4}$$

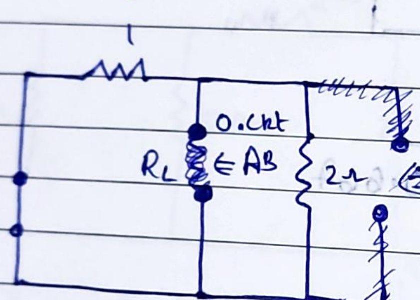
$$\eta = 50\%$$

Q) Calculate the value of R_L which will absorb the max power from circuit in fig. Also calculate value of P_{max}.



To find R_L;

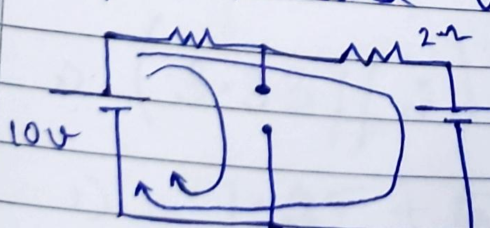
Step 1: Replace 10v with short circuit
1 A " open ckt.
& find Ri



$R_i = 2 \parallel 1 \Rightarrow \frac{2}{3}\,\Omega.$

$R_i = \underline{0.667\,\Omega}$.

Step: 2 ; Find $V_{oc} = V_{AB}$.



$V = IR$

$\Rightarrow (1)(2)$

$\Rightarrow 2v$

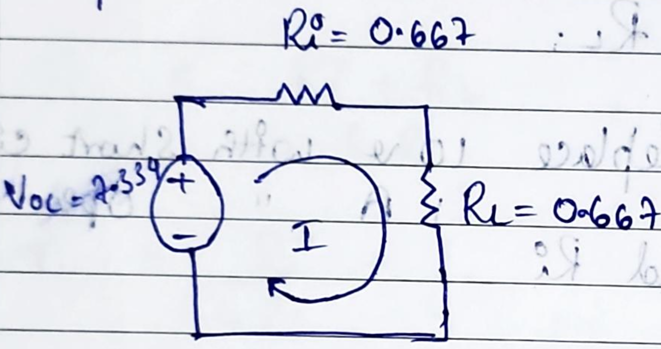
$I = \frac{V}{R} = \frac{10-2}{3} = \frac{8}{3} = 2.667 \, A$

Apply KVL;

$10 - 2.667(1) - V_{AB} = 0$

$V_{OC} = V_{AB} = 7.334 \, V$

Step : 3;



$I_L = \frac{7.334}{0.667 + 0.667}$

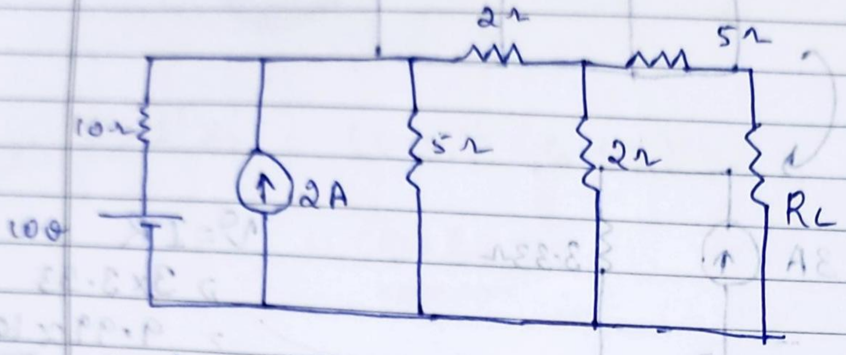
$\Rightarrow 5.5 \, A$

$P_{max} = I^2 R_L$

$\Rightarrow (5.5)^2 \times 0.667$

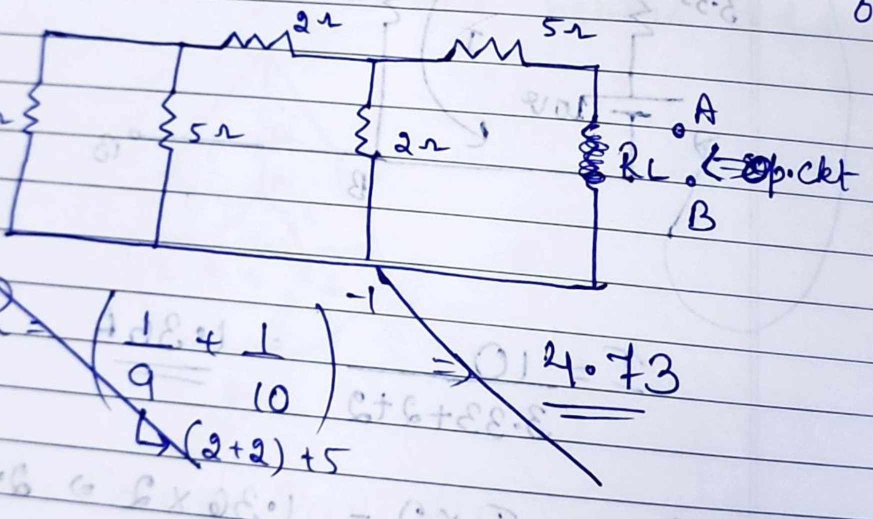
$\Rightarrow 20.17 \, W$

Q) Obtain the max power transfer to the load in the ckt show in fig & also calculate the value of R_L



To find R_L.

Step 1; Replace 10V with S.ckt & 2A with OC



$$\cancel{R = \left(\frac{1}{9} + \frac{1}{10}\right)^{-1} \Rightarrow \underline{\underline{4.73}}}$$

$(2+2)+5$

$$R = (10 \| 5 + 2) \| 2 + 5$$

$$\Rightarrow (3.33 \| 2) + 5$$

$$\Rightarrow 1.25 + 5$$

$$\Rightarrow 6.25 \,\Omega$$

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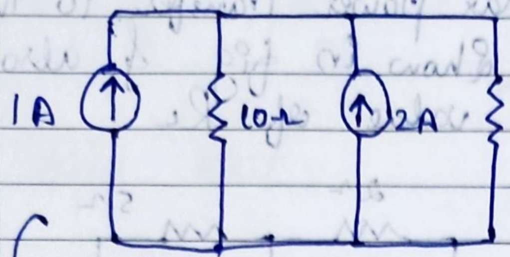
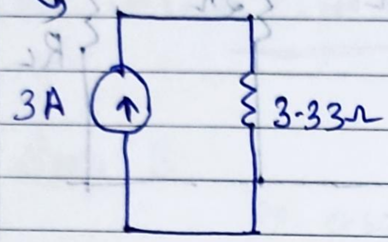
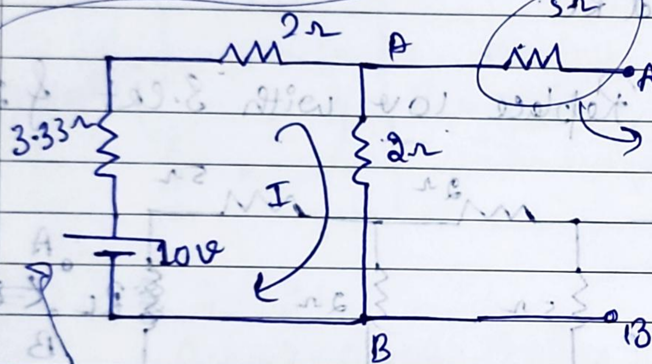
Step 2; find v_{oc}





$v = IR$
$\Rightarrow 3 \times 3.33$
$\Rightarrow 9.99 \approx 10\,v$

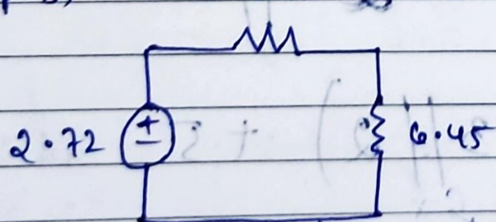


not considered.

$$I = \frac{10}{3.33+2+2} = 1.36\,A$$

$$v_{AB} = I \times 2 = 1.36 \times 2 \Rightarrow 2.72\,v$$

Step: 3;



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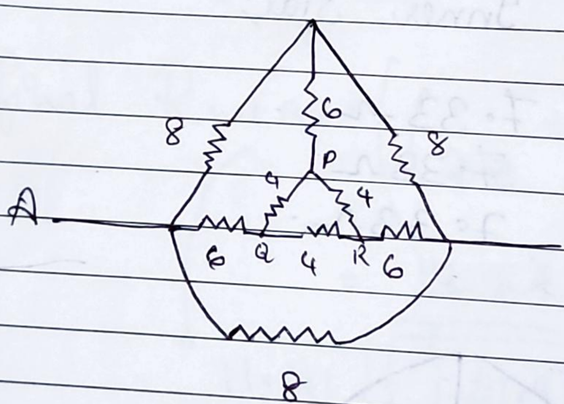
$$I = \frac{2.72}{2\times 6.45}$$

$$= \underline{\underline{0.21\ A}}$$

$$P = I^2 R_L = (0.21)^2 (6.45)$$

$$\Rightarrow \underline{\underline{0.28\ W}}.$$

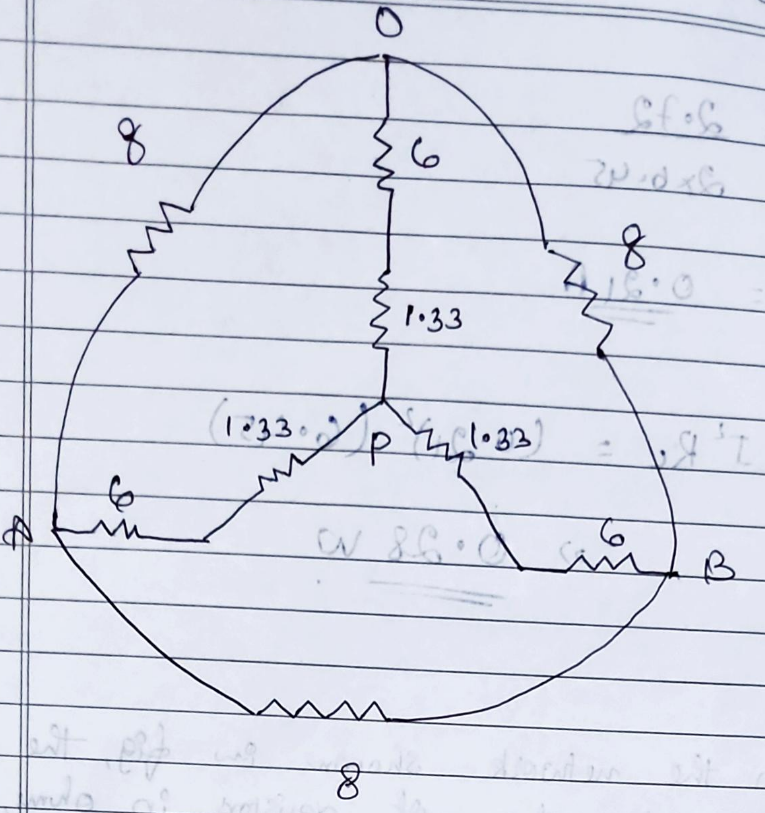
Q) In the network shown in fig, the no's represent value of resistors in ohms, find the value of resistance between A & B.



Step 1; Convert PQR delta → Star.

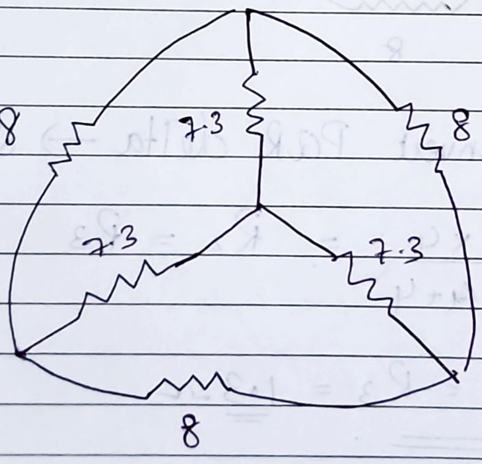
$$R_1 = \frac{4\times 4}{4+4+4} = R_2 = R_3$$

$$\Rightarrow \underline{\underline{R_1 = R_2 = R_3 = 1.3\ \Omega}}.$$



⇒ In the Inner Star;

$R_{net\ OP} = 7.33\,\Omega$.
$R_{net\ PA} = 7.33\,\Omega$.
$R_{net\ PB} = 7.33\,\Omega$.



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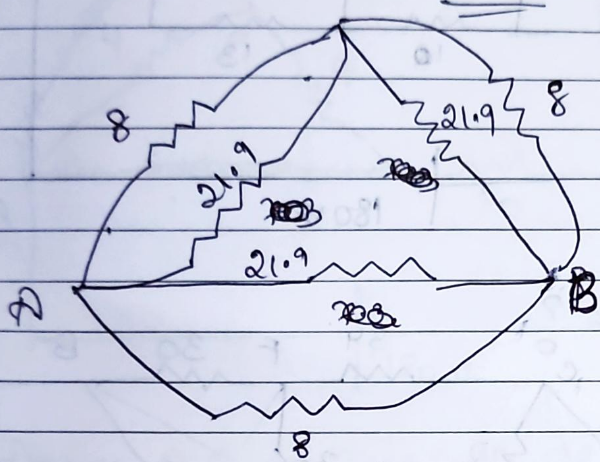
Assume a Δ b/w the 2 Systems.
& convert star $\rightarrow$ Δ.

$$r_1 = 7.3 + 7.3 + \frac{7.3 \times 7.3}{7.3} = r_2 = r_3$$

$$\Rightarrow r_1 = r_2 = r_3 = \underline{21.9\ \Omega}.$$



final $R_{net\,AB} = \left(\left(\frac{1}{21.9} + \frac{1}{8}\right)^{-1} \times 2\right) \Big\| \Big\| R_{AB\ down}$

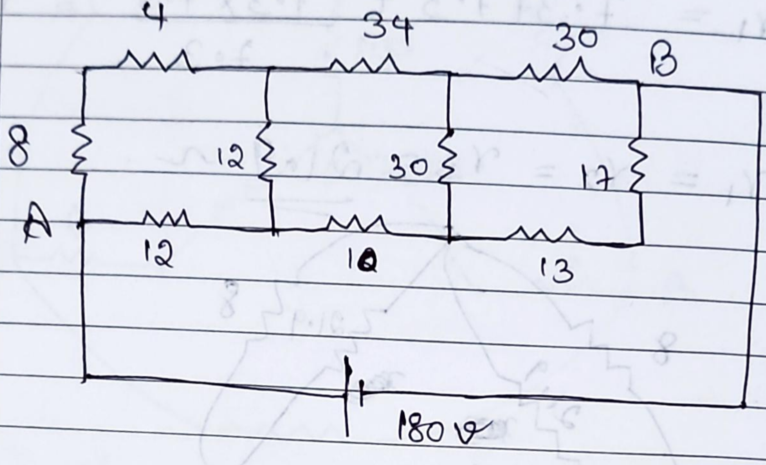
$$= 11.71 \,\|\, (21.9 \| 8)$$

$$\Rightarrow 11.71 \,\|\, 5.855$$

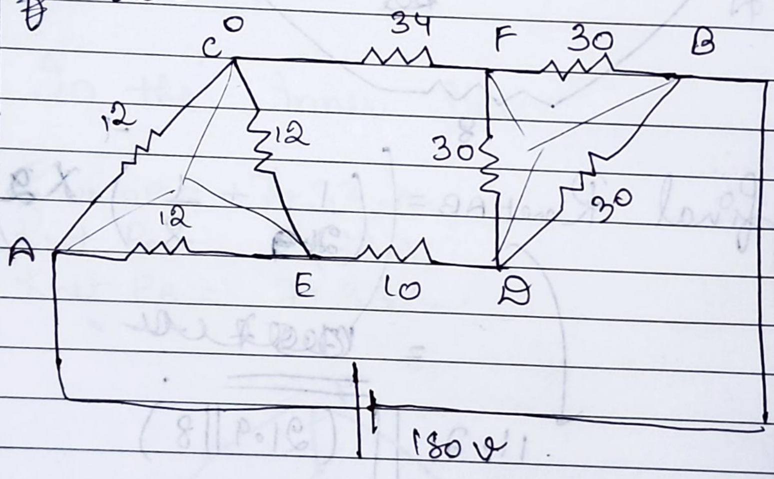
$$\Rightarrow 3.903\ \Omega$$

$$\approx \underline{3.90\ \Omega}$$

Q) Find the current in 10Ω resistor in the given network using Star delta Conversionⁿ.



$i_{10} = ?$



Convert ACE delta → Star.

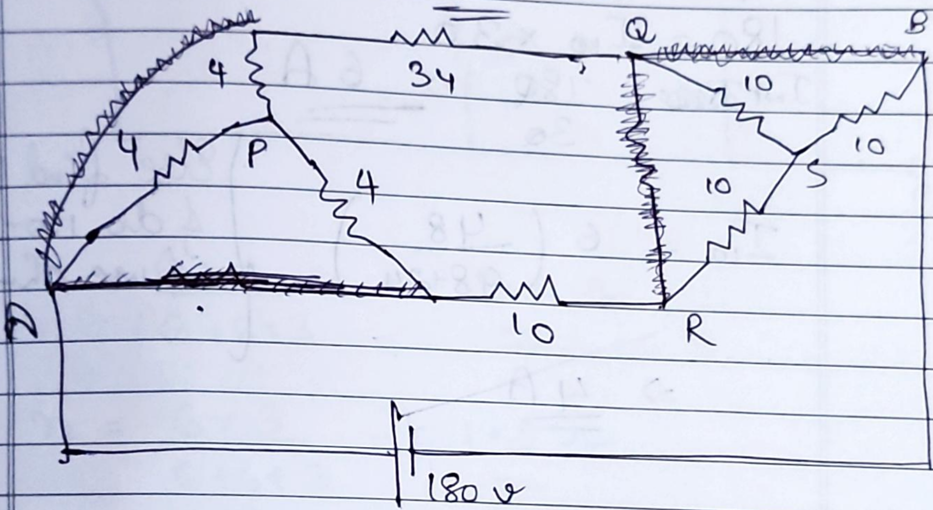
$$\gamma_1 = \frac{12 \times 12}{12 + 12 + 12} = \gamma_2 = \gamma_3$$

$\Rightarrow 4 = \gamma_1 = \gamma_2 = \gamma_3$.

Convert BDF delta → star.

$$r_1 = r_2 = r_3 = \frac{30 \times 30}{30+30+30}$$

$$\Rightarrow r_1 = r_2 = r_3 = \underline{\underline{10\ \Omega}}$$

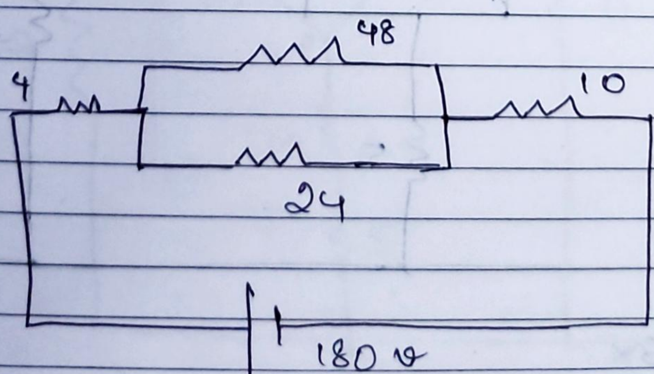


Across $PQ = 34+4 \Rightarrow 38\,\Omega$

" $PR = 4+10 \Rightarrow 14\,\Omega$

Across $PQS = 38+10 \Rightarrow 48\,\Omega$.

" $PRS = 14+10 \Rightarrow 24\,\Omega$



$$R_{48\|24} \Rightarrow \left(\frac{1}{48}+\frac{1}{24}\right)^{-1} \Rightarrow 16\,\Omega.$$

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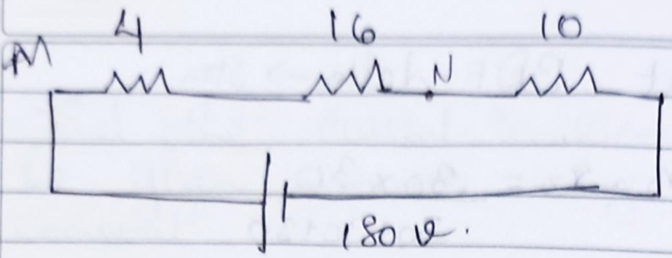


$V = I R_{net}$

$180 = I \times 30$

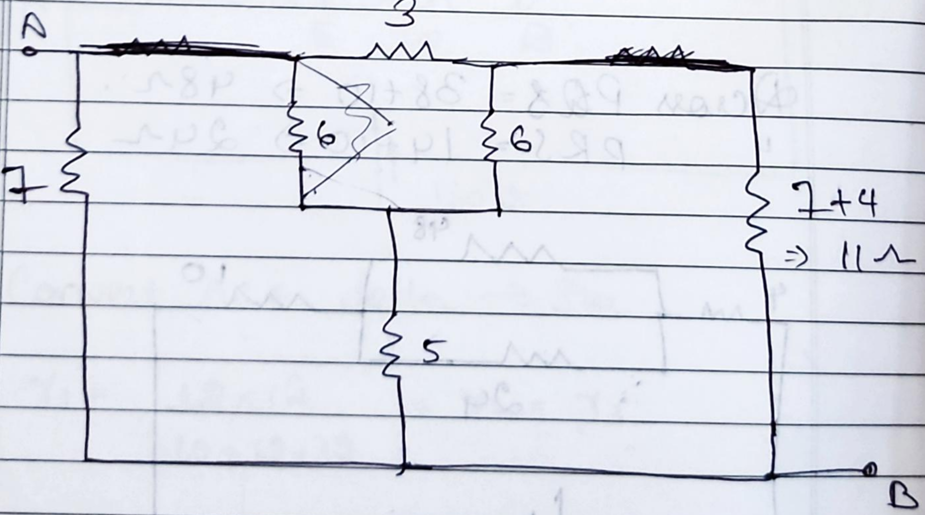
$I_{net} = \frac{180}{30} \Rightarrow \underline{\underline{6\ A}}$

$I_{10} = 6\left(\frac{48}{48+24}\right)$

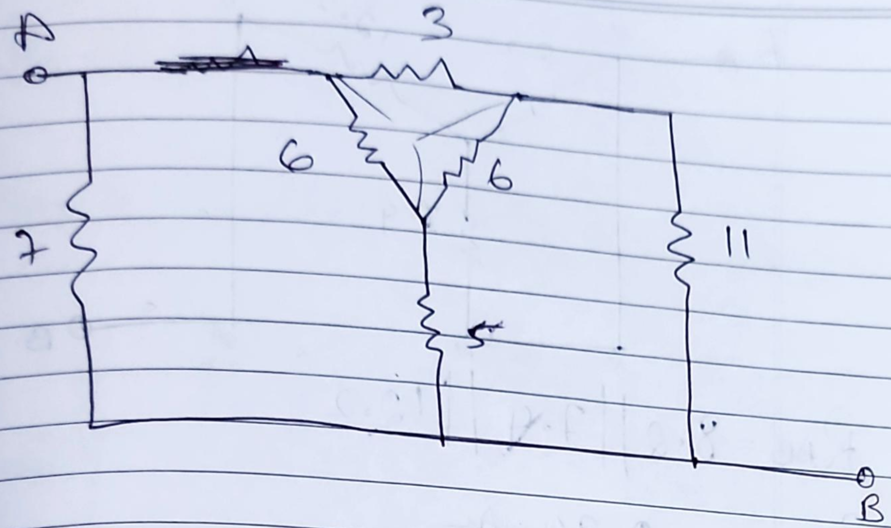
$\Rightarrow \underline{\underline{4\ A}}$

Else find V_{MN} & do $180 - V_{MN}$ & use ohm's law

Q) Calculate the R_{net} b/w A & B in the figure



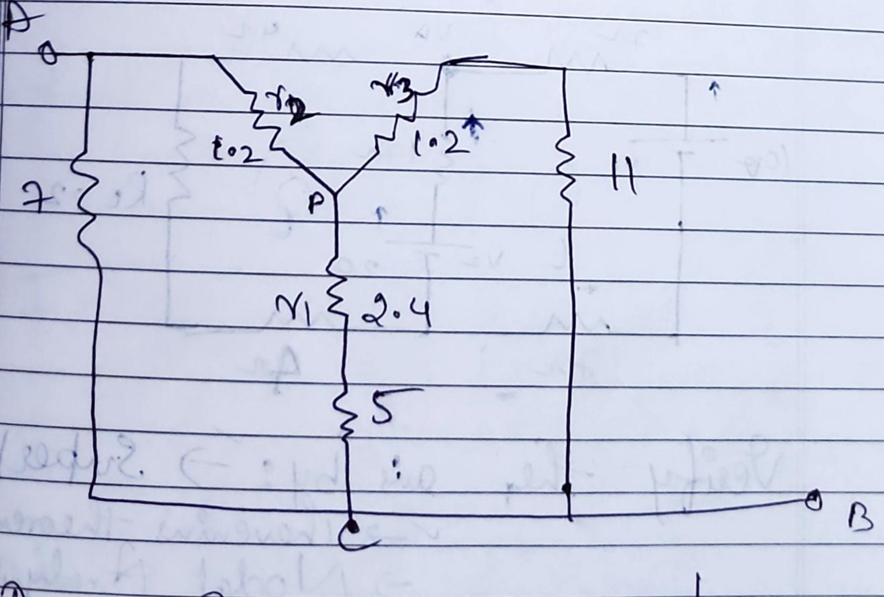
ans)



$$r_1 = \frac{6 \times 6}{6+6+3} = 2.4\ \Omega$$

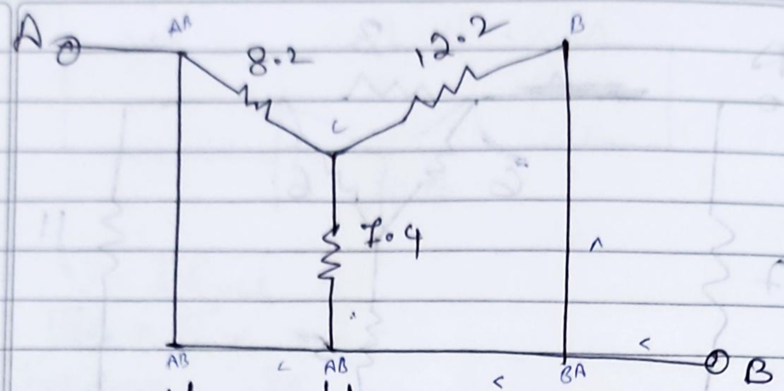
$$r_2 = \frac{6 \times 3}{6+6+3} = 1.2\ \Omega$$

$$r_3 = \frac{6 \times 3}{6+6+3} = 1.2\ \Omega$$



Across R_{net} PA = 8.2 Ω | Across R_{net} PC] 7.4 Ω

" R_{net} PB = 12.2 Ω

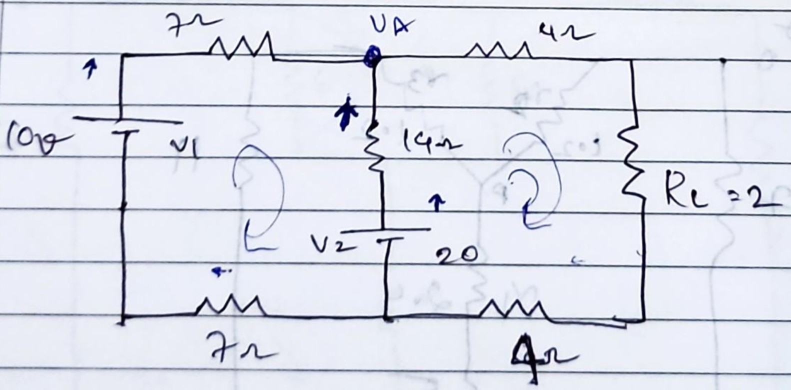


$R_{AB} = 8.2 \,||\, 7.4 \,||\, 12.2$

$R_{net} \Rightarrow$ ~~2.9494~~

$\therefore$ R_{net} across AB = ~~2.9494~~
$\approx$ ~~[illegible]~~
$\Rightarrow$ $\underline{\underline{3.69\,\Omega}}$

Q) Find the current in Load R_L using Superpos^n theorem :



Verify the ans by : → Superpos^n
→ Thevenin's theorem
→ Nodal Analysis
→ Mesh Analysis