-BEE
-NT

DC circuit Analysis

- Network analysis

→ A network element analysis is a component of circuit having different characteristic which may be:-

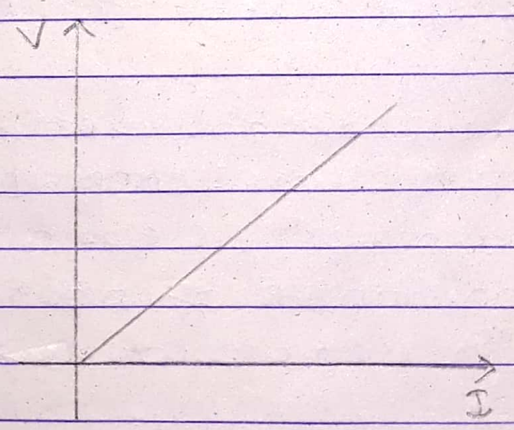
i.) Active and passive elements
ii.) Linear and non-linear elements
iii.) unilateral and bilateral elements
iv.) Lumped and distributed elements

i.) Active and passive elements

If a circuit element has the capability of enhancing (increasing or decreasing) level of signal passing through It is called active element. Eg: Diode, transistors. Reversely, resistors, inductors and capacitors, (R, L, C) are passive elements because they donot have any means of signals enhancing.

ii.) Linear and Non-linear elements.

A linear element shows linear characteristic of voltage vs current.



for a non-linear element the current passing through it does not change linearly with the linear change in applied voltage.

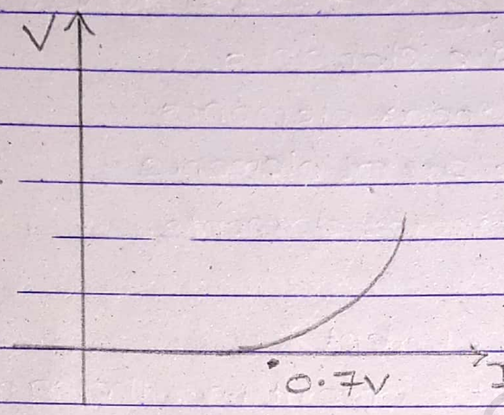


Fig. I – V characteristic curve of a diode

iii) unilateral and bilateral elements

If the magnitude of the current passing through an elements is affected due to change in polarity of the applied voltage. The element is called as unilateral elements.
Eg: diode transistors.

If the current magnitude remains same even if the applied emf polarity changes is called bilateral elements. Eg: Resistor, inductor, capacitor.

iv.) Lumped Network and distributed network

Physically seperate network elements like R, L and C are known as lumped network whereas a transmission line or the cable is an example of distributed network as through out the line they are not physically seperable.

• Resistance (R)

→ Resistance is a property of a material which oppose the flow of electric current. Resistance can be defined mathematically using ohm's law.

• ohm's law

→ It states that, "the ratio between voltage across a circuit element to the current passing through the circuit elements always remains constant and this constant is equal to the value of resistance of that circuit element".

Mathematically,

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

It is measured ohm (Ω)

Note:-

1 Kilo(K) :- 10^3 1 milli (m) = 10^{-3}
1 mega (M) = 10^6 1 micro = 10^{-6}
1 Giga (G) = 10^9 1 nano = 10^{-9}
1 pico = 10^{-12}

Resistance of any material can also be defined mathematically,

$$R = \rho \frac{l}{A}$$

Also, Resistance of most metal varies with temperature, Resistance (R_2) at temperature (T_2) is

$$R_2 = R_1 [1 + \alpha(T_2 - T_1)]$$

Where,

α_1 = temperature coefficient of resistance at temperature t_1.

R_1 = Resistance at temperature T_1

R_2 = Resistance at temperature T_2

$$\alpha_1 = \frac{R_2 - R_1}{R_1(T_2 - T_1)}$$

It's unit is $1°C$ or $1°K$.

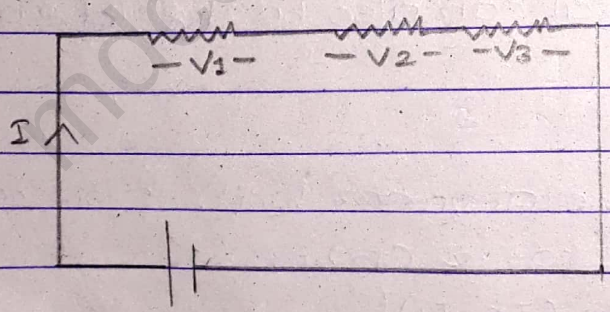
※ D.C circuit

→ A dc circuit is an electric circuit that consists of any combination of constant voltage sources, constant current sources and resistors. Direct current is the unidirectional flow of electric charge.

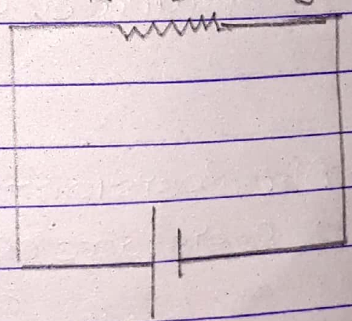
※ Series And Parallel combination of Resistor

i) series combination

→ When the resistors are connected end to end so that they form only one path for the flow of current then resistor are said to be connected in series and such circuits are known as series circuits.



2.1. Resistance in series



Equivalent resistance

Total voltage (V) $= V_1 + V_2 + V_3$

$$IR_T = IR_1 + IR_2 + IR_3$$

$$R_T = R_1 + R_2 + R_3$$

Conclusion: -

1) when a number of resistors are connected in series the equivalent resistance (R_T) is given by the arithmetic sum of their individual resistances.
2) same current flows throughout the circuit.
3) voltage drops are additive.

※ voltage divider rule: -

we know that: -

$$V = V_1 + V_2 + V_3$$

$$V = IR_1 + IR_2 + IR_3$$

$$I = \frac{V}{R_1 + R_2 + R_3} \quad \text{— (i)}$$

Now,

$$V = IR_1$$

for mean (i)

$$V_1 = \frac{V}{R_1 + R_2 + R_3} \times R_1$$

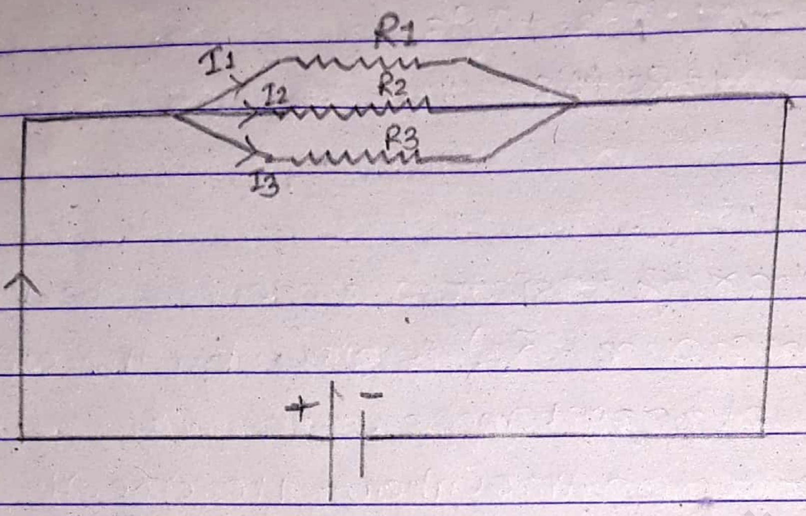
$$\therefore V_1 = \left(\frac{R_1}{R_T}\right) V.$$

Similarly,

$$V_2 = \frac{R_2}{R_T} \times V$$

$$V_3 = \frac{R_3}{R_T} \times V$$

ii.) Parallel combination



When a number of resistors are connected in such a way that end of each of them is joined to a common point and the other ends begins joined to another common points then resistors are said to be connected in parallel and such circuits are called parallel circuits.

$$I = I_1 + I_2 + I_3$$

$$\frac{V}{R_T} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$\therefore \frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

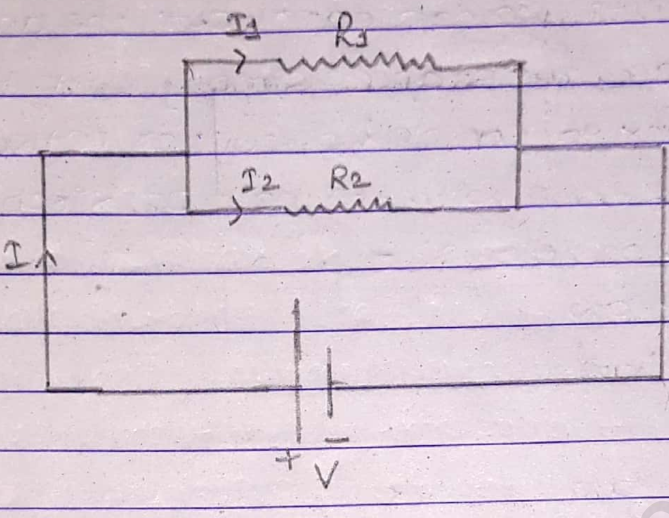
If there are only two resistors in parallel then the equivalent resistance is

$$\frac{1}{R_1} = \frac{1}{R_2} + \frac{1}{R_3}$$

$$R_T = \frac{R_1 R_2}{R_1 + R_2}$$

If a number of conductors are connected in parallel, then the reciprocal of the combined resistance is equal to the sum of the reciprocal of the individual resistance.

* Current divider law:-



From the above fig:-

$$I_1 = \frac{V}{R_1}$$

$$= \frac{1}{R_1} \times IR$$

$$= \frac{1}{R_1} \times I \times \frac{R_1 R_2}{R_1 + R_2}$$

$$\boxed{I_1 = \frac{R_2}{R_1 + R_2} \times I}$$

similarly

$$\boxed{I_2 = \frac{R_1}{R_1 + R_2} \times I}$$

If 3 Resistors then,

$$I_1 = \frac{R_1}{R_1 + R_2 + R_3} \times I$$

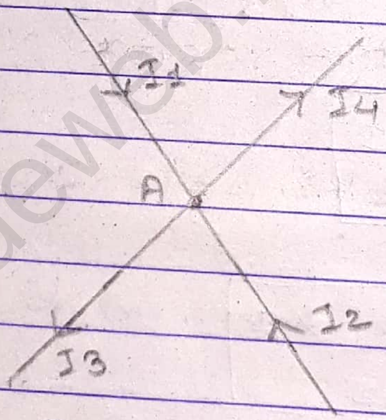
* Kirchoff's law

In simple circuits, we can carry out the analysis of current, voltage and resistance simply with the help of Ohm's law. However in complex circuit or network, the calculation can be done with the help of Kirchoff's law which are stated as follows: -

i.) Kirchoff's current law
ii.) Kirchoff's voltage law

* Kirchoff's current law

This Law is also called as Kirchoff's 1st law or point or junction rule. According to this rule, at any node of a several circuit elements, the sum of currents entering the node must equal the sum of currents leaving it. This law is based on conservation of charge.



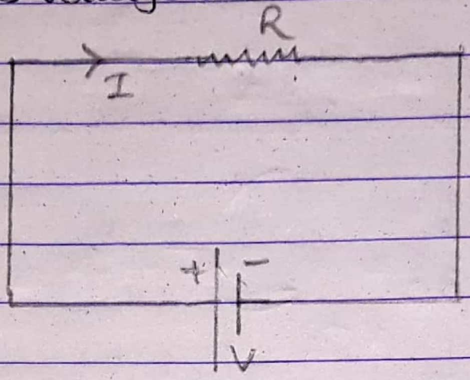
$$I_1 + I_2 = I_3 + I_4$$

If any electrical network the algebric sum of current meeting at a point 'A' is always zero.
Alternatively, sum of incoming current = sum of outgoing current

i.e $I_1 + I_2 = I_3 + I_4$

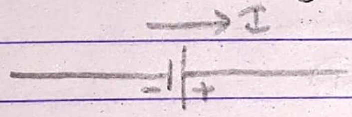
$$I_1 + I_2 - I_3 - I_4 = 0$$

* Kirchoff's voltage law:-

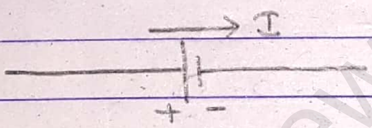


This law is also called Kirchoff's second law or Kirchoff's Loop (or mesh rule). According to this rule; the algebric sum of the products path (mesh) in a network t algebric sum of the emf in that path is always equal to zero.

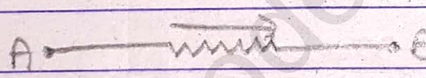
Determination of voltage

1.) 

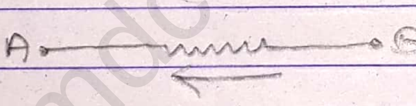
Rise in potential (+ve)

2.) 

fall in potential (-ve)

3.) 

fall in potential (-ve)

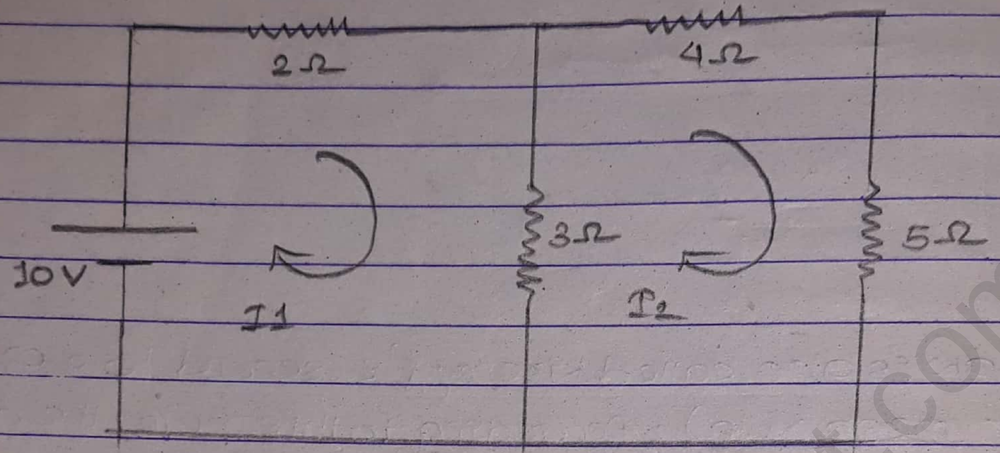
4.) 

Rise in potential (+ve)

→

Numericals:-

Eg. Q1.



Assuming I_1 and I_2 be the clockwise current flowing via loop 'I' and loop 'II' respectively

Apply KVL on loop I,

$$10 - I_1 \times 2 - (I_1 - I_2) \times 3 = 0$$

$$10 - 2I_1 - 3I_1 + 3I_2 = 0$$

$$-5I_1 + 3I_2 = -10 \quad \text{--- (i)}$$

Applying KVL on loop I_2,

$$-I_2 \times 4 - I_2 \times 5 - (I_2 - I_1).3 = 0$$

or, $-4I_2 - 5I_2 - 3I_2 + 3I_1 = 0$

or, $-9I_2 - 3I_2 + 3I_1 = 0$

or, $-12I_2 + 3I_1 = 0 \quad \text{--- (ii)}$

solving (i) and (ii)

$$12I_2 - 20I_1 = -40$$

$$-12I_2 + 3I_1 = 0$$

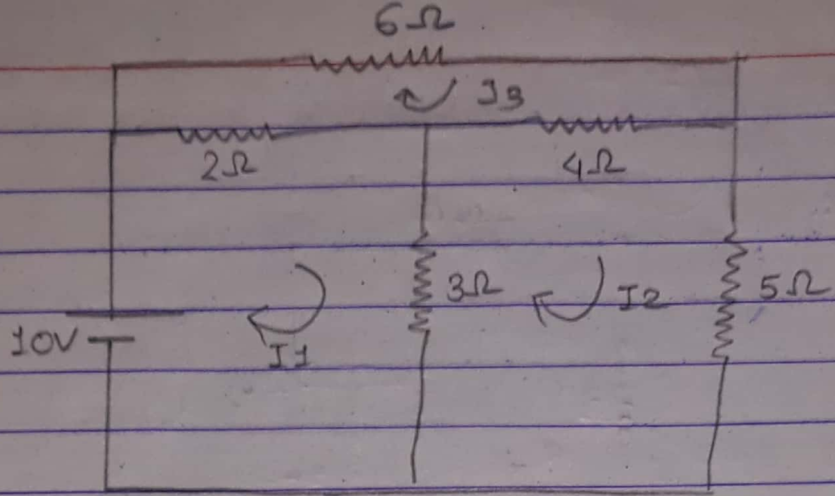
$$-17I_1 = -40$$

$$\therefore I_1 = 2.35A$$

$$-11.75 + 3I_2 = -10$$

$$I_2 = 0.587A$$

Q2.



Assuming I1, I2 and I3 be the clockwise current flowing via loop I, loop II and loop III respectively.

Apply KVL on loop I:-

$$+10 - 2(I_1 - I_3) - (I_1 - I_2) \times 3 = 0$$

$$10 - 2I_1 + 2I_3 - 3I_1 + 3I_2 = 0$$

$$10 - 5I_1 + 3I_2 + 2I_3 = 0 \quad -(i)$$

Apply KVL on loop II:-

$$-(I_2 - I_3) \times 4 - 5I_2 - (I_2 - I_1) \times 3 = 0$$

$$-4I_2 + 4I_3 - 5I_2 - 3I_2 + 3I_1 = 0$$

$$3I_1 - 12I_2 + 4I_3 = 0 \quad -(ii)$$

Again, Applying KVL on loop III

$$-I_3 \times 6 - (I_3 - I_2) \times 4 - (I_3 - I_1) \times 2 = 0$$

or, $-6I_3 - 4I_3 + 4I_2 - 2I_3 + 2I_1 = 0$

or, $2I_1 + 4I_2 - 12I_3 = 0 \quad -(iii)$

on solving,

$$I_1 = 2.93A$$

$$I_2 = 1.31A$$

$$I_3 = 0.82A$$

$V_{4\Omega} = (I_2 - I_3) \times 4$

$= (1.31 - 0.82) \times 4$

$= 0.49 \times 4 = 1.96V$

$V_{5\Omega} = I_2 \times 5 = 1.31 \times 5 = 6.55V$

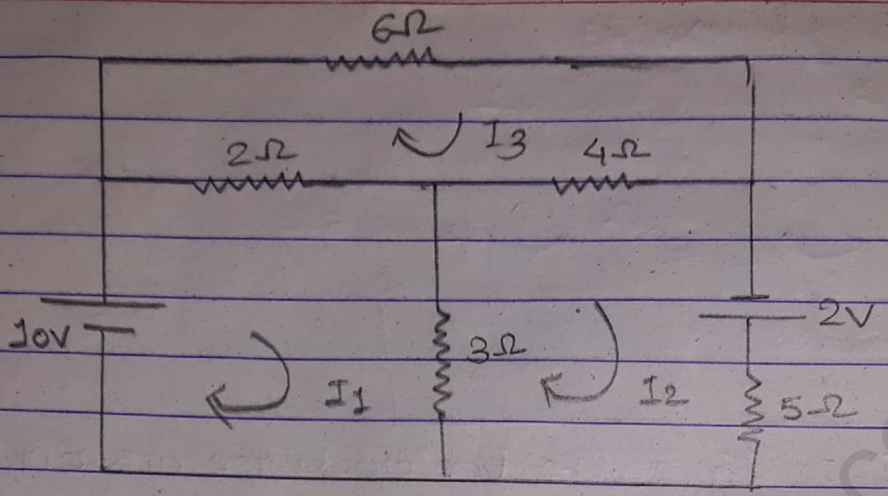
$V_{2\Omega} = (\cancel{I_2}\, I_1 - I_3) \times 2$

$= (2.93 - 0.82) \times 2$

$= 2.11 \times 2$

$= 4.22V$

Q3.)



Assuming I1, I2, I3 be the clockwise current flowing via loop I, loop II, and loop III respectively.

Applying KVL on loop I,

$$+10-(I_1-I_3)\times 2-(I_1-I_2)\times 3=0$$

$$+10-2I_1+2I_3-3I_1+3I_2=0$$

$$10-5I_1+3I_2+2I_3=0$$

$$-5I_1+3I_2+2I_3=-10 \quad -(i)$$

Applying KVL on loop II,

$$+2-I_2\times 5-(I_2-I_1)\times 3-(I_2-I_3)\times 4=0$$

$$+2-5I_2-3I_2+3I_1-4I_2+4I_3=0$$

$$+2-12I_2+3I_1+4I_3=0$$

$$3I_1-12I_2+4I_3=-2 \quad -(ii)$$

Applying KVL on loop III,

$$-I_3\times 6-(I_3-I_2)\times 4-(I_3-I_1)\times 2=0$$

$$-6I_3-4I_3+4I_2-2I_3+2I_1=0$$

$$2I_1+4I_2-12I_3=0 \quad -(iii)$$

on solving,

$I_1=3.13$ $I_3=0.94$

$I_2=1.26$

i.) $3\Omega = (I_1 - I_2) \times 3$

$= (3.13 - 1.26) \times 3$

$= 5.7V$

ii) $4\Omega = (I_2 - I_3) \times 4$

$= (1.26 - 0.94) \times 4$

$= 1.28V$

iii) $2\Omega = (I_1 - I_3) \times 2$

$= (3.13 - 0.94) \times 2$

$= 4.38V$

iv) $5\Omega = 5 \times I_2$

$= 5 \times 1.26$

$= 6.3V$

* Node Analysis

It is one of the application of KCL:-

Steps of nodal analysis:-

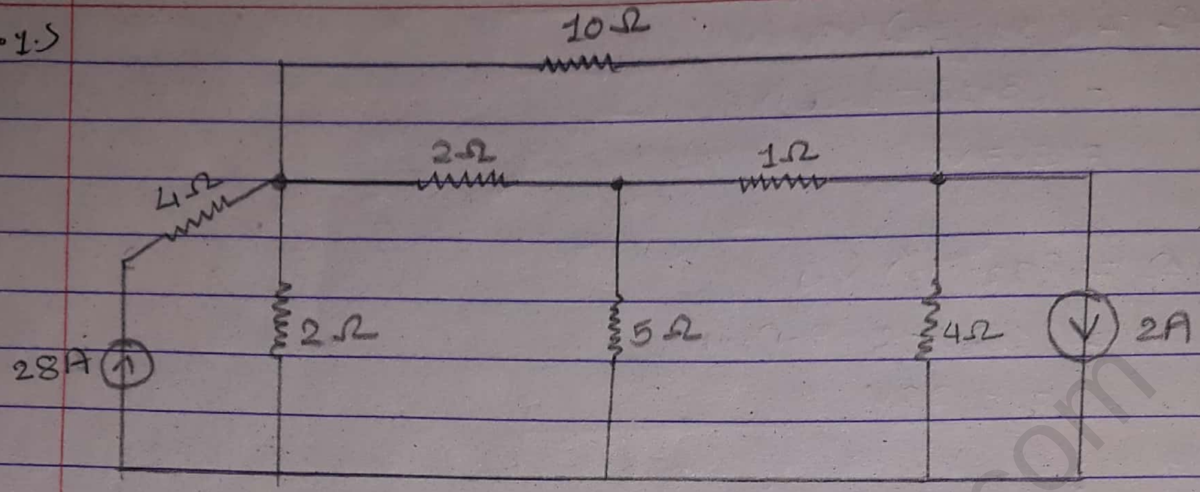
1.) Find out the possible number of nodes.

2.) Among them select one node as the reference node (ground) and assign others nodes as V_1, V_2, V_3 ....

3.) Analyses whether the circuit consist of source transformation or not.

→

Eg. 1.)



KCL for node (i)

$$\frac{V_1 - V_3}{10} + \frac{V_1 - V_2}{2} + \frac{V_1 - 0}{2} = 28$$

or, $$\frac{V_1 - V_3 + 5V_1 - 5V_2 + 5V_1}{10} = 28$$

or, $11V_1 - 5V_2 - V_3 = 280$

KCL for node (ii)

$$\frac{V_2 - V_1}{2} + \frac{V_2 - V_4}{5} + \frac{V_2 - V_3}{1} = 0$$

or, $$\frac{5(V_2 - V_1) + 2(V_2 - V_4) + 10(V_2 - V_3)}{10} = 0$$

or, $5V_2 - 5V_1 + 2V_2 - 2V_4 + 10V_2 - 10V_3 = 0$

or, $-5V_1 + 17V_2 - 10V_3 = 0$ — (ii)

KCL for node (iii)

$$\frac{V_3 - V_1}{10} + \frac{V_3 - V_2}{1} + \frac{V_3 - 0}{4} + 2 = 0$$

$$\Rightarrow \frac{4(V_3 - V_1) + 40(V_3 - V_2) + 10V_3}{40} = -2$$

$\Rightarrow 4V_3 - 4V_1 + 40V_3 - 40V_2 + 10V_3 = -80$

$\Rightarrow -4V_1 - 40V_2 + 54V_3 = -80$ — (iii)

on solving (i), (ii) & (iii) we get,

$V_1 = 36V$

$V_2 = 20V$

$V_3 = 16V$

a.) $I_{4\Omega} = 28A$ (b) $I_{2\Omega} = \frac{V_1 - V_2}{2} = \frac{36-20}{2} = 8A$

c) $I_{10\Omega} = \frac{V_1 - V_3}{10} = \frac{36-16}{10} = 2A$

g.) $I_{4\Omega} = \frac{V_3 - 0}{4} = \frac{16}{4} = 4A$

d.) $I_{5\Omega} = \frac{V_2 - 0}{5} = \frac{20}{5} = 4A$

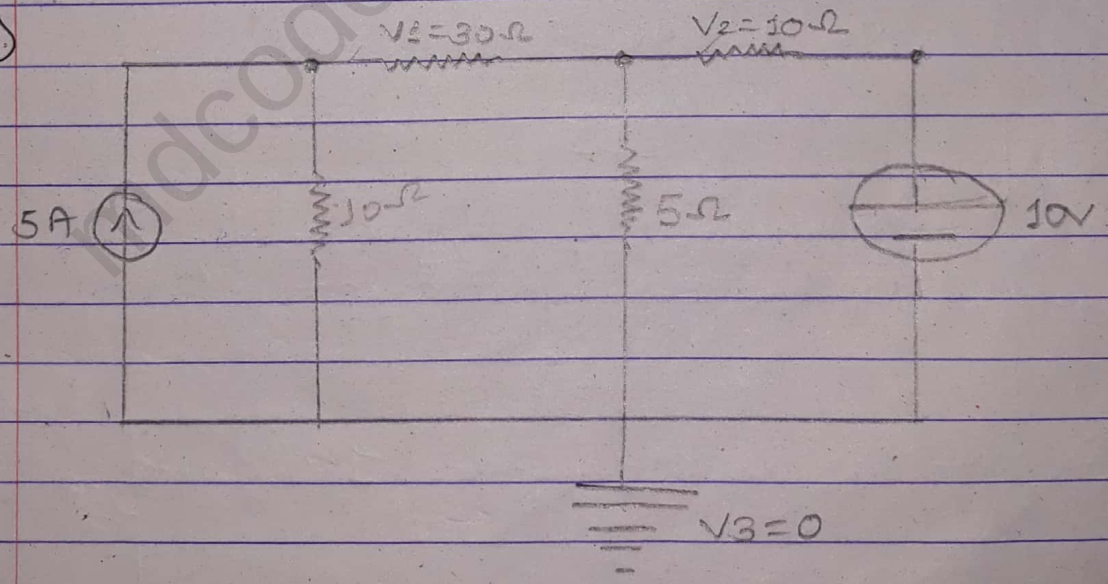
h.) $I_{10\Omega} = V_1 - V_3$
$= 36 - 16$
$= 20V$

e.) $P_{5\Omega} = \frac{V_2^2}{R} = \frac{(20)^2}{5} = 80$ watt

i.) $V_{5\Omega} = V_2 - 0 = 20V$

f.) $I_{1\Omega} = \frac{V_2 - V_3}{1} = \frac{20-16}{1} = 4A$

Q. 2)



Soln:

KCL for node (i)

$$\frac{V_1 - V_2}{3} + \frac{V_1 - 0}{10} = 5$$

$$\text{or, } \frac{10(V_1 - V_2) + 3V_1}{30} = 5$$

$$\text{or, } 10V_1 - 10V_2 + 3V_1 = 150$$

$$\Rightarrow 13V_1 - 10V_2 = 150 \quad \text{--- (i)}$$

for node (2)

$$\frac{V_2 - V_1}{3} + \frac{V_2 - 0}{5} + \frac{V_2 - 10}{1} = 0$$

$$\Rightarrow \frac{5(V_2 - V_1) + 3V_2 + 15(V_2 - 10)}{15} = 0$$

$$\Rightarrow 5V_2 - 5V_1 + 3V_2 + 15V_2 - 150 = 0$$

$$\Rightarrow -5V_1 + 8V_2 + 15V_2 = 150$$

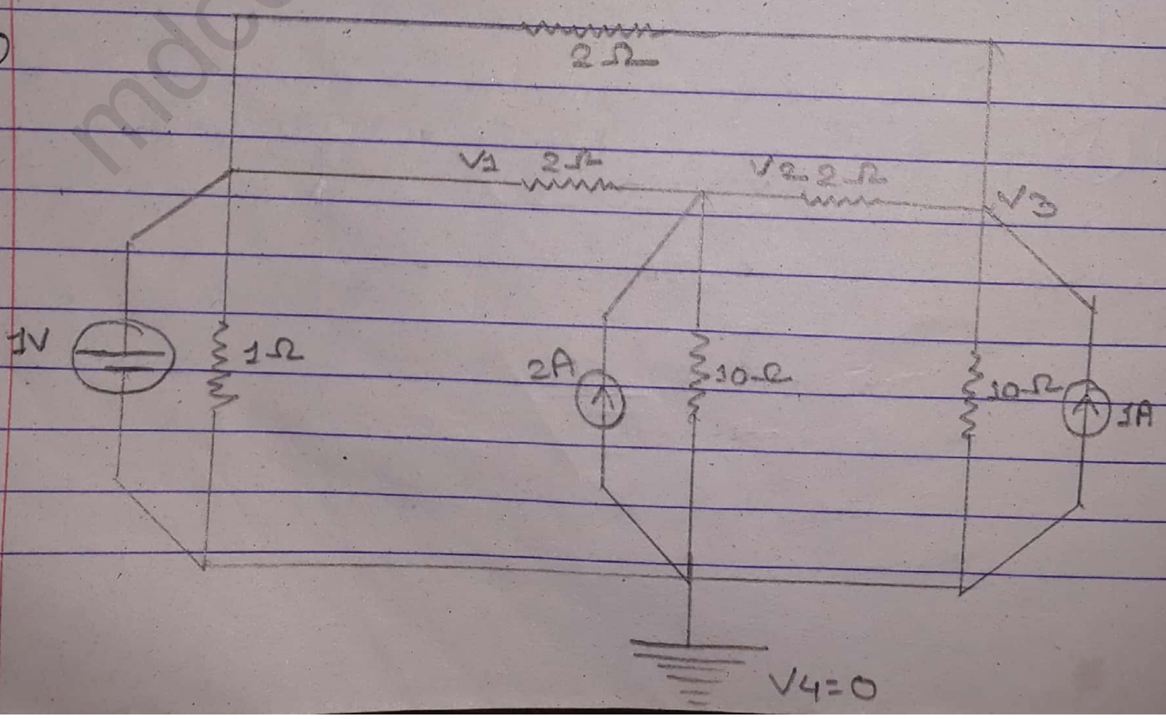
$$\Rightarrow -5V_1 + 23V_2 = 150 \quad \text{--- (ii)}$$

on solving we get,

$$V_1 = 19.87V$$

$$V_2 = 10.84V$$

eg (3)



From fig.

$V_1 - 1 = 0$

$\therefore V_1 = 1V$

KCL for node 2

$$\frac{V_2 - V_1}{2} + \frac{V_2 - V_3}{2} + \frac{V_2 - 0}{1} = 0$$

$\Rightarrow V_2 - V_1 + V_2 - V_3 + 2V_2 = 0$

$\Rightarrow 4V_2 - V_1 - V_3 = 0$

$\Rightarrow -V_1 + 4V_2 - V_3 = 0$ — (ii)

KCL for node (3)

$$\frac{V_3 - V_1}{2} + \frac{V_3 - V_2}{2} + \frac{V_3 - 0}{1} = 1$$

$$\Rightarrow \frac{V_3 - V_1 + V_3 - V_2 + 2V_3}{2} = 1$$

$\Rightarrow 4V_3 - V_2 - V_1 = 2$

$\Rightarrow 4V_3 - V_1 - V_2 = 2$ — (iii)

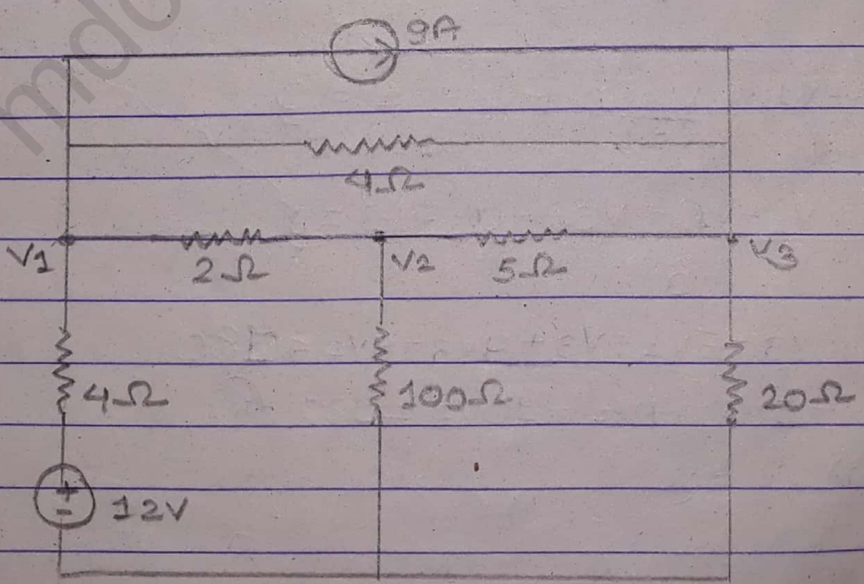
on solving eqn (i), (ii) & (iii)

$V_2 = 1.53V$

$V_3 = 1.33V$

Q-2.)

a)



$V_{5\Omega} = ?$ $I_{12V} = ?$

Soln:

From Nodal analysis,

For node 1,

$$\frac{V_1-V_2}{2} + \frac{V_1-12-0}{4} + \frac{V_1-V_3}{5} + 9 = 0$$

$$\Rightarrow \frac{10(V_1-V_2)+5(V_1-12)+4(V_1-V_3)}{20} + 9 = 0$$

$$\Rightarrow 10V_1 - 10V_2 + 5V_1 - 60 + 4V_1 - 4V_3 + 180 = 0$$

$$\Rightarrow 19V_1 - 10V_2 - 4V_3 - 60 + 180 = 0$$

$$\Rightarrow 19V_1 - 10V_2 - 4V_3 + 120 = 0 \quad -(i)$$

For node 2,

$$\frac{V_2-V_3}{5} + \frac{V_2-0}{100} + \frac{V_2-V_1}{2} = 0$$

$$\text{or, } \frac{20(V_2-V_3)+V_2+50(V_2-V_1)}{100} = 0$$

$$\text{or, } \frac{20V_2-20V_3+V_2+50V_2-50V_1}{100} = 0$$

$$\text{or, } -50V_1 + 71V_2 - 20V_3 = 0 \quad -(ii)$$

For node 3,

$$\frac{V_3-V_1}{4} + \frac{V_3-0}{20} + \frac{V_3-V_2}{5} = 9$$

$$\text{or, } \frac{5(V_3-V_1)+V_3+4(V_3-V_2)}{20} = 9$$

$$\text{or, } 5V_3 - 5V_1 + V_3 + 4V_3 - 4V_2 = 180$$

$$\text{or, } -5V_1 - 4V_2 + 10V_3 = 180 \quad -(iii)$$

On solving (i), (ii) & (iii)

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$V_1 = 6.35V$

$V_2 = 11.76V$

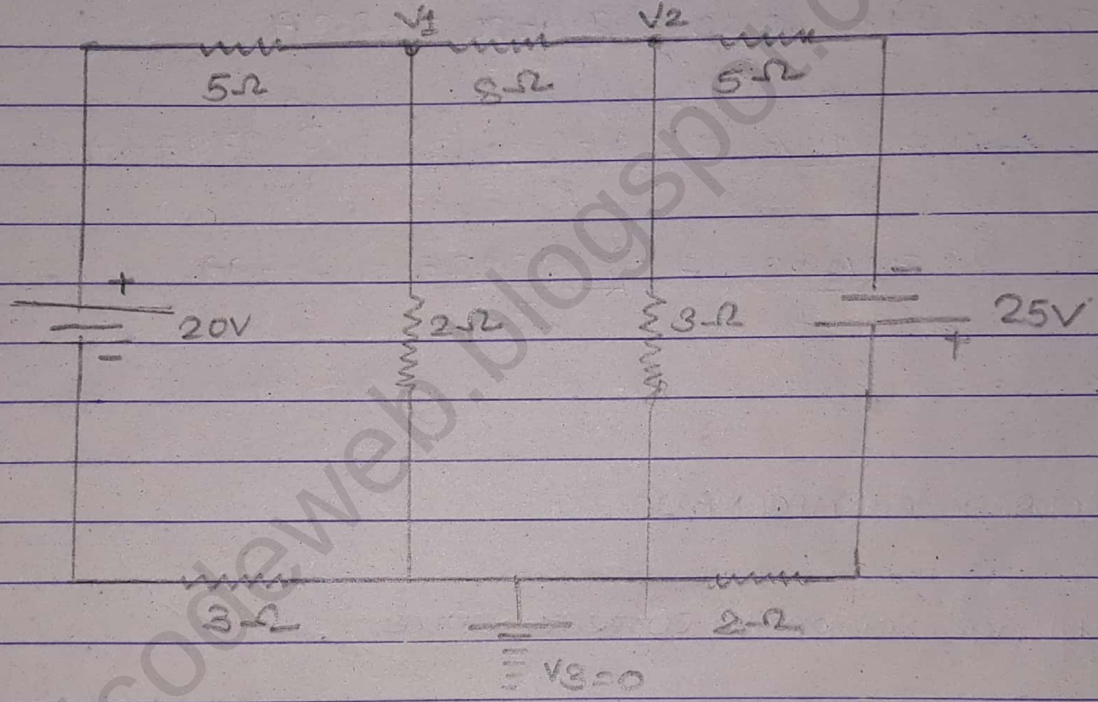
$V_3 = 25.88V$

$V_{5\Omega} = V_2 - V_3 = 11.76V - 25.88V$

$= -14.12V$

$I_{12V} = \frac{V_1 - 12 - 0}{4} = \frac{6.35 - 12}{4} = -1.4125A$

b.)



Loop current = ?

soln:

for node I

$$\frac{V_1 - V_2}{8} + \frac{V_1 - 0}{2} + \frac{V_1 - 20 - 0}{8} = 0 \quad \text{-(i)}$$

for node II

$$\frac{V_2 - V_1}{8} + \frac{V_2 - 0}{3} + \frac{V_2 + 25 - 0}{7} = 0 \quad \text{(ii)}$$

solving (i) & (ii) we get,

$V1 - V2 + 4V1 + V1 - 20 = 0$

or, $6V1 - V2 - 20 = 0$ —(i)

$21V_2 - 21V_1 + 56V_2 + 24V_2 + 600 = 0$ —(ii)

or, $-21V_1 + 101V_2 + 600 = 0$ —(ii)

Solving eqn (i) & (ii) we get,

$V_1 = 2.4V$

$V_2 = -5.43V$

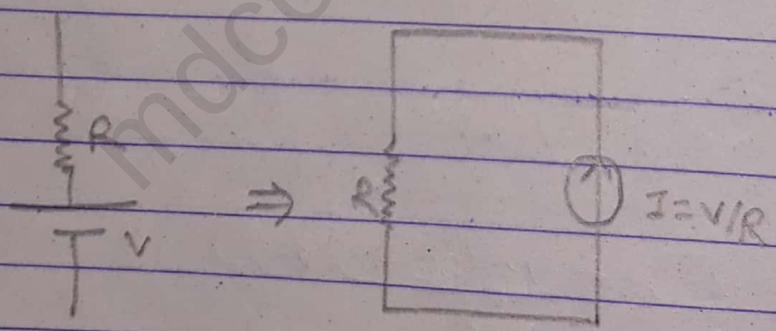
Then, $I_1 = \frac{V_1 - 20}{8} = \frac{2.4 - 20}{8} = -2.2A$

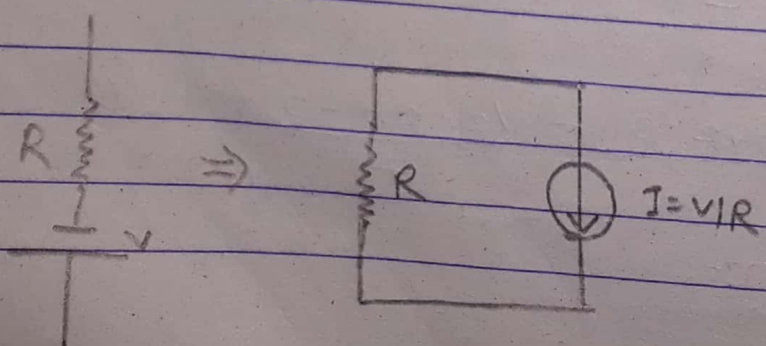
$I_2 = \frac{V_1 - V_2}{8} = \frac{2.4 - (-5.43)}{8} = 0.97875A$

$I_3 = \frac{V_2 + 25}{7} = \frac{-5.43 + 25}{7} = 2.79A$

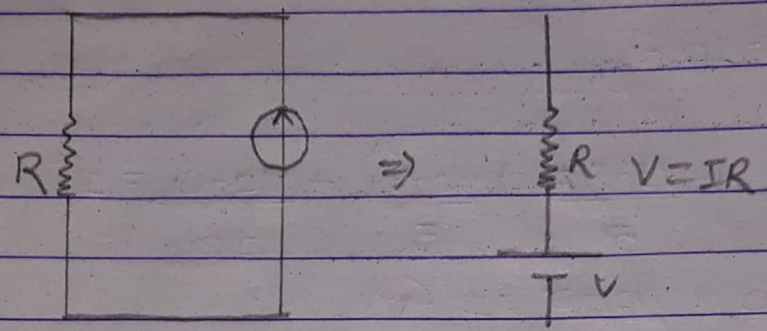
* SOURCE TRANSFORMATION:-

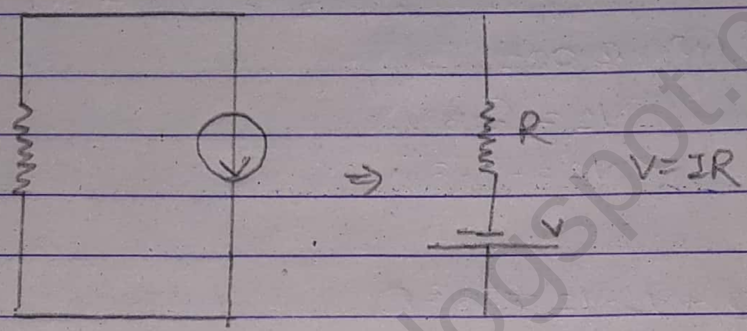
a) voltage source to current source



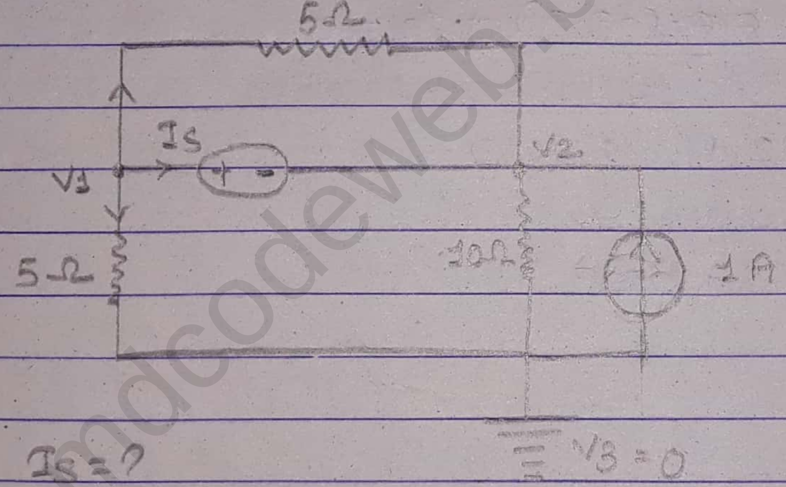


b.) current source to voltage source





Q.1.)



Is = ?

Soln :-

Node I,

$$\frac{V1-0}{5} + \frac{V1-V2}{5} + Is = 0$$

NOTE:- If there is a pure voltage source in between the non-zero node then it is called a super node.

from fig,

$$V_1 - 10 - V_2 = 0$$

$$V_1 - V_2 = 10 \quad \text{(i)}$$

supernode,

$$\frac{V_1 - 0}{5} + \cancel{\frac{V_1 - V_2}{5}} + \cancel{\frac{V_2 - V_1}{5}} + \frac{V_2 - 0}{10} = 1$$

$$\frac{V_1 - 0}{5} + \frac{V_2 - 0}{10} = 1 \quad \text{(ii)}$$

or $2V_1 + V_2 = 10$

Solving (i) & (ii) we get,

$$V_1 = 6.6V$$

$$V_2 = -3.3V$$

Again,

$$\frac{V_1 - 0}{5} + \frac{V_1 - V_2}{5} + I_S = 0$$

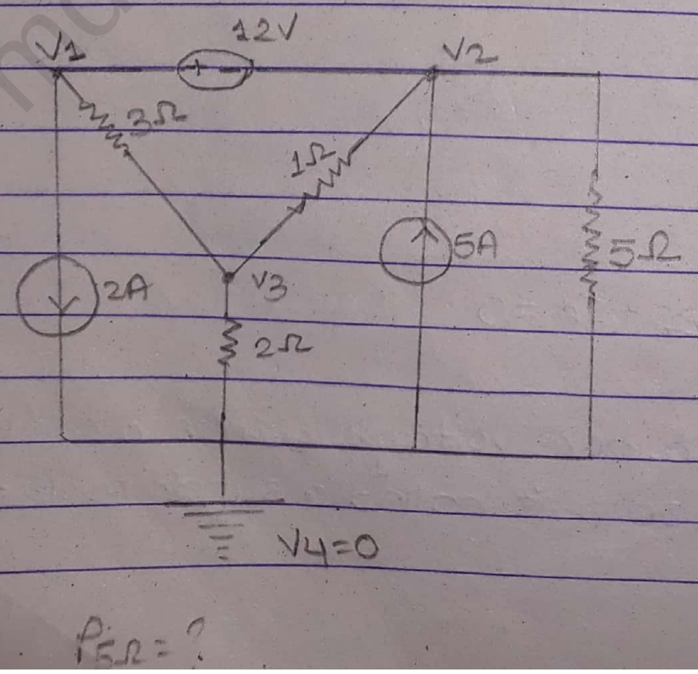
or, $\frac{6.6}{5} + \frac{6.6 - (-3.3)}{5} + I_S = 0$

or, $1.32 + 1.98 + I_S = 0$

or, $I_S + 3.3 = 0$

$\therefore I_S = -3.3A$

Q.2.)



$P_{5\Omega} = ?$

soln:-

from fig;

$$V_1 - 12 - V_2 = 0$$

$$V_1 - V_2 = 12 \quad -①$$

Supernode,

$$\frac{V_1 - V_3}{3} + \frac{V_2 - V_3}{1} + \frac{V_2 - 0}{5} = 5 \quad -②$$

For node III,

$$\frac{V_3 - V_1}{3} + \frac{V_3}{2} + \frac{V_3 - V_2}{1} = 0 \quad -③$$

$V_1 - V_2 = 12$

$5V_1 + 18V_2 - 20V_3 = 75$

$-2V_1 - 6V_2 + 11V_3 = 0$

Solving ①, ② & ③ we get

$$V_1 - V_2 = 12 \quad -①$$

$$3V_2 + 5V_1 - 5V_3 + 15V_2 - 15V_3 = 75$$

$$5V_1 + 18V_2 - 20V_3 = 75 \quad -②$$

$$2V_3 - 2V_1 + 3V_3 + 6V_3 - 6V_2 = 0$$

$$11V_3 - 2V_1 - 6V_2 = 0 \quad -③$$

Solving ①, ② & ③ we get,

$$V_1 = 15.38V$$

$$V_2 = 3.38V$$

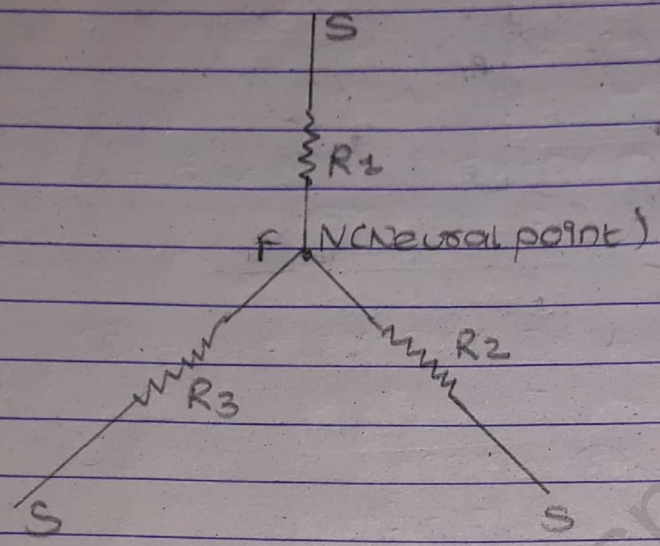
$$V_3 = 4.64V$$

$$P_{5\Omega} = \frac{V_2^2}{R} = \frac{(3.38)^2}{5} = 2.284 \text{watt}$$

$\rightarrow$

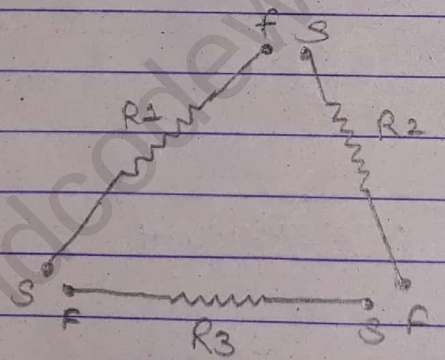
* Star (Y) - Delta (Δ) Transformation

a) Star connected loop (Y- wye)



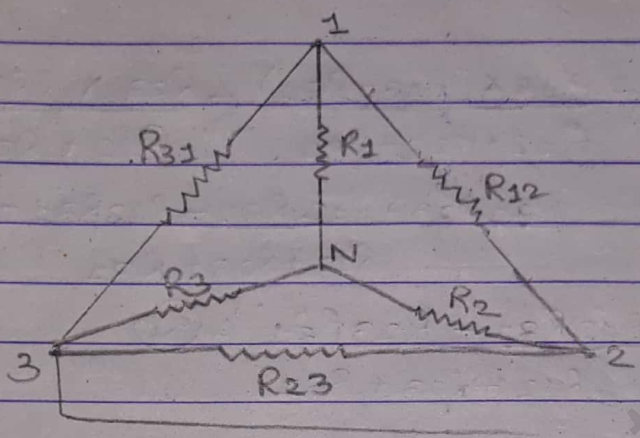
Three resistor are said to be connected in star if the similar ends of three resistor are joined at a single point.

b.) Delta (Δ) connected loop



Three resistor are said to be connected in delta if the dissimilar end of resistor are joined together i.e if starting end of one resistor is joined to the finishing end of another resistor.

INP ** Delta (Δ) - star (Y) transformation



Three resistor R_{12}; R_{23} & R_{31} are delta connected. This delta connected load is replaced by star connected load with R_1, R_2 & R_3 respectively.

For delta connection,-

Resistance between terminal 1 & 2 $= R_{12} \parallel (R_{23}+R_{31})$

$$= \frac{R_{12} \times (R_{23}+R_{31})}{R_{12}+R_{23}+R_{31}}$$

For star connection;

Resistance between terminal 1 & 2 $= R_1 + R_2$

$$\therefore R_1+R_2 = \frac{R_{12} \times (R_{23}+R_{31})}{R_{12}+R_{23}+R_{31}} \quad -(i)$$

similarly,

$$R_2+R_3 = \frac{R_{23} \times (R_{31}+R_{12})}{R_{12}+R_{23}+R_{31}} \quad -(ii)$$

and,

$$R_3+R_1 = \frac{R_{31} \times (R_{12}+R_{23})}{R_{12}+R_{23}+R_{31}} \quad -(iii)$$

Now, subtracting eqn (ii) from eqn (i)

$$R_1 + \cancel{R_2} - \cancel{R_2} - R_3 = \frac{R_{12} \times (R_{23} + R_{31})}{R_{12} + R_{23} + R_{31}} - \frac{R_{23} \times (R_{31} + R_{12})}{R_{12} + R_{23} + R_{31}}$$

$$= \frac{\cancel{R_{12} R_{23}} + R_{12} R_{31} - R_{23} R_{31} - \cancel{R_{23} R_{12}}}{R_{12} + R_{23} + R_{31}}$$

$$R_1 - R_3 = \frac{R_{12} R_{31} - R_{23} R_{31}}{R_{12} + R_{23} + R_{31}} \quad \text{— (iv)}$$

Adding eqn (iv) with (iii) we get,

$$R_1 - \cancel{R_3} + \cancel{R_3} + R_1 = \frac{R_{12} R_{31} - R_{23} R_{31}}{R_{12} + R_{23} + R_{31}} + \frac{R_{31} \times (R_{12} + R_{23})}{R_{12} + R_{23} + R_{31}}$$

$$2R_1 = \frac{R_{12} R_{31} - \cancel{R_{23} R_{31}} + R_{31} R_{12} + \cancel{R_{31} R_{23}}}{R_{12} + R_{23} + R_{31}}$$

$$\text{or, } \cancel{2} R_1 = \frac{\cancel{2} R_{12} R_{13}}{R_{12} + R_{23} + R_{31}}$$

$$\therefore R_1 = \frac{R_{12} R_{13}}{R_{12} + R_{23} + R_{31}} \quad \text{— (v)}$$

Similarly,

$$R_2 = \frac{R_{23} R_{21}}{R_{12} + R_{23} + R_{31}} \quad \text{— (vi)}$$

$$R_3 = \frac{R_{31} R_{32}}{R_{12} + R_{23} + R_{31}} \quad \text{— (vii)}$$

* Star-Delta (Y-Δ) transformation

Now, Multiplying (v & vi), (vi & vii) and (vii & v) and adding together.

$$R_1R_2+R_2R_3+R_3R_1$$

$$\Rightarrow \frac{R_{12}R_{13}}{R_{12}+R_{23}+R_{31}} \times \frac{R_{21}R_{23}}{R_{12}+R_{23}+R_{31}} + \frac{R_{21}R_{23}}{R_{12}+R_{23}+R_{31}} \times \frac{R_{31}R_{32}}{R_{12}+R_{23}+R_{31}}$$

$$+ \frac{R_{31}R_{32}}{R_{12}+R_{23}+R_{31}} \times \frac{R_{12}R_{13}}{R_{12}+R_{23}+R_{31}}$$

$$\Rightarrow \frac{R_{12}^2R_{23}R_{13}}{(R_{12}+R_{23}+R_{31})^2} + \frac{R_{12}R_{23}^2R_{31}}{(R_{12}+R_{23}+R_{31})^2} + \frac{R_{12}R_{23}R_{31}^2}{(R_{12}+R_{23}+R_{31})^2}$$

$$\Rightarrow \frac{R_{12}R_{23}R_{31}\cancel{(R_{12}+R_{23}+R_{31})}}{(R_{12}+R_{23}+R_{31})^{\cancel{2}}}$$

$$\therefore R_1R_2+R_2R_3+R_3R_1 = \frac{R_{12}R_{23}R_{31}}{R_{12}+R_{23}+R_{31}} \quad \text{-- (viii)}$$

Dividing (viii) by (v)

$$\frac{R_1R_2+R_2R_3+R_3R_1}{R_1} = \frac{\cancel{R_{12}}R_{23}\cancel{R_{31}}}{\cancel{R_{12}+R_{23}+R_{31}}} \times \frac{\cancel{R_{12}+R_{23}+R_{31}}}{\cancel{R_{12}}\cancel{R_{13}}}$$

$$\frac{R_1R_2+R_2R_3+R_3R_1}{R_1} = R_{23}$$

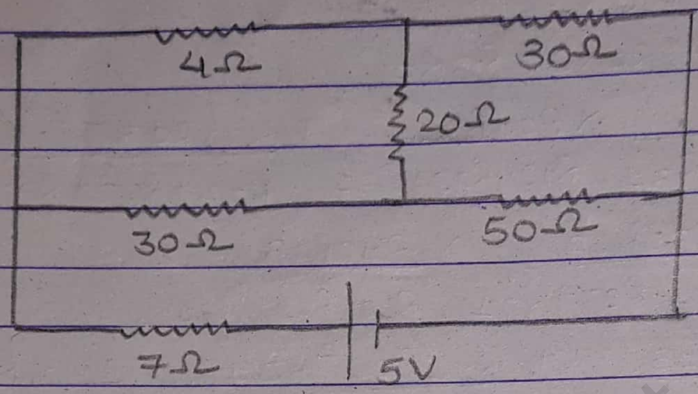
$$\therefore R_{23} = \frac{R_1R_2+R_2R_3+R_3R_1}{R_1}$$

Similarly,

$$R_{12} = \frac{R_1R_2+R_2R_3+R_3R_1}{R_3}$$

$$R_{31} = \frac{R_1R_2+R_2R_3+R_3R_1}{R_2}$$

Q.) using star-delta transformation, find the current from the battery -



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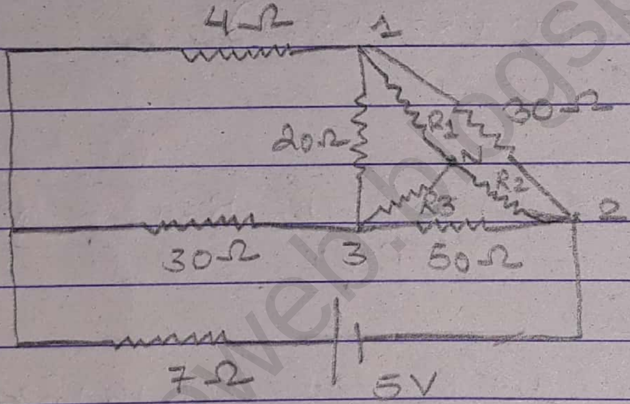


$$R_1 = \frac{R_{12}R_{13}}{R_{12}+R_{23}+R_{31}}$$

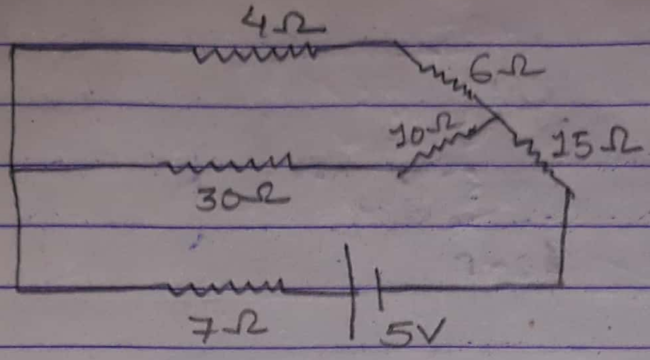
$$= \frac{30 \times 20}{30+20+50}$$

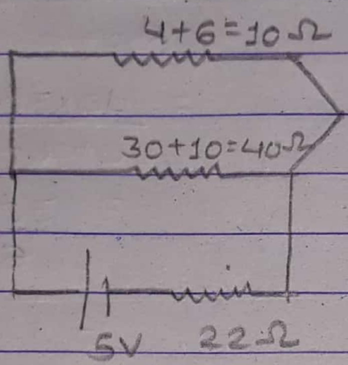
$$= \frac{600}{100}$$

$$= 6\Omega$$

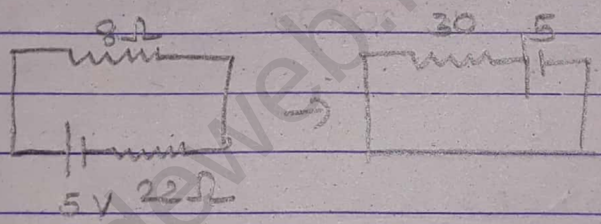
$$R_2 = \frac{R_{23}R_{21}}{R_{12}+R_{23}+R_{31}} = \frac{50 \times 30}{50+30+20} = 15\Omega$$

$$R_3 = \frac{R_{31}R_{32}}{R_{12}+R_{23}+R_{31}} = \frac{20 \times 50}{50+30+20} = 10\Omega$$





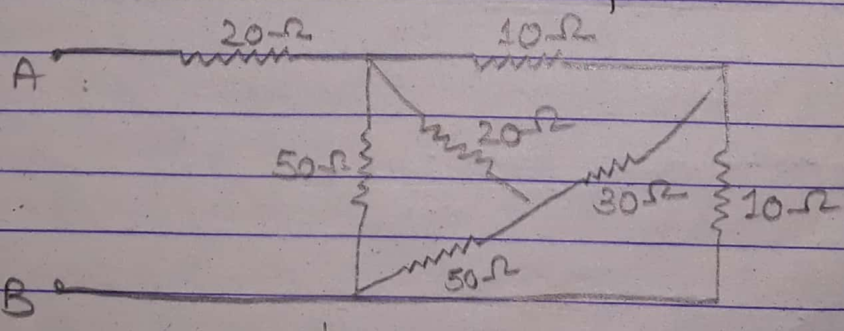
$= \frac{1}{10} + \frac{1}{40} = \frac{40 \times 10}{40+10} = \frac{400}{50} = 8\Omega$

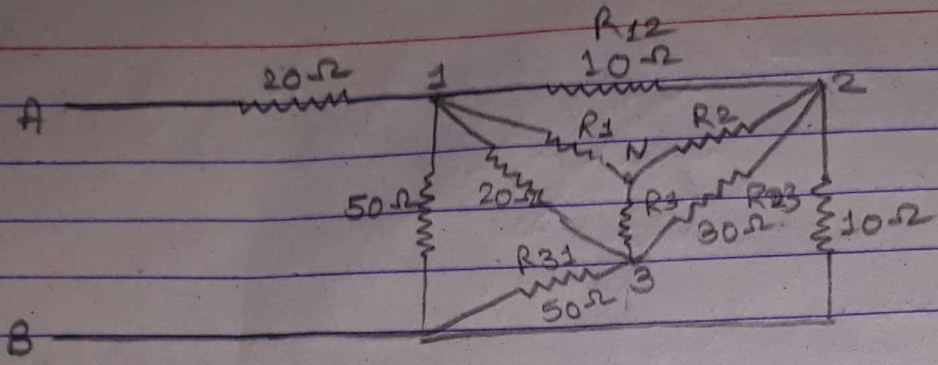


$I = \frac{V}{R} = \frac{5}{30} = 1/6$
$= 0.167 A$

* Using delta-star transformation, find the equivalent resistance between terminal A & B.

→ star-delta (10, 20, & 30 loop)

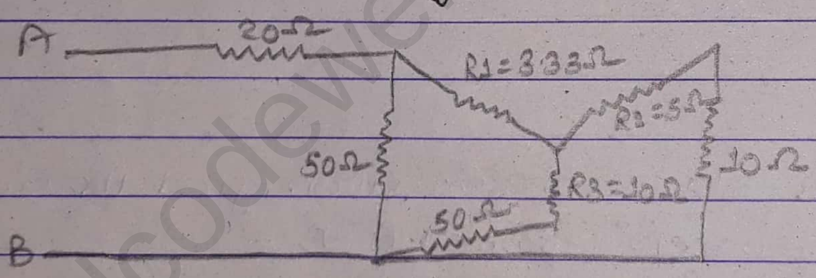


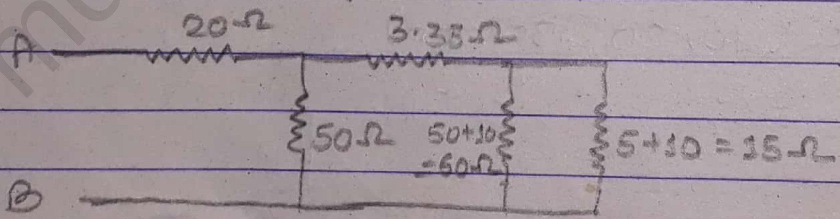


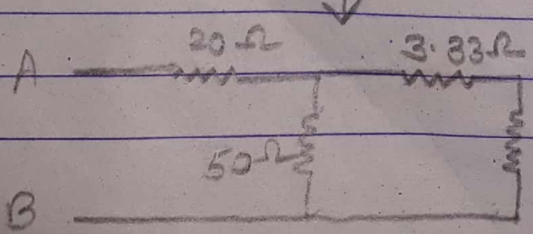
$$R_1 = \frac{R_{12}R_{13}}{R_{12}+R_{23}+R_{31}} = \frac{10 \times 20}{10+20+30} = \frac{20\cancel{0}}{6\cancel{0}} = 3.33\,\Omega$$

$$R_2 = \frac{R_{21}R_{23}}{R_{12}+R_{23}+R_{31}} = \frac{10 \times 30}{10+20+30} = \frac{30\cancel{0}}{6\cancel{0}} = 5\,\Omega$$

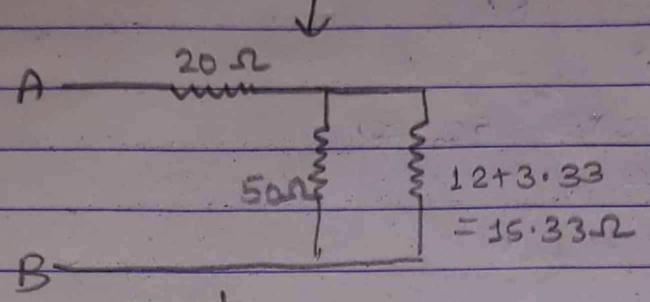
$$R_3 = \frac{R_{31}R_{32}}{R_{12}+R_{23}+R_{31}} = \frac{20 \times 30}{10+20+30} = \frac{60\cancel{0}}{6\cancel{0}} = 10\,\Omega$$

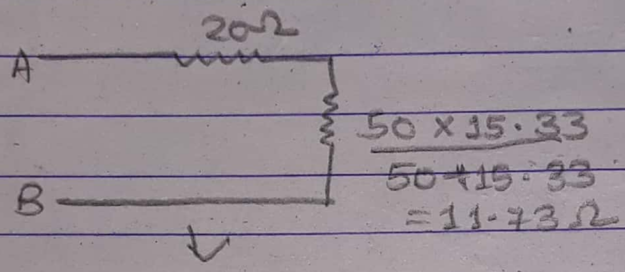


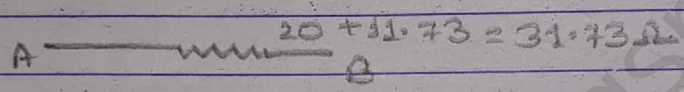




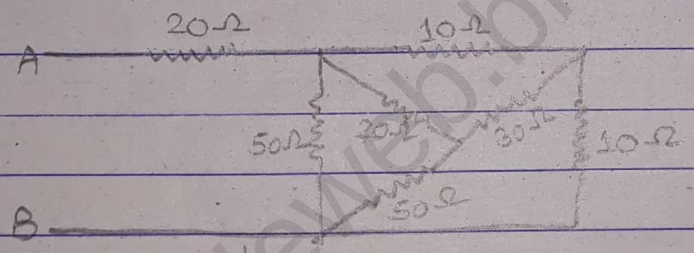
$$\frac{60 \times 15}{60+15}\,\Omega = 12\,\Omega$$

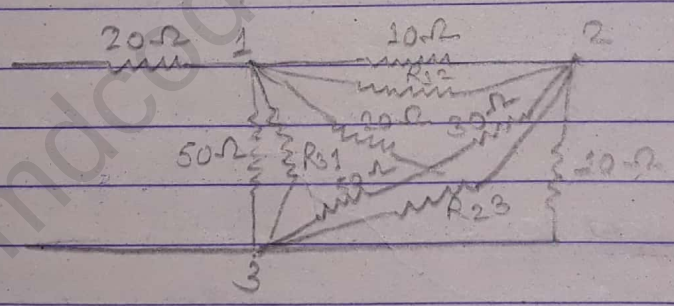






※ Delta-star





$$R_{12} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

$$= \frac{20 \times 30 + 30 \times 50 + 50 \times 20}{50}$$

$$= \frac{3100}{50}$$

$$= 62\Omega$$

$$R_{23} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

$$= \frac{20 \times 30 + 30 \times 50 + 50 \times 20}{20}$$

$$= \frac{310\cancel{0}}{2\cancel{0}}$$

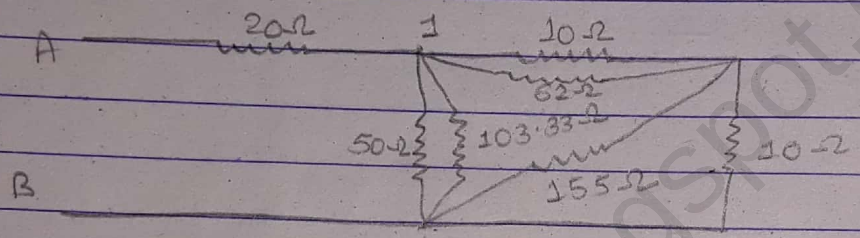
$$= 155\Omega$$

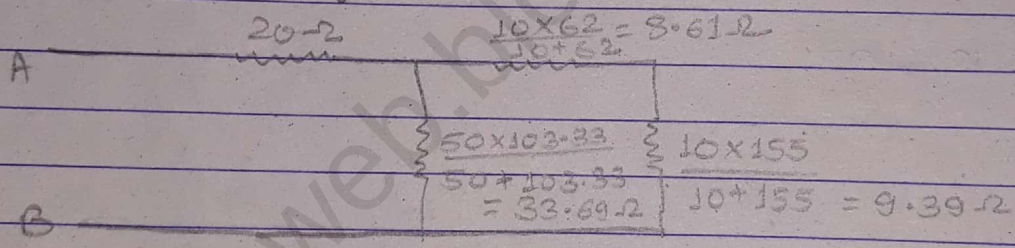
$$R_{31} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

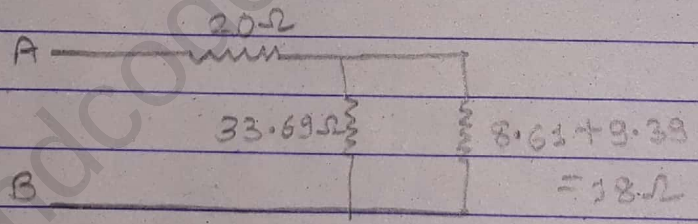
$$= \frac{20\times30 + 30\times50 + 50\times20}{30}$$

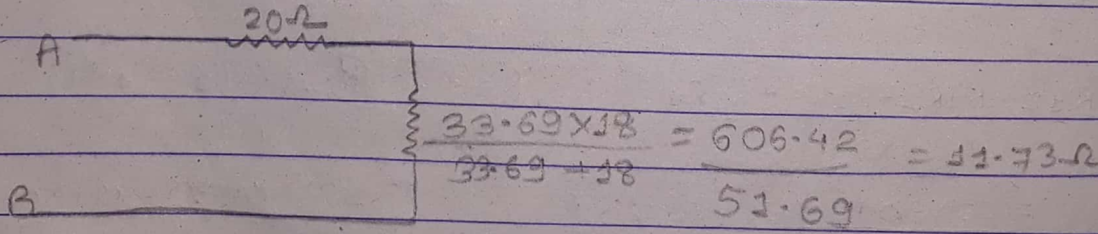
$$= \frac{3100}{30}$$

$$= 103.33\,\Omega$$

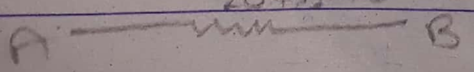




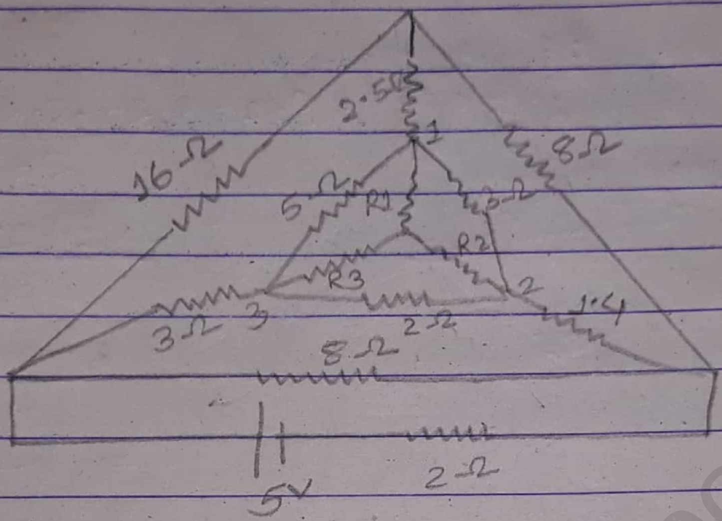




$$20 + 11.73 = 31.73\,\Omega$$



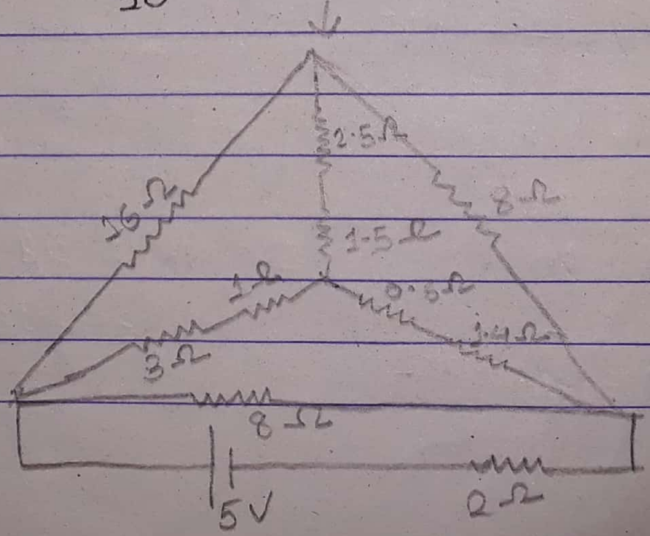
Find the current along the battery.

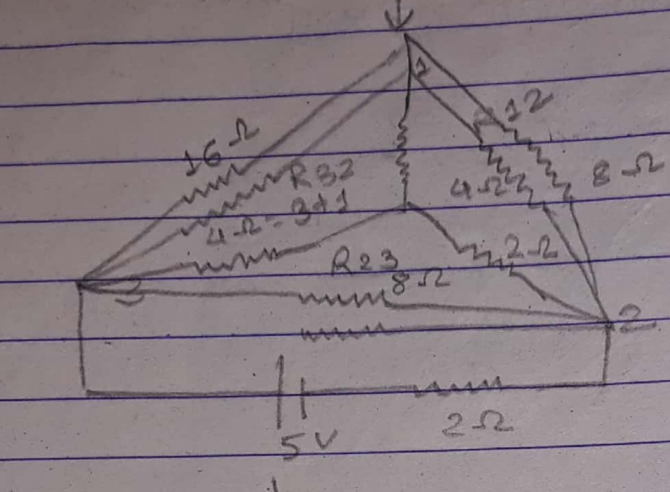


$$R_1 = \frac{R_{12} R_{13}}{R_{12}+R_{23}+R_{31}} = \frac{3 \times 5}{5+3+2} = \frac{15}{10} = 1.5\,\Omega$$

$$R_2 = \frac{R_{21} R_{23}}{R_{12}+R_{23}+R_{31}} = \frac{3 \times 2}{5+3+2} = \frac{6}{10} = 0.6\,\Omega$$

$$R_3 = \frac{R_{31} R_{32}}{R_{12}+R_{23}+R_{31}} = \frac{5 \times 2}{5+3+2} = \frac{10}{10} = 1\,\Omega$$



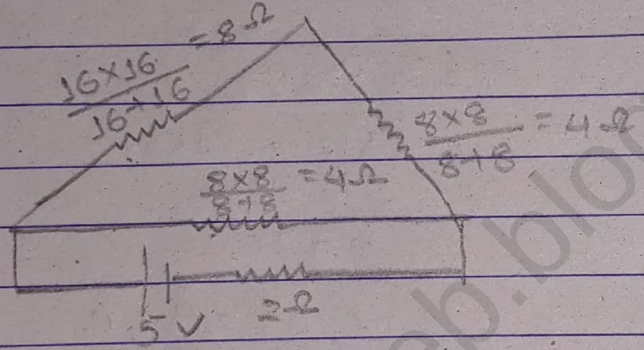


$$R_{12} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$

$$= \frac{4\times2 + 2\times4 + 4\times4}{4}$$

$$= \frac{8+8+16}{4}$$

$$= 8\,\Omega$$



$$R_{23} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

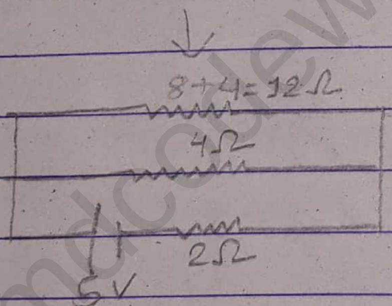
$$= \frac{16+16}{4}$$

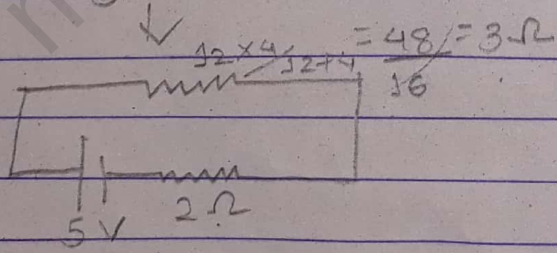
$$= 8\,\Omega$$

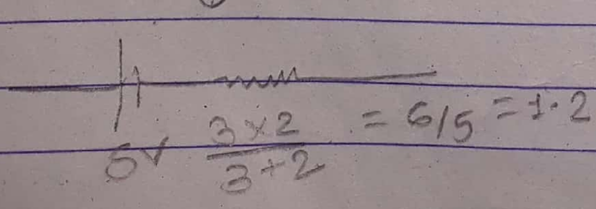
$$R_{31} = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

$$= \frac{32}{2}$$

$$= 16\,\Omega$$







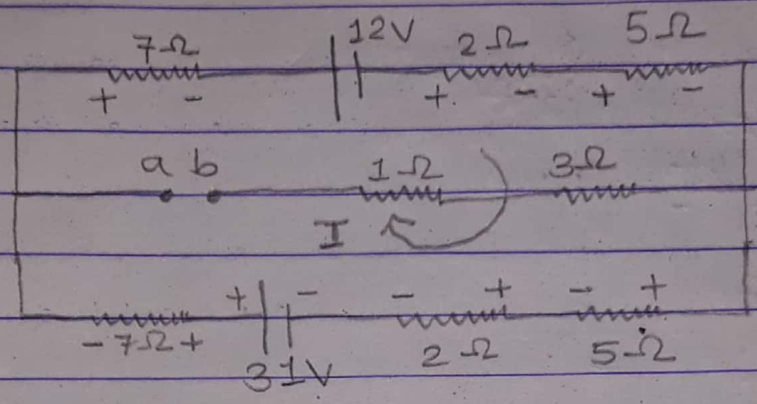
$$I = V/R = 5/1\cdot2$$

$$= 4\cdot167\,A$$

If $(- \text{ to } +) = $ '+'
$(+ \text{ to } -) = $ '−'

Voltage between two points ($V_{ab}/V_{Th}/V_{oc}$)

Q.1)



Soln:

For the loop

$$-7I + 12 - 2I - 5I - 5I - 2I + 31 - 7I = 0$$

$$I = 0.67A$$

Then, Vab for path I,

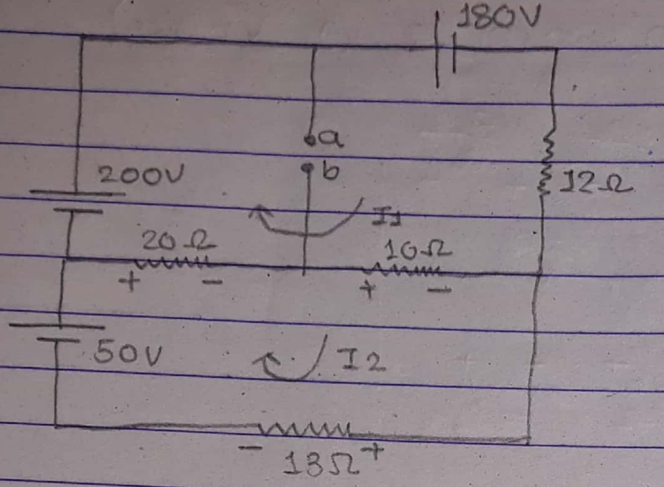
$$V_{ab} = -7I - 12 - 2I - 5I$$
$$= -7I - 12 - 7I$$
$$= -14I - 12$$
$$= -14 \times 0.67 - 12$$
$$= -21.38V$$

for Path II,

$$V_{ab} = +7I - 31 + 2I + 5I$$
$$= 7I - 31 + 7I$$
$$= 14I - 31$$
$$= 14 \times 0.67 - 31$$
$$= -21.62V$$

→

Q.2.)



soln: For loop I,

$$200-180-12I_1-10(I_1-I_2)-20(I_1-I_2)=0$$

or, $20-12I_1-10I_1+10I_2-20I_1+20I_2=0$

or, $20-22I_1+30I_2-20I_1=0$

or, $20-42I_1+30I_2=0$

or, $-42I_1+30I_2=-20$ — (i)

For loop II,

$$50-20(I_2-I_1)-10(I_2-I_1)-13I_2=0$$

$50-20I_2+20I_1-10I_2+10I_1-13I_2=0$

$50-30I_2+20I_1+10I_1-13I_2=0$

$50-43I_2+30I_1=0$

or, $-43I_2+30I_1=-50$ — (ii)

solving (i) and (ii) we get,

$I_1=2.6A$

$I_2=2.98A$

$I_1-I_2=-0.38A$

$I_2-I_1=0.38A$

Path I,

$$V_{ab} = -200 - 20(I_2 - I_1)$$
$$= -200 - 20 \times 0.38$$
$$= -207.6V$$

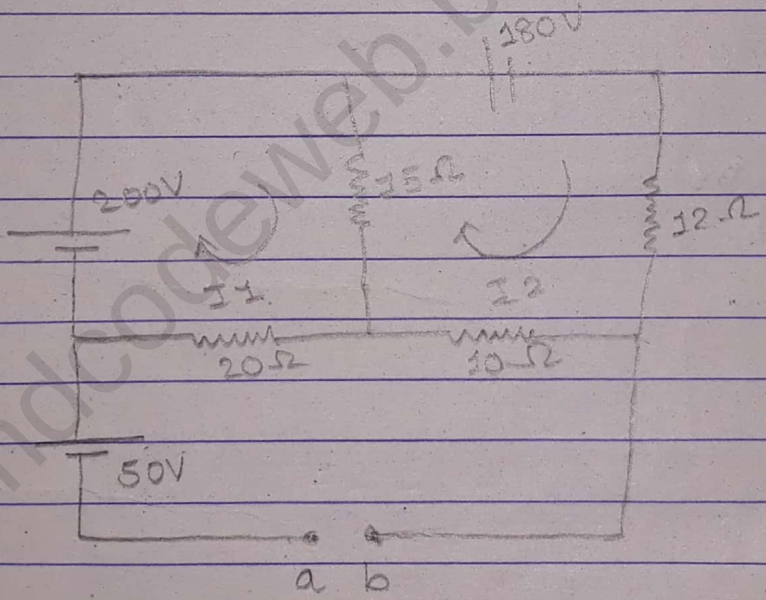
Path II,

$$V_{ab} = -180 - 12I_1 + 10(I_2 - I_1)$$
$$= -180 - 12 \times 0.26 + 10 \times 0.38$$
$$= -207.4V$$

Path III,

$$V_{ab} = -200 - 50 + 13I_2 + 10(I_2 - I_1)$$
$$= -200 - 50 + 13 \times 2.98 + 10 \times 0.38$$
$$= -207.46V$$

Q.3



From Loop I,

$$200 - 15(I_1 - I_2) - 20I_1 = 0$$
$$200 - 15I_1 + 15I_2 - 20I_1 = 0$$
$$-35I_1 + 15I_2 = -200 \quad \text{— (P)}$$

From loop II,

$$180-12I_2-10I_2-15(I_2-I_1)=0$$

$$180-12I_2-10I_2-15I_2+15I_1=0$$

$$180-37I_2+15I_1=0$$

$$15I_1-37I_2=-180 \quad \text{--- (ii)}$$

Solving (I) & (II)

$$I_1=4.39A$$

$$I_2=-3.08A$$

Path I,

$$V_{ab}=50+20I_1+10I_2$$

$$=50+20\times4.39+10\times-3.08$$

$$=107V$$

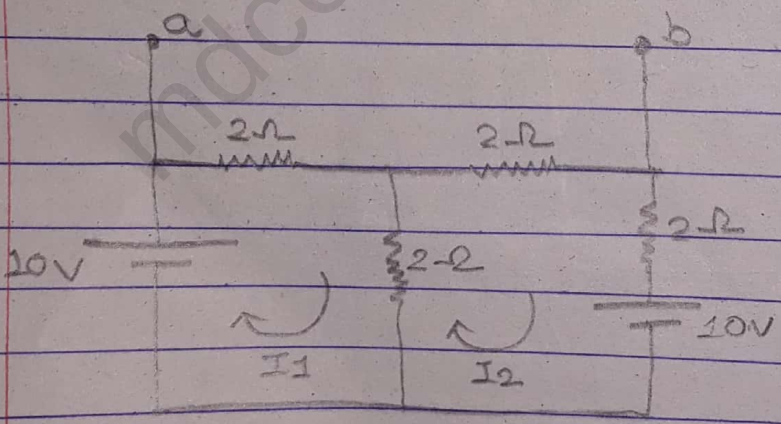
Path II,

$$V_{ab}=50+200-15(I_1-I_2)+10I_2$$

$$=250-15(4.39+3.08)+10\times(-3.08)$$

$$=107.3V$$

Q.4



for loop I,

$$10-2I_1-2(I_1-I_2)=0$$

$$10-2I_1-2I_1+2I_2=0$$

$$10-4I_1+2I_2=0 \quad \text{--- (i)}$$

For loop II

$$-2(I_2 - I_1) - 2I_2 - 2I_2 - 10 = 0$$

$$-2I_2 + 2I_1 - 2I_2 - 2I_2 - 10 = 0$$

$$-6I_2 + 2I_1 - 10 = 0$$

$$2I_1 - 6I_2 = 10 \quad - \text{(ii)}$$

Solving (i) & (ii)

$$I_1 = 2A \quad I_2 = -1A$$

for path I,

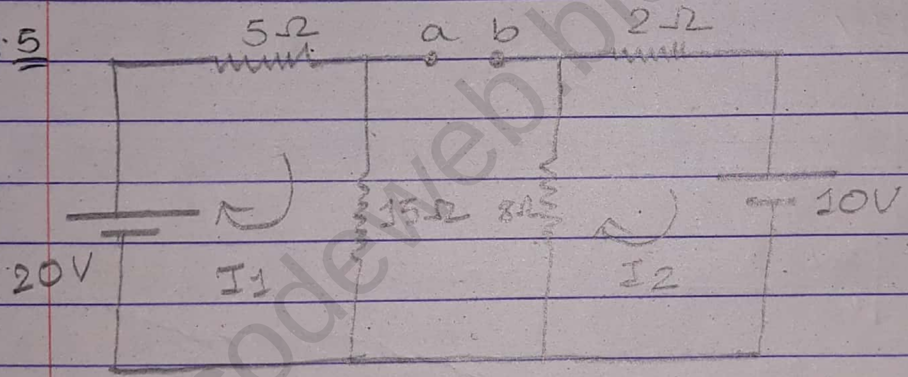
$$V_{ab} = -2I_1 - 2I_2$$

$$= -2\times 2 - 2\times -1$$

$$= -4 + 2$$

$$= -2V$$

Q.5



for loop I,

$$20 - 5I - 15I_1 = 0$$

$$20 - 20I_1 = 0$$

$$I_1 = 1A$$

For loop II,

$$-8I_2 - 2I_2 + 10 = 0$$

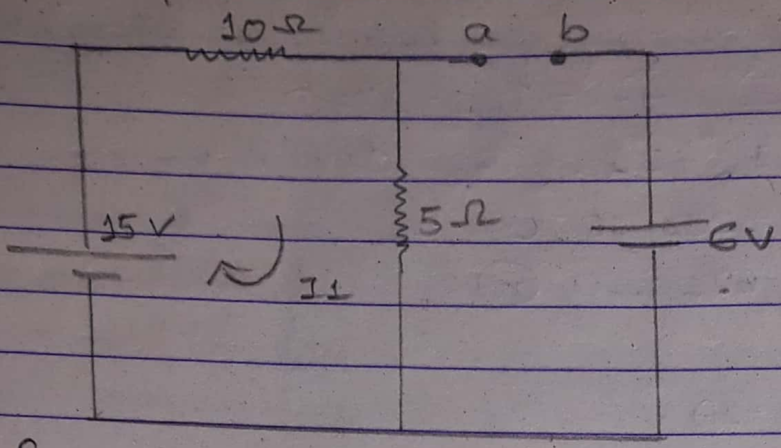
$$-10I_2 + 10 = 0$$

$$I_2 = -1A$$

$$V_{ab} = -15I_1 - 8I_2$$

$$= -15 + 8 = -7V$$

Q.6

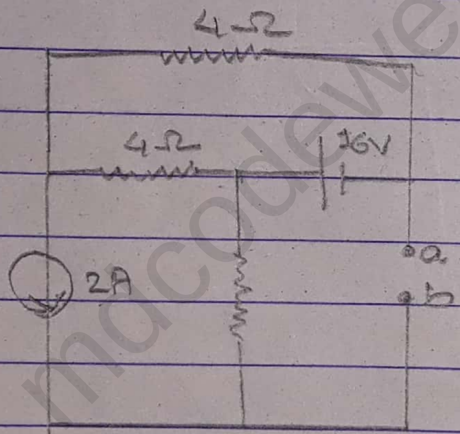


for loop I,

$$15 - 10I_1 - 5I_1 = 0$$
$$15 - 15I_1 = 0$$
$$I_1 = 1A$$

$$V_{ab} = -5I_1 + 6$$
$$= -5 + 6$$
$$= 1V$$

IMP
Q.7



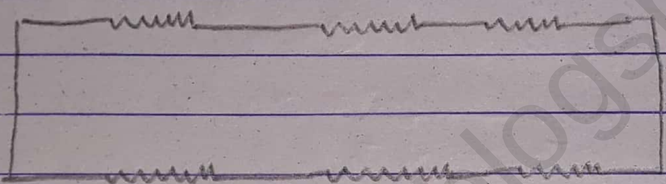
$$I = 2A$$

$$V_{ab} = -16 + 2 \times 2$$
$$= -16 + 4$$
$$= -12V$$

* Determination of equivalent resistance of circuit (R_{eq} / R_{Th})

Note:- 1.) voltage source छ भने short (close) गर्ने।
2.) current source छ भने open गर्ने।
And
leaving behind their internal resistance

Numericals.

1.)


* NETWORK THEOREM

1.) Thevenin's Theorem KVL
2.) Norton's Theorem
3.) Superposition Theorem

1.) Thevenin's Theorem:-
Statement:- It states that "equivalent voltage (open circuit voltage (V_{Th} / V_{ab} / V_{oc}) is calculated and equivalent resistance (R_{Th}) is calculated and is connected in series with load resistance (R_L) and further the circuit is analyzed."

How to thevenized a circuit

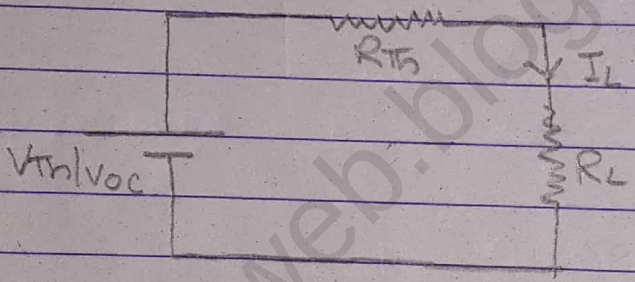
Step 1:- Calculate Thevenin's voltage (V_{Th}/V_{oc}/V_{ab}) and take magnitude value only.

Step 2:- Calculate Thevenin's resistance.

i) All voltage are short circuited leaving their internal resistance.

ii) All current source are open circuited leaving behind their internal resistance.

iii) Step 3:- Finally, equivalent diagram of Thevenin's theorem is

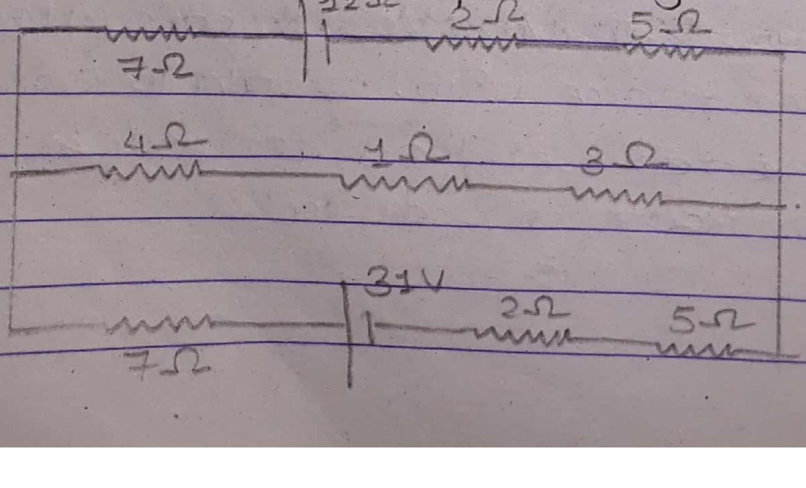


Then,

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

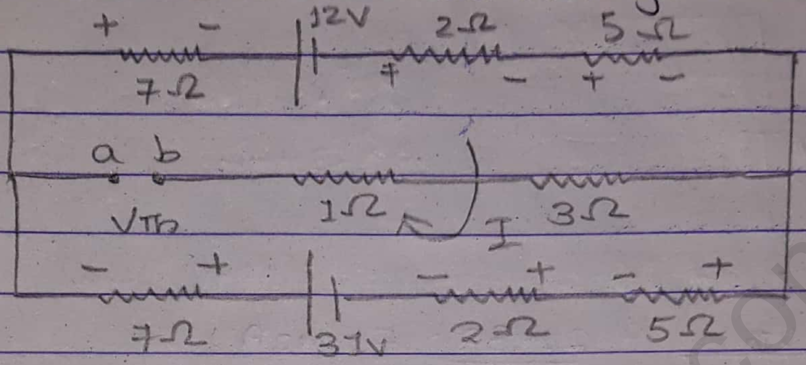
Questions of Thevenin's theorem

1) Find the power dissipated by 4Ω resistor.



Soln:-

Step 1:- Calculate Thevenin's voltage (V_{Th} / V_{oc})



KVL for loop I,

$$-7I - 12 - 2I - 5I - 5I - 2I + 31 - 7I = 0$$

$$I = 0.67A$$

$$V_{ab} | V_{Th} = -7I - 12 - 2I - 5I$$

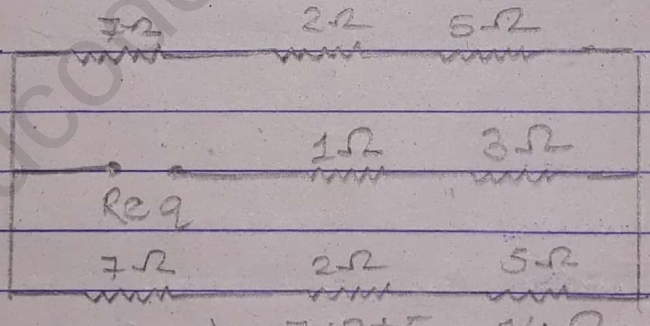
$$= -14I - 12$$

$$= -14 \times 0.67 - 12$$

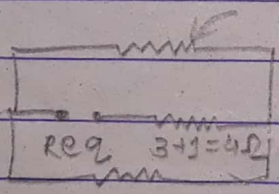
$$= -21.38V$$

$$\therefore V_{ab} = |V_{Th}| = |-21.38| = 21.38V$$

Step 2:- Calculate Thevenin's Resistance (R_{Th})

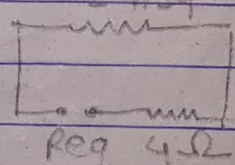


$$7 + 2 + 5 = 14\Omega$$

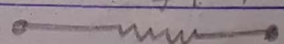


$$7 + 2 + 5 = 14\Omega$$

$$14 // 14 = \frac{14 \times 14}{14 + 14} = 7\Omega$$

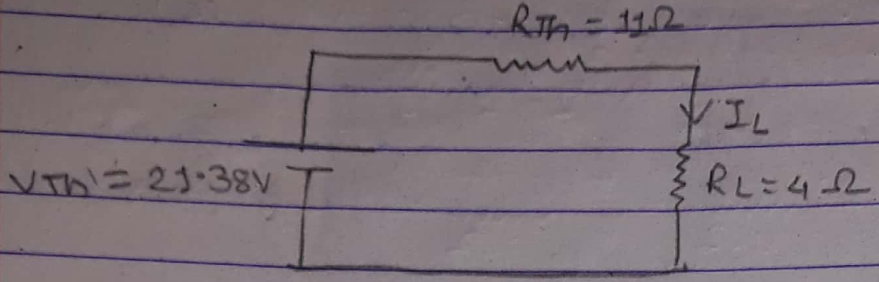


$$7 + 4 = 11\Omega$$



$$\therefore R_{Th} = 11\Omega$$

Step 3:- circuit diagram of Thevenin's theorem

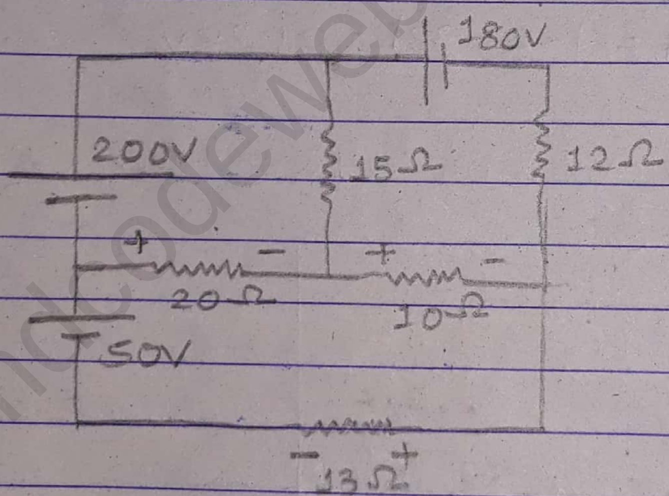


$$I_L = \frac{V_{Th}}{R_{Th} + R_L} = \frac{21.38}{15} = 1.42A$$

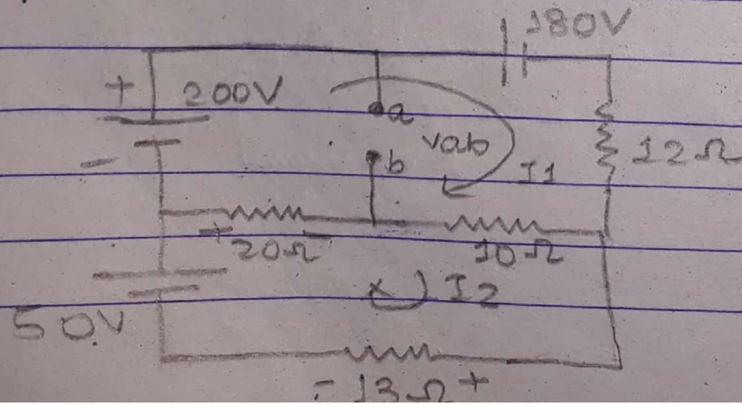
Now,

$$P_{4\Omega} = I_4^2 \times R_L = (1.42)^2 \times 4$$
$$= 8.6 \text{ watt.}$$

Q.2. Find the current through 15 Ω resistor using Thevenin's theorem.



Step 1:- Calculate Thevenin's voltage (V_{Th})



KVL for loop I,

$$200-180-12I_1-10(I_1-I_2)-20(I_1-I_2)=0$$

$$20-12I_1-10I_1+10I_2-20I_1+20I_2=0$$

$$-51I_1+30I_2=-20 \quad \text{(i)}$$

KVL for loop II,

$$50-20(I_2-I_1)-10(I_2-I_1)-13I_2=0$$

$$50-20I_2+20I_1-10I_2+10I_1-13I_2=0$$

$$30I_1-33I_2=-50 \quad \text{(ii)}$$

on solving (i) & (ii) we get,

$$I_1=2\cdot6A, \quad I_2=2\cdot98A$$

$$I_1-I_2=-0\cdot38A$$

$$I_2-I_1=0\cdot38A$$

Now,

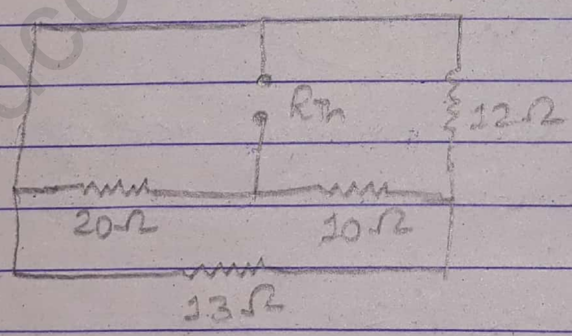
$$V_{Th}=-200-20(I_2-I_1)$$

$$=-200-20\times0\cdot38$$

$$=-207\cdot6V$$

$$V_{Th}=|V_{Th}|=207\cdot6V.$$

Step 2 :- Calculate thevenin's resistance R_{Th}

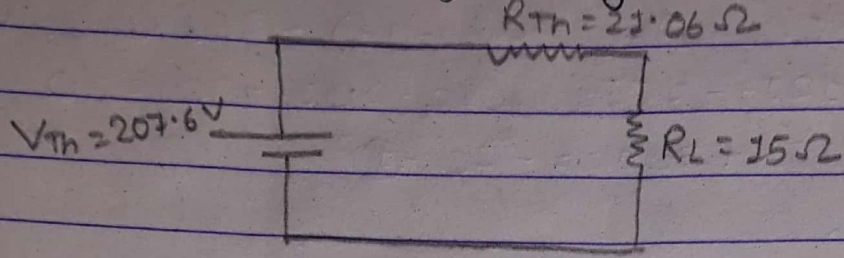


$$R_{Th}=[(10|20)\,||\,13]+12$$

$$=\left[\frac{30\times13}{30+13}\right]+12$$

$$=21\cdot06\Omega$$

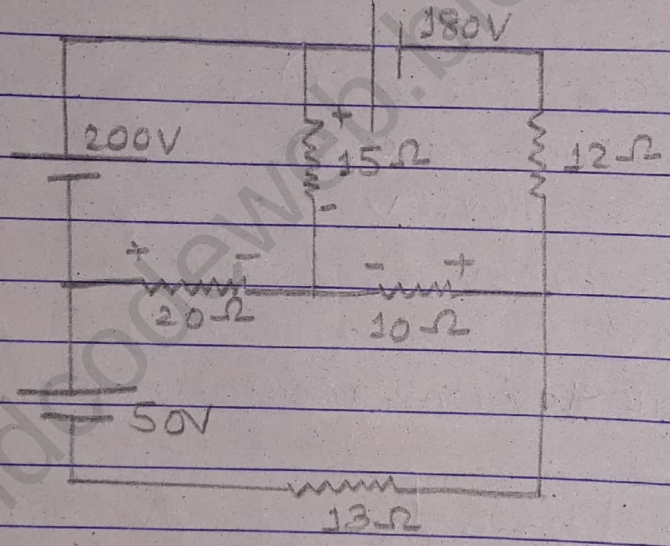
Step 3:- Circuit diagram of thevenin's theorem



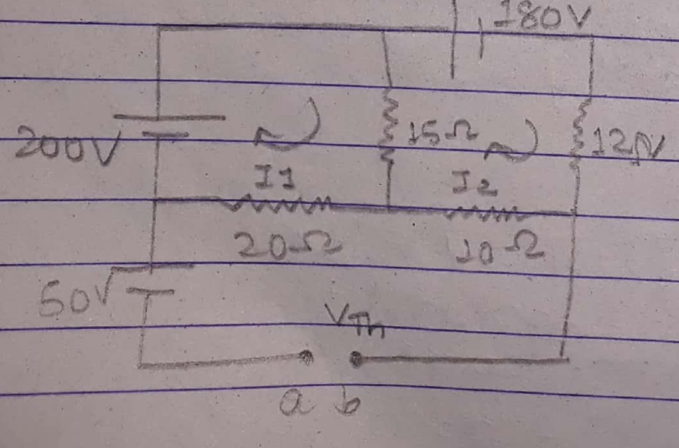
$$I_{15\Omega} = I_L = \frac{V_{Th}}{R_{Th}+R_L} = \frac{207.6}{21.06+15}$$

$$= \frac{207.6}{36.06} = 5.75A$$

Q.3 find the voltage through $13\,\Omega$ resistor using Thevenin's theorem



Step I :- Calculate the thevenin's voltage (V_{Th})



KVL for loop I,

$$200 - 15(I_1 - I_2) - 20I_1 = 0$$

$$200 - 15I_1 + 15I_2 - 20I_1 = 0$$

$$-35I_1 + 15I_2 = -200 \quad \text{— (i)}$$

KVL for loop II,

$$180 - 12I_2 - 10I_2 - 15(I_2 - I_1) = 0$$

$$180 - 12I_2 - 10I_2 - 15I_2 + 15I_1 = 0$$

$$15I_1 - 37I_2 = -180 \quad \text{— (ii)}$$

solving (i) and (ii) we get,

$$I_2 = -3.08A$$

$$I_1 = 4.39A$$

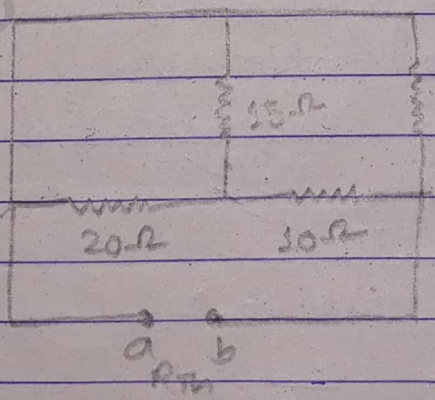
$$V_{ab} = 50 + 20I_1 + 10I_2$$

$$= 50 + 20 \times 4.39 + 10 \times -3.08$$

$$= 107V$$

$$V_{Th} = 107V$$

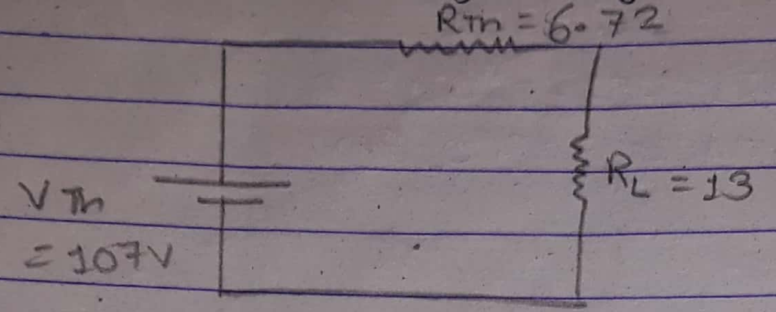
Step 2:- calculate Thevenin's resistance (R_{Th})



$$R_{Th} = [(20 \parallel 15) + 12] \parallel 10$$

$$= 6.72\Omega$$

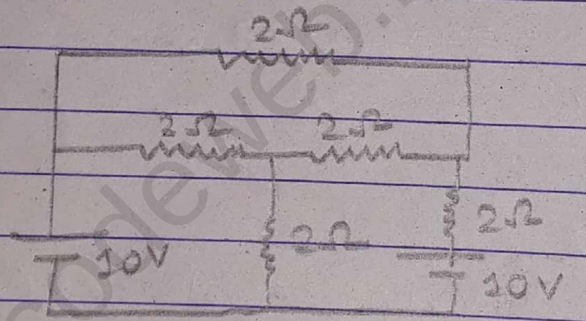
Step 3: circuit diagram of Thevenin's theorem



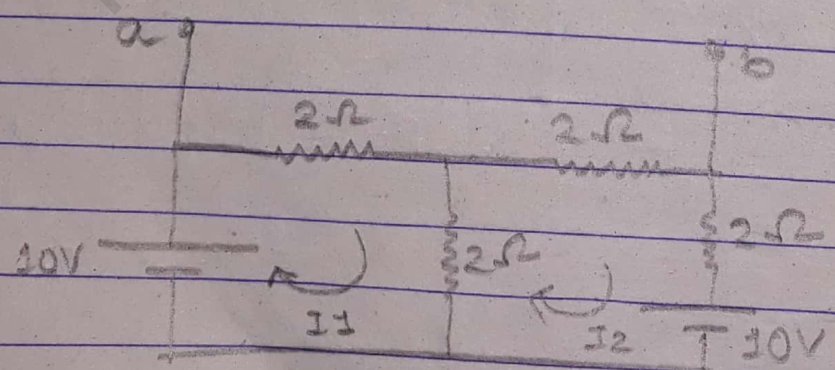
$$I_L = \frac{V_{Th}}{R_{Th}+R_L} = \frac{107}{6.72+13} = \frac{107}{19.72} = 5.42A$$

$$V_{13} = I_{13} \times R_L = 5.42 \times 13 = 70.46V$$

Q.4 Find the power dissipated by 2 Ω resistor by using Thevenin's theorem



Step 1: Calculate Thevenin's theorem (V_{Th})



KVL for loop I,

$$10 - 2I_1 - 2I_1 + 2I_2 = 0$$

$$-4I_1 + 2I_2 = -10 \quad \text{(i)}$$

KVL for loop II,

$$10 - 2I_2 + 2I_1 - 2I_2 - 2I_2 = 0$$

or, $-6I_2 + 2I_1 = -10 \quad \text{(ii)}$

Solving (i) & (ii) we get,

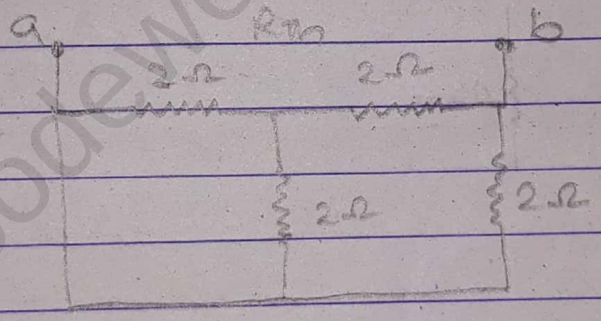
$$I_1 = 2A$$

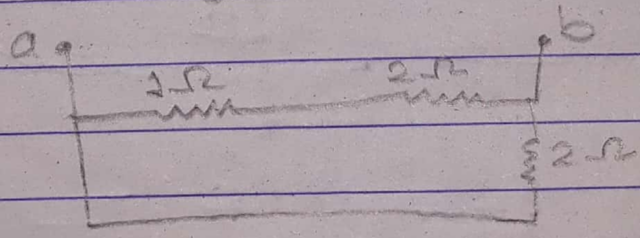
$$I_2 = -1A$$

$$V_{ab} = -2I_1 - 2I_2$$
$$= -2\times 2 - 2\times(-1)$$
$$= -4+2$$
$$= -2V$$

$$V_{Th} = |V_{Th}| = 2V$$

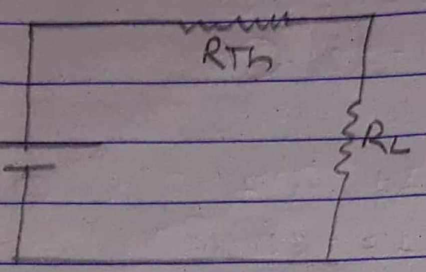
Step 2: Calculate Thevenin's theorem (R_{Th})





$$R_{Th} = 3 \parallel 2$$
$$= \frac{3\times 2}{3+2} = \frac{6}{5} = 1.2\,\Omega$$

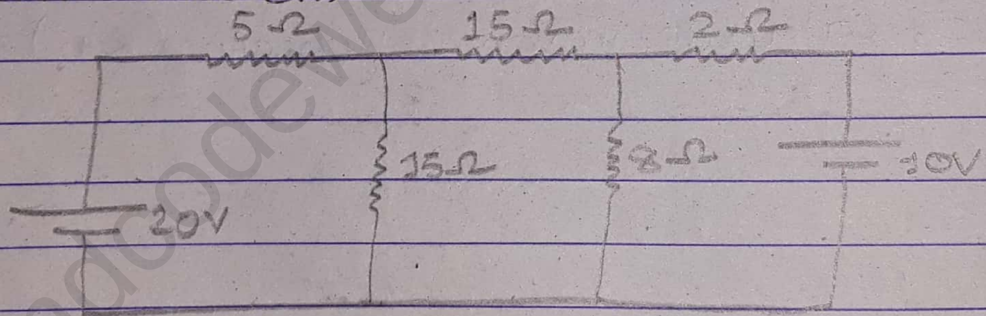
Step 3 : Circuit diagram of thevenin's theorem.



$$I_L = \frac{V_{Th}}{R_{Th} + R_L} = \frac{2}{1.2+2} = \frac{2}{3.2} = 0.625A$$

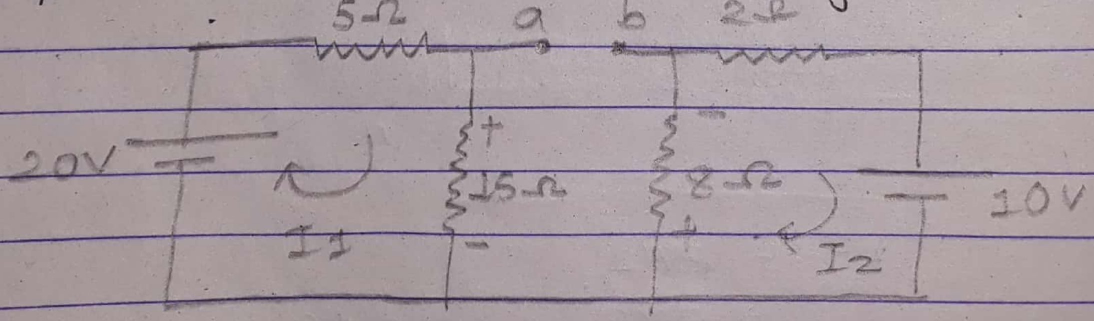
$$P_{2\Omega} = (I_{2\Omega})^2 \times R_L$$
$$= (0.625)^2 \times 2$$
$$= 0.78 \text{ watt}$$

Q.5 Find the power dissipated by 15Ω resistor by using thevenin's theorem.



Soln:-

Step 1 :- Calculate thevenin's voltage (V_{Th}/V_{ab})



KVL for loop I,

$$20 - 5I_1 - 15I_1 = 0$$

$$-20I_1 = -20$$

$$I_1 = 1A$$

KVL for loop II,

$$-8I_2 - 2I_2 - 10 = 0$$

$$-10I_2 = +10$$

$$I_2 = -1A$$

$$V_{Th} = -15I_1 - 8I_2$$

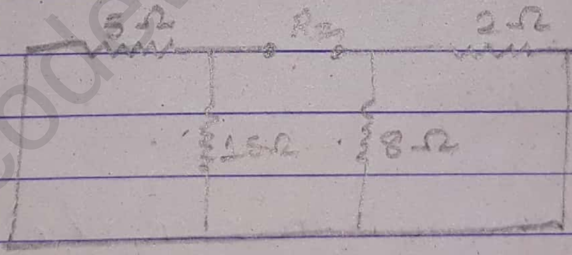
$$= -15 \times 1 + 8$$

$$= -15 + 8$$

$$= -7V$$

$$V_{Th} = |-7| = 7V$$

step 2: calculate thevenin's resistance (R_{Th})



$$R_{Th} = [(5 \parallel 15) + (8 \parallel 2)]$$

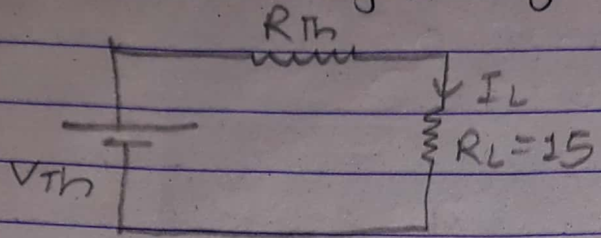
$$= \left[\frac{5 \times 15}{5+15} + \frac{8 \times 2}{8+2}\right]$$

$$= \left[\frac{75}{20} + \frac{16}{10}\right]$$

$$= [3.75 + 1.6]$$

$$= 5.35\,\Omega$$

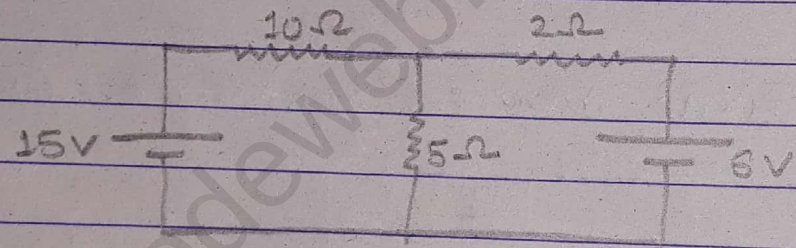
Step 3 :- circuit diagram of Thevenin's theorem



$$I_L = \frac{V_{Th}}{R_{Th}+R_L} = \frac{7}{5.35+15} = \frac{7}{20.35} = 0.34A$$

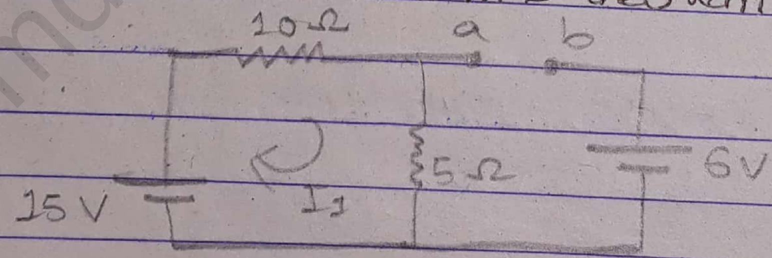
$$P_{15} = (I_{15})^2 \times R_L$$
$$= (0.34)^2 \times 15$$
$$= 1.734 \text{ watt.}$$

Q.6 Find the current through 2 Ω resistor using thevenin's theorem.



Soln:

Step 1:- Calculate thevenin's theorem (V_{Th})



KVL for loop I,

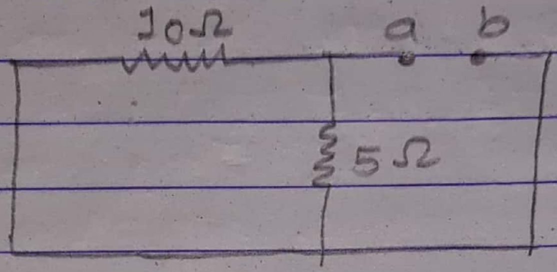
$$15 - 10I_1 - 5I_1 = 0$$
$$15 - 15I_1 = 0$$
$$I_1 = 1A$$

$$V_{Th} = -5I_1 + 6$$

$$= -5 \times 1 + 6$$

$$V_{Th} = 1V$$

Step 2: calculate thevenin's resistance (R_{Th})



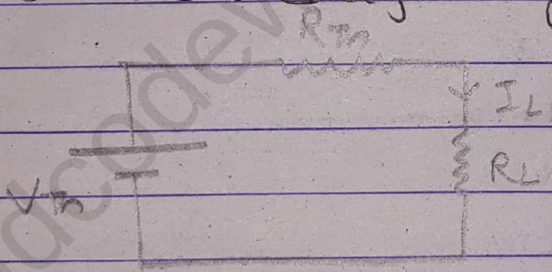
$$R_{Th} = 10 \parallel 5$$

$$= \frac{10 \times 5}{10 + 5}$$

$$= \frac{50}{15}$$

$$= 3.33\Omega$$

Step 3: circuit diagram of thevenin's theorem



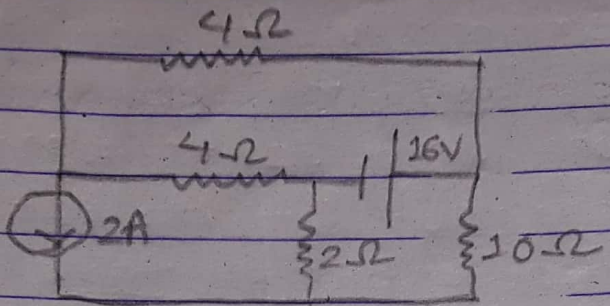
$$I_{2\Omega} = I_L = \frac{V_{Th}}{R_{Th} + R_L}$$

$$= \frac{1}{3.33 + 2}$$

$$= \frac{1}{5.33}$$

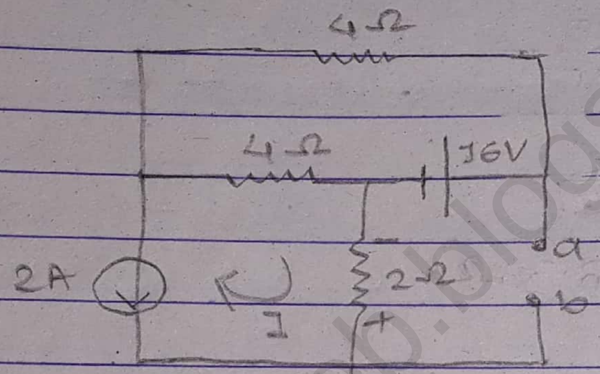
$$= 0.187A$$

Q.7 find voltage across 10 Ω resistor using Thevenin's theorem.



Soln:-

Step 1: Calculate thevenin's voltage (V_{Th})



$I = 2A$

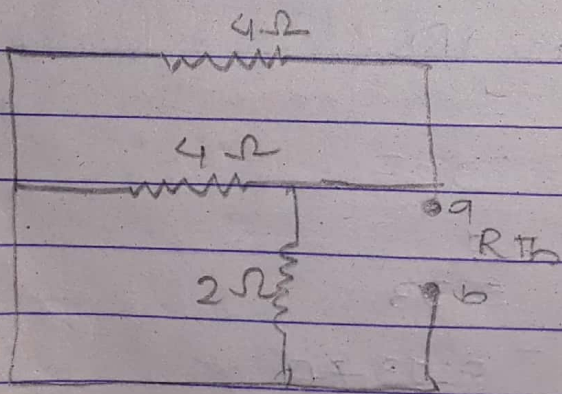
$V_{Th} = -16 + 2 \times 2$

$= -16 + 4$

$= -12V$

$V_{Th} = |V_{Th}| = 12V$

Step 2: calculate thevenin's resistance (R_{Th})



$$R_{th} = (4 \parallel 4) \parallel 2$$

$$= \left(\frac{4 \times 4}{4+4}\right) \parallel 2$$

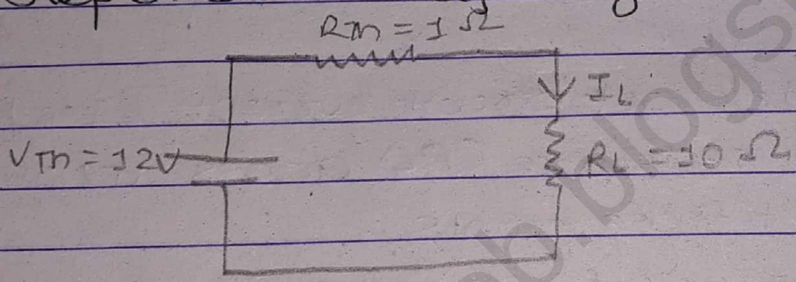
$$= \left(\frac{16}{8}\right) \parallel 2$$

$$= 2 \parallel 2$$

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

$$\therefore R_{th} = 1\,\Omega$$

Step 3: circuit diagram of thevenin's theorem



$$I_L = \frac{V_{Th}}{R_{th} + R_L} = \frac{12}{1+10} = \frac{12}{11} = 1.09A$$

Again,

$$V_{2\Omega} = I_L \times R_L$$

$$= 1.09 \times 10$$

$$= 10.90V$$

→

2) Norton's Theorem

Statements:- "Any two points across a resistance of a network can be replaced by an equivalent current source together with shunt resistance. The current source is equal to the short current circuit across the two point & shunt resistance is equal to the equivalent resistance looking back into the network from the two terminal with all sources replaced by their internal resistances."

* How to nortanize a circuit?

Step I :- Calculate short circuit current [Isc / In]

a) Remove the load resistance (RL) across the two points and short circuit those points.

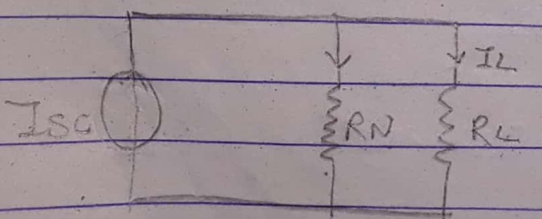
b) calculate the current flowing through those points

Step II :- Calculate the equivalent resistance of the network (RN)

a) All voltage source are short leaving behind their internal resistance.

b) All current source are open circuit leaving behind their internal resistance.

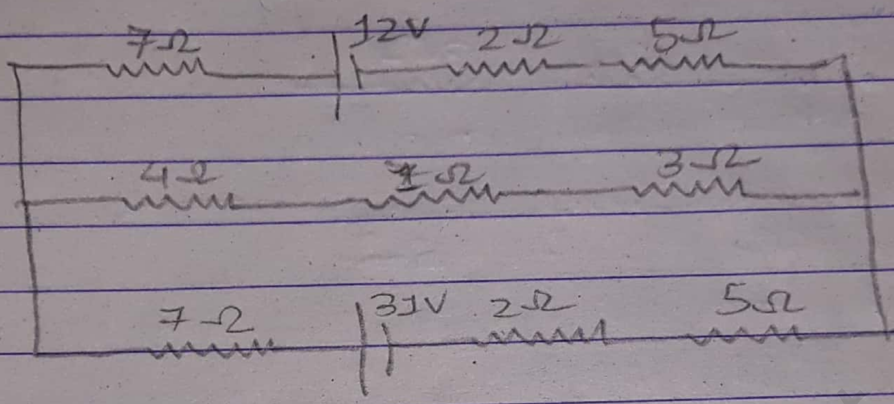
Step III :- Circuit diagram of Norton's theorem is



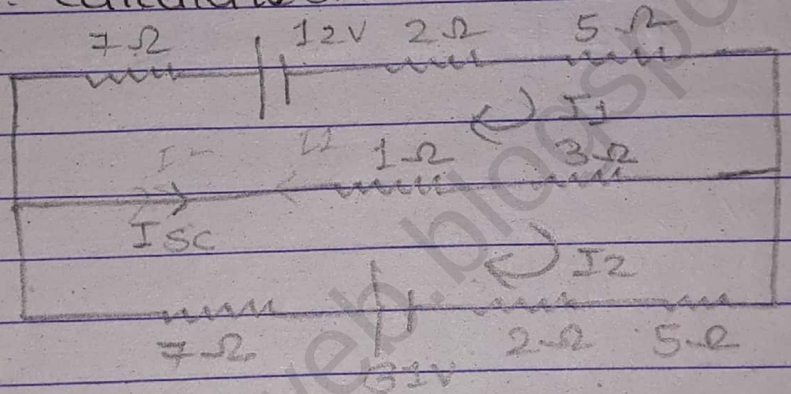
$$I_L = \frac{R_N}{R_N + R_L} \times I_{sc}$$

E.g. Find the power dissipated by 4Ω resistor by using Norton's theorem.

a:>



Step I :- Calculate short circuit current (I_{SC}/I_N)



KVL for loop 1,

$$-7I_1 - 12 - 7I_1 - 4(I_1 - I_2) = 0$$

$$-18I_1 + 4I_2 = 12 \quad \text{(i)}$$

KVL for loop 2,

$$-7I_2 + 31 - 7I_2 - 4(I_2 - I_1) = 0$$

$$\therefore 4I_1 - 18I_2 = -31 \quad \text{(ii)}$$

on solving (i) & (ii)

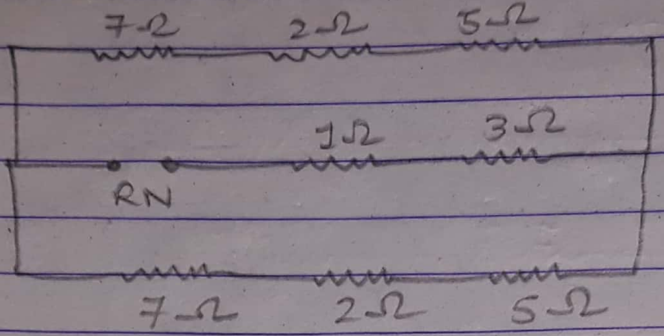
$$I_1 = -0.29A$$

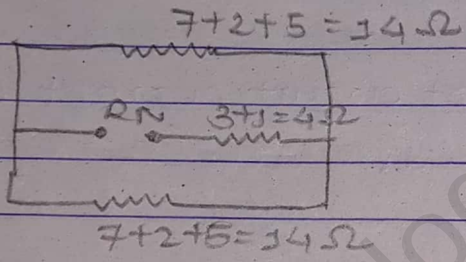
$$I_2 = 1.65A$$

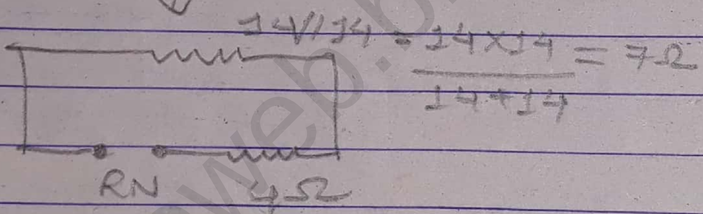
$$I_{SC} = I_2 - I_1 = 1.65 - (-0.29A)$$

$$= 1.94A$$

Step II: Calculate Norton's resistance (R_N)

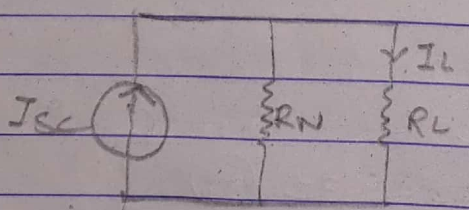






$R_N = 7+4 = 11\ \Omega$

Step III: Circuit diagram of Norton's theorem



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

$$= \frac{11}{11+4} \times 1.94 = 1.42A$$