09/06/17

Chapter-

Current Electricity

* **Electric current:** (i, I)   Ampere (A)

rate of flow of charge

$$i = \frac{q}{t} = \frac{dq}{dt} \longrightarrow \text{Stantaniow}$$

$$i = \frac{\Delta q}{\Delta t}$$

It is neither Scalar nor Vector.

Que: charge flowing throwing a wire is given by $q = \alpha t - \beta t^2$ Coulomb. Find the current throw wire:

Ans: $i = \frac{dq}{dt}$ $i = \alpha - 2\beta t$

ii) Current is increses in the ~~direction of~~ wire.

Ans false

iii) Magnitude of Current first decrease ~~increses~~ then increases.

Ans: True.

Que: Current flowing in a conducting wire is $I = \alpha t$ Amp. find total charge from throw the wire take time to.

Ans:

$I = \frac{dq}{dt}$

$\int dq = \int I dt$

q

$I = \alpha t$ Amp.

$\frac{dq}{dt} = \alpha t$

$$\int dq = \int_0^{t_0} \alpha t \, dt$$

$$q = \frac{\alpha t_0^2}{2}$$

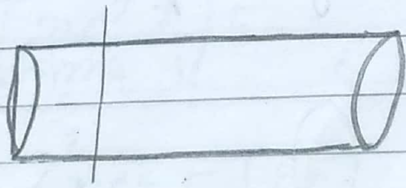
ii) find average current in t_0 time.

Total Charge / Total time

$$I_{avg.} = \frac{q_{total}}{\text{total time}} = \frac{\alpha t_0^2/2}{t_0}$$

$$= \frac{\alpha t_0}{2}$$

* Current in conductors :



In every Conductor free electrons are in random motion due to thermal energy. These electrons Collide each other and also to the atoms of Conductor After everythere collision their direction change Hence there average displacement is zero and on any section the no. of electrons Crossing in one direction is equals to no. of electrons crossing in other direction. Hence net flow of charge at any Cross section is zero thats where electric current in the absence of Voltage Sources zero.

* **Relaxation time : (τ)**

Time interval b/w two Conjugative collision called Relaxation time.

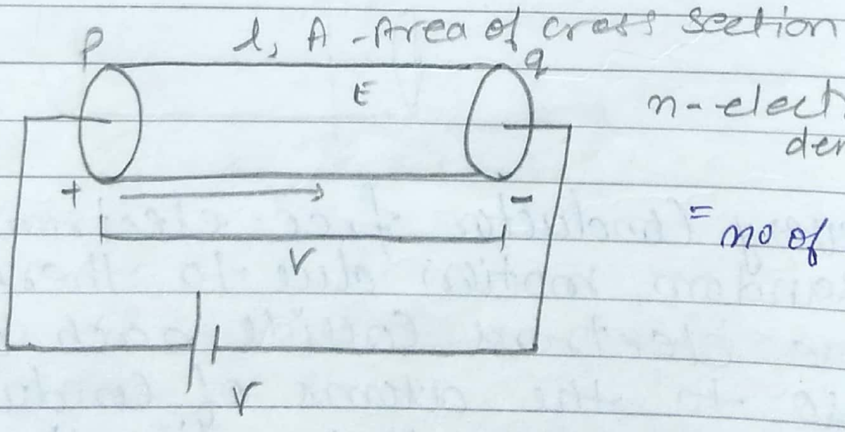
$\tau \simeq 10^{-14}$ sec.

* **Free path or mean free path :**

It is the average distance travelled by electron b/w two Conjugative collisions.

$$\lambda_{avg} = \frac{\lambda_1 + \lambda_2 + \lambda_3 - - \lambda_n}{n}$$

* ON increasing temp. Relaxation time decreases



n - electron density = no of e^-/vol.

Electric field : $\frac{V}{l}$

$F_e = eE$ ($F = ma$)

$a = \frac{eE}{m}$ $V_d = a\tau$

Drift velocity

$V_d = \frac{eE\tau}{m}$ $\quad a = \frac{eE}{m}$

drift speed: $v = \frac{j}{ne}$.

$V_d = a\tau = \frac{eE\tau}{m}$

drift velocity

Total no. of electron $= nAl$
total charge $q = neAl$

$i = \frac{q}{t} = neA\left(\frac{l}{t}\right)$

$I = neAV_d$ — drift velocity

$I = neA\frac{eE}{m}\tau$

$I = \left(\frac{ne^2\tau}{m}\right)AE$ $\quad \frac{I}{A} = j$ (current density)

$\frac{I}{A} = \left(\frac{ne^2\tau}{m}\right)E$

$\frac{ne^2\tau}{m} = \sigma$ → Conductivity of wire

$J = \left(\frac{ne^2\tau}{m}\right)E$

C.density $J = \sigma E$

$\rho = \frac{1}{\sigma} = \frac{m}{ne^2\tau}$

$I = neAV_d$

$I = neA\frac{eE}{m}\tau$

$I = \left(\frac{ne^2\tau}{m}\right)A\frac{V}{l}$ $\quad \therefore I = \sigma\frac{A}{l}V$

H.W : J·A

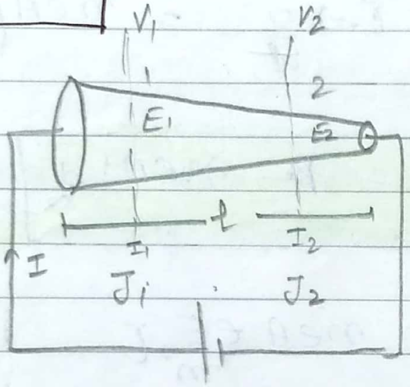
$$V = \frac{1}{\sigma A} \cdot I$$

$$V = \rho \frac{l}{A} I$$

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

$V = IR$ → Ohm's law

Q!



a) $I_1 = I_2$
b) $V_1 < V_2$
c) $J_1 < J_2$
d) $E_1 < E_2$

$V = IR$

direction of current is opposite to the dirn of flow of electron or in the direction of charge.

* Current density (j)

$$j = \frac{I}{A} \quad A/m^2$$

j is a vector quantity

* Its direction is in the direction of current.

$$I = \vec{J} \cdot \vec{A}$$

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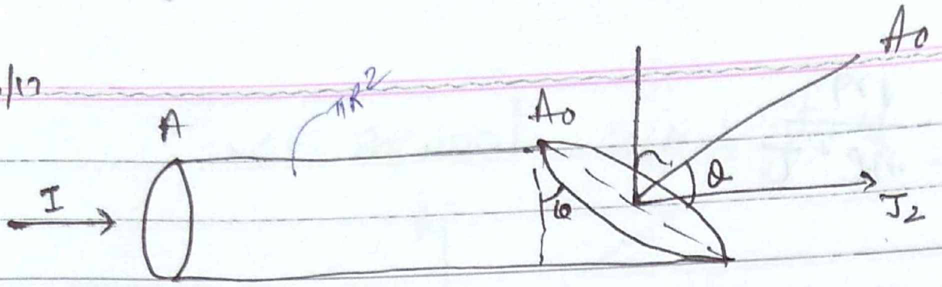
Ex:



Find J_1 and J_2

$$J_1 = \frac{I}{A}$$

$$I = J_2 A_0 \cos\theta$$

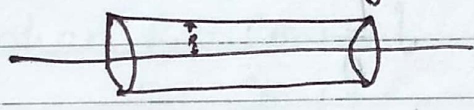
$$J_2 = \frac{I}{A_0 \cos\theta}$$

Variable

Que:- Current in a conducting wire of radius R is flowing such that current density in the wire is

a) J_0 A/m²

b) $J_0 \frac{r}{R}$ A/m²

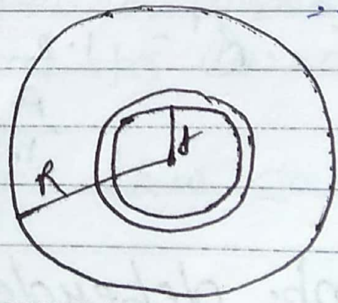


find net current flowing throwing the wire in both cases.

Ans: a) $I = JA = J_0 \pi R^3$

$I = JA$, $J = J_0$

b)

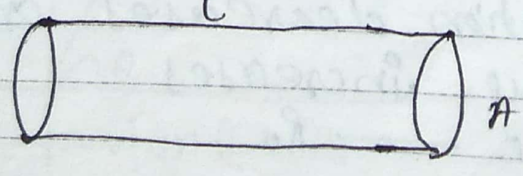


$$dA = 2\pi r dr$$

$$dI = J dA = \frac{J_0 2\pi}{R} r^2 dr$$

$$I = J_0 \frac{2\pi}{R} \int_0^R r^2 dr$$

* Resistance of a wire (Resistor):



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

$$R = \frac{\rho l}{A}$$ Ohm (Ω) = $\frac{Volt}{A}$

$$\rho = \frac{m}{ne^2\tau}$$

Que: Resistance of a cylinderical wire is R_0 if its length is doubled find new Resistance.

Ans: lA = Constant

$$R_0 = \rho \frac{l}{A} \qquad R = \rho \frac{l'}{A'} = \rho \frac{2l}{A/2}$$

$$R = 4R_0$$

(ii) If wire is streech by 20% find % change in Resistance.

Ans $$R = \rho \frac{L}{A}$$

$$l' = 1.2\,l$$

$$A' = \frac{A}{1.2}$$

$$R' = \frac{1.2\,l}{\frac{A}{1.2}} \qquad R' = 1.44\,R$$

$T \uparrow$ $\tilde{R}$ and Res $\uparrow$

* Temp. dependence on Resistance:

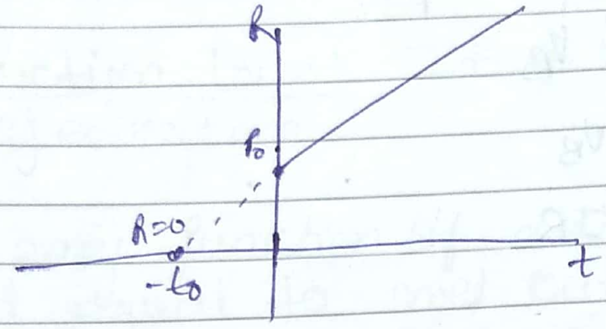
When temp. is increase due to thermal energy Collision b/w electrons become more frequent. Hence Relaxation decreases and Resistivity and Resistance increases

$0°C$ —— R_0

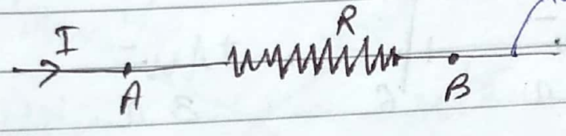
$t°C$ —— $R_t = R_0(1 + \alpha \Delta t$

$V = I\,Ⓡ$

α = Thermal cofficient of Resistance



* Ohm's law :-

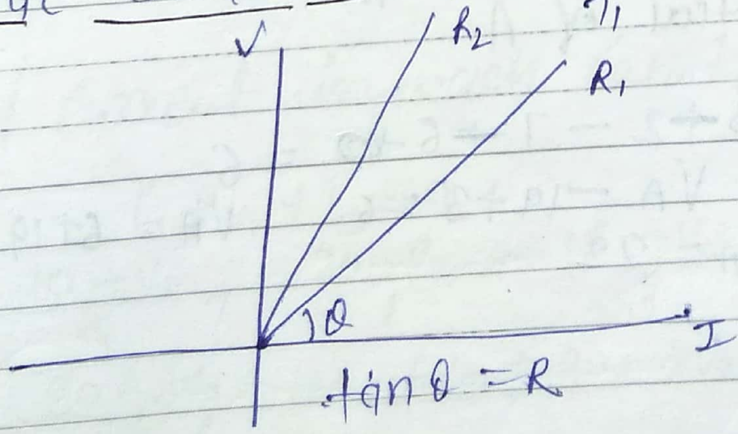


$V = IR$ when R – Const, T – Const.

Pot. diff

* when temp. and shape of a conductor are constant then Potential difference across the conductor is directly proportional to current.

* The Conductors following ohm's law called ohmic conductor

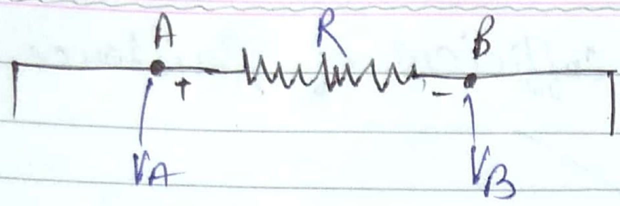


$$\begin{bmatrix} R_2 > R_1 \\ T_2 > T_1 \end{bmatrix}$$

$\tan\theta = R$

$V = IR$ $\quad V = Ⓡ I$

slope m



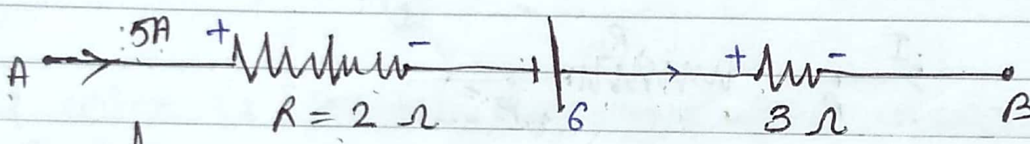
$V_A - IR = V_B$

$V_A - V_B = IR$

$V = IR$

Que:-

V=IR



$V_A = 10$ volt.

Find potential of B.

Ans: $V_A = 10$ volt

$V_A - 10 + 6 - 15 = V_B$

$V_B = -9$ Volt.

$V_A - V_B = IR$

$10 - V_B = 5 \times 6$

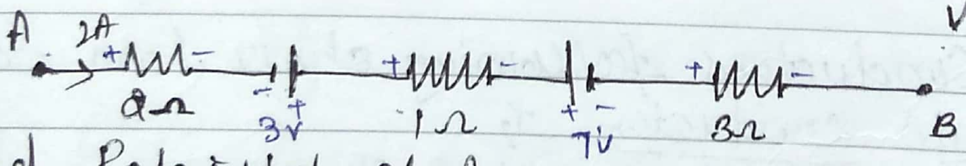
$-V_B = 30 - 10$

$= 20$

$V_B = -20$

Que:

$V_B = 6V$



find Potential of A

$V_A + 4 + 3 + 2 - 7 + 6 = 6$

V_A

$V_A - 19 + 3 = 6$

$V_A = 6 + 19 - 3$

$V_A = 22$

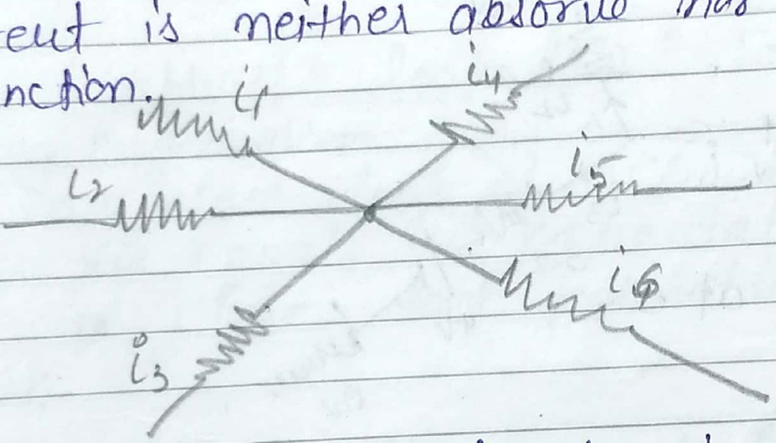
* Kirchhoff's law:

(1) **Junction law:** It is based on Charge Conservation.

At any junction of a circuit net incoming current equal to net outgoing current.

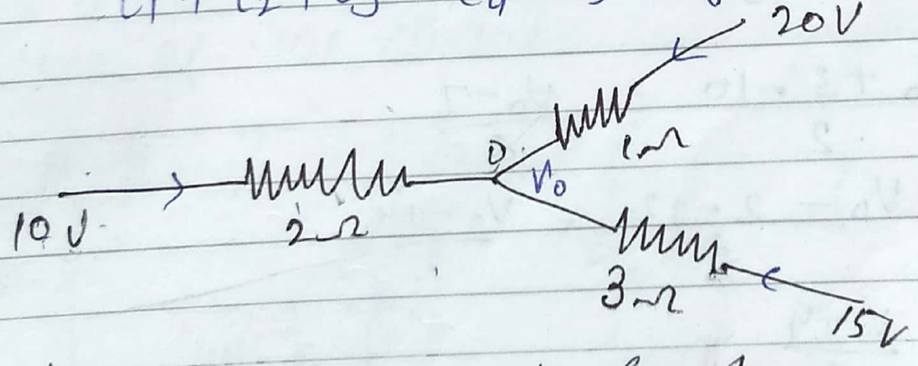
OR

Current is neither absorve nor Release at the junction.



$i_1 + i_2 + i_3 = i_4 + i_5 + i_6$

Que:



Let 0 = V

Find current in each Resistance.

Ans:

$i_1 + i_2 + i_3 = 0$

$\frac{10 - V_0}{2} + \frac{20 - V_0}{1} + \frac{15 - V_0}{3} = 0$

$\frac{30 - 3V_0 + 120 - 6V_0 + 30 - 2V_0}{6} = 0$

$-11V_0 + 180 = 0$

$11V_0 = 180$ $\quad V_0 = \frac{180}{11}$ Volt.

$V_0 = \frac{180}{11}$ volt

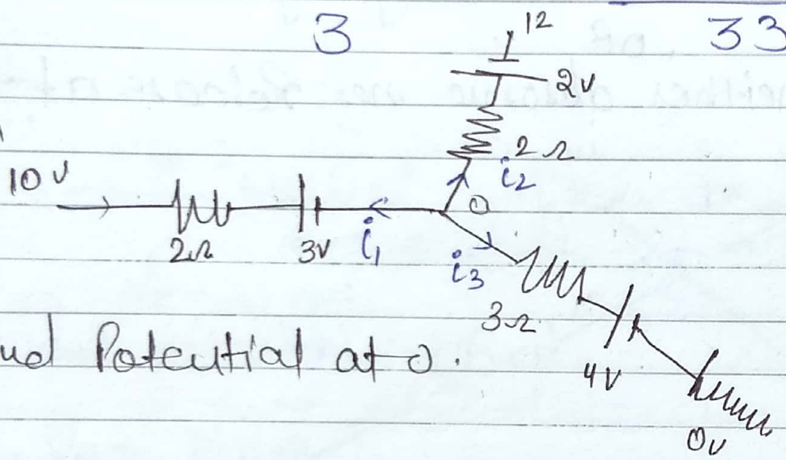
H.W.: J.M
S-2 Q. 1, 5, 6, 9
Raa.

$$i_1 = \frac{10 - \frac{180}{11}}{2} = \frac{110 - 180}{11 \times 2} = \frac{-70}{22}\ A$$

$$i_2 = \frac{20 - \frac{180}{11}}{1} = 20 - \frac{180}{11} = \frac{40}{11}$$

$$i_3 = \frac{15 - \frac{180}{11}}{3} = \frac{165 - 180}{33} = \frac{-15}{33}$$

Que!



find Potential at o.

$$i_1 + i_2 + i_3 = 0$$

$$i_1 = \frac{V_0 + 3 - 10}{2} = \frac{V_0 - 7}{2}$$

$$i_2 = \frac{V_0 - 2 - 12}{2} = \frac{V_0 - 14}{2}$$

$$i_3 = \frac{V_0 - 4}{3}$$

$$\frac{V_0 - 7}{2} + \frac{V_0 - 14}{2} + \frac{V_0 - 4}{3} = 0$$

$$\frac{3V_0 - 21 + 3V_0 - 42 + 2V_0 - 8}{6} = 0$$

$$3V_0 - 21 + 3V_0 - 42 + 2V_0 - 8 = 0$$

$$8V_0 = 71$$

$$V_1 = \frac{71}{8}\ \text{volt.}$$

$i_1 = \frac{7/8 - 7}{2}$

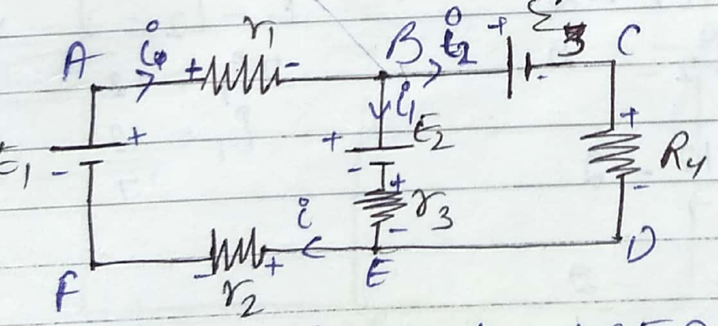
$i_2 =$

$i_3 =$

2) Kirchhoff's Voltage law
or
Kirchhoff's loop law : It is based on energy conservation.

* In any close loop of a circuit ~~net~~ Potential drop is equals to potiental gained or In a close loop potiential difference is zero.

* It is used to find current in different branches of the circuit.



$i = i_1 + i_2$ —(i)

Apply K.V.L in loop ABEFA

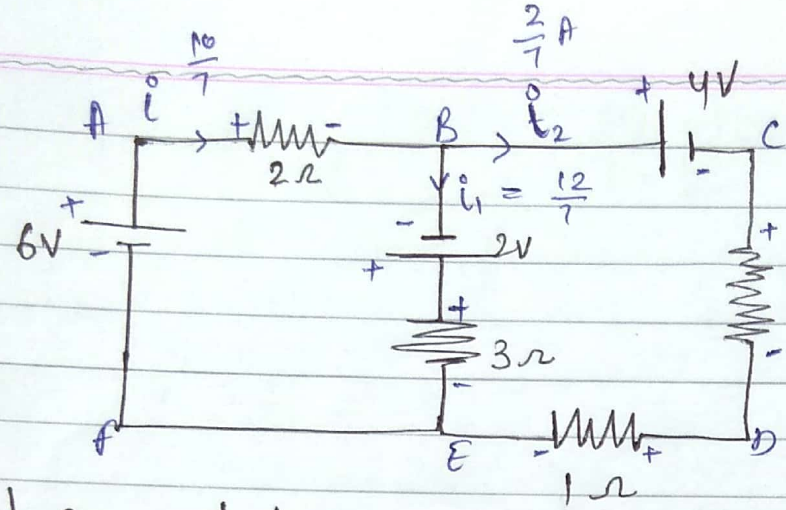
$-i r_1 - E_2 - i_1 r_3 - i r_2 + E_1 = 0$

loop BCDEB

$-E_3 - i_2 R_4 + i_1 R_3 + E_2 = 0$

Race ⇒ 13
S:1 = 7 Q
S-2 ⇒ 1, 2, 5, 6, 9

Que!



$i = i_1 + i_2$ —(1)

find current in each resistor

Sol! In loop ABEFA

$-2i + 2 - 3i_1 + 6 = 0$ ⇒ $-2(i_1+i_2) + 2 - 3i_1 + 6 = 0$

~~$-5i - 2i - 3i_1 + 8 = 0$~~ (i) = $-5i_1 - 2i_2 + 8 = 0$

$5i_1 + 2i_2 = 8$ —(1)

In loop BCDEB.

$-4 - 2i_2 - 1i_2 + 3i_1 - 2 = 0$

~~$-6V - 4i_2 + 3i_1 = 0$~~ —(ii)

$-3i_2 + 3i_1 - 6 = 0$

$3i_1 - 3i_2 = 6$

$i_1 - i_2 = 2$

$\frac{12}{7} - i_2 = 2$

$i_2 = \frac{12}{7} - 2$

$i_2 = -\frac{2}{7}$

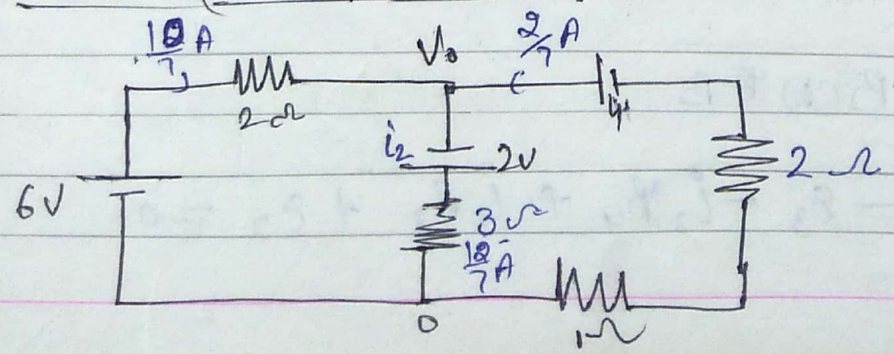
$i_1 - i_2 = 2$ × 2

$7i_1 = 12$

$i_1 = \frac{12}{7}$

* Alternate method!

Junction (node) Method!



$i_1 + i_2 + i_3$

$$\frac{V_0 - 6}{2} + \frac{V_0 + 2}{3} + \frac{V_0 - 4}{3} = 0$$

$$\frac{3V_0 - 18 - 2V_0 + 4 + 2V_0 - 8}{6} = 0$$

$$3V_0 - 18 - 2V_0 + 4 + 2V_0 - 8 = 0$$

$$7V_0 - 22 = 0$$

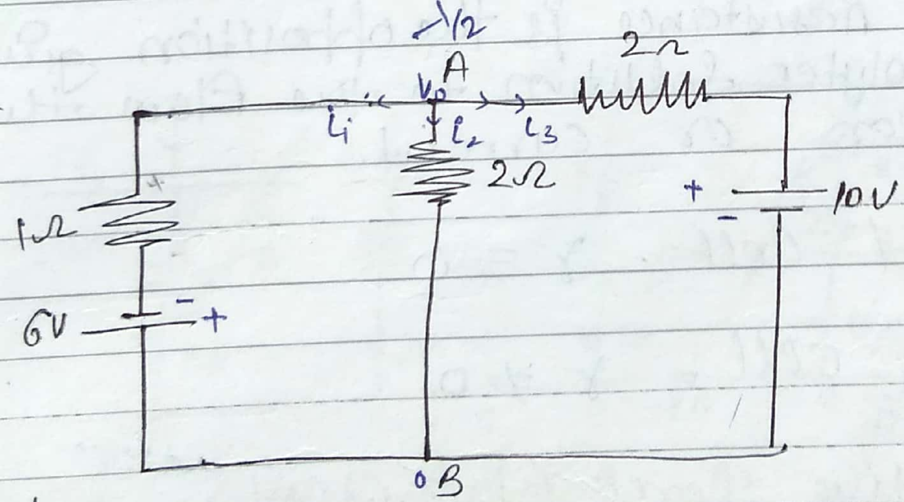
$$V_0 = \frac{22}{7}$$

$$i_1 = \frac{V_0 - 6}{2} = \frac{\frac{22}{7} - 6}{2} = \frac{-\frac{20}{7}}{2} = \frac{-10}{7}\ A$$

$$i_2 = \frac{V_0 + 2}{3} = \frac{\frac{22}{7} + 2}{3} = \frac{\frac{36}{7}}{3} = \frac{12}{7}\ A$$

$$i_3 = \frac{\frac{22}{7} - 4}{3} = \frac{50}{21} - \frac{6}{21} = \frac{-2}{7}\ A$$

Que:-



$i_1 + i_2 + i_3$

find Current in AB.

$$\frac{V+6}{1} + \frac{V}{2} + \frac{V-10}{2} = 2V + 12 + V + V - 10 = 0$$

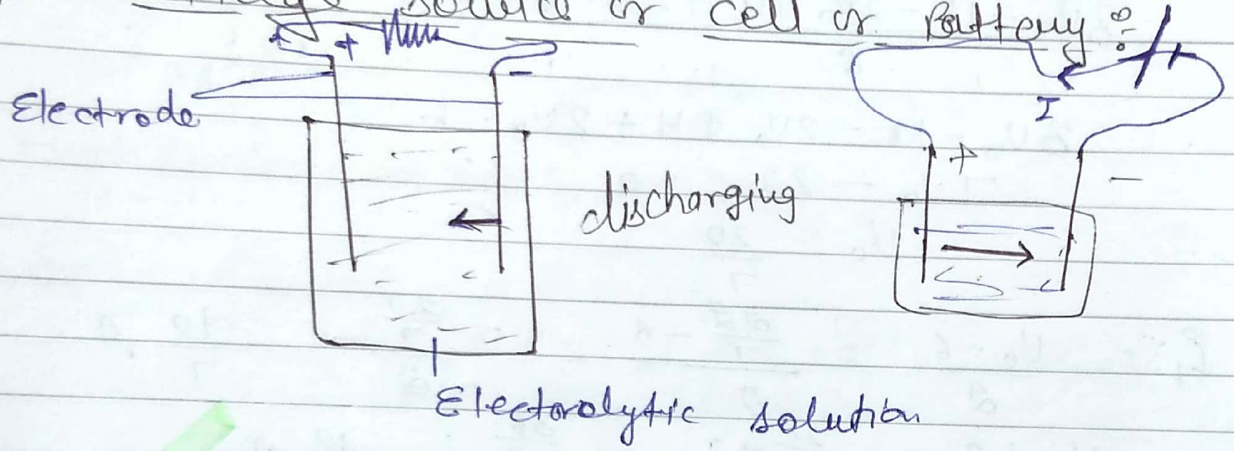
$$4V + 2 = 0$$

$$V = -\frac{1}{2}$$

$i_2 = -\frac{10}{4} A$ (Current from B to A)

$i_3 = \frac{-\frac{10}{2} - 10}{2} = \frac{-21}{2}$

* Voltage Source or cell or Battery :



* Internal Resistance of cell (r) :

Internal Resistance is the opposition given by electrolytic solution to the flow the solution or current.

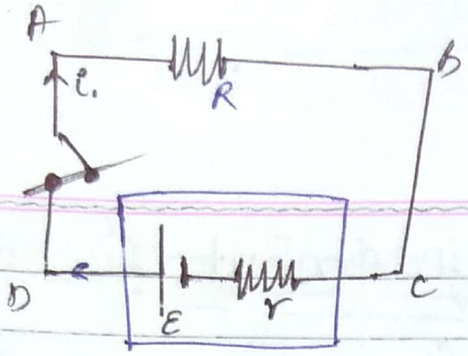
Ideal Cell : $r = 0$

Real cell = $r \neq 0$

* Electromotive force (E.M.F) (E) → (not force)

It is work done by the battery to move a unit charge along the circuit.

$$EMF = \frac{W_o}{q} \quad J/C = Volt$$



$+ \rightarrow$ --- dis

$- \rightarrow$ --- ch

$-iR - ir + E = 0$

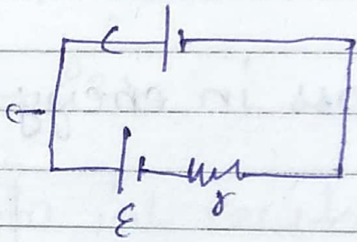
$$i = \frac{E}{R+r}$$

Potential difference across terminal of battery:

$V = E - ir$ — discharge.

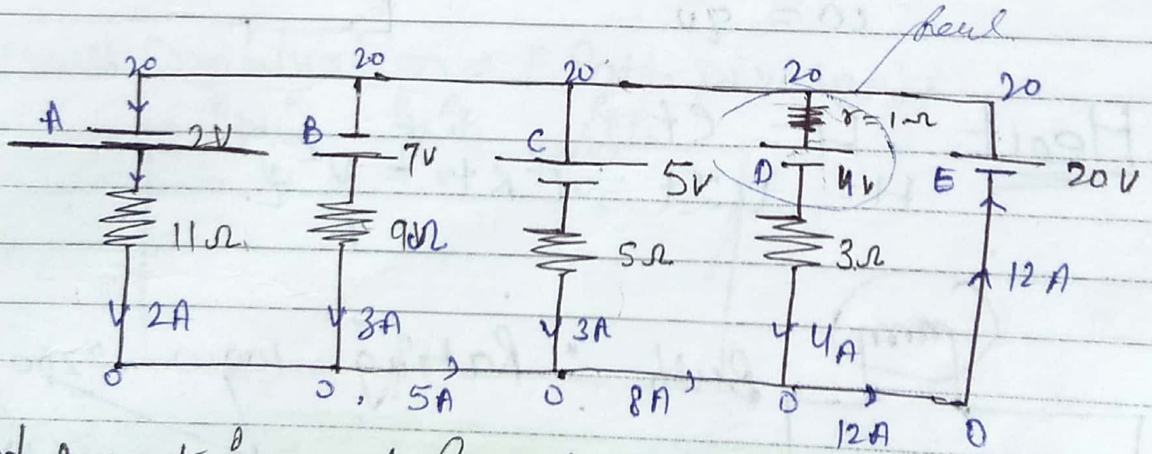
$V = E$ if $i = 0$

$V = E + ir$ - charge



Ideal cell : $V = E$

Que:



(i) Find current in each Branch.

A, B, F discharge

C, D ~~Discha~~ Charge

(ii) Find Potential difference in battery D.

$V = E + ir$

$= 4 + 4 = 8$ Volt.

Current H.W ⇒ Race ÷ 13
Q-1 ⇒ 1,2,3,4
Q-1 ⇒ 1,2,3,4,5

$H = i$

* Power of Circuit elements :

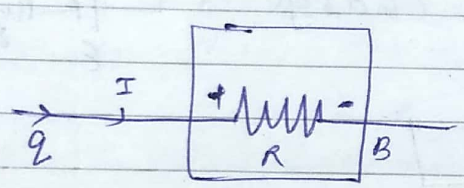
$$H = i^2 R t$$

$$\frac{H}{t} = i^2 R = P$$

When current flow throw the a conducting wire electrical energy is converted in Heat.

Heat produced per unit time called Power.

Loss in energy takes place due to collisions of e^-s.



$$P = \frac{W}{t} = \frac{q}{t}V$$

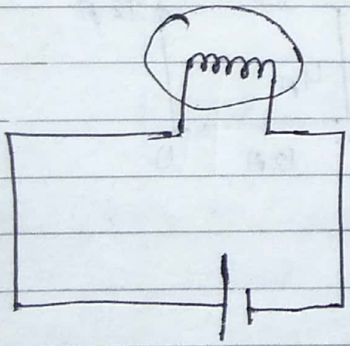
$V = IR$

$W = qV$

Power: $P = VI = I^2 R = \frac{V^2}{R}$

Heat $H = Pt$

$$H = VIt = i^2 R t = \frac{V^2}{R} t.$$



Bulb. Rating - 100W - 200 V bulb
max value that can work.

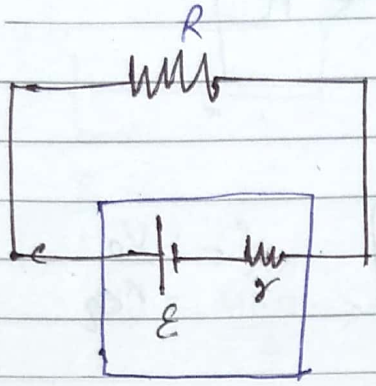
$$P = \frac{V^2}{R}$$

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

Series C. ⇒ Pottential diff → different i^2r
Current → same

Series Potential Divider

* Power in a Battery :



$i = \frac{E}{R+r}$

Pot. diff across battery
$V = E - ir$

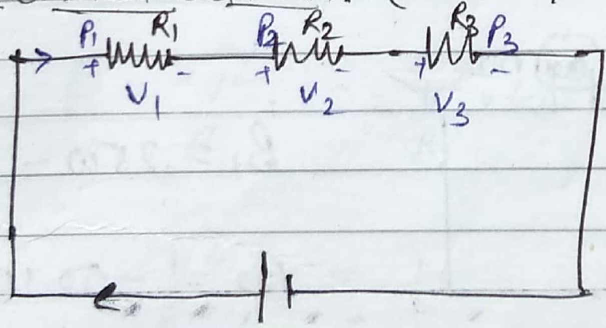
Power in battery $= VI$
$= EI - I^2r$.

Power delivered by battery to the external current $EI - i^2r$.

Power loss in the battery due to int. resistance $= i^2r$.

* Combination of Resistors :-

1) Series Combination : (Pott. Divider).



* Current in each resistor is same But Potential is different.

$-V_1 - V_2 - V_3 + V_0 = 0$
$V_1 + V_2 + V_3 = V_0$

$V_1 = iR_1$
$V_2 = iR_2$
$V_3 = iR_3$

$V \propto R$

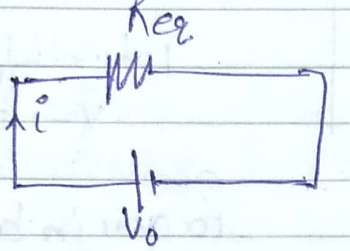
$\frac{V_1}{V_2} = \frac{R_1}{R_2}$

$P_1 = i^2 R_1$

$P_2 = i^2 R_2$

$P_3 = i^2 R_3$

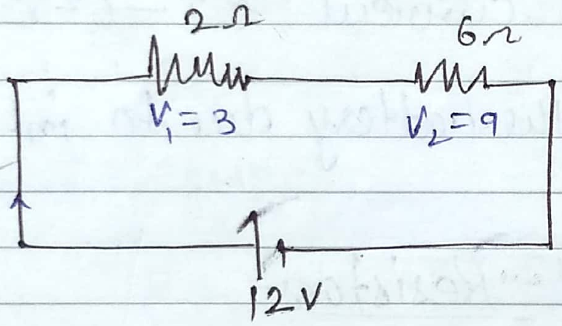
$P \propto R$



$i = \frac{V_0}{R_{eq}}$

$R_{eq} = R_1 + R_2 + R_3 + \ldots$

Que:



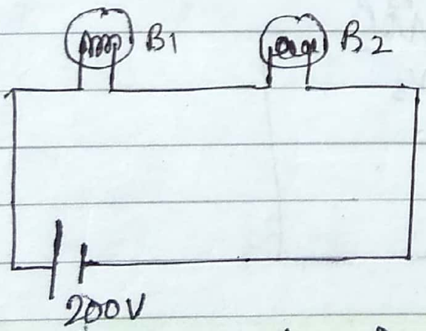
series find curr

find current

$i = \frac{12}{8} = 1.5A$

$\frac{V_1}{V_2} = \frac{1}{3}$

Que:



$B_1 = 25W - 100V$

$B_2 = 50W - 100V$

which bulb gets feuse.

Ans:

$\frac{V^2}{P}$

$R_1 = \frac{(100)^2}{25} = 2R$

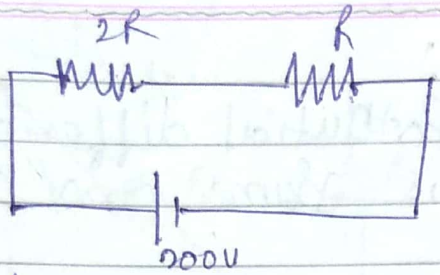
$R_2 = \frac{(100)^2}{50} = R$

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

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

$P = i^2 R = \frac{V^2}{R}$

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



V ∝ R　　$V = IR$ ↑ same

$\frac{V_1}{V_2} = \frac{2}{1}$

$V_1 = \frac{400}{3} > 100V$　　get fused

$V = IR$

$V_2 = \frac{200}{3} < 100V.$

Que: An electric heater boil some amount of water in 12 minute when connected to a Battery. Another heater boil same amount of water in 8 minute using same battery. How much time will it take to boil same amount of water using same Battery when both the wires connected in series

Ans

$P = \frac{V^2}{R_1} = \frac{V^2}{R_1} \times t_1 = H$

$\frac{V^2}{R_2} t_2 = H.$

$\left(\frac{V^2}{R_1 + R_2}\right) t = H$

$t = \frac{H}{V^2}(R_1 + R_2)$

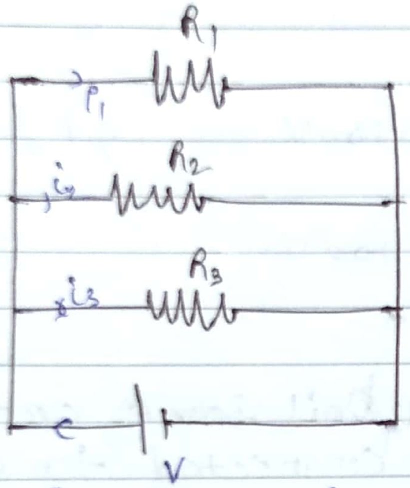
$t = \frac{H}{V^2} \times \frac{V^2}{H}(t_1 + t_2)$

$t = t_1 + t_2$

Parallel ⇒ pott. diff — same
current — diff.

* Parallel Combination :

In Parallel comb. Pottential difference across each Resistor is same and current is different.



$i_1 = \frac{V}{R_1}$

$i_2 = \frac{V}{R_2}$

$i_3 = \frac{V}{R_3}$

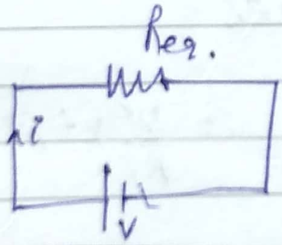
$i = i_1 + i_2 + i_3$

$I \propto \frac{1}{R}$

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

$$\boxed{I \propto \frac{1}{R}} \quad = \quad P = \frac{V^2}{R}$$

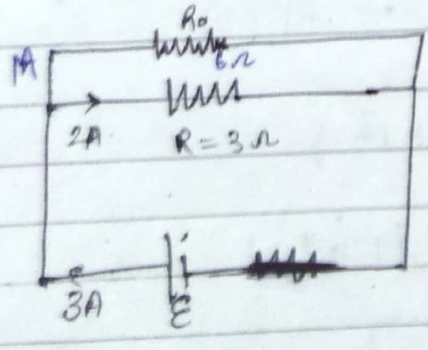
equivalent :



$i = \frac{V}{R_{eq}}$

$$\boxed{\frac{V}{R_{eq}} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}}$$

Que :



find R_0 and ε

$i = \frac{\varepsilon}{R} =$

$2 = \frac{\varepsilon}{3}$

$\varepsilon = 6$

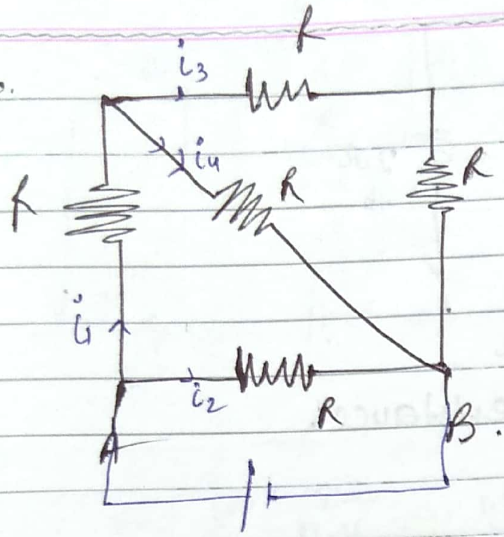
$1 \times R_0 = 2 \times 3$

$R_0 = 6\ \Omega$

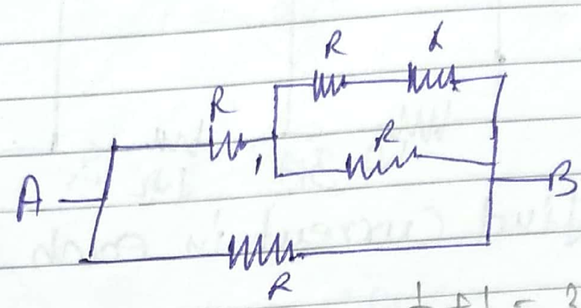
H.W: S-1 = 5, 11, 13, 14, 16, 17, 18, 19
Race

A = series
V = Parall to ckt

Que.



Find R_{eq} b/w A & B



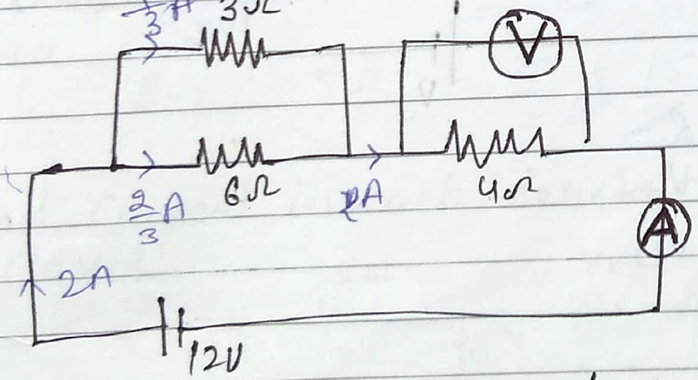
$\frac{1}{2}+1 = \frac{3}{2}$

$= \frac{2}{3}+1 = \frac{5}{3}$

$\frac{3}{5}+1 = \frac{8}{5}$

$= \frac{5}{8}$

Que:

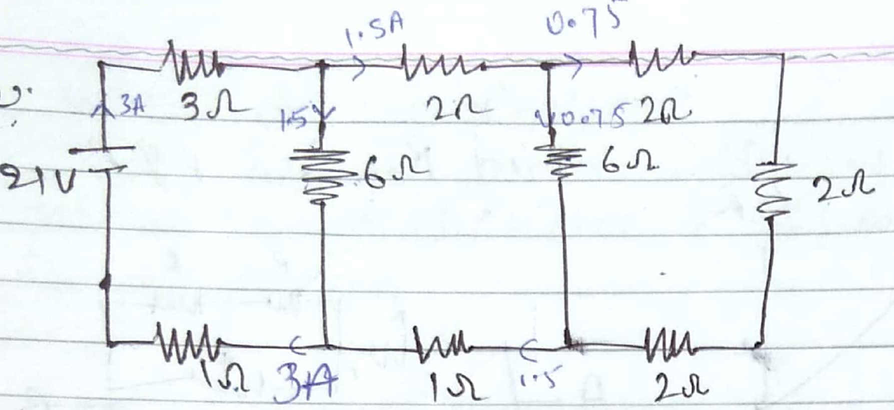


find reading of A and V.

Ans: A = 2A
V = 8

$\frac{1}{6} + \frac{1}{6} = \frac{1}{R_{eq}}$

Que:

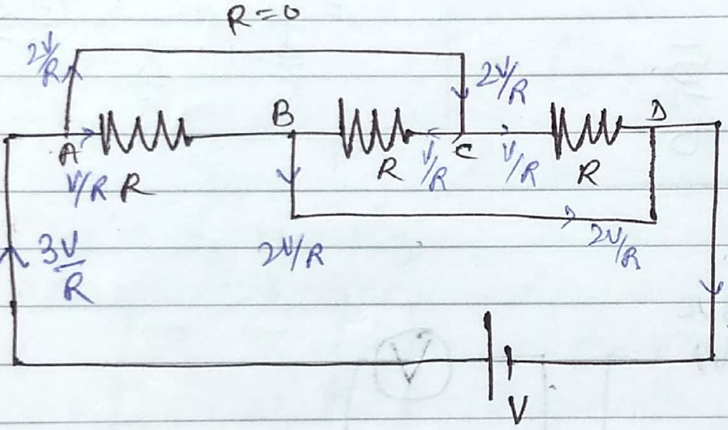


Find current in each resistance.

$R_{eq} = 7\Omega$

Que:

Short circuit



Find :
(i) Req = ?
(ii) Current in each Resistance

$V = IR$

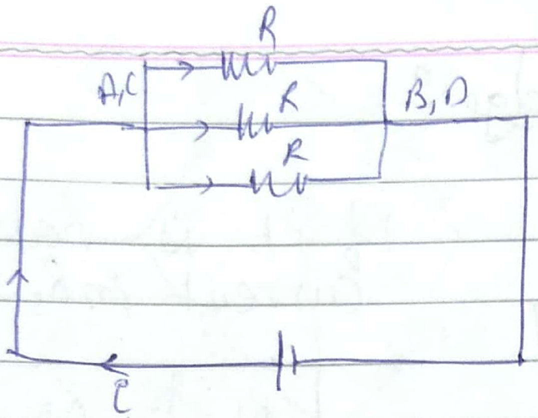
$V_A = V_C$

$V_B = V_D$

Short Circuit: when two points are connected by a wire of negligible resistance Potential of both the Point becomes equal and they are called Short circuit.

Method of equipotential Point :

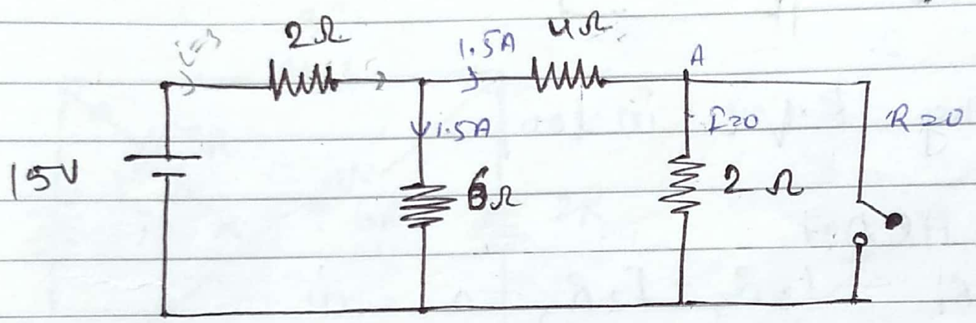
In any circuit all, the points having same potential can be considered as a single Point.



$R_{eq} = \frac{R}{3}$

$i = \frac{3V}{R}$

Que:

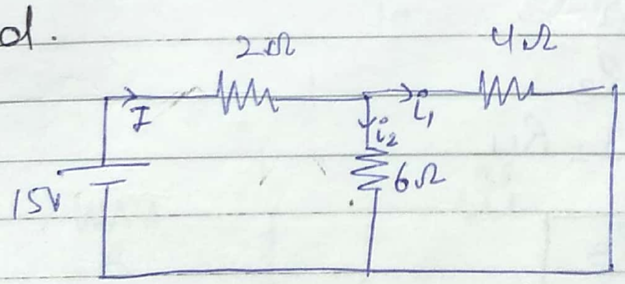


i. find current in each Resistance when switch is open

Ans $R_{eq} = 5\Omega$ :: $I = \frac{15}{5} = 3\ A$

ii) find current in each Resistance when Switch is closed.

Ans

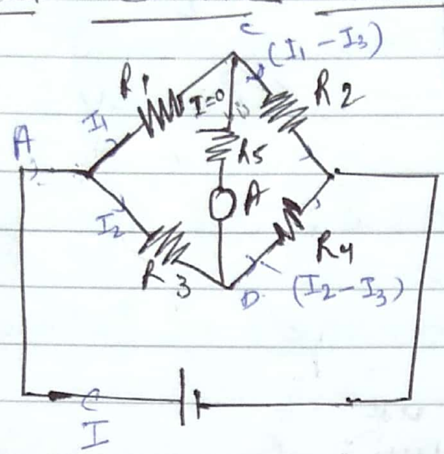


$I = \frac{15}{R_{eq}}$ $\quad \frac{I_1}{I_2} = \frac{3}{2}$

$I_1 + I_2 = I$

Imp.

* Wheat - stone Bridge :



If it is Balanced current in $R_5 = 0$

$$\boxed{\frac{R_1}{R_2} = \frac{R_3}{R_4}}$$

Appling K.V.L in loop

ACDA

$-I_1 R_1 - I_3 R_5 + I_2 R_3 = 0$ — (i)

loop CBDC

$(I_1 - I_3) R_2 + (I_2 + I_3) R_4 + I_3 R_5 = 0$ — (2)

If W.S.B is Balanced

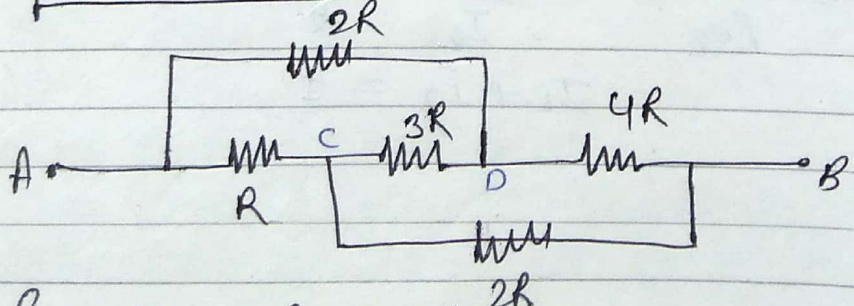
$I_3 = 0$

$I_1 R_1 = I_2 R_3$

$I_1 R_2 = I_2 R_4$

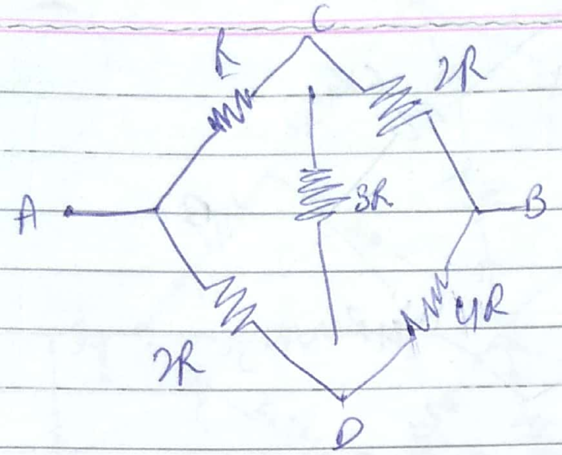
$$\boxed{\frac{R_1}{R_2} = \frac{R_3}{R_4}}$$

Que:



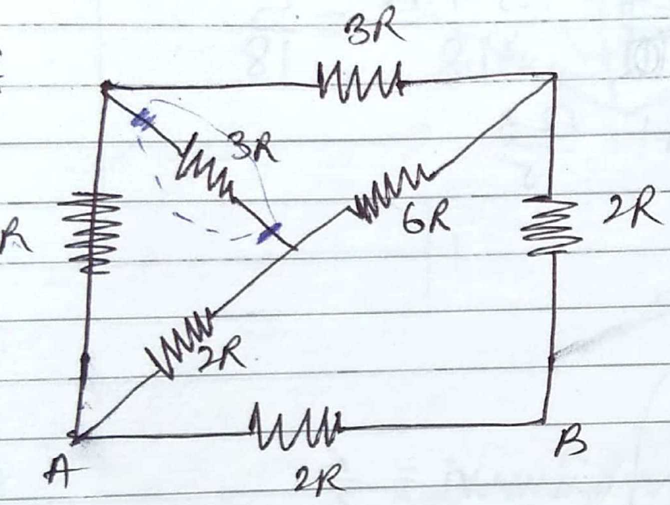
i) Req b/w A and B.

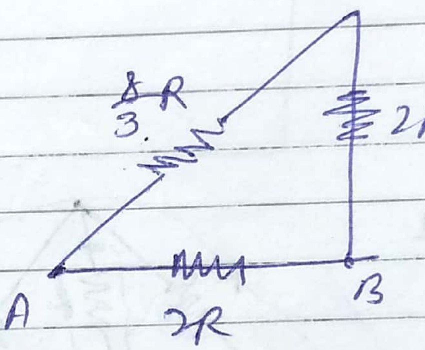
H.C.V: P-187 Race.
Solved Ex: 1-7, 9-17,
Ex: 4, 24, 28, 32, 33, 34.



$R_{eq} = 2R$

Ex:





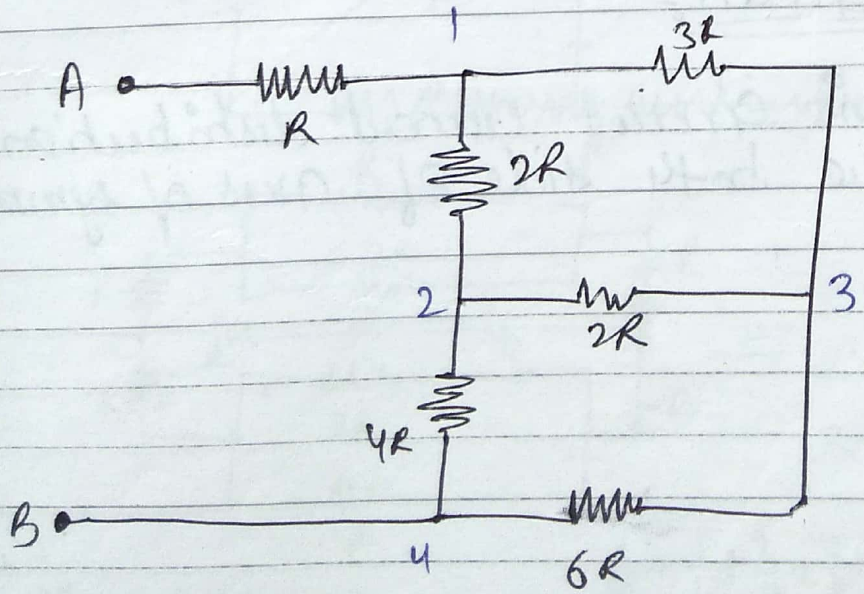
$\frac{14}{3}R$

$\frac{3}{14R} + \frac{1}{2R}$

$\frac{3+7}{14R}$

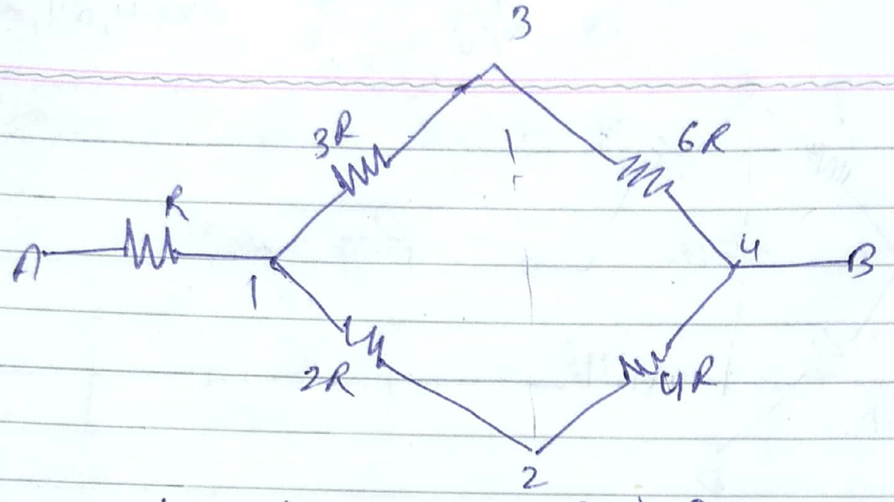
$\frac{14R}{10} = \frac{7R}{5}$ Ans

Q.2



$\frac{1}{4}+\frac{1}{6}$

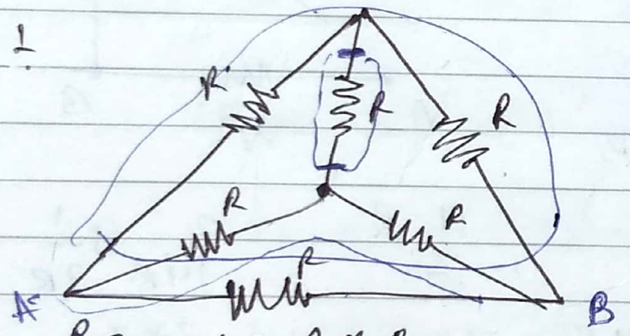
$\frac{1+}{9}$



$$\frac{1}{6}+\frac{1}{9}=\frac{3+2}{18}=\frac{5}{18}$$

$$\frac{18}{5}+1 \quad \frac{23}{5}$$

Que :



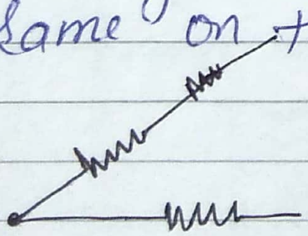
Req b/w A & B.

$R_{eq} = \frac{R}{2}$

* Symmetric Circuit :

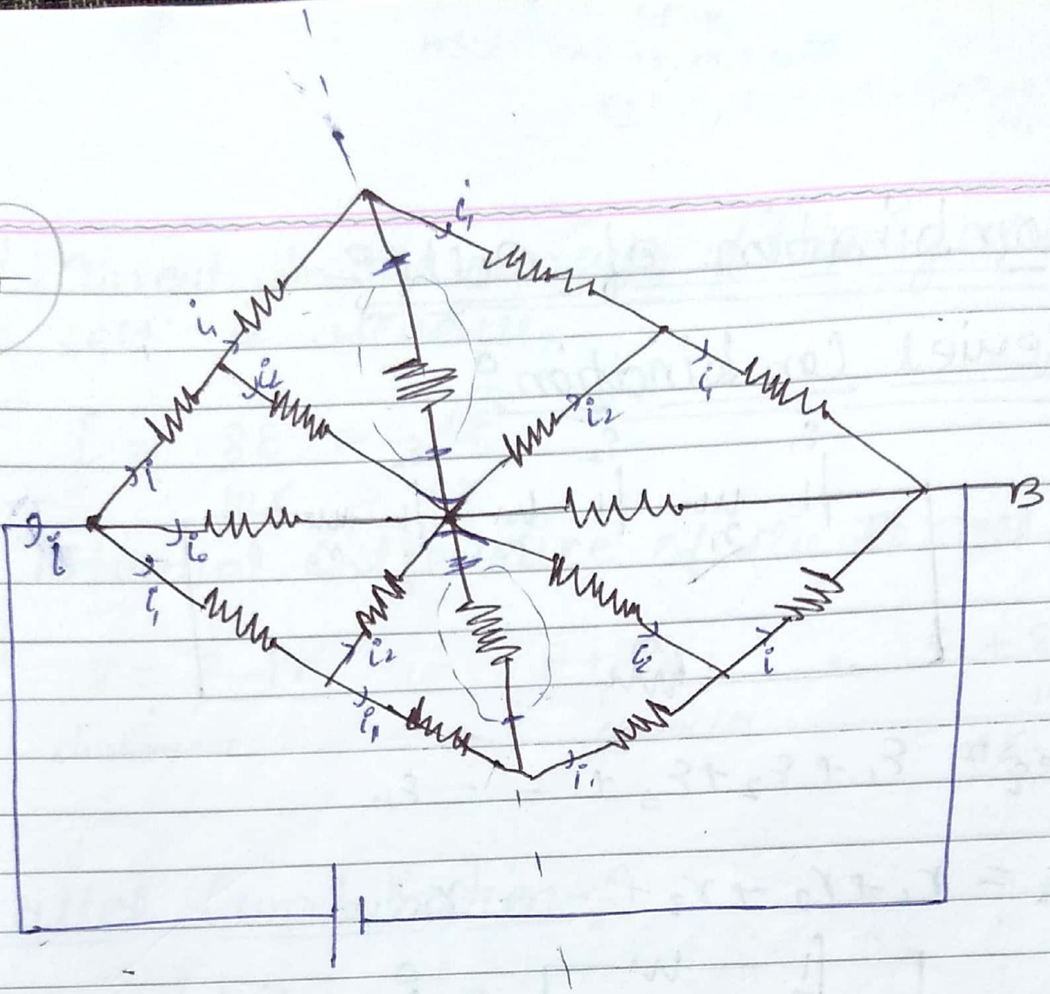
In a Symmetric circuit current distribution is same on the both side of axis of symmetric.

Ex :

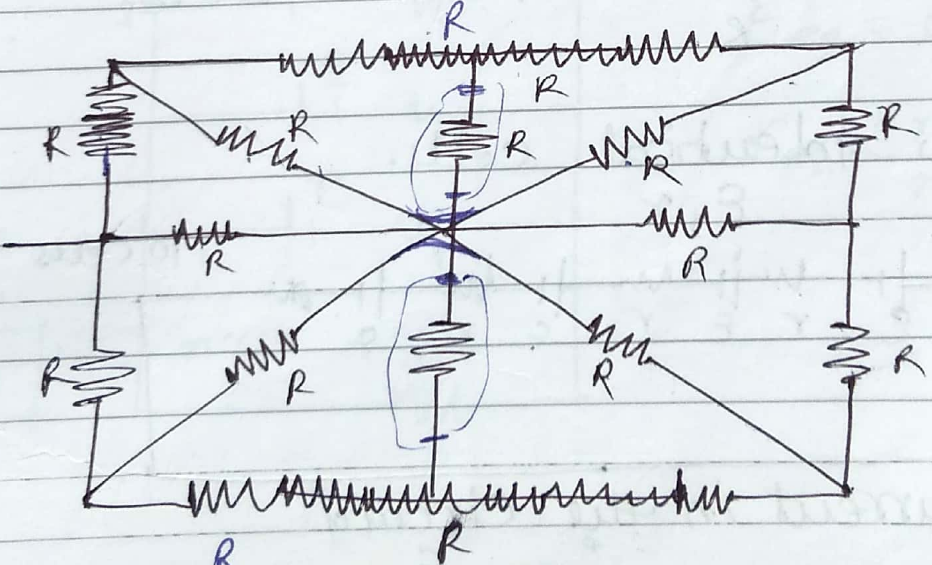


Q: X

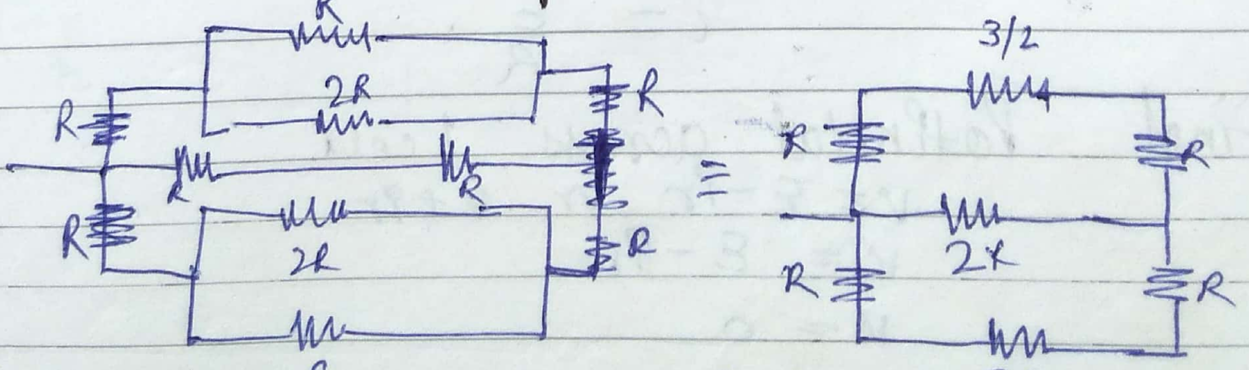
Ex:



Que:



$\frac{4R}{3} < R$



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

$\frac{2+1}{2} = \frac{3}{2}$

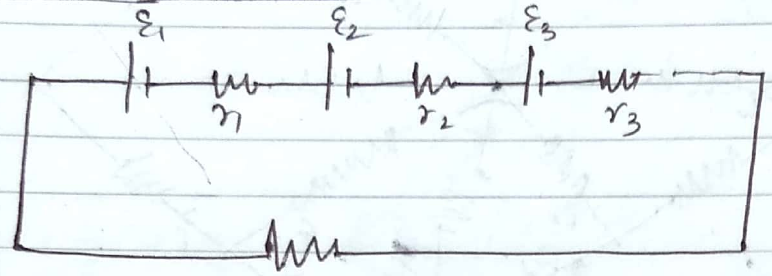
$\frac{1}{1} + \frac{1}{1} + \frac{2}{3} + \frac{1}{1}$

$\frac{3+2+3}{3} = \frac{8}{3}$

$= \frac{9}{8}\ \Omega$

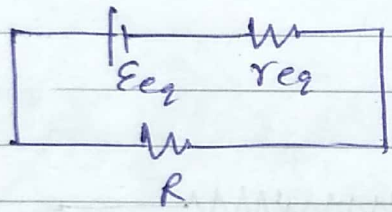
* Combination of Cells :-

1) Series Combination :



$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 + \dots \varepsilon_n$

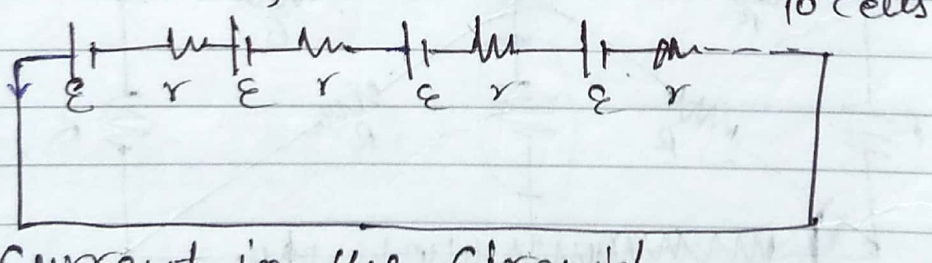
$r_{eq} = r_1 + r_2 + r_3 + \dots r_n$



$i = \dfrac{\varepsilon_{eq}}{R + r_{eq}}$

Qw: 10 identical cells.

ε, r



i) Find current in the circuit

$i = \dfrac{\varepsilon}{R}$.

ii) Find Potential across 1 cell.

$V = \varepsilon - ir$ or $\varepsilon + ir$

$V = \varepsilon - ir$

$V = 0$

H.C.V = Ex: 18, 24, 23, ~~25~~,
Ex: 17, 18, 19, 23, 25, 27, 28, — 31
41 – 45

iii) Find current in the current if polarity of one of the cell is reverse.

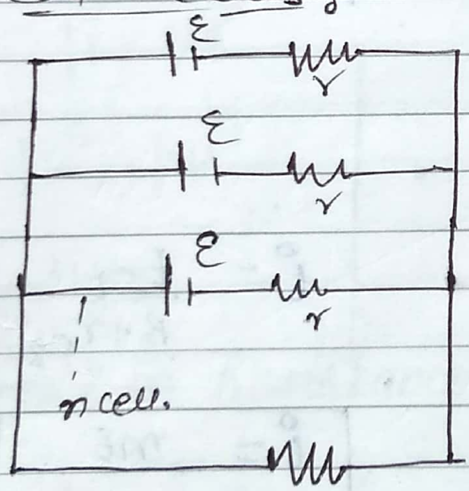
$$i = \frac{8\varepsilon}{10r} = \frac{4\varepsilon}{5r}$$

Find potential difference of the cell.

$V = \varepsilon - ir$ (discharge) or $\varepsilon + ir$ (charge) $= \varepsilon + \frac{8\varepsilon}{10r} \times r$
$= \frac{9\varepsilon}{5}$

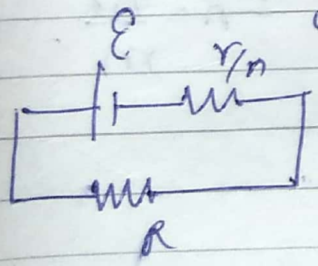
2) Parallel Combination:

(1) Identical Cells:



$E_{eq} = E$

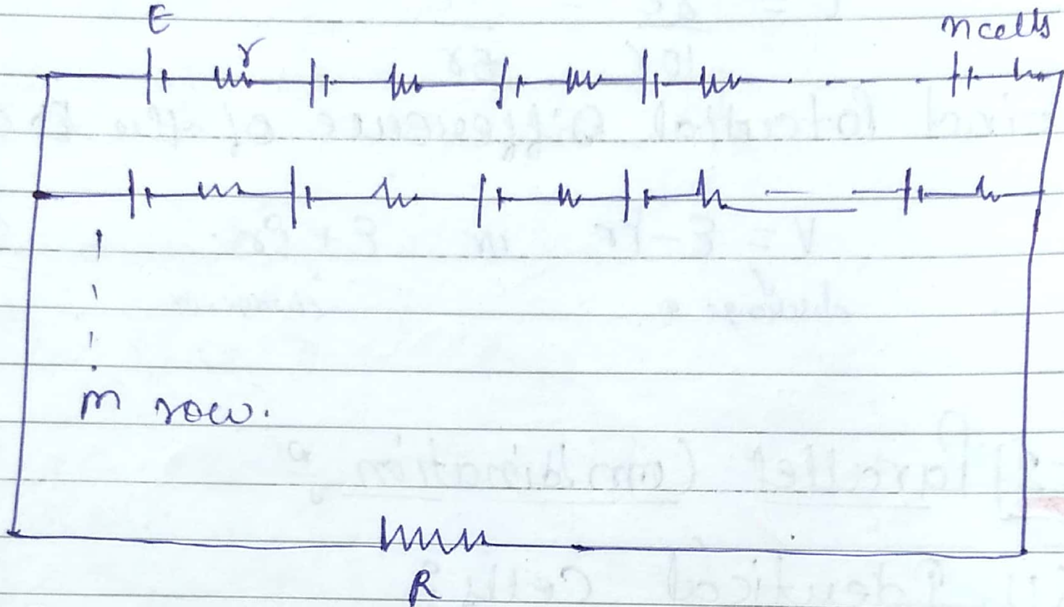
$r_{eq} = \frac{r}{n}$



$$i = \frac{\varepsilon}{R + \frac{r}{n}}$$

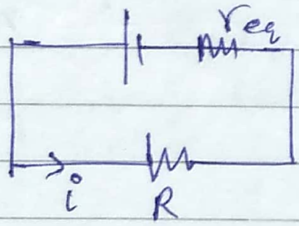
* Mixed Combination:

Identical cells:-



$E_{eq} = nE$

$r_{eq} = \frac{nr}{m}$



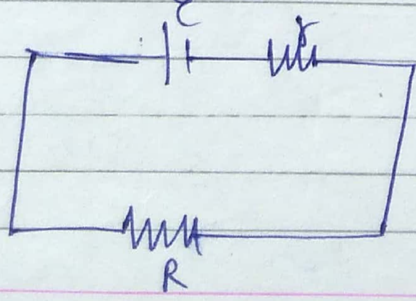
$i = \frac{E_{eq}}{R + r_{eq}}$

$$\boxed{i = \frac{nE}{R + \frac{nr}{m}}}$$

max Power

$= R = \frac{nr}{m}$

* Maximum Power transfer ~~power~~ theorem:



$i = \frac{\varepsilon}{R + r}$

$P_R = i^2 R$

$P_R = \frac{\varepsilon^2 R}{(R + r)^2}$

MAX

for maximum Power

$$\frac{dP}{dR} = 0$$

$$= \frac{\varepsilon^2[(R+r)^2 - 2R(R+r)]}{(R+r)^4} = 0$$

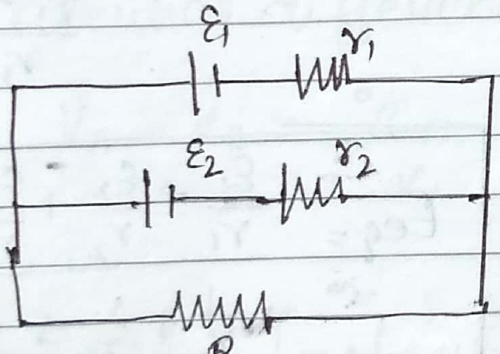
$$(R+r)^2 - 2R(R+r) = 0$$

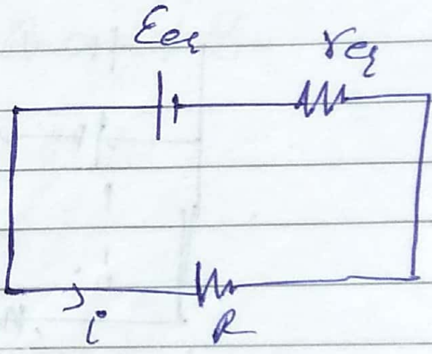
$$R + r - 2R = 0$$

$$R = r$$

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

Que:





find Current in Resistance in R.

Ans:

$$-iR - i_2 r_2 + \varepsilon_2 = 0$$

$$iR + i_2 r_2 = \varepsilon_2 \times r_1$$

$$iR + i_1 r_1 = \varepsilon_1 \times r_2$$

$$iR(r_1 + r_2) + (i_1 + i_2)(r_1 r_2) = \varepsilon_1 r_2 + \varepsilon_2 r_1$$

$$i\left(R(r_1 + r_2) + r_1 r_2\right) = \varepsilon_1 r_2 + \varepsilon_2 r_1$$

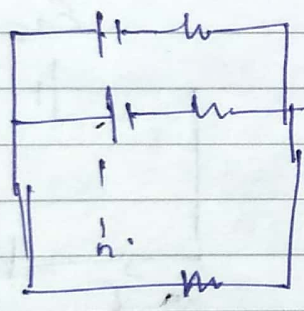
$$i = \frac{E_1 r_2 + E_2 r_1}{R(r_1 + r_2) + r_1 r_2}$$

$$i = \frac{\frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}}{R + \frac{r_1 r_2}{r_1 + r_2}}$$

$$E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2} \qquad E_{eq} = \frac{E_1 r_1 + E_2 r_1}{r_1 + r_2}$$

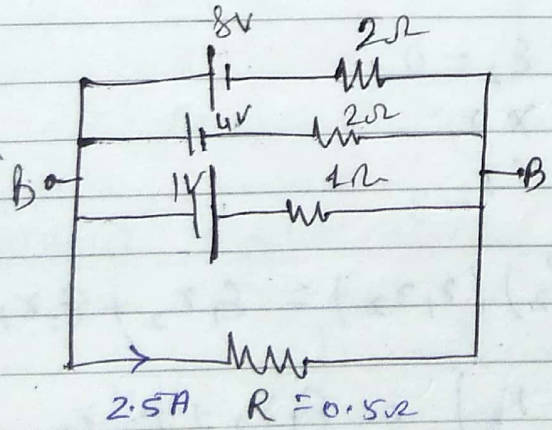
$$r_{eq} = \frac{r_1 r_2}{r_1 + r_2} \qquad E_{eq} = \frac{\frac{E_1 r_2 + E_2 r_1}{r_1 r_2}}{\frac{r_1 + r_2}{r_1 r_2}}$$

clear



$$E_{eq} = \frac{\frac{E_1}{r_1} + \frac{E_2}{r_2} + \frac{E_3}{r_3} + \cdots}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} + \cdots}$$

Que:

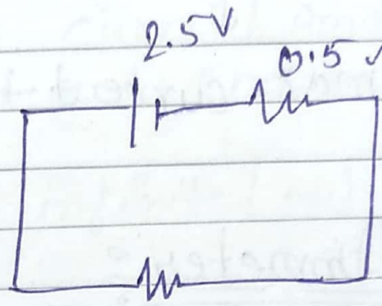


(i) find R. show that Power in it is maximum

$$\frac{1}{r_{eq}} = \frac{1}{2} + \frac{1}{2} + 1$$

$$r_{eq} = \frac{1}{2} = 0.5\,\Omega$$

ii) find current in R.



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

$$E_{eq} = \frac{4+2-1}{2}$$
$$= 2.5\,V.$$

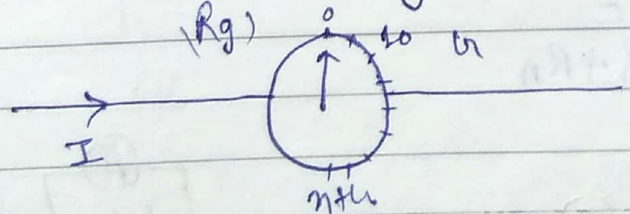
$$i = 2.5\,A$$

iii) find Potential difference b/w A and B.

$$V_A - V_B = iR$$
$$= 1.25\,V.$$

* Electrical Instruments :

1. **Galvanometer :** It deceted the Persente of current in any branch of the circuit.
It can talerate only small current



$$\text{Current Sensitivity} = \frac{\text{Current}}{\text{deflection/division}} = i_0$$

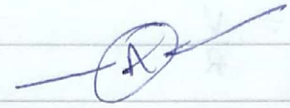
n = no. of division.

full scale deflection current $I_g = nI_0$ ($\simeq$ mA)

↓

(max. current that galvanometer can tolerate)

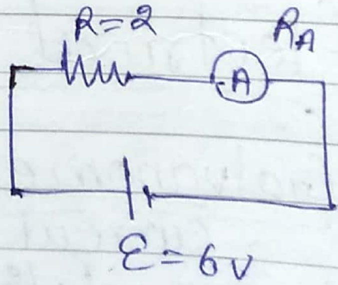
2) Ammeter :



It can major any amount of current in the circuit because its Range can be increase.

Ammeter is always apply in series combination

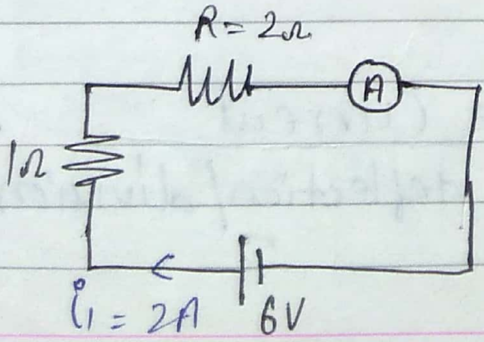
* Its resistance should be very small for ideal ammeter resistance should be zero. So that Presence of Ammeter does not affect the magnitude of current.

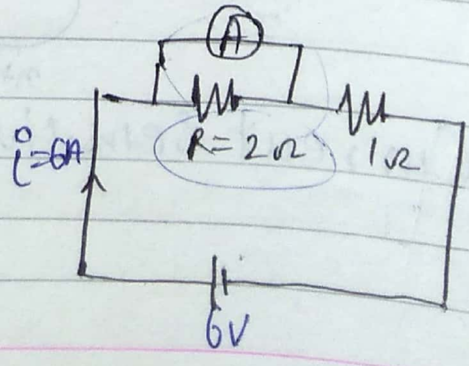


$$i = \frac{\mathcal{E}}{R}$$

$$i_1 = \frac{\mathcal{E}}{R + R_A}$$

Que:





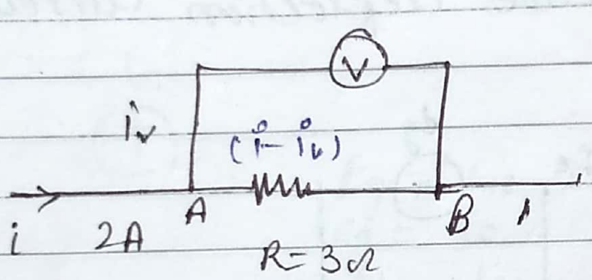
H.W: S-1 ⇒ upto 20 Que. 45 Que left.
O-1: upto 46 Que.
O-2: 1, 2, –8 Que. 10, 11, 12

3) ✗ **Voltmeter:** It major Potential difference b/w any two Points. It is always applyed in Parallel combination so it

Its resistance should be very high. So that due to persence of voltmeter current and Potential difference do not gets change.

Resistance of Voltmeter is infinite (∞).

$R_V \uparrow$ $R_A \downarrow$

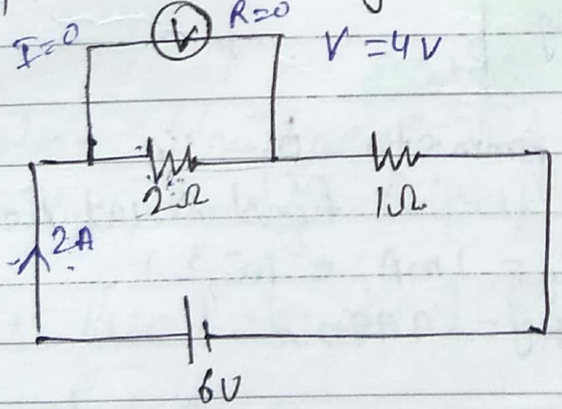


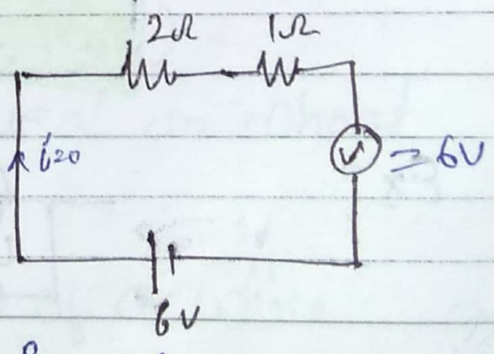
$V_A - V_B = iR$

~~V_A~~ $V_A - V_B = (i - i_v)R$

Ideal voltmeter $= R \approx \infty$

Ex: find reading of voltmeter



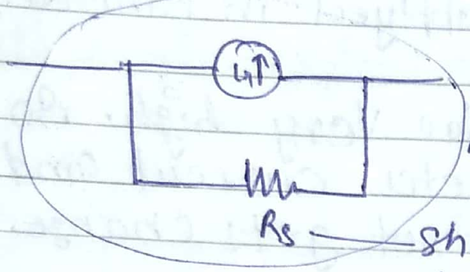


$i = \frac{6}{2+1+R_V} = 0$

* Conversion of Galvano meter into Ammeter:

Ammeter

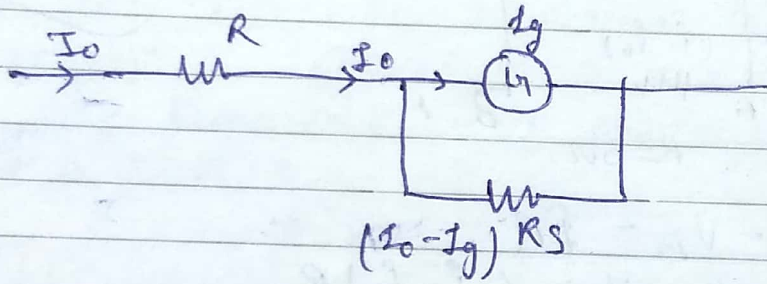
Range 0 - I_0 Amp.



Rs — shunt resistance

→ low resistance

I_g — full scale deflection current ≃ mA

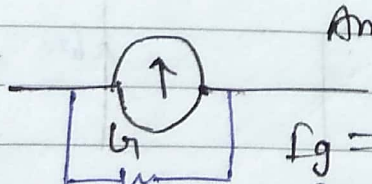


$$\frac{1}{R_A} = \frac{1}{R_g} + \frac{1}{R_s}$$

$$I_g R_g = (I_0 - I_g) R_S$$

$$R_S = \frac{I_g R_g}{I_0 - I_g}$$

Ex:



Ammeter 0 - 1 A

find shunt Resistance

$I_g = 1 mA = 10^{-3} A$

$R_g = 9990 \Omega$

$$= \frac{10^{-3} \times 9990}{1 - .001} A$$

$$= \frac{10^{-3} \times 9990}{.999} = 10 \Omega$$

Ammeter 0 - 100 A

$$R_S = \frac{10^{-3} \times 9990}{10^2 - 10^{-3}}$$

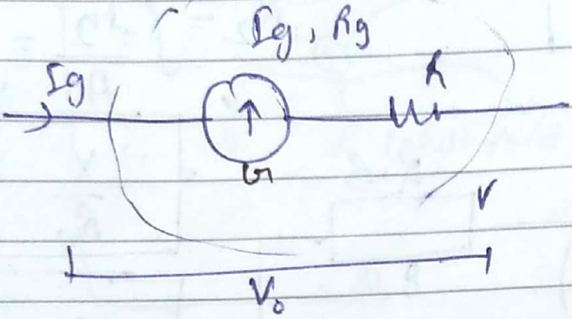
$R_S = 9990 \times 10^{-5}$

$= .090 \Omega$

$= 0.1$ A

20/08 - Rg

(2) Conversion of Galvanometer into Voltmeter:

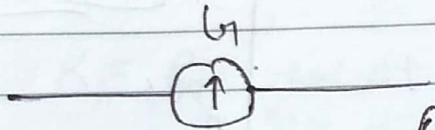


Voltmeter $0 - V_0$

$I_g R_g + I_g R = V_0$

$$R = \frac{V_0}{I_g} - R_g$$

Que!



$I_g R = V_0 - I_g R_g$

$I_g (R - R_g) = V_0$

$I_g = \frac{V_0}{R - R_g}$

$I_g = 1 mA$
$R_g = 50 \Omega$
Voltmeter $= 0 - 3V$
Find R.

$R = \frac{V_0}{I_g} - R_g$

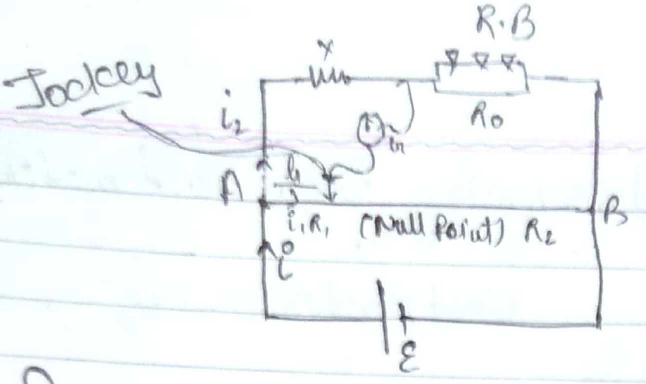
$R = \frac{3V}{10^{-3}} - 50 = \quad = 2950$

(Slide wire Bridge)

* **Meter Bridge:** It is based on Wheatstone Bridge Principle.

It is used to find Resistance of a wire

~~It is based~~ Its working is based on Null point method.



$L_{AB} = 1m = 100cm$

$R_{AB} = \rho\frac{l}{A} = R_0$

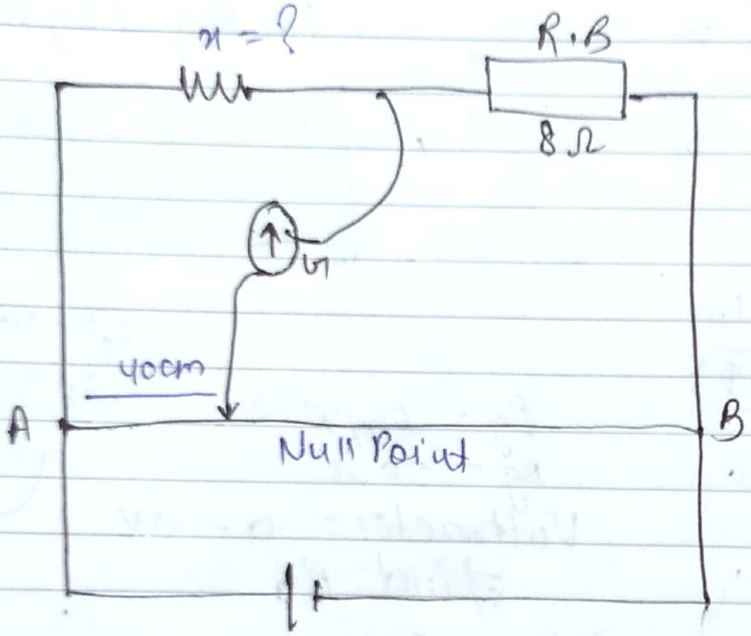
$R_1 = \rho\frac{l_1}{A}$,

$R_2 = \rho\frac{l_2}{A} = \rho\frac{100-l_1}{A}$

$$\boxed{\frac{X}{R_0} = \frac{R_1}{R_2}}$$

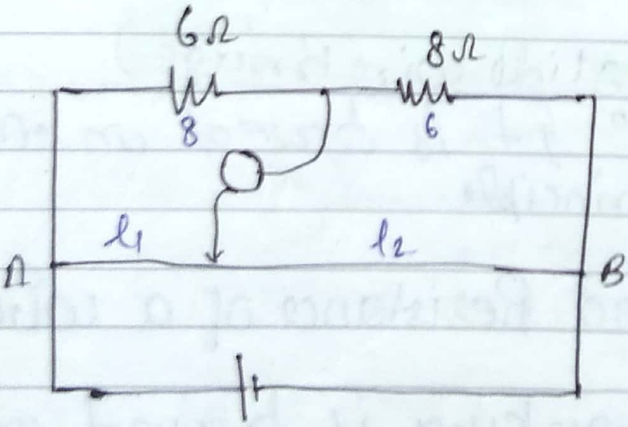
$$\boxed{\frac{X}{R_0} = \frac{l}{100-l}}$$

Que:



$= \frac{X}{8} = \frac{40}{60} = \frac{16}{3}$

Q.2



find shift in the Position of Null Point If Resentences are interchange.

Ans:

$\frac{6}{8} = \frac{l_1}{100-l_1}$ $\qquad$ $\frac{8}{6} = \frac{l_2}{100-l_2}$

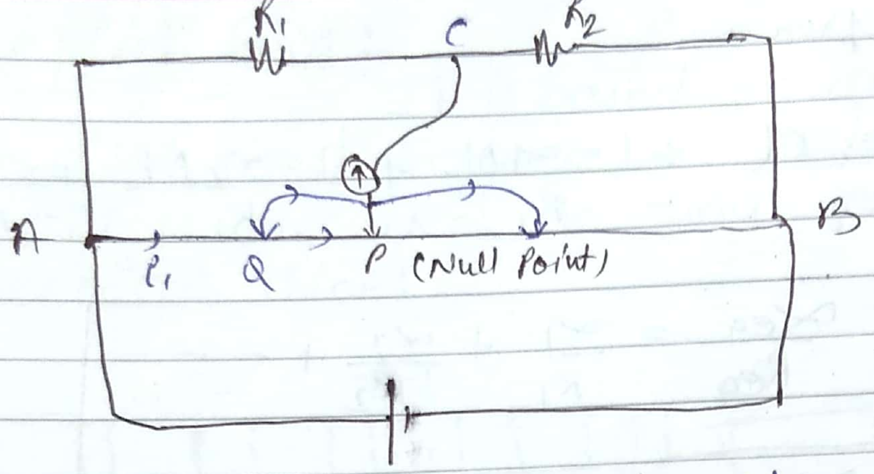
$l_1 = \frac{300}{7}$ $\qquad$ $= l_2 = \frac{400}{7}$

Null Point Shift $= l_2 - l_1 = \frac{400}{7} - \frac{300}{7} = \frac{100}{7}$ Ans

Raa =)

[C + R]

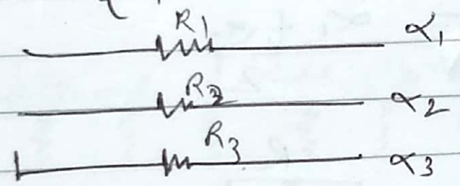
Que :-



null Point at Jocky at left

(O-1)
Q 17

$R = R_0(1 + \alpha \Delta t)$



$R_{eq} = R_1 + R_2 + R_3$

$R_{eq}(1 + \alpha_{eq}\Delta t) = R_1(1 + \alpha_{eq_1}\Delta t) + R_2(1 + \alpha_{eq_2}\Delta t) + R_3(1 + \alpha_{eq_3}\Delta t)$

$R_{eq}\alpha_{eq}\Delta t = R_1\alpha_{eq_1}\Delta t + R_2\alpha_{eq_2}\Delta t + R_3\alpha_{eq_3}\Delta t$

$\alpha_{eq} = \dfrac{R_1\alpha_1 + R_2\alpha_2 + R_3\alpha_3 - -}{R_1 + R_2 + R_3 - -}$

$\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + - -$

$\dfrac{1}{R_{eq}(1 + \alpha_{eq}\Delta t)} = \dfrac{1}{R_1(1 + \alpha_1\Delta t)} + \dfrac{1}{R_2(1 + \alpha_2\Delta t)} + \dfrac{1}{R_3(1 + \alpha_3\Delta t)}$

$= \dfrac{(1 + \alpha_{eq}\Delta t)^{-1}}{R_{eq}} = \dfrac{(1 + \alpha_1\Delta t)^{-1}}{R_1} + \dfrac{(1 + \alpha_2\Delta t)^{-1}}{R_2} - -$

Binomial approx :

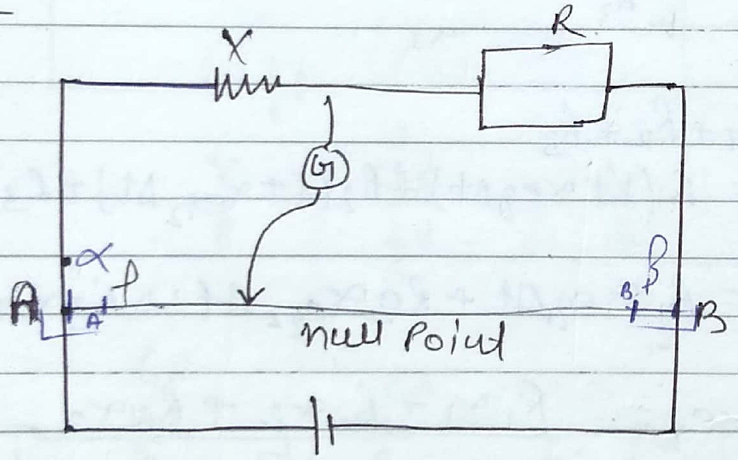
$$\frac{1-\alpha_{eq}\Delta t}{R_{eq}} = \frac{1-\alpha_1\Delta t}{R_1} + \frac{1-\alpha_2\Delta t}{R_2} + \frac{\alpha_3\Delta t}{R_3} + \text{---}$$

$$\boxed{\frac{\alpha_{eq}}{R_{eq}} = \frac{\alpha_1}{R_1} + \frac{\alpha_2}{R_2} + \text{---}}$$

$$\frac{\alpha_{eq}}{R/2} = \frac{\alpha_1}{R} + \frac{\alpha_2}{R}$$

$$\alpha_{eq} = \frac{\alpha_1+\alpha_2}{2}$$

Note:-



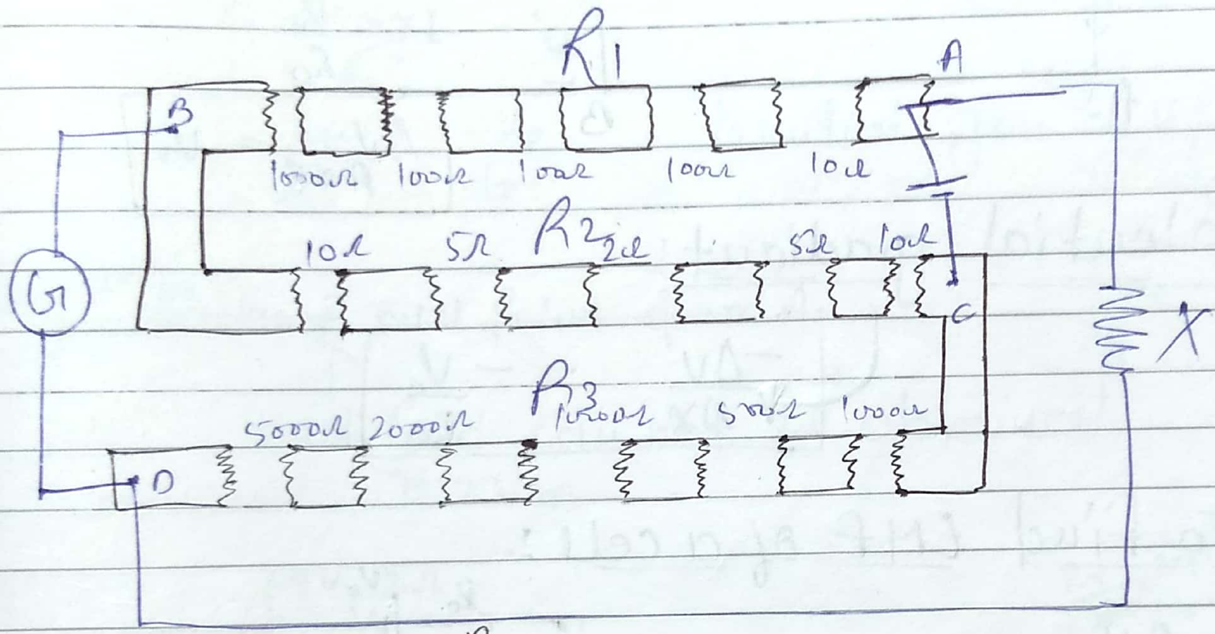
$$\frac{X}{R} = \frac{l}{100-l}$$

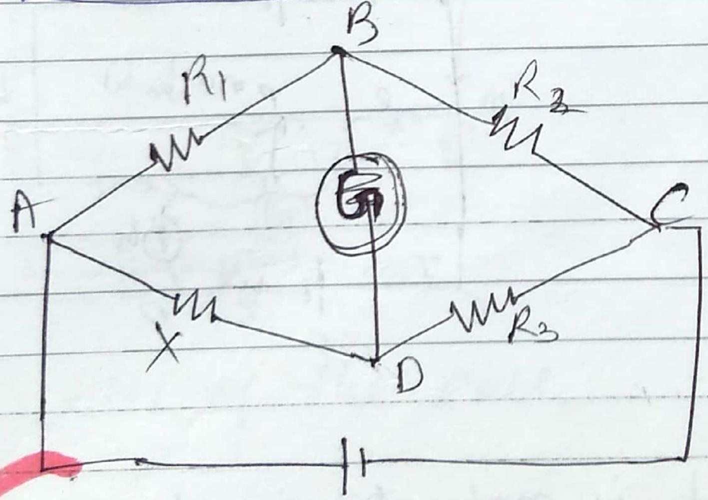
1) meter Bridge is most Sensitive or meter Bridge gives acquarate Reading when null point is obtained at the mid poion of wire A B.

* Ends correction $\frac{X}{R} = \frac{l+\alpha}{100-l+\beta}$

* Post office Box :

It is based on wheat stone bridge. It is used to measure Resistance of a wire. It is also used to find any breakage in electrical lines





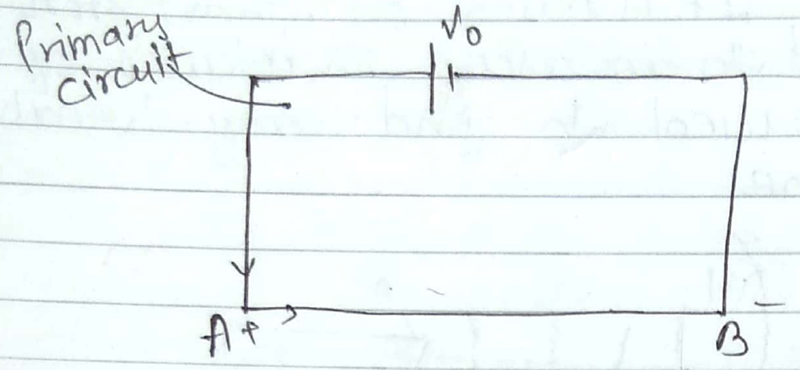
$$\frac{R_1}{x} = \frac{R_2}{R_3}$$

* Potentiometer :

It is used to find Potential difference b/w any two points. It is also used to measure and compared EMF and Internal Resistance of the cells. It is better device then Voltmeter

H.W: O-2 ⇒ Q (9,13) ≠ left 11 Que.
J-M: 1 to 10 Qu

It is based on null Point method.



$L_{AB} = L_0$

$R_0 = \rho \frac{L_0}{A}$

$i = \frac{V_0}{R_0}$

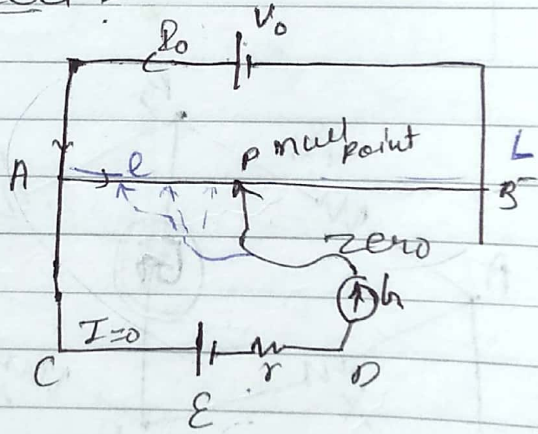
$\boxed{\Delta V_{A \to B} = V_0}$

Potential gradiant:

$$\boxed{\frac{-\Delta V}{\Delta x} = -\frac{V_0}{L_0}}$$

pot. gra

1) To find EMF of a cell:



$E = \Delta V_{A \to P}$

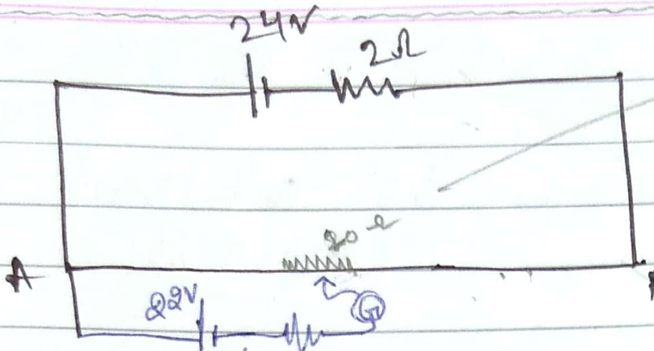
$$\boxed{E = \frac{V_0}{L_0} l}$$

*1) If $E > V_{AB}$

then null point is not obtained.

2) If cell is conected opposite to primary cell.

Que:



$L_{AB} = 200$ cm.

$R_{AB} = 10\ \Omega$.

find potential gradiant.

$V_B = iR$

$= 20$ Volt

Ans: $E = \frac{V_0}{l_0} \times l$

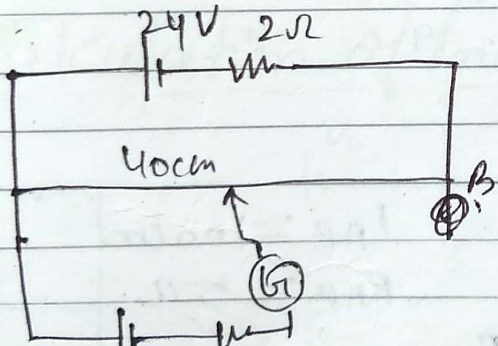
$-\frac{\Delta V}{\Delta x} = \frac{-V_0}{l_0}$

Potential gra. 0.1 V/cm.

$= \frac{V_0}{l_0} = \frac{20}{200} = 0.1$

find distance null Point from A.

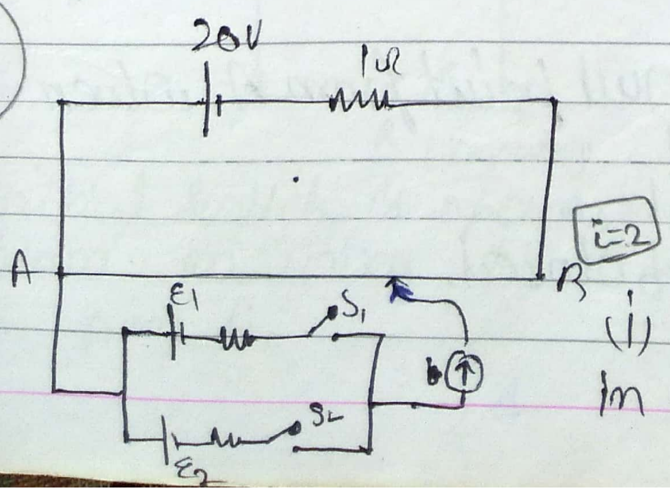
Here null Point can not be obtained because $E > V_{AB}$



find EMF of the cell : $E = \frac{V_0 \times l}{l_0}$

$0.1 \times 40 = 4$ V

Que:



$R_{AB} = 9\ \Omega$

$L_{AB} = 100$ cm.

(i) find Potential gradiant in Potentio wire

$\mathcal{E} = \frac{V_0}{L_0} \times l.$

$i = 2A$

$V_0 = iR_0$

$= 18V$

$\frac{V_0}{l_0} = 0.18 V/cm$

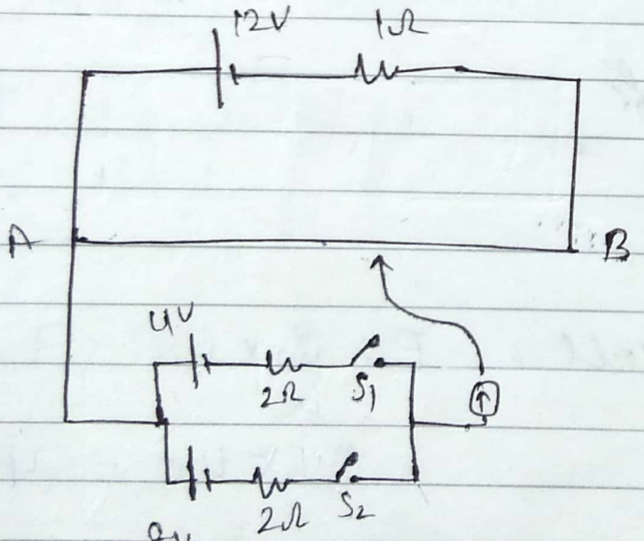
When switch S_1 is closed null point is obtained at 30 cm from A. When only S_2 is closed null point is obtained 50 cm from A find. $\frac{E_1}{E_2}$?

Ans: $\frac{E_1}{E_2} = \frac{l_1}{l_2} = \frac{3}{5}$

$E_1 = 5.4 \quad = 0.18 \times 30 = 5.4$

$E_2 = 9 \quad = 0.18 \times 50 = 9$

Que)



$L_{AB} = 100 cm.$

$R_{AB} = 5\Omega.$

$i = 2A.$

$\frac{V_0}{l_0} = \frac{2}{100} = 0.02$

(1) Find distance of null point from A when
(i) only S_1 is closed 40
(ii) only S_2 is closed 80
(iii) S_1 and S_2 are closed. 60

$I = 2A$ ✓ ε_2

$V_{AB} = V_0 = 10V$

$L_0 = 100cm$

$\varepsilon = \left(\frac{V_0}{L_0}\right) l$

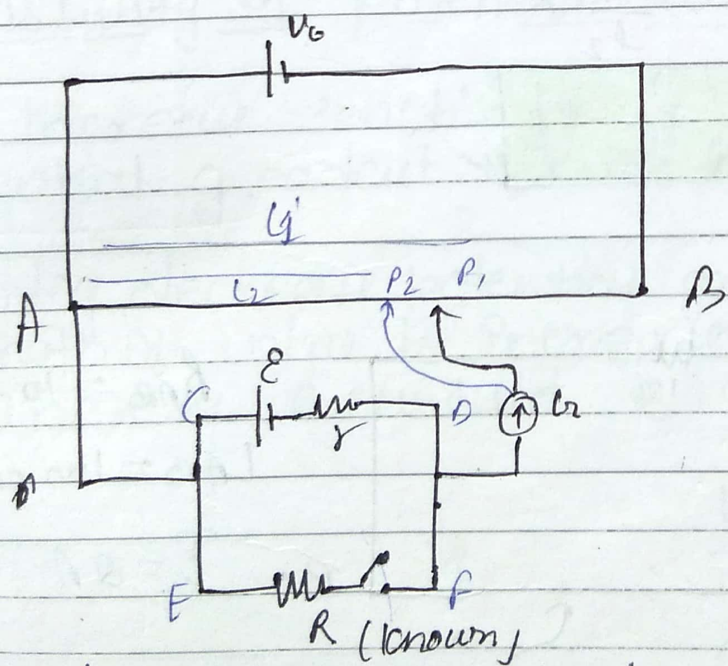
$4 = \frac{10}{100} \times l_1$ $\quad$ $8 = \frac{10}{100} \times L_2$

$l_1 = 40cm$ $\quad$ $L_2 = 80 cm$

$\Rightarrow \varepsilon_{eq} = \frac{2+4}{1}$

$\varepsilon_{eq} = 6V$

* Calculation of Internal Resistance :



$L_{AB} = L_0$

$V_{AB} = V_0$

Pot. grad. $= \frac{V_0}{L_0}$

Initial switch is open and null point is obtain on wire AB let it is at dist. l_1 from A.

$$E = \frac{V_0}{L_0} l_1$$

(ii) Now switch is closed and again null point is obtain on wire AB Let it is at distance L_2 from A.

Ans:

$$E = \frac{V_0}{L_0} l_1 \quad \text{--- (1)}$$

$$i = \frac{\varepsilon}{R+r}$$

$$iR = \left(\frac{V_0}{L_0}\right) l_2 \quad \text{--- (ii)}$$

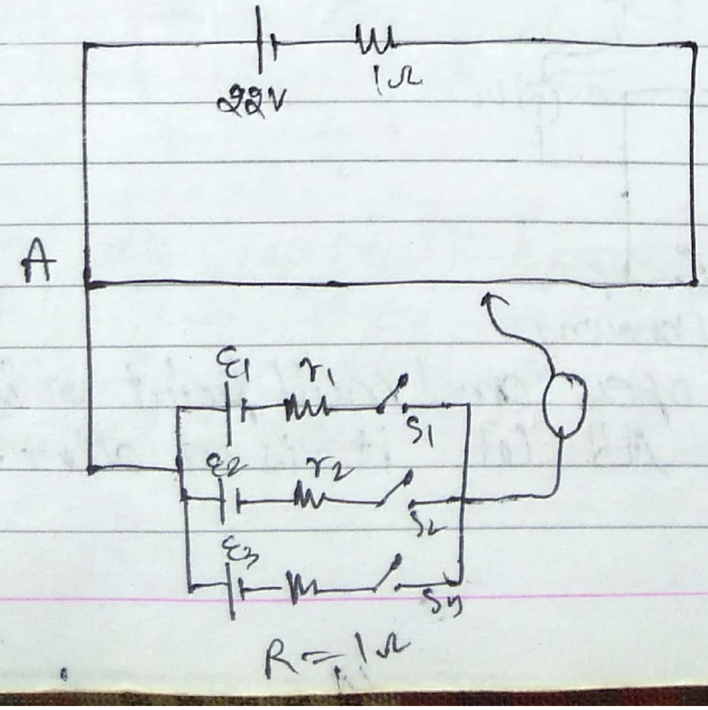
$$\frac{E}{iR} = \frac{l_1}{l_2}$$

$$\frac{R+r}{R} = \frac{l_1}{l_2}$$

$$R + r = \frac{l_1}{l_2} R$$

$$r = R\left(\frac{l_1}{l_2} - 1\right)$$

Que:



$R_{AB} = 10\,\Omega$

$L_{AB} = 100\text{ cm}$

$i = 2A$

H.W! J.A-19,7
left complete.

(i) when only S_1 is closed null point at 80 cm from A when S_1 and S_2 are closed then null point at 40 cm from A find E_1 and R_1.

Ans. A = 2A $\frac{V_0}{l_0} = \frac{20}{100} = 0.2$

$E_1 = \frac{V_0}{l_0} l_1$

$= \frac{20}{100} \times 80 = 16V$

$r_1 = R\left(\frac{l_1}{l_2} - 1\right)$

$= R\left(\frac{80}{40} - 1\right) =$

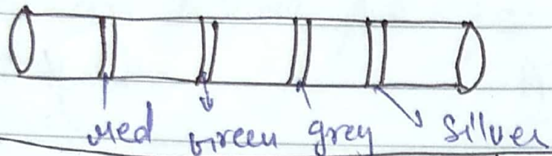
* Senstivity of potentiometer:

* To increase senstivity of potentiometer potential greadent is decreased.

* To ~~deg~~ decrease potential greadent either length of wire is increase or current in primary circuit is decrease.

$\uparrow \quad \rightarrow = \frac{V_0}{l_0}$

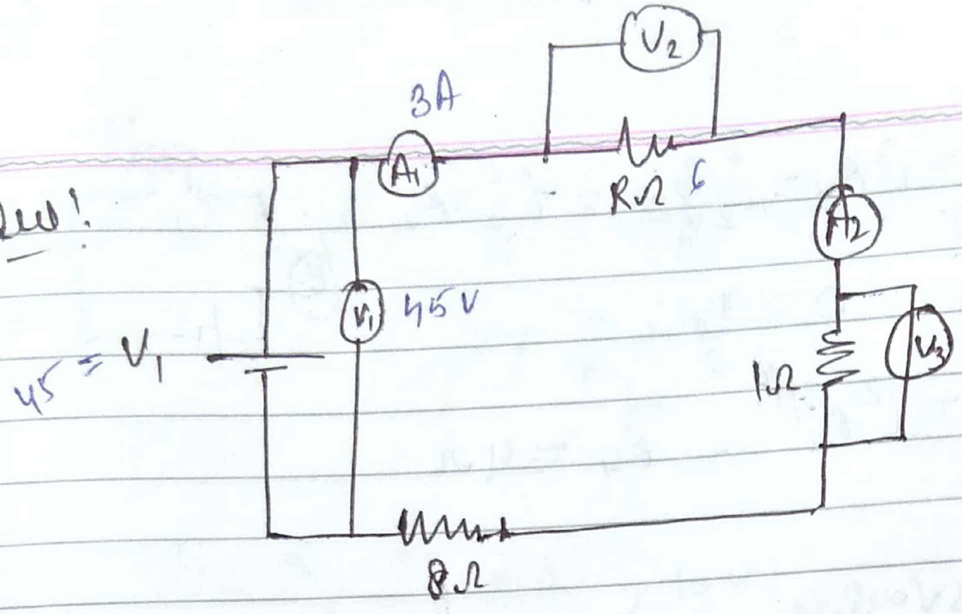
Colour Code for Carbon Resistors:



Colour	Strip A	Strip B	Strip C	Strip D Tolerance
Black	0	0	10^0	
Brown	1	1	10^1	
Red	2	2	10^2	
Orange	3	3	10^3	
yellow	4	4	10^4	
Green	5	5	10^5	
Blue	6	6	10^6	
violet	7	7	10^7	
Grey	8	8	10^8	
White	9	9	10^9	
Gold	–	–	10^{-1}	±5%
Silver	–	–	10^{-2}	±10%
No colour	–	–	–	±20%

B B Roy Great Britain very
Good watch of Gold & Silver

Que!



All are Ideal.

$9+R$

$V_1 + 45V = 27 + 3R$

If Reading of V_1 is 45V
& A_1 is 3A

find R.

Ans

$$i = \frac{45}{9+R}$$

$$3 = \frac{45}{9+R}$$

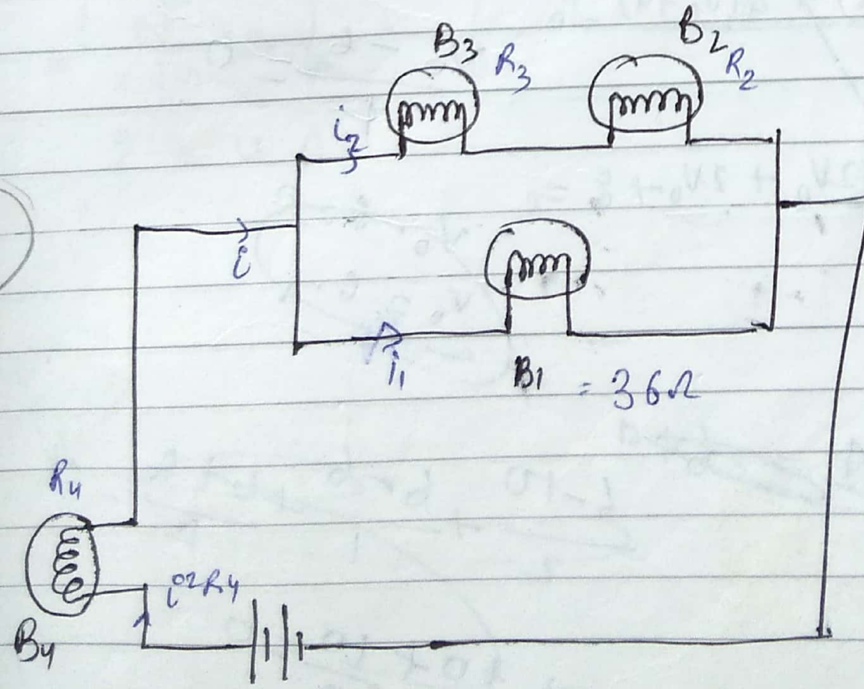
$27 + 3R = 45$

$3R = 45 - 27$

$R = \frac{18}{3} = 6\,\Omega$

$$R = 6\,\Omega$$

Q.2

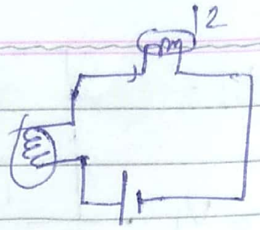


Power in each bulb is same and Resistance of B_1 is 36 Ω

Q/ find Resistance of B_2, B_3, B_4

Test syllabus upto - Voltmeter

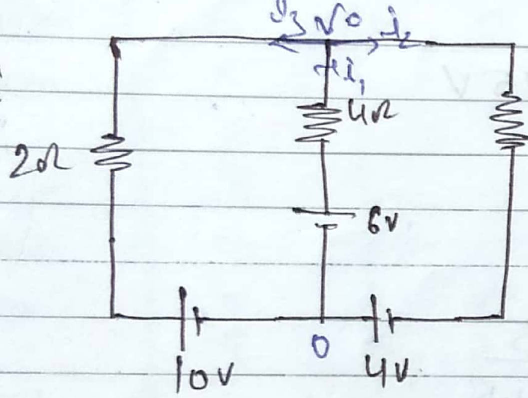
B_1 $i_1^2 36 = i^2 R_4 = i_2^2 3 = i_2^2 R_2$



$\frac{V^2}{2R} = \frac{2V^2}{36}$ $R = 9\Omega$

$3i^2 R_4 = i^2 R_2$ $R_4 = 4\Omega$

Que:



find R so that current ~~is~~ ~~20~~ in 4Ω is zero.

~~$V_0 - 10$~~

~~$\frac{V_0 + 4 + 6}{R}$~~

~~$\frac{V_0 - 10 + 6}{2}$~~ ~~$\frac{V_0 + 10}{R}$~~

$\frac{V_0 - 10}{2} + \frac{V_0 - 6}{1 \times 4} + \frac{V_0 + 4}{R} = 0$

↑ mistake $1 \to 4$.

$\frac{R(V_0 - 10) + 2R(V_0 - 6) + 2(V_0 + 4)}{2R} = 0$

$RV_0 - 10R + 2RV_0 - 12V_0 + 2V_0 + 8 = 0$

$RV_0 - 10R$

~~$V_0 + 6$~~

$\frac{V_0 - 6}{4} = 0$

$V_0 - 6 = 0$
$V_0 = 6$.

~~$\frac{V_0 + 4}{R}$~~ ~~$6 + 4$~~

$\frac{6 - 10}{2} + \frac{6 - 6}{1} + \frac{6 + 4}{R} = 0$

$-2 + 0 + \frac{10}{R} = 0$

0

$V_o - 10$

$\frac{V_0 - 6}{4} = 0 \quad V_0 - 6 = 0$

$V_0 = 6$

$\frac{6+4}{R} = 0 \quad V = IR$

$i_1 + i_2 + i_3 = 0, \quad \frac{V_0 - 6}{4} + \frac{V_0 + 4}{R} + \frac{V_0 - 10}{2} = 0$

$0 + \frac{10}{R} + \frac{-4}{2} = 0$

$\frac{10}{R} - \frac{2}{1} =$

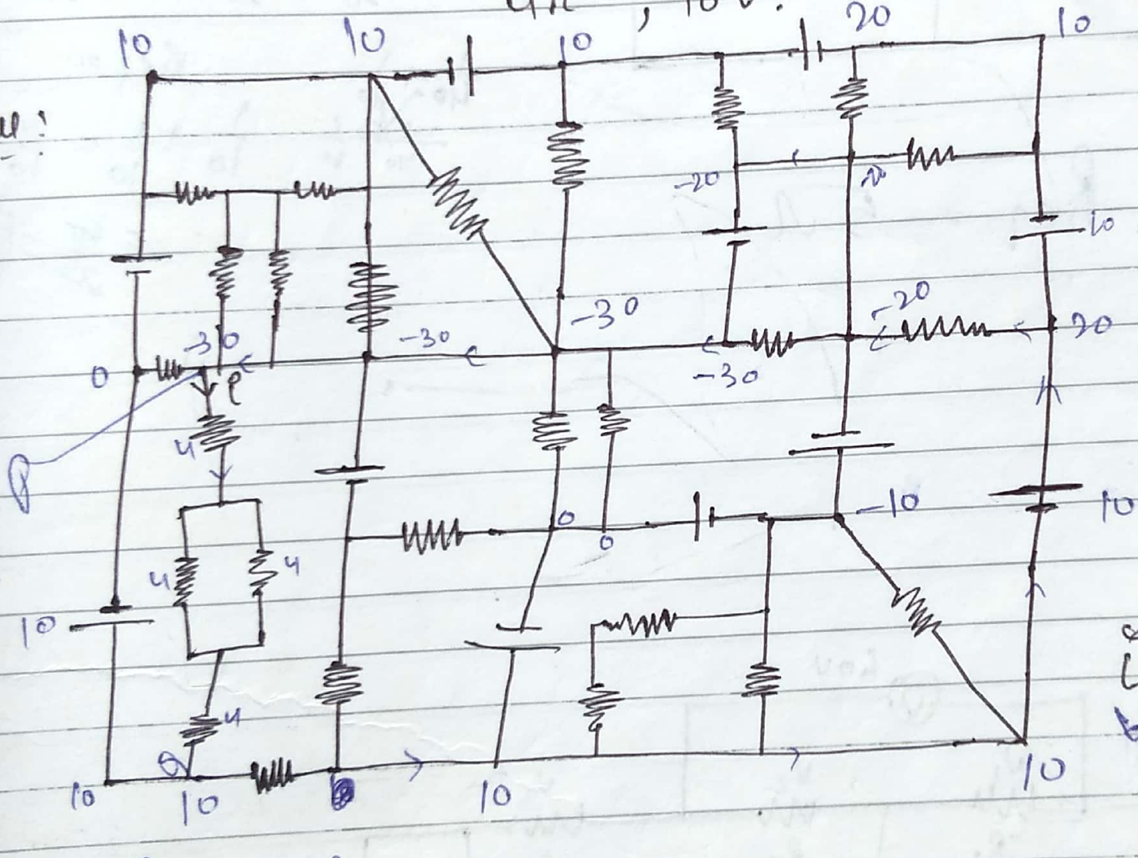
$\frac{10 - 2R}{R} = 0$

$10 - 2R = 0$

$R = \frac{-10}{-2} = 5$

4Ω , 10V.

Que:

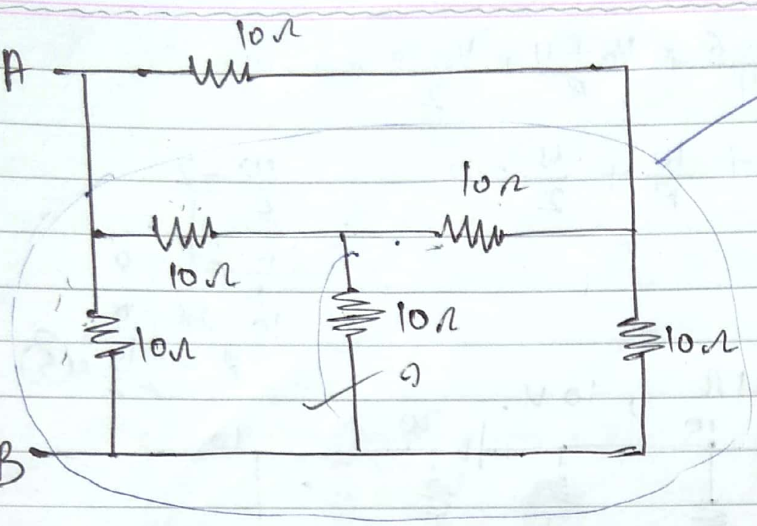


$i = ?$ b/w P and Q

$i = 4$ A

check voltage now

Q. A



Find R_{eq}.

$\frac{1}{20} + \frac{1}{20} = \frac{2}{20} = \frac{1}{10}$

$R_{eq} = 10$

$\frac{1}{40} + \frac{1}{10}$

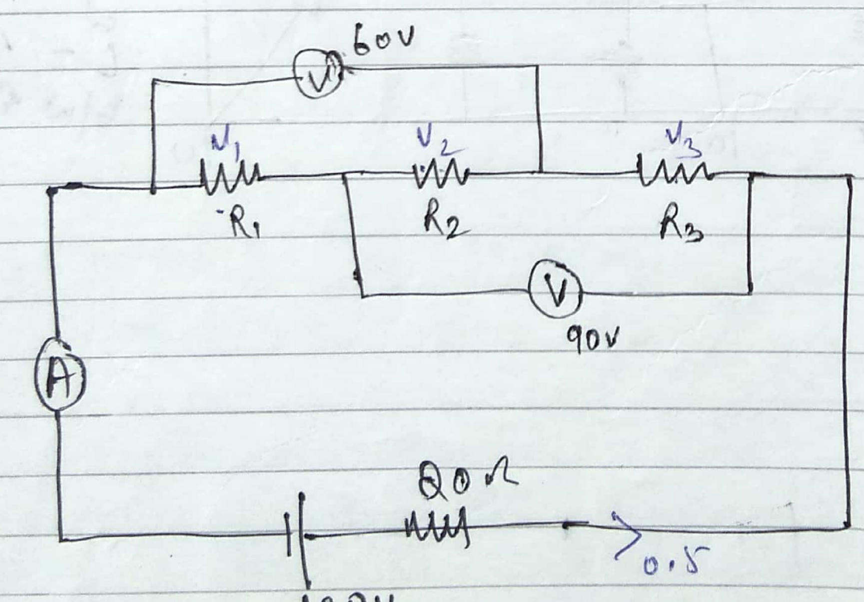
$\frac{1+4}{40} = \frac{6}{40}$

$\frac{1}{10} + \frac{1}{10} = \frac{2}{10}$

$= \frac{10}{2} = 5$

$R_{eq} = 5\Omega$

Que!



$V_1 + V_2 = 60$
$V_2 + V_3 = 90$

$V_1 + V_2 + V_3 = 110$
$60 + V_3 = 110$
$V_3 = 110 -$

J- Advanced.

$V_1 + V_2 + V_3 = 110$

$V_1 = 20$

$V_2 = 40$

$V_3 = 50$

$R_{eq} = 80$

~~Req~~ 80

$V_1 + V_2 + V_3 = 110$

$V_1 = 110 - 90$

$V_1 = 20$

$\Rightarrow V_1 + V_2 = 60$

$V_2 = 60 - 20 = 40$

$40 + V_3 = 90$

$V_3 = 90 - 40 = 50$