Charge: The charge is considered as the quantity of Electricity.

Unit of charge is Coulomb [C]

Current: Rate of flow of charge in an electric circuit due to drift of Electrons.

Current is given by, $I = \frac{dq}{dt} = \frac{Q}{t}$.

Unit of current is Ampere (A).

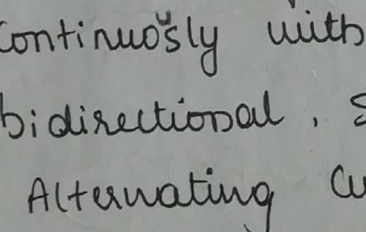
Types of Electric Current:

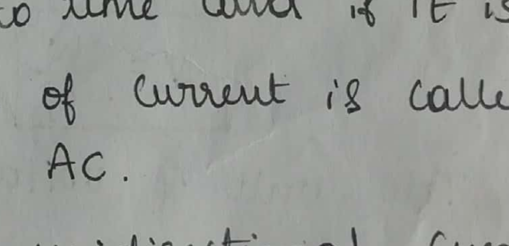
If the flow of current remains same in one direction only, it is called Unidirectional Current.

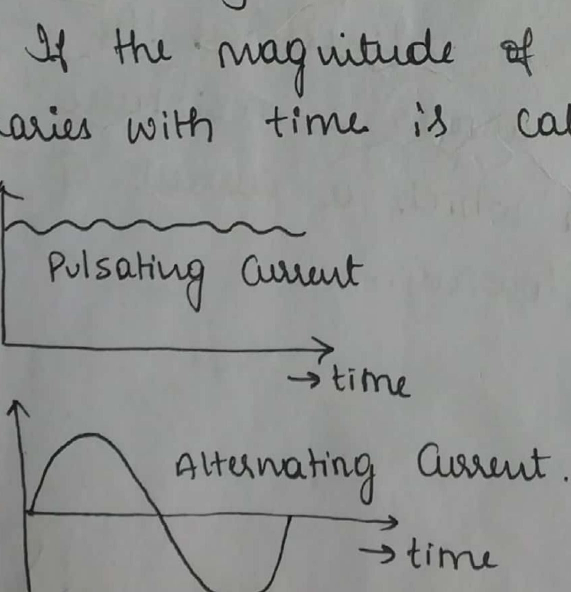
If the magnitude of the unidirectional current remains constant with time, it is called direct current or DC.

If the magnitude of the current varies continuously with respect to time and if it is bidirectional, such type of current is called Alternating Current or AC.

If the magnitude of unidirectional current varies with time is called pulsating current.







Current density [J]: The current density in a conductor carrying current is the current per unit area of the cross section of the conductor.

Unit of current density is ampere/metre^2 [A/m^2]

The current density is given by

$$\boxed{J = \frac{I}{A}} \ A/m^2$$

Potential difference: The potential difference between any two points of charged conductor is the amount of work that has to be done to bring a unit positive charge from a point of lower potential to the point of higher potential.

The unit of potential difference is Volt.

If the energy required to move a charge of 'Q' Coulomb from point 'A' to point B is 'w' joules, the voltage 'V' between A & B is given as,

$$\boxed{V = \frac{W}{Q}}$$

The unit of voltage is Volts [V]

Volt [V]: One volt is defined as the potential difference across a resistance of one ohm, through which a current of one ampere is flowing.

Electric field in a Conductor:

When a battery is connected across two ends of a conductor, an electric field is set up at every point within the conductor. Hence the electrons keep flowing in the conductor. The flow of these electrons constitutes an electric current.

Unit of electric field is Volt/metre [V/m].

Electrical Energy:

Total amount of electrical work done in an electrical circuit.

Unit of energy is Joules [J]

Electrical Energy = Power x time

= $V \times I\, t$ Joules or watt sec

$P = V \times I$

Practically energy is measured in kWh

1Wh = 3600 Joules or W.s

1kWh = 3600 X 1000 Joules = 3.6×10^6 Joules.

Electrical Power:

The rate at which electrical work is done in an electrical circuit.

The Unit of Power is watt [W]

$P = VI$.

Note: Horse Power (hp) is also used as a unit of Power.

$\boxed{1\ hp = 746\ W}$

Electromotive Force [EMF] :

Emf of a source is the energy imparted by the source to each coulomb of charge passing through it.

Emf is not a force, but its is the energy expended on each charge.

$$E = \frac{W}{Q} \ J/C$$

where $E \rightarrow$ Energy imparted by the source

$Q \rightarrow$ charge transferred through the source in coulomb.

Difference between emf & Potential difference

The emf of a device is a measure of the energy the battery gives to each coulomb of charge.

The potential difference between two points is a measure of the energy used by one coulomb in moving drom one point to another.

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DC CIRCUITS.

OHM'S LAW :

It states that the potential difference between the two ends of a conductor is directly proportional to the current flowing through it, provided its temperature and other physical parameters remain unchanged.

$$V \propto I \quad \text{or} \quad V = IR.$$

Constant of proportionality R is called resistance of conductor.

Resistance : The unit ohm is defined as the resistance which permits a flow of one ampere of current when a potential difference of one volt is applied to the resistance.

$$I \propto V \quad \text{or} \quad I = GV$$

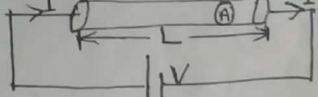
G → constant, called as conductance.

$\boxed{G = \frac{1}{R}}$ The conductance is reciprocal of the resistance

The SI unit of conductance is siemen [S].

The resistance, or opposition to the flow of current through a conductor depends on how narrow is its cross section and how long is its length.
In other words, the electrical resistance of a conductor is directly proportional to its length [L] and inversely proportional to its area of cross section [A].

$$R \propto \frac{L}{A} \quad \text{or} \quad R = \rho \cdot \frac{L}{A}$$



ρ → Constant, known as resistivity of the material.
The unit of resistivity is ohm metre [Ω m].

Limitations of ohm's Law:

i) It does not holds good for non linear devices such as semi conductor & zener diodes.

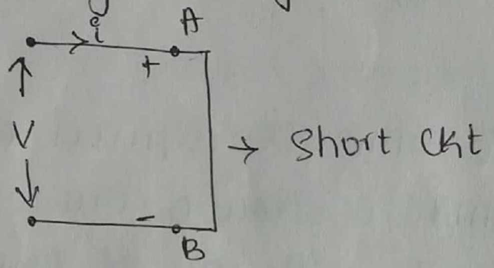
ii) It is not applicable to non metallic conductors.

iii) Cannot be applied to arc lamps.

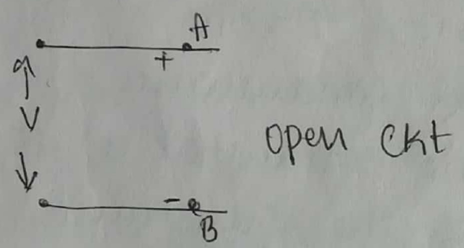
iv) Does not holds good when temperature raises rapidly.

Short Circuit & Open Circuit:

A short circuit permits current to flow without any resulting voltage ($v=0$, $R=0$, $i \neq 0$).



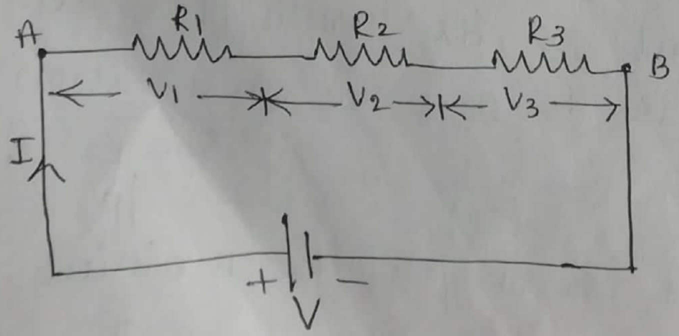
An open circuit permits voltage with no current ($R=\infty$, $v \neq 0$, $i=0$).



No power is required for the short ckt or open ckt.

Series Combination of Resistances:

Two or more resistances are said to be connected in series, if same current flows through them But there will be voltage drop across each resistor (element).

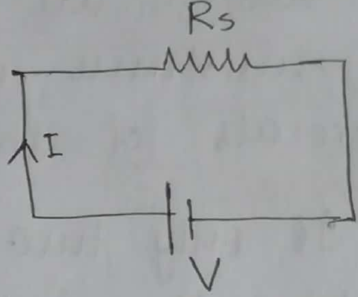


The applied voltage V must be equal to sum of three individual voltages. (voltage drops)

$$V = V_1 + V_2 + V_3$$

$$= IR_1 + IR_2 + IR_3$$

$$V = I(R_1 + R_2 + R_3) \rightarrow ①$$



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

$$\boxed{R_s = R_1 + R_2 + R_3} \rightarrow ②$$

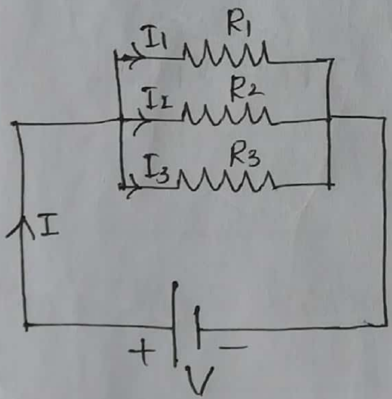
Thus, the equivalent resistance of a number of resistance connected in series is equal to the sum of individual resistances

Substitute ② in ①.

$$\boxed{V = IR_s}$$

Parallel Combination of Resistances:

All the starting point and ending point of resistors are shorted and given to a voltage source in series, same voltage exists across all the resistors. The current drawn by each resistor is different.



The total current I entering the circuit divides into I_1, I_2, & I_3.

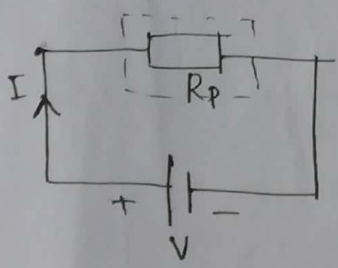
$$I = I_1 + I_2 + I_3$$

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

$\because V = IR$

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

$$I = V\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$$



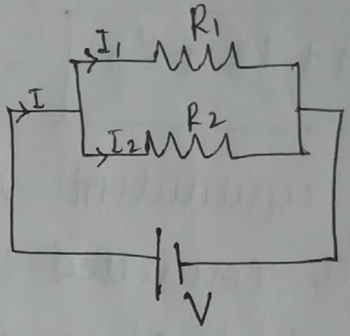
$$\frac{I}{V} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

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

When resistors are connected in parallel, the total resistance is equal to sum of the reciprocals of the individual resistances.

If only two resistors are connected in parallel, the equivalent resistance is given by,

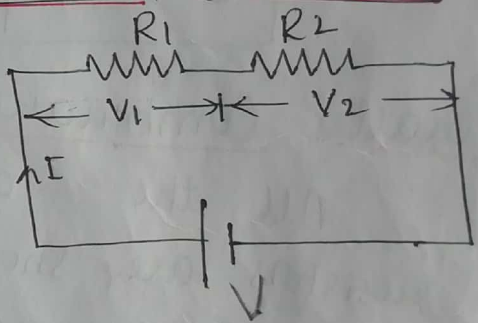
$$\frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2}$$



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

$$\boxed{R_p = \frac{R_1 R_2}{R_1 + R_2}}$$

Voltage division in two Resistors (In Series)



The total resistance

$$R = R_1 + R_2$$

Current in the ckt,

$$I = \frac{V}{R} = \left(\frac{V}{R_1 + R_2}\right) \rightarrow ①$$

(V_1) The vtg drop across R_1, $V_1 = IR_1 \longrightarrow ②$

Replace equ ① in ②

$$IR_1 = \left(\frac{V}{R_1 + R_2}\right) \cdot R_1$$

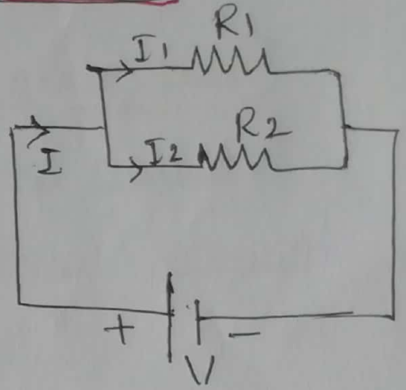
$IR_1 = V_1$

$$V_1 = \frac{V \cdot R_1}{R_1 + R_2}$$

$$V_2 = \frac{VR_2}{R_1 + R_2}$$

Current division in parallel Circuits

The current through R_1 is I_1.



$$\boxed{I_1 = \frac{V}{R_1}} \longrightarrow (1)$$

Current through R_2 is I_2,

$$\boxed{I_2 = \frac{V}{R_2}} \longrightarrow (2)$$

$\div$ (1) by (2)

$$\frac{I_1}{I_2} = \frac{\cancel{V}/R_1}{\cancel{V}/R_2} = \frac{R_2}{R_1}$$

$$\boxed{\frac{I_1}{I_2} = \frac{R_2}{R_1}} \longrightarrow (3)$$

$$I = I_1 + I_2$$
$$I_2 = I - I_1$$
$$I_1 = I - I_2$$

$$\frac{I_1}{I - I_1} = \frac{R_2}{R_1}$$

$$\boxed{I_1 = \frac{R_2(I - I_1)}{R_1}} \qquad \boxed{I_2 = \frac{R_1(I - I_2)}{R_2}}$$

$$I_1R_1 = R_2 I - R_2 I_1 \qquad I_2R_2 = R_1 I - R_1 I_2$$

$$I_1(R_1 + R_2) = R_2 I \qquad I_2(R_2 + R_1) = R_1 I$$

$$\boxed{I_1 = \frac{IR_2}{R_1 + R_2}} \qquad \boxed{I_2 = \frac{IR_1}{R_1 + R_2}}$$

For ckts having three resistors in parallel,

$$I_1 = I\left[\frac{R_2R_3}{R_1R_2 + R_2R_3 + R_3R_1}\right]$$

$$I_2 = I\left[\frac{R_1R_3}{R_1R_2 + R_2R_3 + R_3R_1}\right]$$

$$I_3 = I\left[\frac{R_1R_2}{R_1R_2 + R_2R_3 + R_3R_1}\right]$$

Kirchoff's Laws :

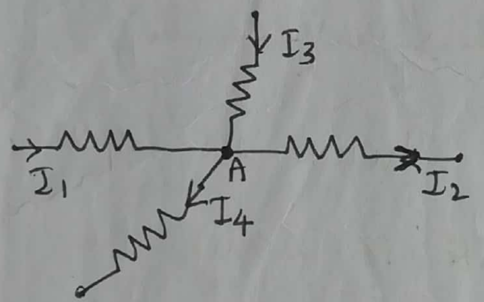
Kirchoff's first law : [Current or Node law]

" the algebraic sum of all the currents meeting at junction of an electrical circuit is zero."

or

" The sum of incoming currents towards any point is equal to the sum of outgoing currents away from that point."

Figure shows the junction 'A' of an electric ckt at which four currents I_1, I_2, I_3 & I_4 meet. All the currents entering the junction are taken as +ve and all the currents leaving the junction are taken as −ve.



According to KCL,

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

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

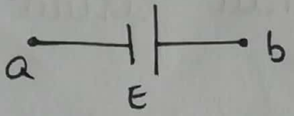
Kirchoff's Second Law : [Voltage law]

" In any closed electrical circuit, the algebraic sum of products of currents & Resistances [vtg drop] plus the algebraic sum of all the emf's in the circuit is zero.

Algebraic Sum of emf's + Algebraic sum of vtg drops = 0

$$\therefore \Sigma E + \Sigma IR = 0 .$$

All the voltage rises are taken as +ve
all the voltage drops are takes as −ve.
Figure represents a battery of emf E volts
connected between two points a & b
which can be traced from



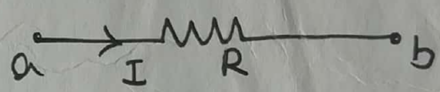
a to b or from b to a
when it is traced from a to b [−ve to +ve],
it is a voltage rise. Hence emf is +ve.

∴ E_{ab} is positive.

when the battery is traced from b to a
[+ve to −ve], it is a voltage fall. Hence
emf is −ve.

∴ E_{ba} is Negative.

Consider a resistor R connected between
two points a & b,



through which a
current I is flowing as shown in figure.
The voltage drop (V_{ab}) = IR is along the
direction of current. It is a voltage fall
hence −ve.

The voltage drop (V_{ba}) = IR is against
the direction of the current. It is a vtg rise
and hence positive.

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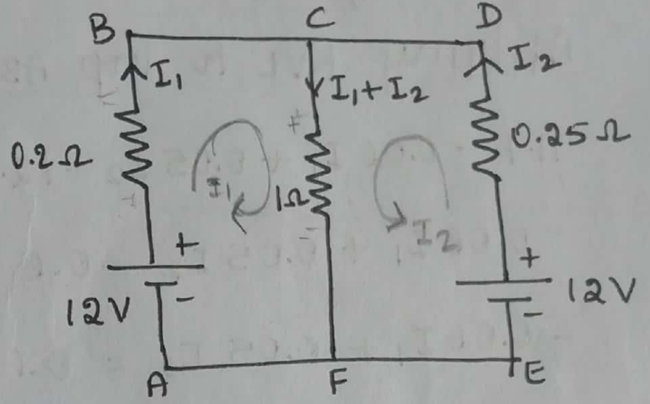
Numerical:

1. Two 12V batteries with internal resistances 0.2 Ω and 0.25 Ω respectively are joined in parallel and a resistance of 1 Ω is placed across the terminals. Find the current supplied by each battery.



Applying KVL to the loop BCFAB,

$$12 - 0.2I_1 - 1(I_1 + I_2) = 0$$

$$12 - 1.2I_1 - I_2 = 0$$

$$1.2I_1 + I_2 = 12 \longrightarrow (1)$$

for the loop CDEFC,

$$12 - 0.25I_2 - 1(I_1 + I_2) = 0$$

$$12 - 1.25I_2 - I_1 = 0$$

$$1.25I_2 + I_1 = 12 \quad \text{(or)}$$

$$I_1 + 1.25I_2 = 12 \longrightarrow (2)$$

Solving eqn (1) & (2)

$I_1 = 6A$

$I_2 = 4.8A$

$$\cancel{1.2}I_1 + I_2 = 12$$

$$(I_1 + 1.25I_2 = 12) \times 1.2$$

$$\underline{\overset{(-)}{}\cancel{1.2}I_1 \overset{(-)}{+} 1.5I_2 = \overset{(-)}{}14.4}$$

$$-0.5I_2 = -2.4$$

$$\boxed{I_2 = 4.8}\,A$$

Substitute in eqn (1).

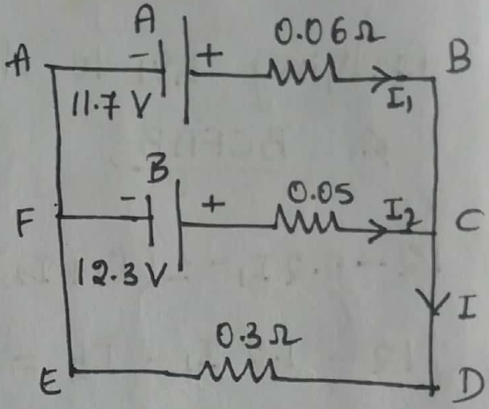
$$1.2I_1 + 4.8 = 12$$

$$1.2I_1 = 7.2$$

$$\boxed{I_1 = 6A}$$

2. Two storage batteries A & B are connected in parallel to supply a load of 0.30Ω. The open ckt emf of A is 11.7V and that of B is 12.3V. The internal resistances are 0.06Ω and 0.05Ω respectively. Find the current supplied to the load.

Applying KVL to loop ABCFA,



$$11.7 - 0.06 I_1 + 0.05 I_2 - 12.3 = 0$$

$$-0.06 I_1 + 0.05 I_2 - 0.6 = 0$$

$$-0.06 I_1 + 0.05 I_2 = 0.6 \rightarrow (1)$$

For the loop FCDEF,

$$12.3 - 0.05 I_2 - 0.3 I = 0$$

WKT, $I = I_1 + I_2$

$$12.3 - 0.05 I_2 - 0.3(I_1 + I_2) = 0$$

$$12.3 - 0.05 I_2 - 0.3 I_1 - 0.3 I_2 = 0$$

$$0.3 I_1 + 0.35 I_2 = 12.3 \rightarrow (2)$$

Solving eqn (1) & (2)

we get, $I_1 = 11.25$ A

$I_2 = 25.50$ A.

Current supplied to the load

i.e $I = I_1 + I_2$

$I = 11.25 + 25.50$

$$\boxed{I = 36.75 \text{ A}}$$

$-0.06 I_1 + 0.05 I_2 = 0.6$

or

$0.06 I_1 - 0.05 I_2 = -0.6 \quad \times 5$

$0.30 I_1 - 0.25 I_2 = -3.0$

$0.30 I_1 + 0.35 I_2 = 12.3$

$-0.6 I_2 = -15.3$

$$\boxed{I_2 = 25.5 \text{ A}}$$

Substitute in (2)

$0.3 I_1 + 0.35 \times 25.5 = 12.3$

$$\boxed{I_1 = 11.25 \text{ A}}$$

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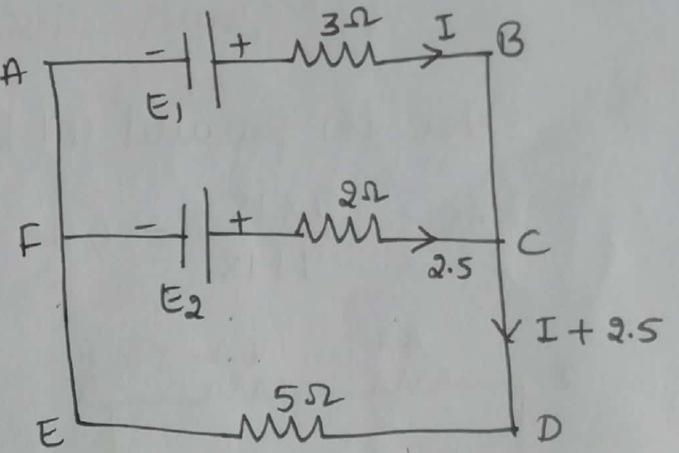
3. In the ckt shown, find E_1 & E_2 and current I when power dissipated in 5Ω resistor is 125 W.



Applying KVL to loop ABCFA,

$$E_1 - 3I + 2\times 2.5 - E_2 = 0$$

$$-3I + 5 + E_1 - E_2 = 0$$

$$3I - 5 = E_1 - E_2 \longrightarrow (1)$$

For the loop CDEFC

$$E_2 - 2\times 2.5 - 5(I+2.5) = 0$$

$$E_2 - 5 - 5I - 12.5 = 0$$

$$E_2 - 5I - 17.5 = 0$$

$$5I + 17.5 = E_2 \longrightarrow (2)$$

given that, the current through 5Ω resistor

$I' = I + 2.5$ & power dissipated $P = 125$ W,

$$P = I^2 R$$

$$125 = (I+2.5)^2 \times 5$$

$$(I+2.5)^2 = 25$$

$$I + 2.5 = 5$$

$$\boxed{I = 2.5\text{ A}} \longrightarrow (3)$$

Substitute (3) in (2)

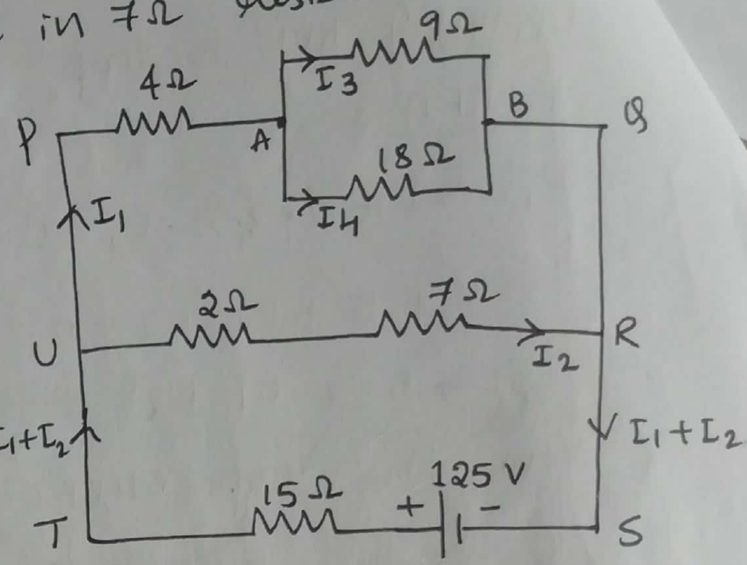
$$5\times 2.5 + 17.5 = E_2$$

$$\boxed{E_2 = 30\text{ V}} \longrightarrow (4)$$

Substitute (4) in (1)

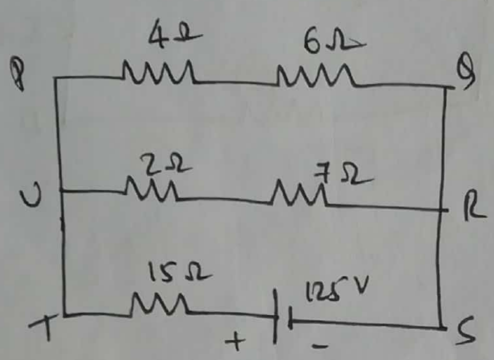
$$\boxed{E_1 = 32.5\text{ V}}$$

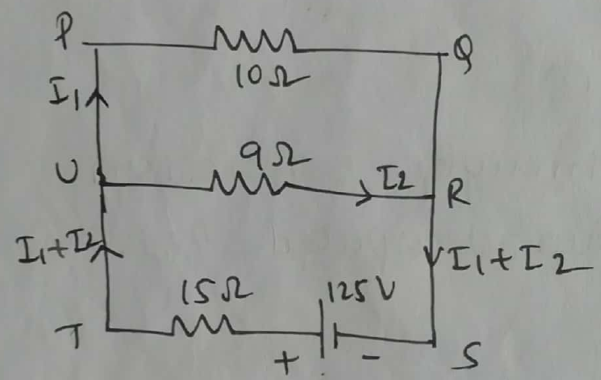
4. Find (i) current in 15Ω resistor
(ii) vtg across 18Ω resistor &
(iii) Power dissipated in 7Ω resistor.



Solve for parallel ckt R_{AB},

$$R_{AB} = \frac{9 \times 18}{9+18} = 6\Omega$$





Applying KVL to PQRUP,

$$-10I_1 + 9I_2 = 0 \rightarrow (1)$$

For loop RSTUR,

$$125 - 15(I_1+I_2) - 9I_2 = 0$$

$$125 - 15I_1 - 15I_2 - 9I_2 = 0$$

$$15I_1 + 24I_2 = 125 \rightarrow (2)$$

By solving (1) & (2)

$$\boxed{\begin{aligned} I_1 &= 3\,A \\ I_2 &= 3.33\,A \end{aligned}}$$

(i) Current in 15Ω resistor is

$$I = I_1 + I_2$$

$$= 3 + 3.33 = \underline{6.33\,A}.$$

(ii)

$$I_4 = \frac{I_1 \times 9}{9+18} = \frac{3 \times 9}{9+18}$$

$$\underline{I_4 = 1\,A}$$

vtg across 18Ω resistor is

$$V_{18} = I_4 \times R = 1 \times 18 = \underline{18V}$$

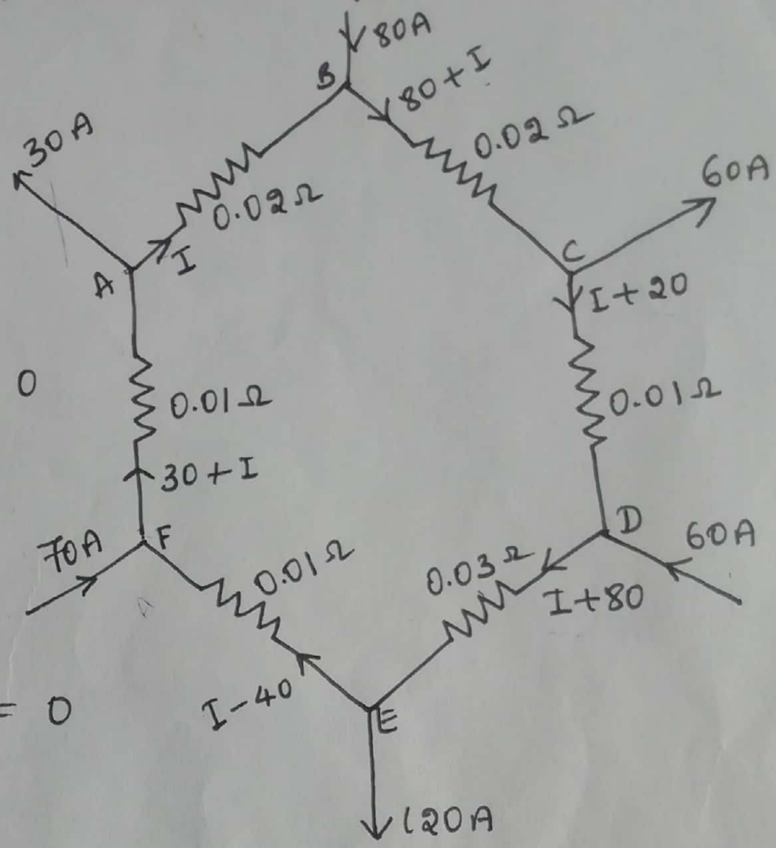
(iii)

$$P = I_2^2 R$$

$$= (3.33)^2 \cdot 7$$

$$\boxed{P = 77.62\ W}$$

Find the current in all branches of the network shown.



$I \times 0.02 + (80+I)0.02$

$+ (I+20)0.01 + (I+80)\times 0.03$

$+ (I-40)0.01 + (I+30)\times 0.01 = 0$

$0.02I + 1.6 + 0.02I +$

$0.01I + 0.2 + 0.03I + 2.4$

$+ 0.01I - 0.4 + 0.01I + 0.3 = 0$

$0.1I + 4.1 = 0$

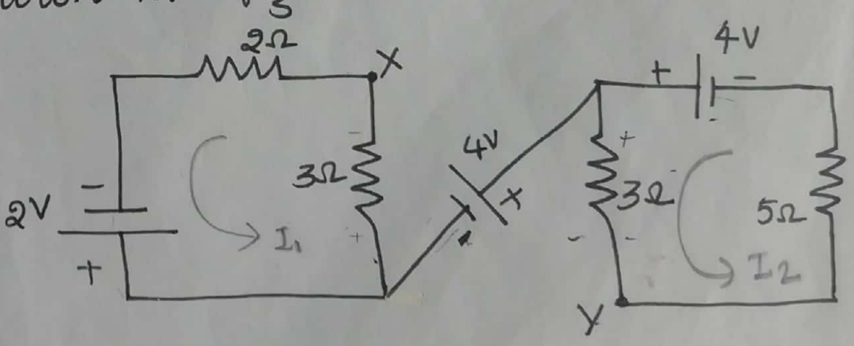
$I = \frac{-4.1}{0.1}$

$\boxed{I = -41\ A}$

Here, the direction of current assumed is clockwise and answer is - 41 A.

If we assume direction of current in anticlockwise, then current $I = 41\ A$.

6. Find the potential difference between points X & Y in the network shown in fig.



$I_1 = \frac{2}{2+3} = 0.4A$

$I_2 = \frac{4}{3+5} = 0.5A$

$\therefore V_{XY} = 3I_2 - 4 - 3I_1$

$= 3\times 0.5 - 4 - 3\times 0.4$

$\boxed{V_{XY} = -3.7\ V.}$

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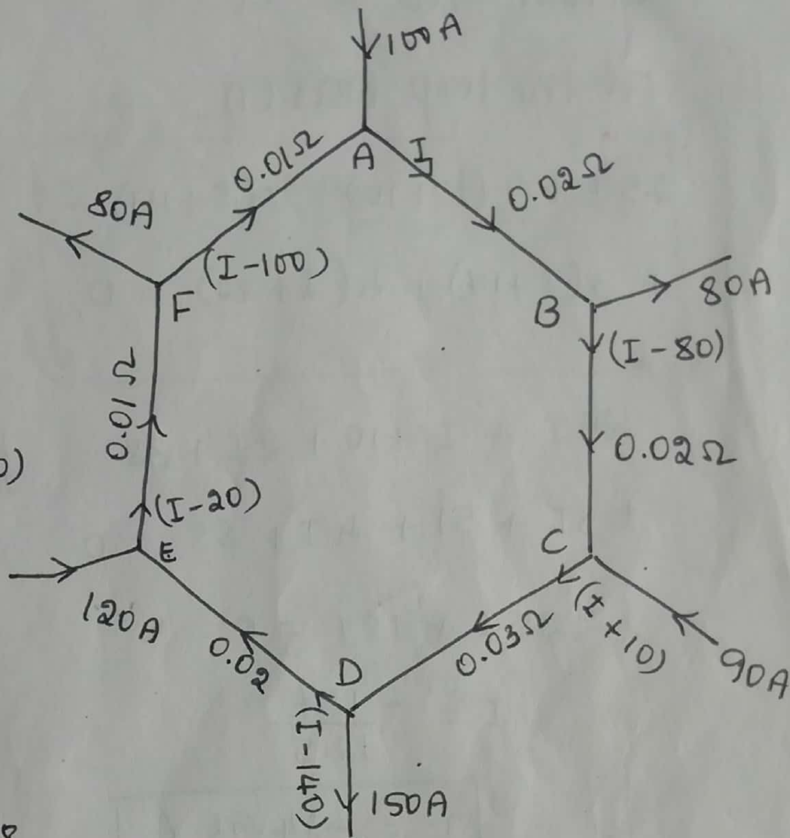
1. Find the currents in the various branches of the given network.

For the loop ABCDEFA,



$0.02I + 0.02(I-80) +$

$0.03(I+10) + 0.02(I-140)$

$+ 0.01(I-20) + 0.01(I-100)$

$= 0$

$0.02I + 0.02I - 1.6 +$

$0.03I + 0.3 + 0.02I - 2.8$

$+ 0.01I - 0.2 + 0.01I - 1 = 0$

$0.11I - 5.3 = 0$

$I = \frac{5.3}{0.11}$

$\boxed{I = 48.18 \text{ A}}$

$I_{AB} = 48.18 \text{ A}.$

$I_{BC} = I - 80 = -31.82 \text{ A}$

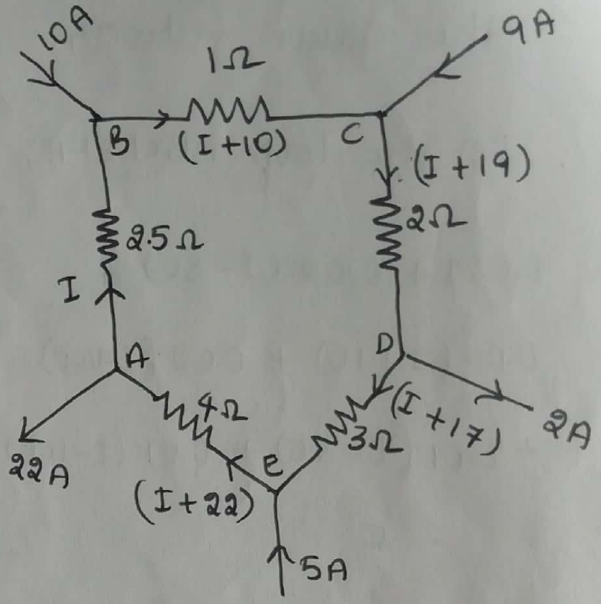
$I_{CD} = I + 10 = 58.18 \text{ A}$

$I_{DE} = I - 140 = -91.82 \text{ A}$

$I_{EF} = I - 20 = 28.18 \text{ A}$

$I_{FA} = I - 100 = -51.82 \text{ A}$

2. For the following figure, find the currents in all the branches and potential difference across AD & CE.



For the loop ABCDEA,

$2.5I + 1(I+10) + 2(I+19)$

$+ 3(I+17) + 4(I+22) = 0$

$2.5I + I + 10 + 2I + 38$

$+ 3I + 51 + 4I + 88 = 0$

$12.5I + 187 = 0$

$$I = \frac{-187}{12.5}$$

$$\boxed{I = -14.96\ A}$$

$I_{AB} = I = -14.96\ A$

$I_{BC} = I+10 = -4.96\ A$

$I_{CD} = I+19 = 4.04\ A$

$I_{DE} = I+17 = 2.04\ A$

$I_{EA} = I+22 = 7.04A$

$V_{AD} = 3(I+17) + 4(I+22)$

$\cancel{= 3I - 51 - 4I - 88}$

Substitute value of I in above eqn.

$V_{AD} = 3(-14.96+17) + 4(-14.96+22)$.

$$\boxed{V_{AD} = -34.28\ V}$$

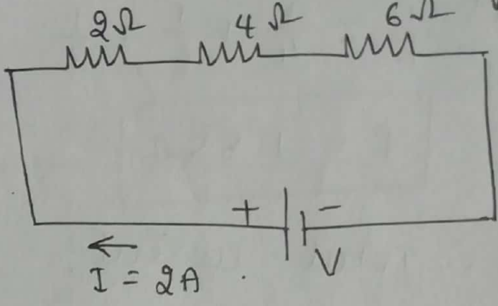
$V_{CE} = +2(I+19) + 3(I+17)$

$= 2(-14.96+19) + 3(-14.96+17)$

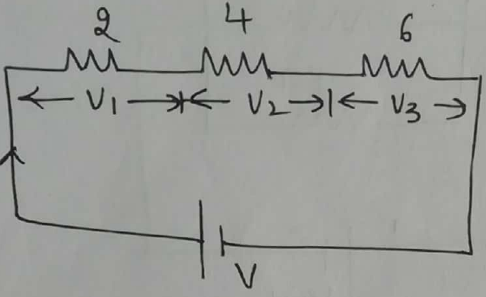
$$\boxed{V_{CE} = -14.2\ V}$$

Numericals on Series ckt & parallel ckt

1) Calculate the voltage across each of the resistors shown in fig. and then calculate the supply voltage V.



Soln:



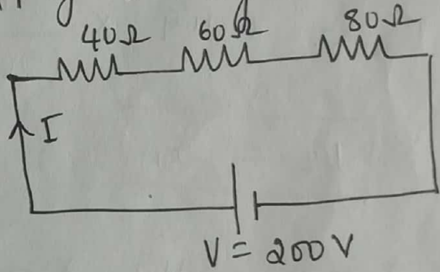
$V_1 = IR_1 = 2 \times 2 = 4V$

$V_2 = IR_2 = 2 \times 4 = 8V$

$V_3 = IR_3 = 2 \times 6 = 12V$

$\therefore$ Supply Vtg, $V = V_1 + V_2 + V_3 = 4 + 8 + 12 = 24V.$

2. For the circuit shown in fig. find the ckt current, given that the supply voltage is 200V.



Soln: Total resistance

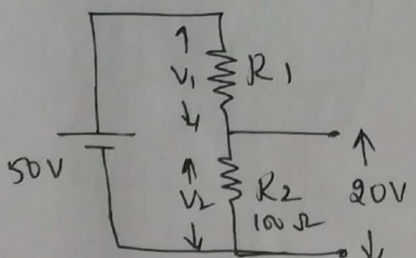
$R_T = (40 + 60 + 80)$

$= 180\Omega$

$\therefore$ The circuit current, $I = \frac{200}{180} = 1.11 A.$

3. In the voltage divider of fig shown, V is given as 50V and the voltage across R_2 (100Ω) is 20V.

Calculate the value of R_1.



$V_2 = V \cdot \frac{R_2}{R_1 + R_2}$

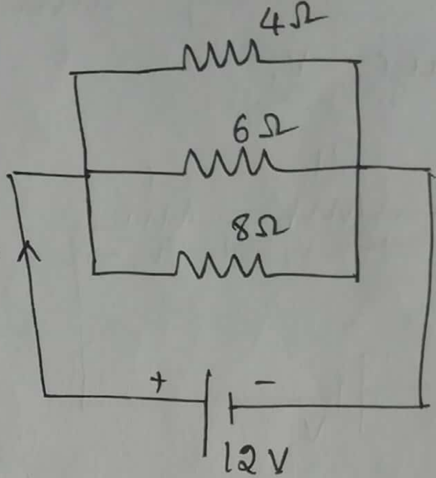
$20 = 50 \times \frac{100}{R_1 + 100}$

$R_1 + 100 = \frac{50 \times 100}{20}$

$R_1 = 250 - 100$

$\boxed{R_1 = 150\Omega}$

4. Find the effective resistance and the Su current to the circuit of fig shown below. and also calculate the branch currents.



Soln:

$$\frac{1}{R} = \frac{1}{4} + \frac{1}{6} + \frac{1}{8}$$

$$\boxed{R = 1.85\Omega}$$

∴ Total current,

$$I = \frac{12}{R} = \frac{12}{1.85} = 6.49\,A$$

$$I_1 = I . \frac{6\times 8}{4\times 6 + 6\times 8 + 8\times 4}$$

$$= 6.49 \times \frac{48}{(24 + 48 + 32)}$$

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

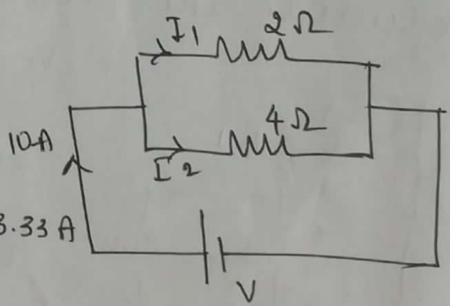
$$I_2 = 6.49 \times \frac{4\times 8}{(24 + 48 + 32)}$$

$$\boxed{I_2 = 2A}$$

$$I_3 = 6.49 \times \frac{4\times 6}{(24 + 48 + 32)}$$

$$\boxed{I_3 = 1.49\,A}$$

5. A current of 10A is divided between two resistors in the ckt. Find the current in each of the two resistors.



Soln:

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

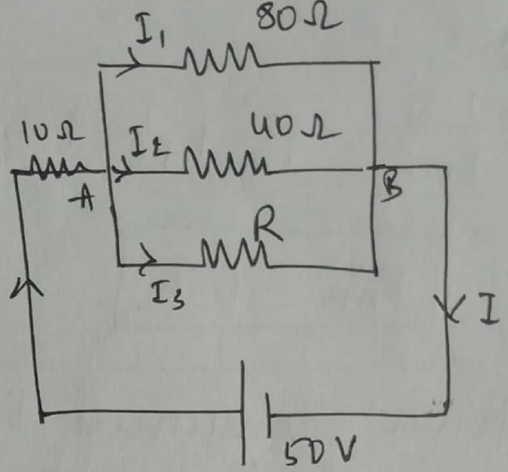
$$= 6.67\,A$$

$$I_2 = (10 - I_1) = 10 - 6.67 = 3.33\,A$$

or $\left[I_2 = 10 \times \frac{2}{2+4} = 3.33\,A \right]$

5. Determine the value of R if the power dissipated in 10Ω resistor is 40W for the ckt shown below.

Soln:



The circuit current flowing through 10Ω resistor is,

$$I^2 = \frac{P}{R}$$

$$= \frac{40}{10}$$

$$I^2 = 4$$

$$\therefore \boxed{I = 2\ A}$$

Vtg drop across the 10Ω resistor $= IR$

$$= 2 \times 10$$

$$= 20V$$

$\therefore$ Vtg drop across AB, $V_{AB} = (50-20) = 30V$

$$\therefore I_1 = \frac{30}{80} = 0.375A.$$

$$I_2 = \frac{30}{40} = 0.750\ A.$$

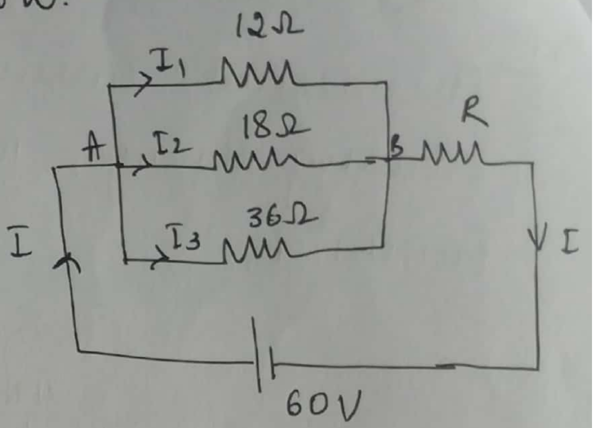
$$I_3 = \frac{30}{R} = 0.874\ A$$

$$I_1 + I_2 + I_3 = I$$

$$0.375 + 0.750 + \frac{30}{R} = 2$$

$$\boxed{R = 34.3\ \Omega}$$

7. In the circuit shown, find the value of resistance R, when the power consumed by the 12Ω resistor is 36 W.



Soln:

$$\frac{1}{R_{AB}} = \frac{1}{12} + \frac{1}{18} + \frac{1}{36}$$

$$\boxed{R_{AB} = 6\Omega}$$

Power consumed by 12Ω resistor is 36W, [12×6]

$P = I_1^2 R$

$36 = I_1^2 \times 12$

$$\boxed{I_1 = 1.732 \text{ A}}$$

Voltage across 12Ω resistor $= I_1 \times 12$

$= 1.732 \times 12$

$= 20.78 \text{ V}$

$\therefore$ $\boxed{V_{AB} = 20.78 \text{ V}}$

Voltage across R $= (60 - 20.78)$

$= 39.22 \text{ V}$

$I_2 = \frac{20.78}{18} = 1.154 \text{ A}$

$I_3 = \frac{20.78}{36} = 0.577 \text{ A}$

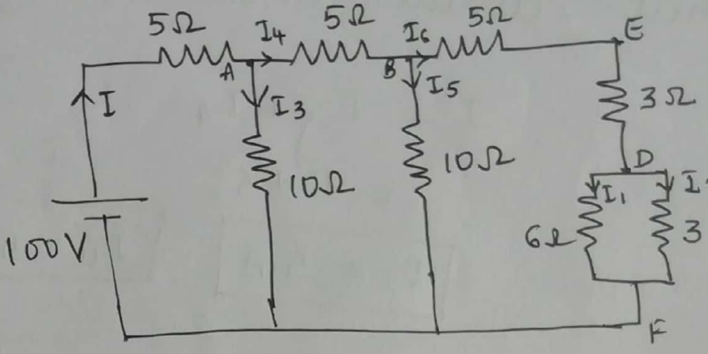
$\therefore$ Total current, $I = I_1 + I_2 + I_3$

$= 1.732 + 1.154 + 0.577$

$\boxed{I = 3.46 \text{ A}}$

$\therefore$ $R = V/I = \frac{39.22}{3.46} = 11.3 \Omega$

8. In the circuit shown in fig. determine
(i) the current supplied by the 100 V source
(ii) the voltage across the 6Ω resistor.



Sol

Soln:

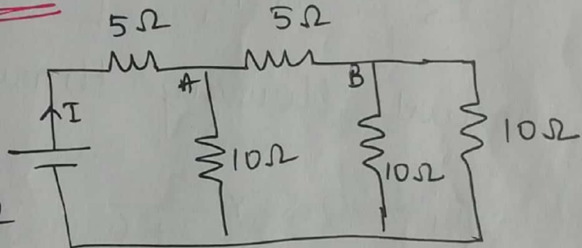
Since 6Ω & 3Ω are in parallel

$$R_{DF} = \frac{3\times6}{3+6} = \frac{18}{9}$$

$$\boxed{R_{DF} = 2\,\Omega}$$

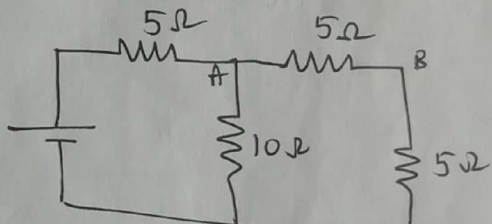
R_{DF} is in series with 3Ω & 5Ω

$= 5+3+2 = 10\,\Omega$



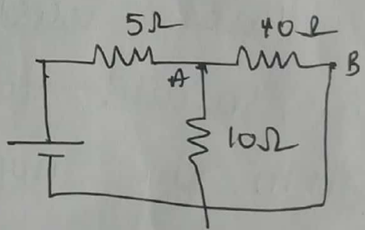
This 10Ω is in parallel with other 10Ω resistance.

$$= \frac{10\times10}{10+10} = \frac{100}{20} = 5\,\Omega$$



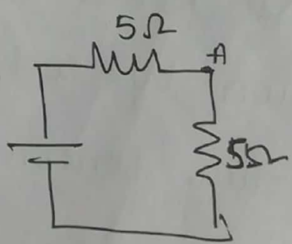
This 5Ω is in series with another 5Ω resistance

$= 5+5 = 10\,\Omega.$



This is in parallel with 10Ω.

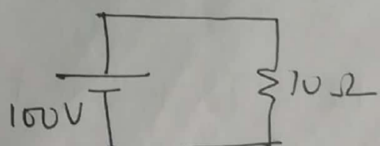
$$\frac{10\times10}{10+10} = 5\,\Omega$$



These two 5Ω are in series

$5+5 = 10\,\Omega$

Current applied by 100 V source



is $= \frac{100}{10} = 10\,A$

WKT $I = I_3 + I_4$

from the ckt diagram, we got to know that current divides equaly as I_3 & I_4

$$I = I_3 + I_4$$
$$= 5 + 5$$

$\boxed{I_3 = 5\,A}$ $\boxed{I_4 = 5A}$.

Aagain at B current divides equally as I_5 & I_6.

$\boxed{I_5 = 2.5\,A}$ $\boxed{I_6 = 2.5A}$

Current flowing through 6Ω resistor

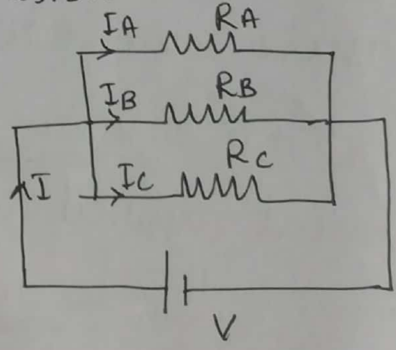
$$I_1 = 2.5 \times \frac{3}{3+6} = 0.833A.$$

voltage across 6Ω resistor is $= 6 \times 0.833\,V$

$= 4.998\,V$

$= 5\,V$

9. Three resistors A, B and C are connected in parallel taking a load current of 12 A from the supply. If $I_B = 2I_A$, $I_C = 3.5 I_B$ and total power drawn is 3 kW, calculate a) Current drawn by each resistor, b) Supply voltage and c) Power consumed by each resistance.



Soln:

$$I = I_A + I_B + I_C$$

$$12 = I_A + 2I_A + 3.5\,I_B$$

$$= 3I_A + 3.5\,(2I_A)$$

$=$

$$3I_A + 7I_A = 12$$

$$10 I_A = 12$$

$$\boxed{I_A = 1.2\ A}$$

We know, $P = VI$

$$3\times10^3 = V \times 12$$

$$\boxed{\therefore V = 250V}$$

$$P_A = VI_A = 250 \times 1.2 = 300W$$

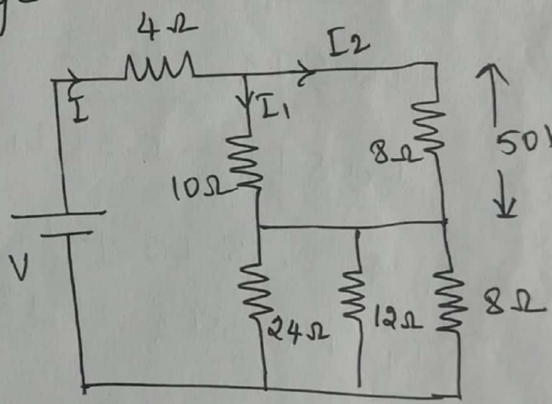
$$P_B = VI_B = 250 \times 2.4 = 600W$$

$$P_C = VI_C = 250 \times 8.4 = 2100W.$$

10. In the circuit shown, Find the

i) voltage drop across 4Ω resistor &

ii) the supply voltage.



Soln:

$$I_1 = \frac{50}{10} = 5A$$

$$I_2 = \frac{50}{8} = 6.25A$$

$$I = I_1 + I_2$$

$$= 5 + 6.25$$

$$\boxed{I = 11.25\ A}$$

i) voltage drop across 4Ω resistor $= 11.25 \times 4$

$$= 45V$$

ii) $24 /\!/ 12\Omega = \dfrac{24\times12}{24+12} = 8\Omega$

$8 /\!/ 8\Omega = \dfrac{8\times8}{8+8} = 4\Omega$

$10 /\!/ 8\Omega = \dfrac{10\times8}{10+8} = 4.44\Omega.$

Total resistance, $R = 4 + 4.44 + 4$

$= 12.44\,\Omega$

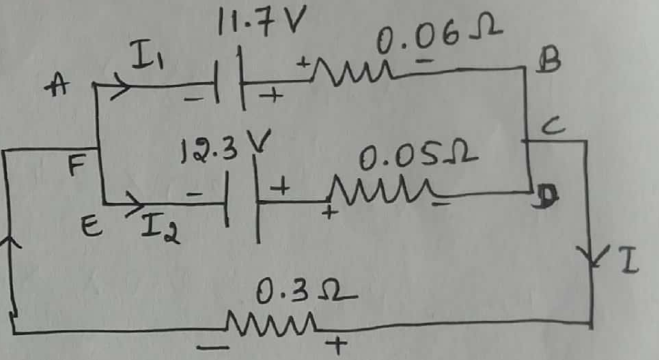
Supply voltage, $V = 12.44 \times I$

$= 12.44 \times 11.25$

$\boxed{V = 140\,V}$

$\boxed{\text{KCL \& KVL}}$

12. Find total current I in the given ckt.



Solⁿ: Apply KVL to the loop : ABCDEFA.

$11.7 - 0.06 I_1 + 0.05 I_2 - 12.3 = 0$

$-0.06 I_1 + 0.05 I_2 - 0.6 = 0$

$-0.06 I_1 + 0.05 I_2 = 0.6 \longrightarrow (1)$

KVL to loop FEDCF

$12.3 - 0.05 I_2 - 0.3 I = 0$ | $I = I_1 + I_2$

$12.3 - 0.05 I_2 - 0.3 (I_1 + I_2) = 0$

$-0.3 I_1 - 0.35 I_2 + 12.3 = 0$

$0.3 I_1 + 0.35 I_2 = 12.3 \longrightarrow (2)$

Solving eqⁿ (1) & (2)

$I_1 = 11.25\,A$ $I_2 = 25.5\,A$

$\therefore$ Total current, $I = (I_1 + I_2)$

$= (11.25 + 25.5)$

$\boxed{I = 36.75\,A}$

DC CIRCUITS

Theory Questions

1. State and explain Ohm's law and discuss its limitations.
2. Sate Kirchhoff's current and voltage law and explain them with the help of an example.

Numericals

1. Two resistors A & B are connected in series across a constant 100V supply. A voltmeter of resistance 10kΩ reads 70V when connected across A, and reads 20V when connected across B. Find the values of A & B using KCL. (Answer: 5kΩ, 1.43kΩ)

2. When a certain battery with internal resistance is loaded by 60Ω resistor, its terminal voltage is 98.4V. When it is loaded by a 90Ω resistor, its terminal voltage is 98.9V. What load resistance would give a terminal voltage of 90V. (Answer: 8.4Ω)

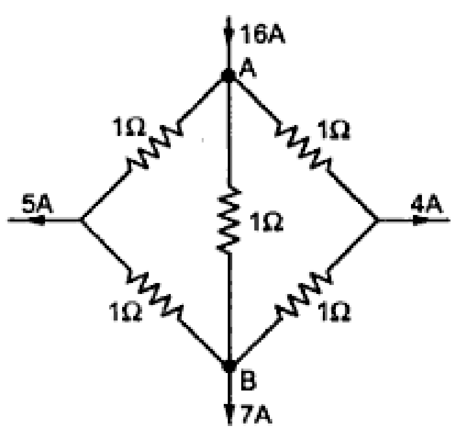
3. Two devices rated 60W, 110V and 40W, 110V are connected in series across 110V dc supply. Find the actual power consumed by each of the load and the total current drawn from the supply. If the loads were connected in parallel across the same supply, what would be the individual powers taken by each of the loads and the total power taken from the source. (Answer: 9.58W, 14.37W, 0.22A, 60W, 40W, 100W)

4. Two batteries of A & B are connected in parallel to supply a load resistance of 1.2Ω. Draw the circuit arrangement. Calculate current in the load and the current supplied by each battery if the emf of A & B are 12.5V & 12.8V respectively. The internal resistance of A being 0.05Ω and that of B is 0.08Ω. (Answer: 4A, 6.25A, 10.25A)

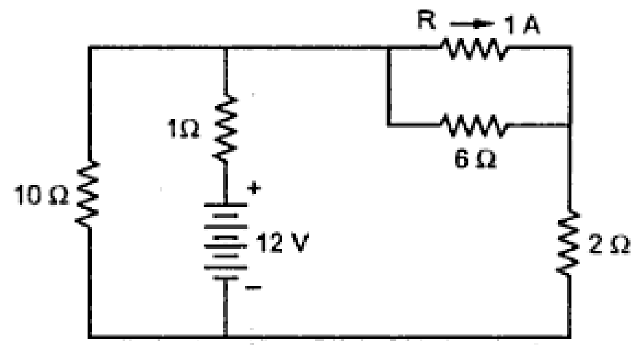
5. Two devices rated 500W, 100V and 256W, 80V has to be connected in parallel across a 100V dc supply. How to design a proper circuit including two safety devices in each branch with its current rating? What will be the total current supplied by the source. (Answer: 5A, 3.2A, 8.2A, 6.25Ω)

6. A 20Ω resistance is joined in parallel with a resistance of RΩ. This combination is then joined in series with a piece of apparatus A and the whole circuit connected to 100V mains. What must be the value of R so that A shall dissipate 600W with 10A passing through it. (Answer: 5Ω)

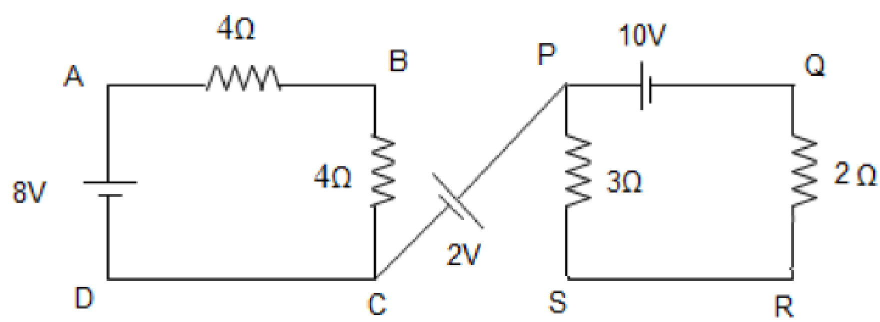
7. Find the current through branch A-B in the circuit shown in the following figure. (Answer: 5.75A)



8. Find the value of 'R' so that 1A would flow in it for the network shown in the following figure. (Answer: 5.38Ω)



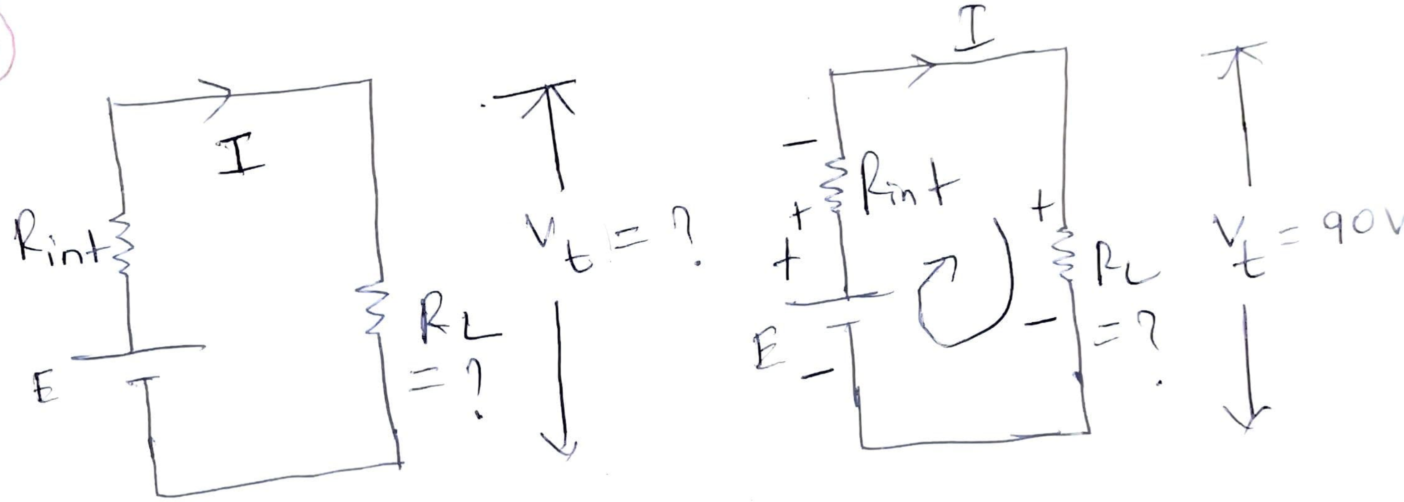
9. Find V_{BS}, V_{AQ} and V_{DR} in the network shown in the following figure. (Answer: 8V, 16V, 4V)



10. Two resistive loads A& B of ratings 100V, 10W and 100V, 2.5W respectively are connected in series across a constant voltage supply of 100V. A voltmeter having an internal resistance of 12kΩ is connected across B. Calculate the voltage across B before and after voltmeter was connected. Also, find the change in supply current when voltmeter is connected. (Answer: 80V, 75V, 5mA)

11. A dc circuit comprises two resistors; resistor A of value 25Ω and resistor B of unknown value connected in parallel, together with a third resistor C of value 5Ω connected in series with the parallel branch. Find the voltage to be applied across the whole circuit and the value of resistor B if the potential difference across C is 90V, and the total power consumed is 4320W. (Answer: 240V, 12.5Ω)

2



$E - I R_{int} - V_t = 0$ KCL → nodal analysis

$E = I R_{int} + V_t$ KVL → Mesh analysis

$$E = \frac{V_t}{R_L} R_{int} + V_t$$

$$E = \frac{98.4}{60} R_{int} + 98.4 \rightarrow \text{Case } (1)$$

$$E = \frac{98.9}{90} R_{int} + 98.9 \rightarrow \text{Case } (2)$$

$$E - 1.64\, R_{int} = 98.4 \rightarrow (1)$$

$$E - 1.1\, R_{int} = 98.9 \rightarrow (2)$$

$R_{int} = 0.925\,\Omega$, $E = 99.91\,V$

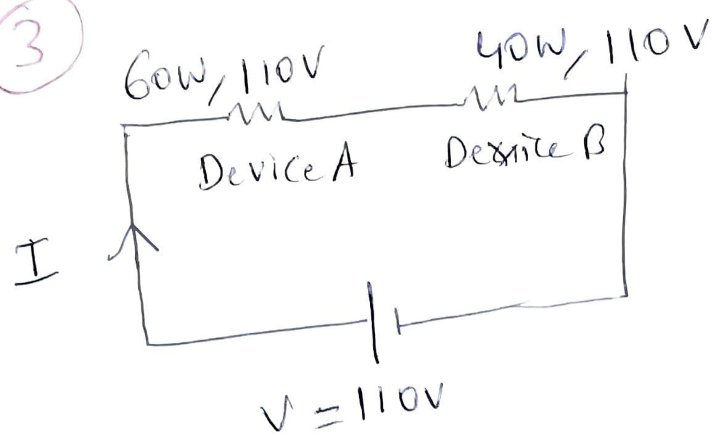
$$E - I R_{int} - V_t = 0$$

$$E = \frac{V_t}{R_L} R_{int} + V_t$$

$$99.91 = \frac{90}{R_L} \times 0.925 + 90$$

$$R_L = 8.387\,\Omega$$

(3)



Case (1) → when loads are in series

For Device A, $R_A = \frac{V^2}{P} = \frac{110^2}{60} = 201.6\,\Omega$

For Device B, $R_B = \frac{110^2}{40} = 302.5\,\Omega$

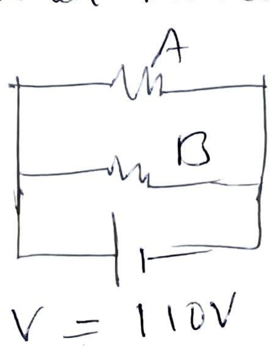
$I = \frac{V}{R_A + R_B} = \frac{110}{201.6 + 302.5}$

$I = 0.218\,A$

$P_A = I^2 R_A = 9.58\,W$

$P_B = I^2 R_B = 14.37\,W$

Case (2) → when Devices are in parallel

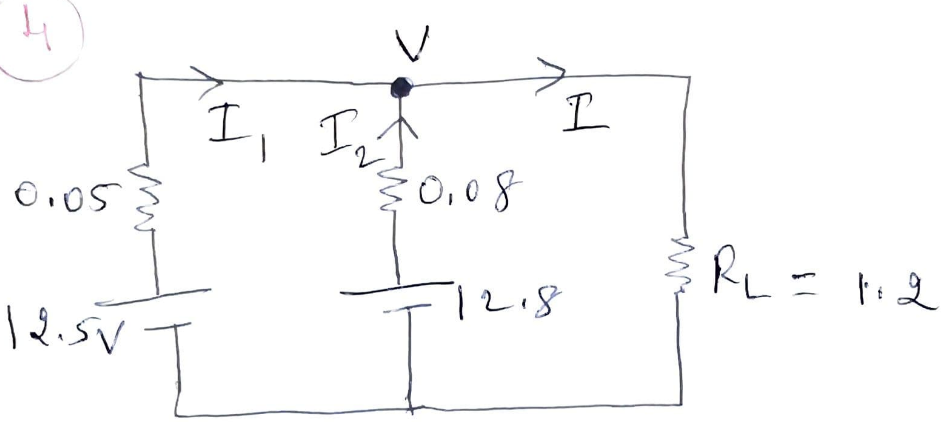


$P_A = \frac{V^2}{R_A} = \frac{110^2}{201.6} = 60\,W$

$P_B = 40\,W$

$P_T = P_A + P_B = 100\,W$

(4)



Apply KCL,

$$I = I_1 + I_2$$

$$\frac{V}{1.2} = \frac{12.5 - V}{0.05} + \frac{12.8 - V}{0.08}$$

$$\underline{\underline{V = 12.3V}}$$

From battery A, $I_1 = \dfrac{12.5 - V}{0.05} = \dfrac{12.5 - 12.3}{0.05} = \underline{\underline{4A}}$

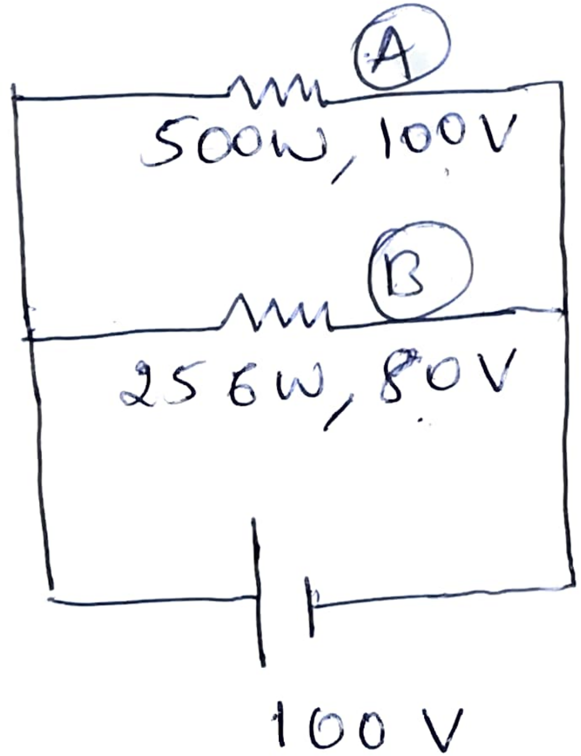
|||ly B, $I_2 = \dfrac{12.8 - V}{0.08} = \dfrac{12.8 - 12.3}{0.08} = \underline{\underline{6.25A}}$

$$I = I_1 + I_2 = 4 + 6.25 = 10.25A$$

(or)

$$I = \frac{V}{1.2} = \frac{12.3}{1.2} = \underline{\underline{10.25A}}$$

5



Device A

$$P = VI$$

$$I_{A\,max} = P/V = \frac{500}{100} = 5A$$

Device B,

$$I_{B\,max} = \frac{256}{80} = 3.2A$$

$$R_B = \frac{V}{I} = \frac{80}{3.2}$$

$$R_B = 25\Omega$$

(5) Continuation

But when 100 volt is applied across device (B) the current is,

$$I_B = \frac{100}{25} = \underline{\underline{4\,A}}$$

w.r.t 80V ⟶ 3.2 A

~~0.8~~ A

w.r.t 100V ⟶ 4 A

∴ Device B will get damage

use Additional resistance in series with device B i.e,

$$R_{ext} = \frac{100-80}{3.2} = \underline{\underline{6.25\,\Omega}}$$

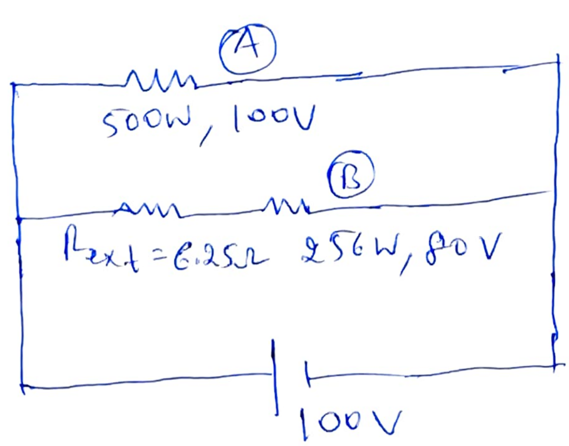
$$V = IR$$

$$R = \frac{V}{I} = \frac{100-80}{3.2} = \underline{\underline{6.25\,\Omega}}$$

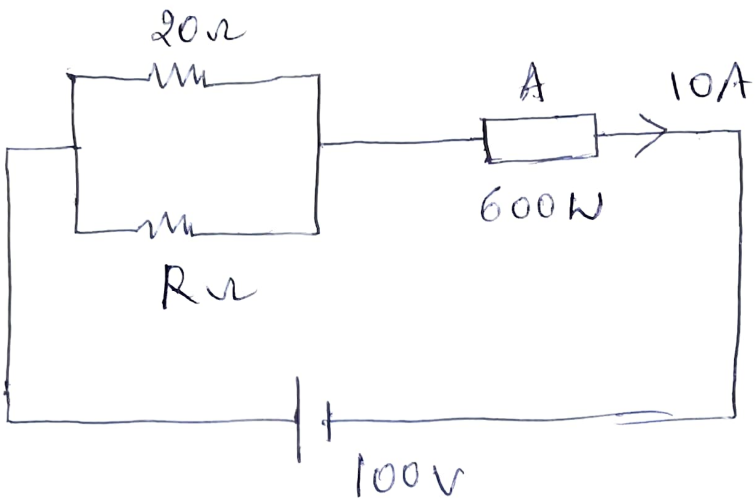
$$I = I_1 =$$

$$I = I_1 + I_2$$

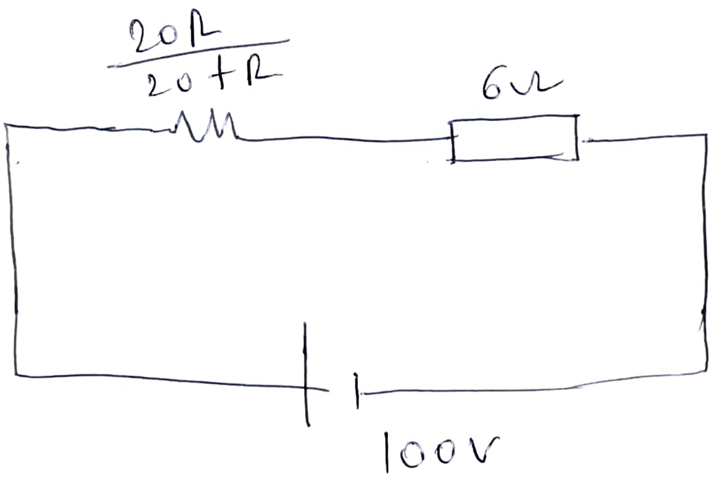
$$= 5 + 3.2 = \underline{\underline{8.2\,A}}$$

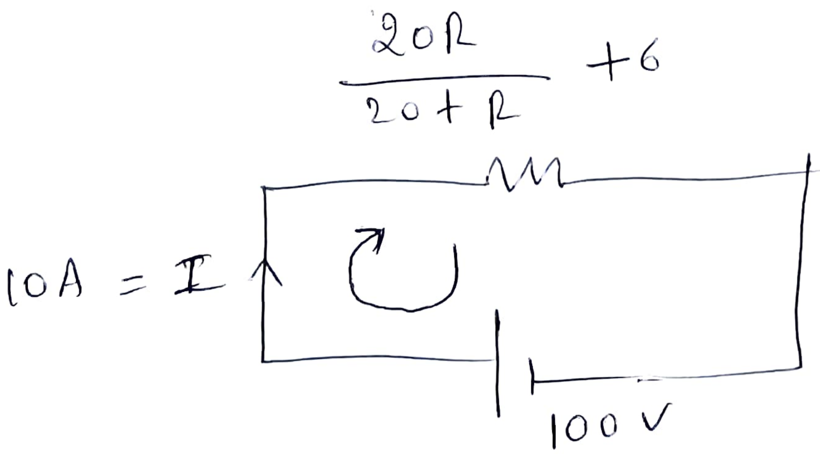


(6)



$$R_A = \frac{600}{I^2} = \frac{600}{10^2} = \underline{\underline{6\,\Omega}}$$

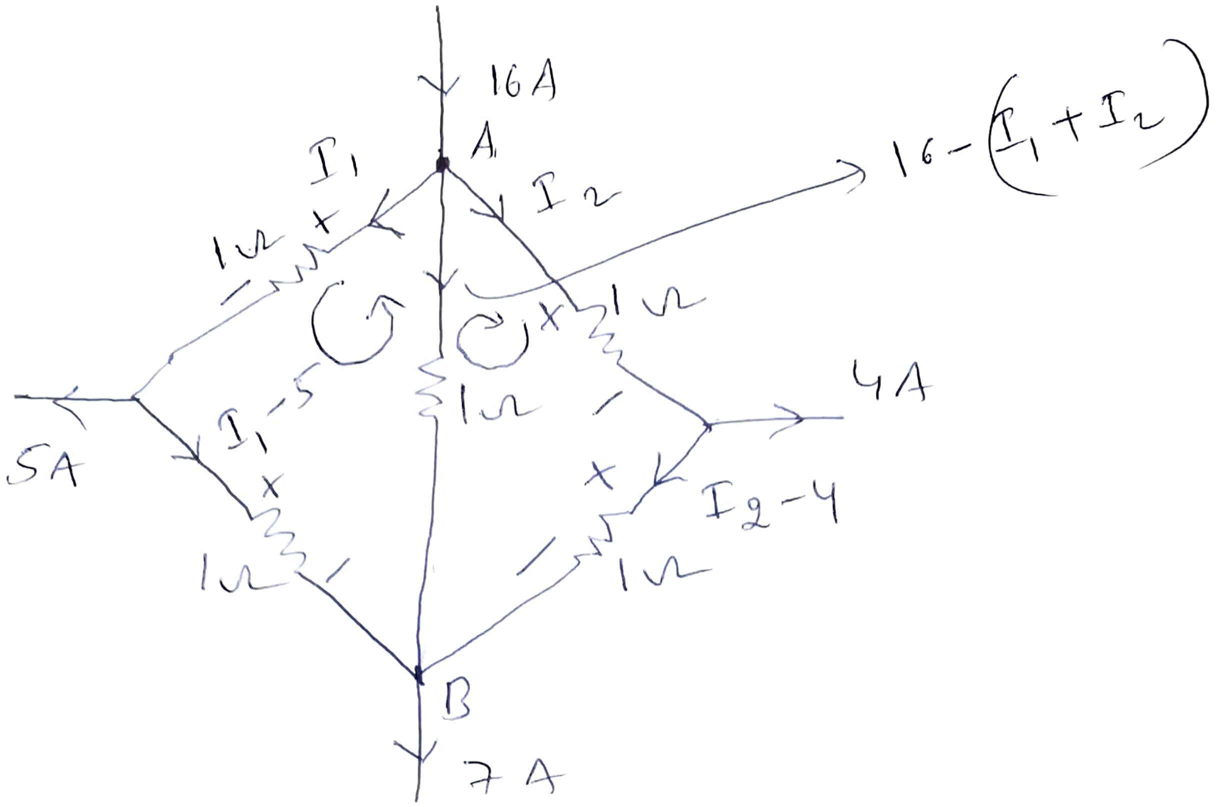




$$100 - \left(\frac{20R}{20+R} + 6\right) \times 10 = 0$$

$$\underline{\underline{R = 5\,\Omega}}$$

(7)



Apply KCL at A,

$$16-(I_1+I_2)=0$$

Apply KVL for I Loop,

$$-1\times I_1 - 1(I_1-5)+16-(I_1+I_2)=0$$

$$3I_1+I_2=21 \longrightarrow (1)$$

Apply KVL for II Loop,

$$-1\times I_2 - 1\times(I_2-4)+16-(I_1+I_2)=0$$

$$3I_2+I_1=20 \longrightarrow (2)$$

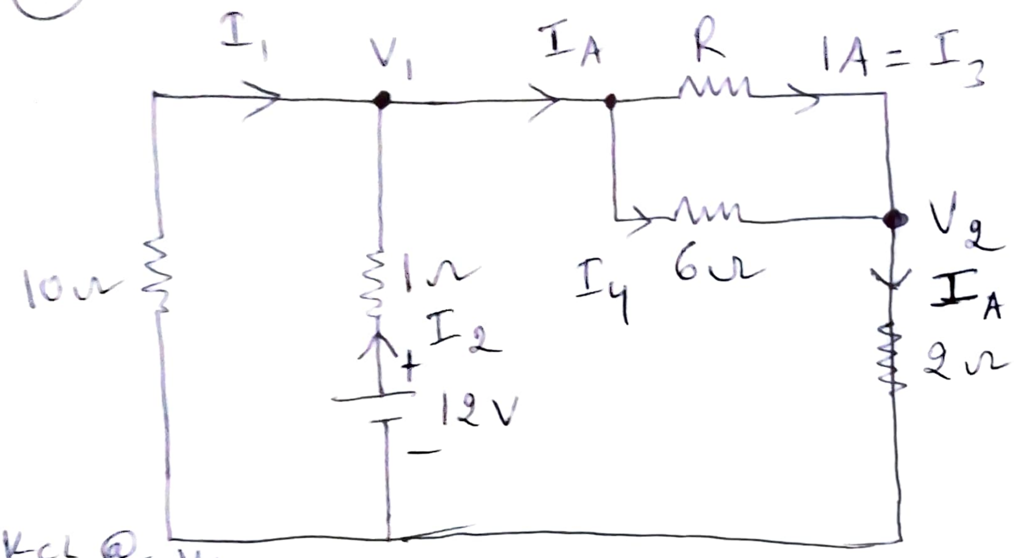
solve (1) & (2),

$$I_1 = 5.375\,A \quad \& \quad I_2 = 4.875\,A$$

Current through Branch AB is, $=16-(I_1+I_2)$

$= 5.75A$

8



KCL @ V_1

$$I_1 + I_2 - I_3 - I_4 = 0 \qquad I_A = I_3 + I_4$$

$$\frac{0 - V_1}{10} + \frac{12 - V_1}{1} = 1 + \frac{V_1 - V_2}{6} \longrightarrow (1)$$

KCL @ V_2

$$\frac{V_1 - V_2}{6} + 1 = \frac{V_2}{2} \longrightarrow (2)$$

solve (1) & (2)

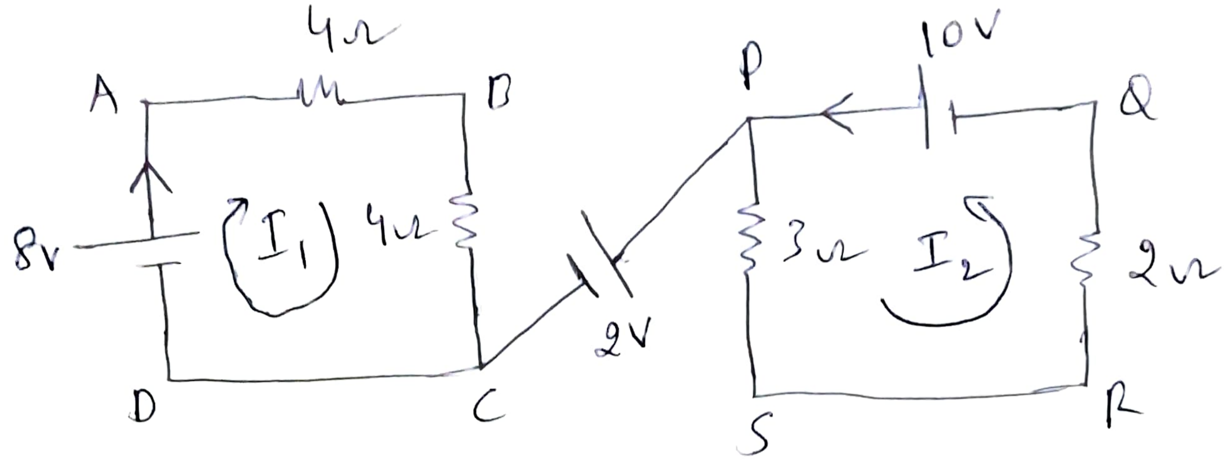
$$-1.266 V_1 + 0.167 V_2 = -11 \longrightarrow (1)$$

$$0.167 V_1 - 0.66 V_2 = -1 \longrightarrow (2)$$

$$V_1 = \underline{\underline{9.16\ V}} \qquad V_2 = \underline{\underline{3.8\ V}}$$

$$R = \frac{V_1 - V_2}{1} = \frac{9.16 - 3.8}{1} = \underline{\underline{5.36\,\Omega}}$$

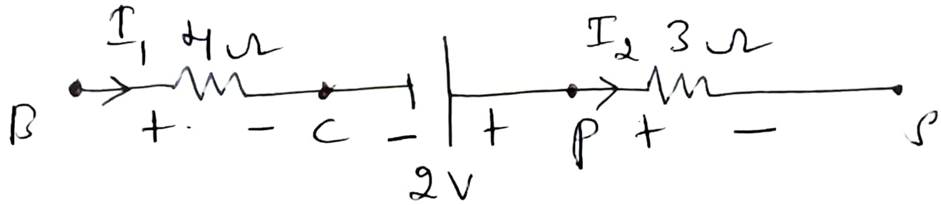
(9)



$I_1 = \frac{8}{4+4} = \underline{1\,A}$ $\quad$ IIIly $\quad I_2 = \frac{10}{3+2} = \underline{2\,A}$

$V_{BS} = ?$, $V_{AQ} = ?$ & $V_{DR} = ?$

$V_{BS} = ?$



$V_{BS} - 4\times 1 + 2 - 3\times 2 = 0$

$V_{BS} = 4 - 2 + 6 = \underline{8\,V}$

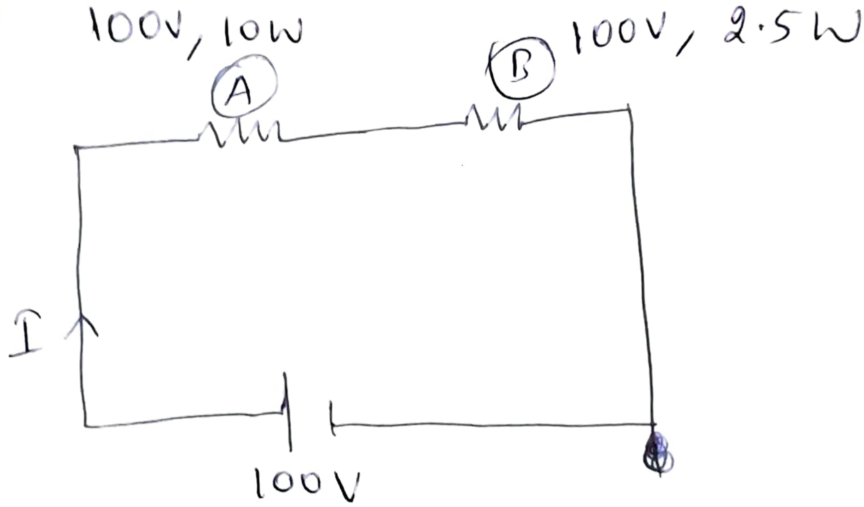
$V_{AQ} - 8 + 2 - 10 = 0$

$V_{AQ} = \underline{16\,V}$

$V_{DR} + 2 - 3\times 2 = 0$

$V_{DR} = \underline{4\,V}$

(10)



from (A), $P = \frac{V^2}{R_A} \Rightarrow R_A = \frac{100^2}{10} = 1\,k\Omega$

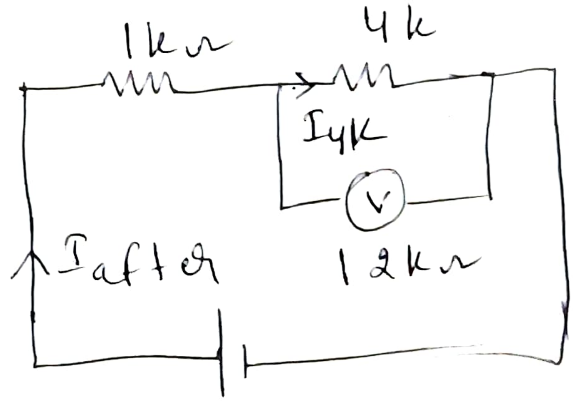
from (B), $R_B = 4\,k\Omega$

$I_{Before} = \frac{100}{5 \times 10^3} = \underline{20\,mA}$

$(V_{Before})_B = I R_B = 20 \times 10^{-3} \times 4 \times 10^3$

$= \underline{80V}$

$(V_{After})_B = ?$



$R_{Tot} = 1k + \frac{4k \times 12k}{4k + 12k}$

$R_{Tot} = \underline{4\,k\Omega}$

$I_{after} = \frac{100}{4k} = \underline{25\,mA}$

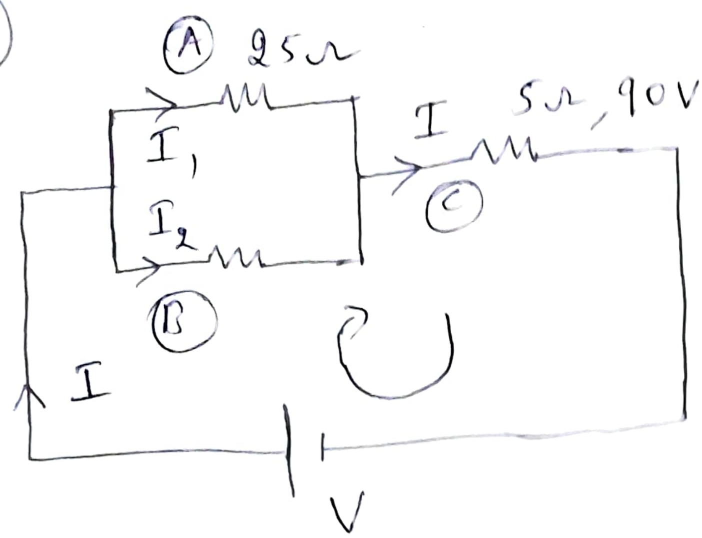
$I_{4k} = I_{after} \times \frac{12\,k\Omega}{12k + 4k} = \frac{25 \times 10^{-3} \times 12k}{16k}$

$= \underline{18.75\,mA}$

$(V_{After})_B = I_{4k} \times 4k = 18.75 \times \cancel{10^{-3}} \times 4 \times \cancel{10^{3}} = \underline{75V}$

Change in supply current $= I_{after} - I_{before} = \underline{5mA}$

(11)



Given → $P = 4320W$

$V = ?$

$R_B = ?$

$$I = \frac{V}{R} = \frac{90}{5} = 18A$$

W.K.T, $P = VI$

$$V = \frac{P}{I} = \frac{4320}{18} = 240V$$

Apply KVL,

$$V - I\left(\frac{30R_B + 125}{25 + R_B}\right) = 0$$

$$\frac{240}{18} = \frac{30R_B + 125}{25 + R_B}$$

$$R_B = 12.49\,\Omega$$