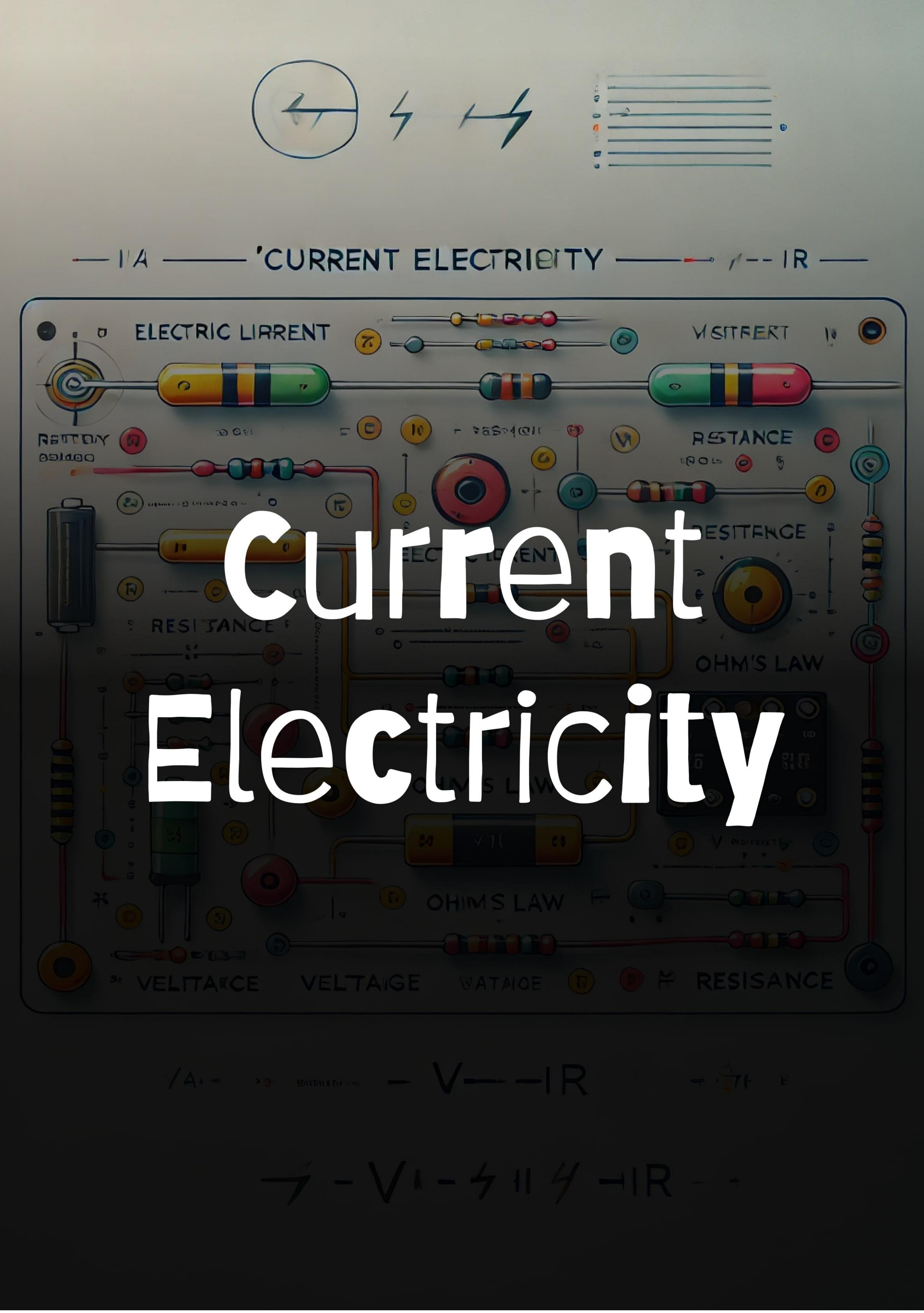

# Current Electricity

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# CURRENT ELECTRICITY

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**Electric Current** :→ The rate of directional flow of electric charge is called electric current.

⇒ Scalar
⇒ Direction of current along the motion of +ve charge and opposite to motion of -ve charge — Ex $\textcircled{+q} \xrightarrow{} i$, $v$; $\xleftarrow{v} \textcircled{q} \rightarrow i$
⇒ Unit (Amp)
⇒ Dimⁿ $(A^1)$

$$\boxed{\text{Electric Current}}$$

At 't' : $\boxed{I_{inst} = \left(\frac{dq}{dt}\right)}$ = Slope of q/t graph is current

In 't' : $\boxed{I_{avg} = \frac{\Delta Q}{\Delta t} = \frac{[Q_f - Q_i]}{t_f - t_i}}$

$\frac{\Delta Q}{t} = \frac{C}{sec}$ ampere

$\int_{t_1}^{t_2} I \cdot dt = \int dQ$

area. $(Q = i \cdot dt)$

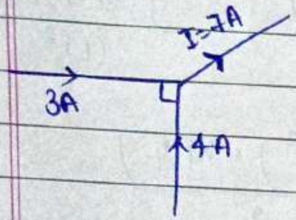
$\boxed{I_{avg} = \frac{\int I dt}{\int dt}}$ charge दुहेगा

avg current function TG

$\boxed{\text{C.G.S Unit of Current} \rightarrow \text{biot}}$

$\boxed{1\ \text{Amp} = 2C/sec}$

Ex:




$$\Delta Q = \int_{t_1}^{t_2} I\,dt = \text{Area of } (I/t)$$

वाली
q → I
slope (q/t) diffⁿ
diffⁿ → वाली

$I_{avg} = \frac{\Delta Q}{\Delta t} = \int I dt$

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

$\int I dt = \int dq$

$\int I\,dt = \Delta Q$

Time Period $\boxed{i = \frac{Q}{T} = Qf}$

$f = \frac{1}{T}$

$\boxed{i = Qf}$ frequency

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Que If Charge $Q = t^2 + 2t - 4$ is flowing through wire then find current at $t = 2$ sec and 2 sec

$$I = \left(\frac{dQ}{dt}\right) = 2t + 2$$

$$(I)_{at\ t=2} = 2 \times 2 + 2 = 6\ \text{Amp}$$

$$I_{avg} = \frac{\int I\,dt}{\int dt} = \frac{\Delta Q}{\Delta t}$$

$$\frac{Q_f - Q_i}{t_f - t_i} = \frac{4-(-4)}{2-0}$$

$$\frac{8}{2} = 4\ \text{Amp}$$

Que If Current flowing through wire $I = 3t^2 + 2t$ then find current at $t = 2$ sec and avg. current in 2 sec

$$I = 3t^2 + 2t$$

$$(I)_{t=2sec} = 3(2)^2 + 2(2)$$

$$3 \times 4 + 4$$

$$\boxed{16\ \text{amp.}}$$

$$I_{Avg} = \frac{\int_0^2 I\,dt}{\int_0^2 dt} = \frac{\int_0^2 (3t^2 + 2t)\,dt}{(t)_0^2}$$

$$= \frac{3\left(\frac{t^3}{3}\right) + 2\left(\frac{t^2}{2}\right)}{2}$$

$$\frac{(t^3 + t^2)_0^2}{2} = \frac{8+4}{2} = \frac{\cancel{12}^{\,6}}{\cancel{2}}$$

$$\boxed{6\ \text{amp}}$$

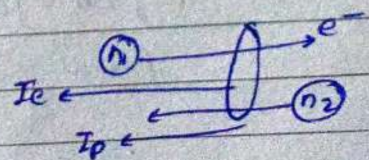
Que Through a given cross section $n_1$ electrons per second from left to right and $n_2$ protons are passing from right to left simultaneously per second are passing. The electric current through that cross section is ($e$ = electronic charge).

(a) $(n_1 + n_2)e$ towards left (b) $(n_2 - n_1)e$ towards right

(c) $(n_1^2 + n_2^2)e$ towards left (d) $(n_2^2 - n_1^2)e$ towards right

$$I = \frac{\Delta Q}{\Delta t} = \frac{n_1 e}{1\ \text{sec}} + \frac{n_2 e}{1}$$

$$(n_1 + n_2)e$$

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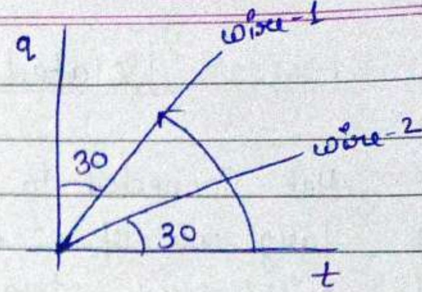
**Que** find ratio of Current $\frac{I_1}{I_2} = ??$

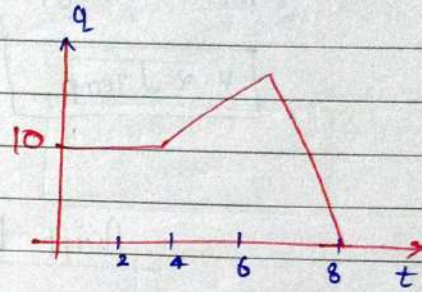



$I$ = Slope $(q/t)$ graph e $= \tan\theta$

$$\frac{I_1}{I_2} = \frac{\tan 60^\circ}{\tan 30^\circ}$$

$$\frac{I_1}{I_2} = \frac{\sqrt{3}}{1/\sqrt{3}} = \boxed{\frac{3}{1}} \text{ Ans}$$

**Que** find Avg Current b/w 0 to 8 sec.

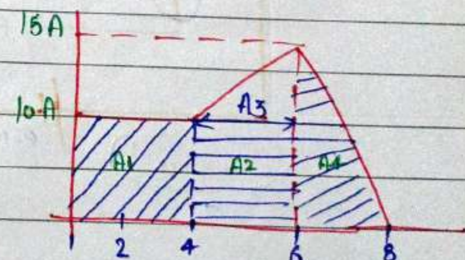



$$I_{avg} = \frac{\Delta q}{\Delta t} = \frac{\int I dt}{\int dt}$$

$$(I_{avg})_{0\text{-}8\,sec} = \frac{q_{t=8} - q_{t=0}}{8-0}$$

$$\frac{0-10}{8} = \frac{-10}{8} \text{ Amp.}$$

**Que** find avg Current b/w 0 to 8 sec




$$I_{avg} = \frac{\int I dt}{\int dt} = \left[\frac{Area}{\Delta t}\right]$$

$$= \frac{40+20+5+15}{8}$$

$$\frac{80}{8} = 10 \text{ Amp}$$

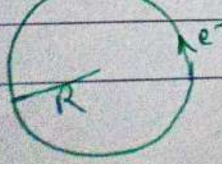
$A_1 = 40$

$A_2 = 20$

$A_3 = \frac{1}{2} \times 2 \times 5$

$A_4 = \frac{1}{2} \times 2 \times 15$

**Que** If electron is moving on the Circular path with frequency f then find Current.




$$I_{avg} = \frac{\Delta q}{\Delta t} = \frac{e}{T} = ef \text{ Amp.}$$

Clock wise Current

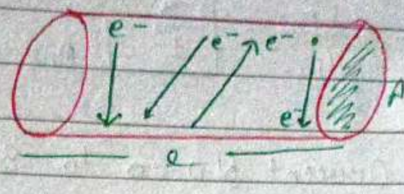
$$I = \frac{e}{T} = \frac{e}{\frac{2\pi R}{v}} = \boxed{\frac{eV}{2\pi R}}$$

velocity

# Isolated Conductor

# Not Connected to the battery. ( $E_{in} = 0$ )
# large no of $e^-$ are in random motion
# with $\underbrace{\text{speed}}_{}$ = $10^4$ m/sec.

due to thermal Energy ( Temp).




Path of e⁻'s : are straight line

Thermal speed

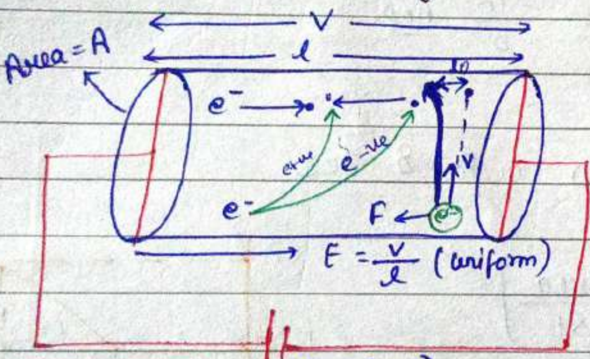
$$\boxed{\frac{1}{2}mv^2 = \frac{3}{2}K_BT}$$

$$V = \sqrt{\frac{3RT}{m}}$$

$$\boxed{v \propto \sqrt{\text{Temp}}}$$

$$\boxed{\langle \text{Velocity} \rangle = 0}$$

## Drift Velocity / OHM Law




$\boxed{V_d = 10^{-4}}$

$E = \frac{V}{l}$ (uniform)

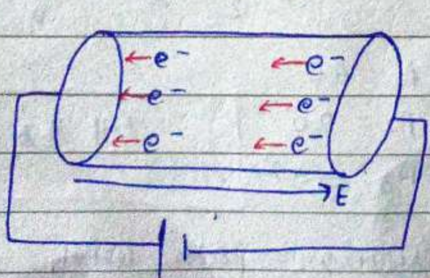
force on $e^- = qE = eE$

$a = \frac{F}{m} = \frac{eE}{m}$ (uniform)

$\boxed{\text{Path of } e^- \rightarrow \text{Parabolic}}$

drifted length = $l_0$
= mean free path.
( avg distⁿ b/w two collision)

Ex




drift Velocities

$$\langle v \rangle = \langle \cancel{v}^{0} \rangle + \langle at \rangle$$

Relaxation time

$$\boxed{\langle v \rangle = \frac{eE}{m}\tau}$$

← Relaxation time

( avg time b/w two collision)

$v_d = a\tau$

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

or $\boxed{\frac{e \times V}{ml} \times \tau}$

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## Drift Velocity

$F = eE$

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

$$\boxed{V_{drift} = \frac{eE\tau}{m}}$$

Relation b/w current and $V_d$

$$\boxed{I = neA V_d}$$

elastic curr

no of $e^-$ per unit Volu.

$\lambda$ = free path

$V = El = E\lambda$

Energy = $qE\lambda$

$I = neAV_d$

$V_d = \frac{I}{neA}$ — (i)

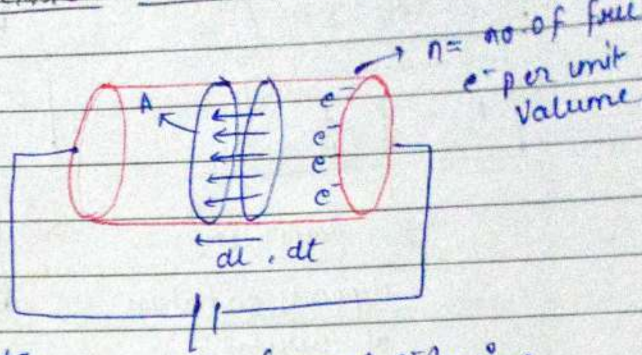
$V_d = \frac{eE\tau}{m_e}$ — (ii)

(ii) — (i)

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

$\frac{V}{l} = \frac{mI}{ne^2A\tau}$

## Expression current in term of drift Velocity




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

N = (no. of $e^-$ Passing through this cross-section)

$= \boxed{nAdl}$ Volume

$dq = Ne$

$dq = nAdle$

$I = nA\left(\frac{dl}{dt}\right)e$

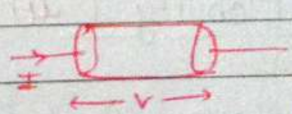
$$\boxed{I = neAV_d}$$

$I = neAV_d$

$$\boxed{V_d = \frac{I}{neA}}$$ — (ii)

$$\boxed{V_d = \frac{eE\tau}{m}}$$ — (i)

$$\boxed{V = \frac{ml\,I}{ne^2A\tau}}$$ microscopic forms of ohms Law




$V \propto I$

$\boxed{V = RI}$ — (iv)

Ohm law

Macroscopic forms of ohm Law

(iii) = (iv)

$\frac{ml\cancel{I}}{ne^2A\tau} = \cancel{I}R$

$$\boxed{R = \frac{ml}{ne^2\tau A}}$$

Resistance

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$$\boxed{R = \frac{ml}{ne^2 \tau A}}$$

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

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

$\rho$ : Resistivity depends on nature of crystal

$$\boxed{\sigma \text{ (conductivity)} = \frac{1}{\rho}}$$

$$\boxed{\sigma = \frac{ne^2 \tau}{m_e}}$$

Conductivity

$$\boxed{\sigma = \frac{ne^2 \tau}{m}} \quad \text{— (I)}$$

$$\rho = \frac{1}{\sigma} \quad \text{— (II)}$$

Resistivity material

$$\boxed{\rho = \frac{m}{ne^2 \tau}} \quad \text{— (III)}$$

$$R = \frac{\rho l}{A} \quad \text{— (IV)}$$

$$\boxed{R = \frac{ml}{ne^2 \tau A}} \quad \text{— (V)}$$

$$\boxed{V = IR} \quad \text{— (VI)}$$

$$\boxed{V = \frac{ml I}{ne^2 \tau A}} \quad \text{— (VII)}$$

$$I = neAv_d \quad \text{— (VIII)}$$

$$v_d = \frac{eE}{m} \tau \quad \text{— (IX)}$$

$$\boxed{E = \frac{V}{l}} \quad \text{— (X)}$$

## Mobility ($\mu$)

Property of charge particle

$$\mu = \frac{v_d}{E}$$

Drift velocity per unit electric field.

Mobility does not depend on drift velocity and electric field.

$$\mu = \frac{eE\tau}{mE}$$

$$\boxed{\mu = \frac{e\tau}{m}} \quad \text{mobility}$$

$$\mu = \frac{e}{m} \propto \text{specific charge}$$

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* Proton $(e, m_p)$

$\mu_p = \frac{e\tau}{m}$

* Deutron $(e, 2m)$

$\mu_D = \frac{e\tau}{2m} = \frac{\mu_p}{2}$

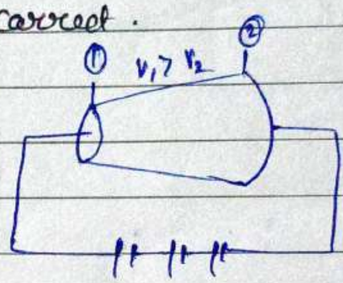
* $\alpha$ - Particle $(2p, 2n)$

$(2e, 4m)$

$$\boxed{\mu_2 = \frac{2e\tau}{4m} = \frac{e\tau}{2m} = \mu_{Deutron}}$$

Qu The Value of drift Speed at Cross section (1) and (2) are $v_1$ and $v_2$ respectively in the conductor shown below in the shape of a truncated Cone. Which of the following is correct.

$$\boxed{V_d = \frac{I}{neA}}$$




## (j) Current Density = electric current per unit area.

$$\boxed{\vec{J} = \frac{I}{A} = \frac{neAV_d}{A}}$$

dirn along the dirn of current

→ Vector

→ Unit Amp / $m^2$

$$\boxed{J = neV_d}$$

↳ putting the value of $V_d$

$V_d = \frac{eE\tau}{m}$ — (11)

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

$J = \frac{ne^2\tau}{m} E$

$$\boxed{\vec{J} = \sigma\vec{E}}$$ Vector form of ohms Law

↳ Conductivity $\boxed{\vec{E} = \rho\vec{J}}$

dirn of J along Electric field.

Q.8 $$\boxed{\downarrow J \propto \frac{1}{A\uparrow}}$$

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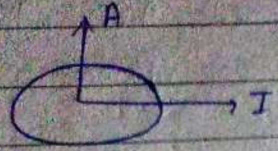
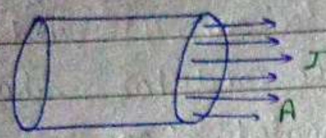
# Current density

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

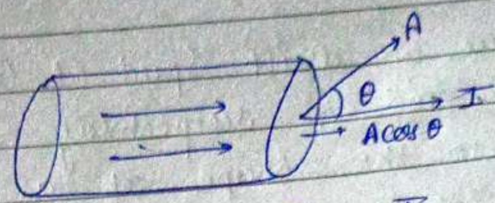
$$J = \frac{I}{A}$$




J = Not define.




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




$$J = \frac{I}{A\cos\theta}$$

$$I = JA\cos\theta$$

Current → $I = \vec{J} \cdot \vec{A} = \boxed{JA\cos\theta}$

Que Current density $\vec{J}$ at an area $\vec{A} = (2\hat{i} + 3\hat{j})\ mm^2$ is $\vec{j} = (3\hat{i} + 4\hat{j})\ A/m^2$. Current through the area is

1. 9 μA
2. Zero
3. 18 μA ✓
4. 12 μA.

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

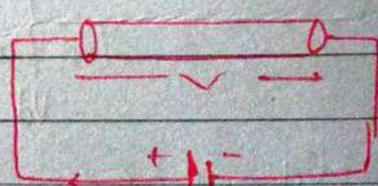
$$(2\hat{i} + 3\hat{j}) \cdot (3\hat{i} + 4\hat{j})$$

$$(6 + 12)$$

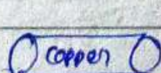
$$18 \times 10^{-6}$$

$$= 18\ \mu A \quad B$$

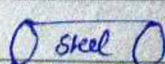
## Resistance




$R \propto l$ — (I)




$R \propto \frac{l}{A}$ — (II)




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

formula

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

ρ = resistivity / specific resistance

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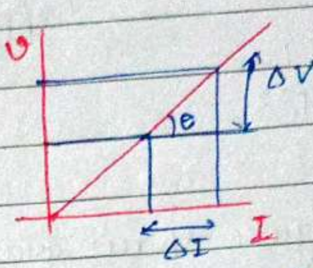
↳ depends on nature of Conductor
↳ does not depend on length and Area.

If length is changes keeping Area = Const

$$R \propto l$$

$$\boxed{\frac{R_1}{R_2} = \frac{l_1}{l_2}}$$

$$\boxed{\frac{\Delta R}{R} = \frac{\Delta l}{l}}$$




slope $\theta = \frac{P}{B} = \frac{\Delta V}{\Delta I} = R$

I or V axis = Slope $\propto \frac{1}{\text{Resist's}}$

If length is changing keeping

$$\boxed{\text{Volume} = \text{Const}}$$

$$R = \frac{\rho l \times l}{(A \times l)}$$

$$R = \frac{\rho l^2}{\text{Volume}} \Rightarrow \boxed{R \propto l^2} \Rightarrow \boxed{\frac{R_1}{R_2} = \frac{l_1^2}{l_2^2}}$$

$$\boxed{\frac{\Delta R}{R} = 2\frac{\Delta l}{l}}$$

Area is changing keeping length Const

$$R = \frac{(\rho l)}{A} \text{ const}$$

$$R \propto \frac{1}{A} \propto \frac{1}{r^2} \quad (r = \text{radius})$$

$$\boxed{\frac{\Delta R}{R} = -\frac{\Delta A}{A} = -2\frac{\Delta r}{r}}$$

$$\boxed{\frac{R_1}{R_2} = \frac{A_2}{A_1} = \frac{r_2^2}{r_1^2}}$$

$$\frac{R'}{} = \left(\frac{l'}{}\right)^2$$

Area is changing keeping Volum. Const

$$R = \frac{\rho l \times A}{A \times A} = \frac{\rho \text{ Volume}}{A^2}$$

$$\boxed{R \propto \frac{1}{A^2} \propto \frac{1}{r^4}}$$

$$\boxed{\frac{R_1}{R_2} = \frac{A_2^2}{A_1^2} = \frac{r_2^4}{r_1^4}}$$

$$\boxed{\frac{\Delta R}{R} = -2\frac{\Delta A}{A} = -4\frac{\Delta r}{r}}$$

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Two copper wires of length l and 2l have radii R and 2R respectively what is ratio of their specific resistance?

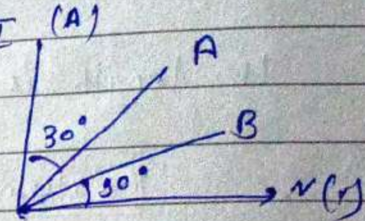
(a) 1 : 2

(b) 2 : 1 — Copper ki alway Same hoga

(c) 1 : 1

(d) 1 : 3

Que figure show graph b/w I and V for two Conductor A and B. their respective resistance are in the ratio.




(1) 1 : 1 — $V = IR$

(2) 1 : 3 — $R = \frac{V}{I}$ (slope of V/I graph is ratio)

(3) 3 : 1

(4) 1 : 2

$$\left(\frac{R_A}{R_B}\right) = \frac{\text{Slope } B}{\text{Slope } A} = \frac{\tan 30}{\tan 60} = \frac{1}{3}$$

Que Two wires A and B of the same material having radii in the radio 1 : 2 Carry Current in the ratio 4 : 1, the ratio of drift Speed of electrons in A and B is.

(a) 16 : 1

(b) 1 : 16 — $I = n_e A v_d$

(c) 1 : 4

(d) 4 : 1

$$v_d = \frac{I}{A} = \frac{I}{\pi r^2}$$

$$v_d \propto \frac{I}{r^2}$$

$$\frac{v_1}{v_2} = \frac{I_1}{I_2}\left(\frac{r_2}{r_1}\right)^2 = \frac{4}{1}\left(\frac{2}{1}\right)^2 = 4 \times 4 = 16 : 1$$

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If a copper wire is stretched to make its radius decrease by 0.1%. Than the percentage increase in resistance is nearly.

(a) 0.1 %.
(b) 0.8 %.
(c) 0.4 %.
(d) 0.2 %

$R \propto \frac{1}{R^2} \propto \frac{1}{r^4}$

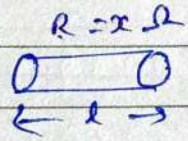
$100 \times \frac{\Delta R}{R} = -4\left(\frac{\Delta r}{r}\right) \times 100$

$= -4(-0.1)\ \%$

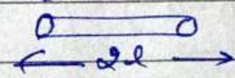
$\boxed{\frac{\Delta R}{R} \times 100 = 0.4\ \%}$

A wire of resistance x Ohm is drawn out, so that its length is increased to twice its original length. and its new resistance becomes 20 Ω then x will be

(1) 5 Ω
(2) 10 Ω
(3) 15 Ω
(4) 20 Ω




V = const




$\underline{R \propto l^2}$

$\frac{x}{20} = \left(\frac{l}{2l}\right)^2$

$\frac{x}{20} = \frac{1}{4} \Rightarrow x \frac{20}{4} = \underline{5\ \Omega}$

A certain piece of copper is to be shaped into a conductor of minimum resistance. Its length and diameter should respectively be

(a) L, D
(b) 2L, $\frac{D}{2}$
(c) $\frac{L}{2}$, 2D
(d) L, $\frac{D}{2}$

$R_{min} \propto \frac{l_{min}}{A_{max.}}$

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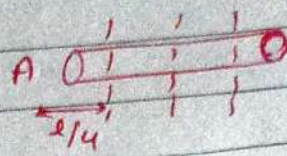
Q. A piece of wire is cut into four equal parts and the pieces are bundled together side by side to form a thicker wire. Compared with that of the original wire the resistance of the bundle is.

(a) The same
(b) 1/16 as much
(c) 1/8 as much
(d) 1/4 as much

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



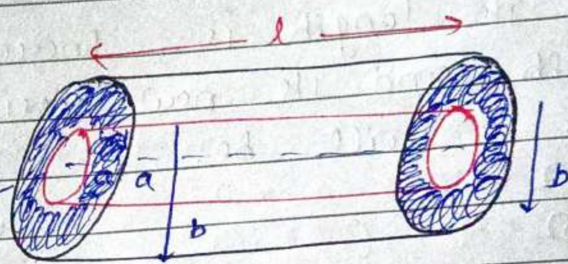

$$R' = \frac{\rho l}{4\times 4A} = \frac{R}{16}$$

$R \propto l$

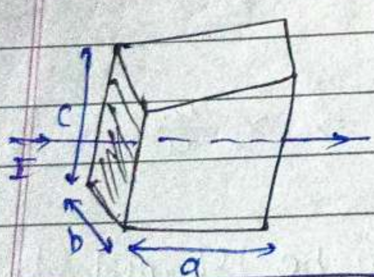
Q.

$$R = \frac{\rho l}{A} = \frac{\rho l}{\pi b^2 - \pi a^2}$$

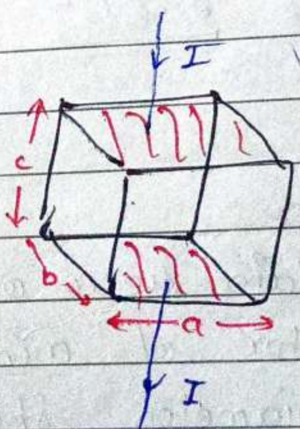
$$\boxed{R = \frac{\rho l}{\pi(b^2-a^2)}}$$




Qu



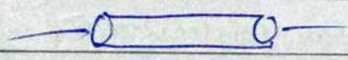

$$\boxed{R = \frac{\rho l}{A} = \frac{\rho a}{cb}}$$




$$\boxed{R = \frac{\rho c}{ab}}$$

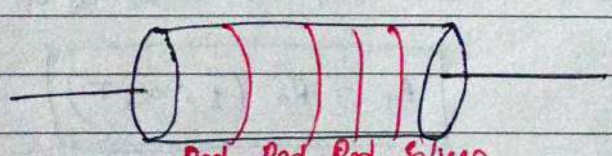
# Resistor Colour Codes

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| B | B | R | O | Y | G | B | V | G | Wite |
| Black | Brown | Red | Orang | Yell | Gree | Blue | Violet | Grey | White |



$R = [52 \times 10^4 \Omega] + 10\%$

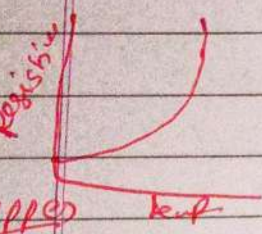
Q. Find the resistance of following Carbon resistor

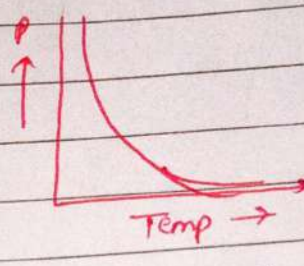



B B R O Y

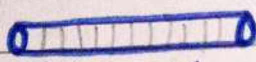
$R = [22 \times 10^2 \Omega] \pm 10\%$

| | Conductor | Insulator | Semiconductor |
|---|---|---|---|
| Temp ↑ | Randomness ↑<br>Resistivity / Resist ↑<br>Conductivity ↓<br>Drift Vel ↓ | Same as Semiconductor | e- hole Pair ↑<br>resistivity ↓<br>Conductivity ↑<br>drift Velocity ↓ |
| Temp ↓ | Randomness ↓<br>Resistivity ↓<br>Conductivity ↑<br>drift Velocity ↑<br>= Copper | | e- hole Pair ↓<br>resistivity ↑<br>Conductivity ↓<br>drift Velocity ↑<br>Silicon<br>Graphite |




## Temperature dependence of Resistance and Resistivity



$R_0, T_0 = 0°C$

$R, T$

$\alpha_R = \frac{\Delta R}{R \Delta T}$

= Relative change in Resistance per unit raise in temp.

Temp$^n$ Coefficient of Resistance

for conductor $\alpha_R \rightarrow +ve$

for Semiconductor $\alpha_R \rightarrow -ve$

Insulator $-ve$.

$\Delta R \propto R_0$ —— (1)

$\Delta R \propto \Delta T \propto (T - T_0)$

$\Delta R \propto \alpha_R$

Temp$^n$ Coefficient of resistance.

$\boxed{\underbrace{\Delta R}_{\text{Change in Resistance}} = \alpha_R R_0 \Delta T} \longrightarrow \Delta R = R_T - R_0 = R_0 \alpha_R \Delta T$

$\boxed{R_T = R_0 (1 + \alpha_R T)}$

$R_T$: Resistance at T

$\alpha_R$: Thermal Coefficient of Resistance

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$$\boxed{\alpha_R = \frac{\Delta R}{R \Delta T}}$$

For Resistivity

$$\alpha_\rho = \frac{\Delta \rho}{\rho \Delta T}$$

= Relative change in resistivity per unit raise temp.

$$R_T = R_0 (1 + \alpha_R T) \quad \text{— (1)}$$

$\hookrightarrow$ Resistance at temp T

$R_0$ = Initial Resistance

$\alpha$ = Temp Coefficient of Resist

If Resistance at temp $T_1$ is $R_1$ and at temp $T_2$ is $R_2$ then find relation b/w them where $\alpha_R \rightarrow$ Temp Coefficient of Resistant.

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

Let assume $R_0$ is temp at $0°C$

$$\frac{R_1 = \cancel{R_0}(1 + \alpha T_1)}{R_2 = \cancel{R_0}(1 + \alpha T_2)} = \boxed{\frac{R_1}{R_2} = \left(\frac{1 + \alpha T_1}{1 + \alpha T_2}\right)}$$

Q Find Relation b/w $\alpha \rightarrow$ Coefficient of linear Expansion $\alpha_R \rightarrow$ Coefficient of Resistance and $\alpha_\rho \rightarrow$ Coefficient of Resistivity.

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

$$\alpha = \frac{\Delta l}{l \Delta T}$$

change error analysis

$$\alpha_R = \frac{\Delta R}{R \cdot \Delta T}$$

$$\frac{\Delta R}{\Delta T R} = \frac{\Delta \rho}{\rho \Delta T} + \frac{\Delta l}{l \Delta T} - \frac{\Delta A}{A \Delta T}$$

$$\alpha_\rho = \frac{\Delta \rho}{\rho \Delta T}$$

$$\alpha_R = \alpha_\rho + \alpha - \beta$$

$$\alpha_R = \alpha_\rho + \alpha - 2\alpha$$

$$\boxed{\alpha_R = \alpha_\rho - \alpha}$$

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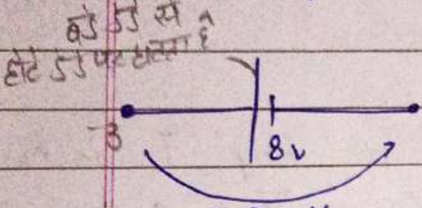
**Battery** → Battery is not a source of charge

→ It is a source of energy.

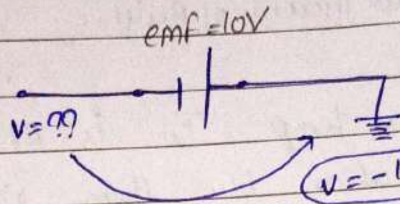
$$\boxed{W = qV}$$

- Maintain const potential diff^n across point where it is connected.




$-3-8 = V$

$V = -11$ Volt

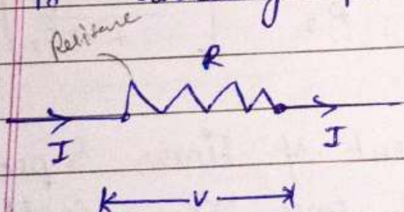



$V+10 = 0$ grnd के लिए zero

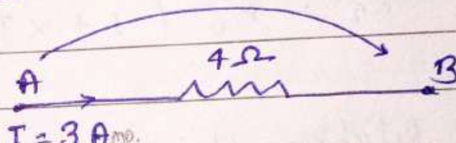
$\boxed{V = -10 \text{ Volt}}$

## Potential drop across resistance → Ohms ने दिया

Potential drop across two end of resistance is directly proportional to current.




drop की value $\boxed{V = RI}$

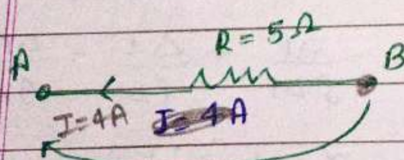



$\boxed{V_A > V_B}$

Current flow from Higher to lower.

$V_A - IR = V_B$

$V_A - V_B = 3 \times 4 = 12$ Volt




$V_B > V_A$

Find $V_A - V_B = ??$

$V_B - 4 \times 5 = V_A$

$\boxed{-20 \text{ Volt} = V_A - V_B}$

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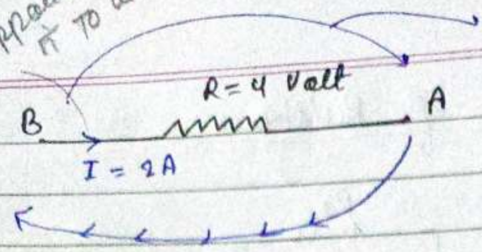
Opposite direction $\pi$ to add negative.

Qu




$V_B - IR = V_A$

$-2 \times 4 = V_A - V_B$

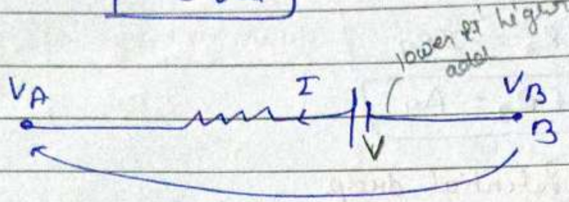
$\boxed{-8 \text{ Volt} = V_A - V_B}$

$V_A + IR = V_B$

$V_A - V_B = -IR$

$= -2 \times 4$

$\boxed{= -8 \text{ Volt}}$

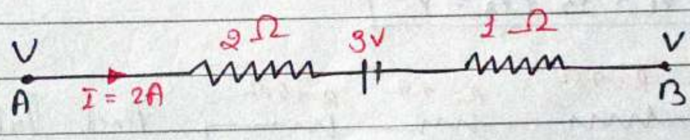



$V_B + V - IR = V_A$

$\boxed{V - IR = V_A - V_B}$

PYQ 2016

Qu The Potential difference $(V_A - V_B)$ b/w the Point A and B in the given figure is.




(a) $-3V$

(b) $+3V$

(c) $+6V$

(d) $+9V$

$V_A - 2 \times 2 - 3 - 2 \times 1 = V_B$

$V_A - 9V = V_B$

$\boxed{V_A - V_B = 9 \text{ Volt}}$ Ans

Qu Value of the Resistance R in the figure is.

(a) $6\Omega$

(b) $8\Omega$

(c) $10\Omega$

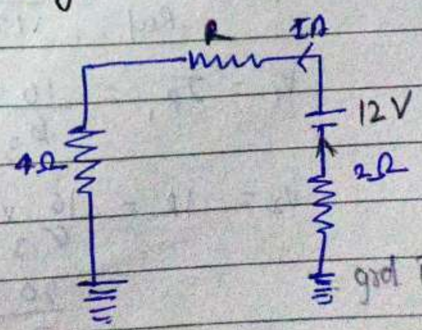
(d) $12\Omega$

$0V - 1 \times 2 + 12 - 1R - 1 \times 4 = 0$

$-2 + 12 - R - 4 = 0$

$12 - 6 = R$

$\boxed{R = 6\Omega}$

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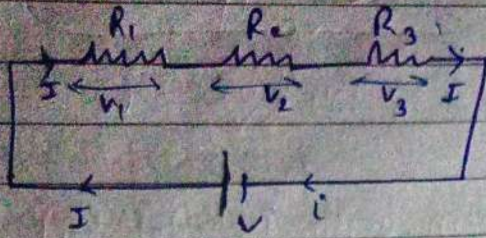
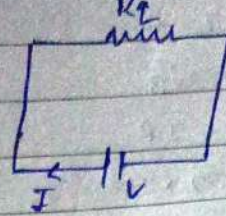
Current remain same

# Series Combination of Resistance





R is same
$R_{eq} = nR$

$$\boxed{V = V_1 + V_2 + V_3}$$

$$IR_1 + IR_2 + IR_3 = IR_{eq}$$

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

→ Law of Potential drop.

$V = IR$ (same)

$V \propto R$

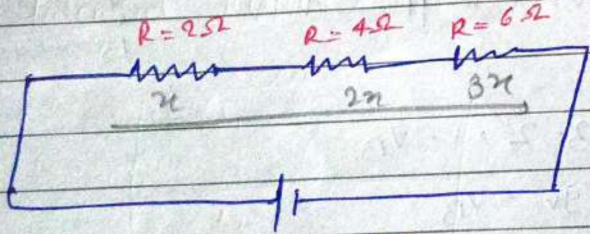
$$\boxed{\frac{V_1}{V_2} = \frac{R_1}{R_2}}$$

# Current is same in all Resistance in series Combination

Sum of potential drop across each other resistance is potential of Battery.

$$\boxed{V_1 + V_2 + V_3 = V}$$

Que



Find Potential drop across each resistance

$e = 20$ Volt

MR

$R_{eq} = 2 + 4 + 6 = 12\,\Omega$

$I = \frac{V}{R_{eq}} = \frac{20}{12} = \frac{10}{6}$ Am

$V_1 = IR_1 = \frac{10}{6_3} \times 2 = \frac{10}{3}$ m

$V_2 = IR_2 = \frac{10}{6_3} \times 4^2$

$\frac{20}{3}$

$V_3 = \frac{10}{6} \times 6 = 10$ volt

$V = IR$

$6x = 20$

$$\boxed{x = \frac{20}{6} \text{ volt}}$$

$(2x) = 2\left(\frac{40}{6}\right)$ volt

$3x = 3\left(\frac{30}{6}\right) = \boxed{10 \text{ V}}$

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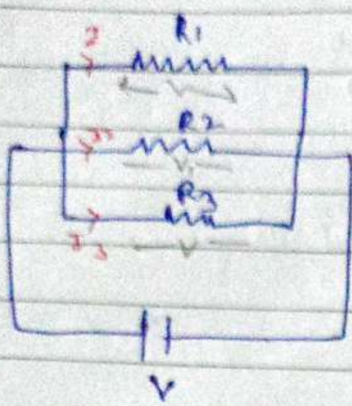
## Parallel Combination of resistance = $\boxed{\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$



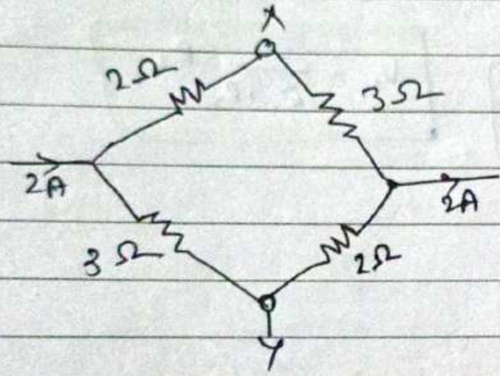

Potential drop across each resistance is same

$$\boxed{I = I_1 + I_2 + I_3}$$

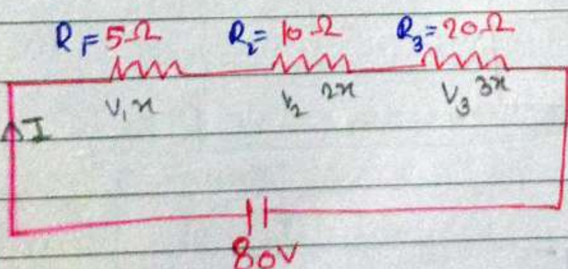
i is different in parallel and V is same

Qu. Find. (1) 1 (2) −1 (3) 2 (4) −2

special




Qu. Find Current and Potential drop across each resistance




5Ω

$x + 2x + 4x = 80$

$7x = 80$

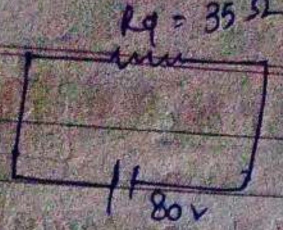
$x = \frac{80}{7}$ volt

Potential drop in 10 Ω

$V_2 = 2x = \frac{160}{7}$ volt

$V_3 = 4\left(\frac{80}{7}\right)$ volt

II Method

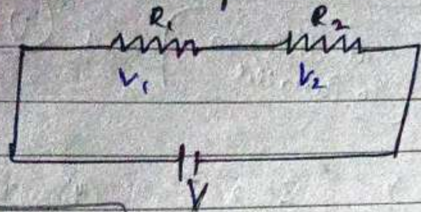



$I = \frac{80}{35}$ Ans

$V_1 = IR = \frac{80}{\cancel{35}_{7}} \times \cancel{5}$

$= \frac{80}{7}$ Ω

**Que** Find Potential drop across $R_1$ and $R_2$




$\boxed{I = \frac{V}{R_q}} = \frac{V}{R_1 + R_2}$

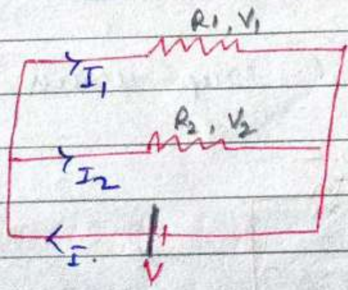
$V_2 = IR_2$

Formula — $\boxed{V_1 = IR_1 = \frac{V}{R_1 + R_2} R_1}$

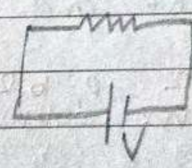
$\boxed{V_2 = \frac{V}{R_1 + R_2} R_2}$

## Parallel Combination

Potential across each resistance is same.




$\boxed{i_1 = \frac{R_2}{R_1 + R_2} i}$




$\boxed{I = I_1 + I_2}$

$\frac{V}{R_q} = \frac{V_1}{R_1} + \frac{V_2}{R_2}$

$\boxed{\frac{1}{R_q} = \frac{1}{R_1} + \frac{1}{R_2}}$

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

n- Identical resistance Connected in Parallel of each resistance R then Req = ??

$\boxed{R_{eq} = \frac{R}{n}}$ =

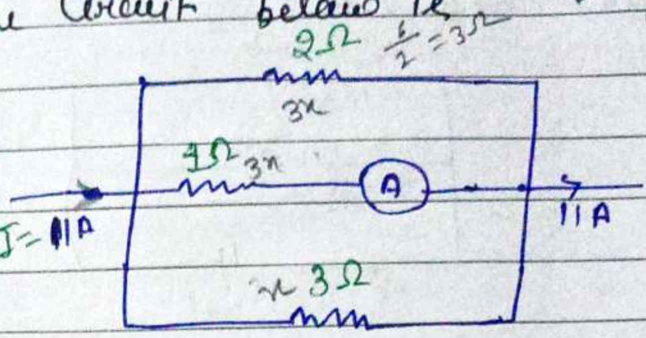
The ammeter reading in the Circuit below is $\quad I \propto \frac{1}{R}$

(a) 2A $\quad R_{eq} = \frac{11}{6}$

(b) 3A $\quad I = 11A$

(c) 6A $\quad \leftarrow V \rightarrow$

(d) 5A $\quad V = IR = 11 \times \frac{6}{11} = \underline{6 \text{ Volt}}$




$$\frac{1}{R_{eq}} = \frac{1}{1} + \frac{1}{2} + \frac{1}{3} = \frac{6+3+2}{6}$$

$$R_{eq} = \frac{6}{4} \Omega$$

Qu The ammeter reading in the Circuit below is.

(a) 2A

(b) 3A

(c) 6A

(d) 5A

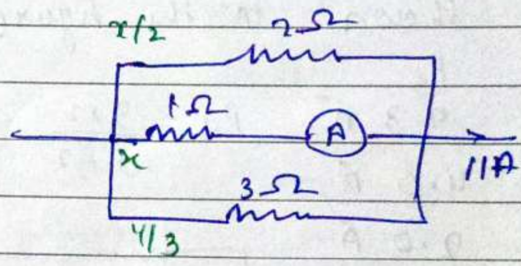
$$\frac{x}{4} = \frac{2}{3}$$

$$4 = \frac{3x}{2}$$

$$\frac{y}{2} + y + \frac{y}{3} = 11$$

$$\frac{3y + 6y + 2y}{6} = 11$$

$$\frac{11y}{6} = 11 = \boxed{y = 6 \text{ Amp}}$$




$\leftarrow V = IR \rightarrow$ same

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

Current utna कितना होगा घटेगा

Qu The reading of the ammeter in the Circuit below is

(a) 5A

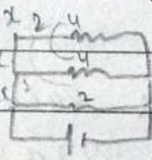
(b) 15A

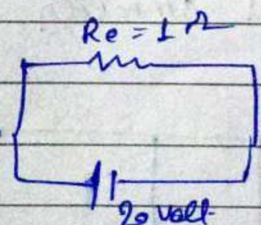
(c) 20A

(d) 25A

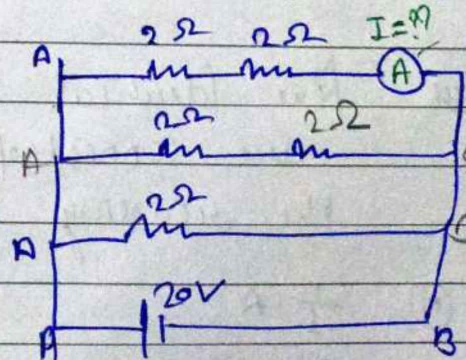
$$4x = 20$$

$$\boxed{x = 5 \text{Amp}}$$






$$I = \frac{20}{1} = \underline{20 \text{ Amp}}$$




$$I = \frac{20}{4} = 5 \text{ Amp}$$

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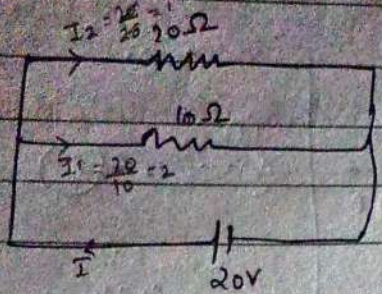
Q. Find I = ??




$I = I_1 + I_2$

3 Amp

2nd method

$R_q = \frac{R_1 R_2}{R_1 + R_2} = \frac{20 \times 10}{20 + 10}$

$I = \left(\frac{V}{R_q}\right) = \frac{\cancel{20}}{\cancel{20}} \times 3$

$\boxed{I = 3 \text{ Amp}}$

Imp

Q. A battery of 12 V and an internal resistance of 0.8 Ω is connected to 3 resistor as of the circuit shown in the figure. The current i in the circuit is

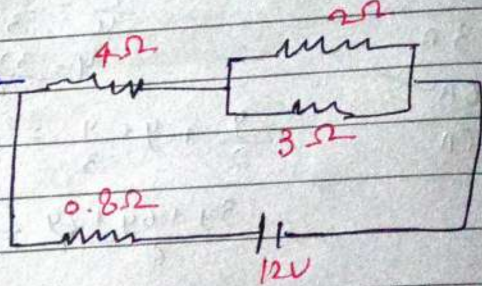
(a) 0.3 A

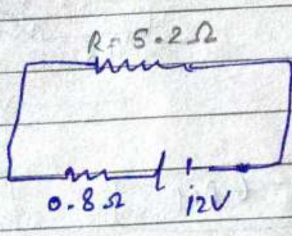
(b) 4.0 A

(c) 2.0 A

(d) 1.33 A

$R_q = \frac{3 \times 2}{3 + 2} = \frac{6}{5}$ 1.2




$I = \frac{12 \text{ Volt}}{6} = 2 \text{ Amp}$

Ques. Five identical lamps each of resistance R = 1100 Ω are connected to 220 V as shown in the figure. The reading of ideal ammeter A is

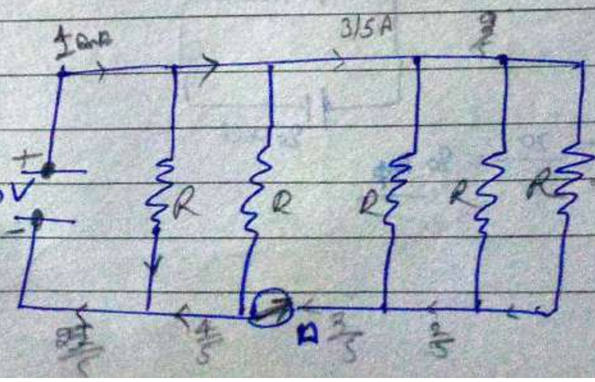
(a) $\frac{1}{5}$ A

(b) $\frac{2}{5}$ A

(c) $\frac{3}{5}$ A

(d) 1 A

emf = 220V




$I = \frac{220 \times 5}{1100} = 1 \text{ Amp}$

$R_{eq} = \frac{R}{5} = \frac{1100}{5}$

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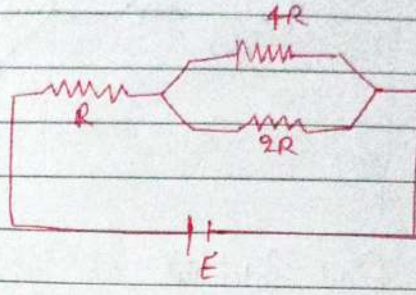
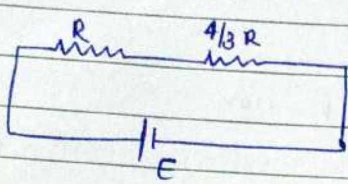
Qu In a network as shown in the figure, the potential difference across the resistance 2R is ( the cell has emf ε volt and no internal resistance )

(1) 2E
(2) 4E/7
(3) E/7
(4) E




$$R_{eq} = \frac{2R \times 4R}{2R + 4R}$$

$$R_{eq} = \frac{8R}{6} = \frac{4}{3}R$$



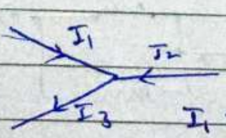

$$= V = \frac{4/3 R}{\frac{4}{3}R + R} E = \frac{4 R/3}{7 R/3} \varepsilon = \boxed{\frac{4E}{7}}$$

## Kirchoff's First Rule :- Junction Rule

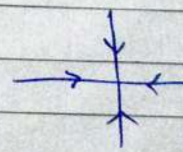
At any junction, the sum of the currents entering the junction is equal to sum of currents leaving the junction

Explanation:

When current are steady there is no accumulation of charges at any junction or at any point in a line therefore rate of ~~rate of flow of~~ charge into the junction is equal to rate of flow of charge from the junction



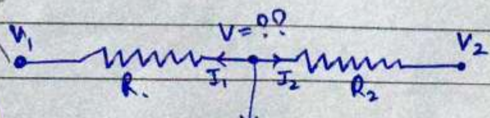

$$I_1 + I_2 = I_3$$



जो निकलता है

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

Qu Find $V_{mid}$ - ??
Point Potential




$$\boxed{V_m = \frac{C_1V_1 + C_2V_2}{C_1 + C_2}}$$

Point Rule

Roz kiya gaye kiya

$$0 = I_1 + I_2$$
$$I_1 = -I_2$$

$$\left(\frac{V_m - V_1}{R_1}\right) = -\left(\frac{V_m - V_2}{R_2}\right)$$

$$\frac{V_m - V_1}{R_1} = \frac{-V_m}{R_2} + \frac{V_2}{R_2}$$

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

$$V_m\left(\frac{1}{R_1} + \frac{1}{R_2}\right) = \frac{V_1}{R_1} + \frac{V_2}{R_2}$$

$$V_m = \frac{\frac{V_1}{R_1} + \frac{V_2}{R_2}}{1/R_1 + 1/R_2}$$

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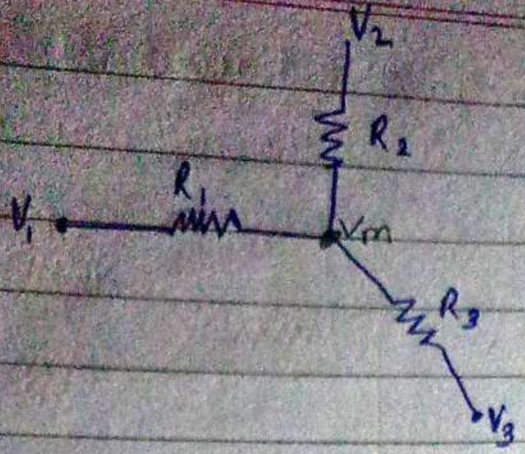
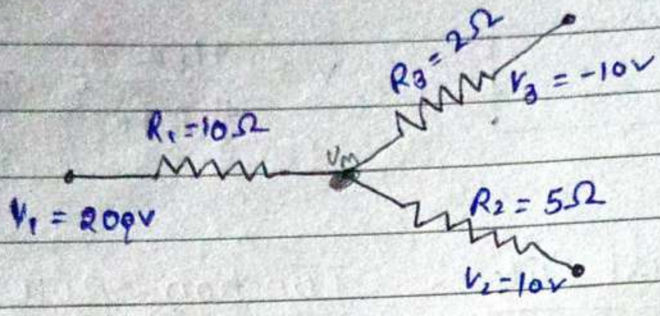



$$\boxed{V_m = \frac{\frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}}{\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)}}$$

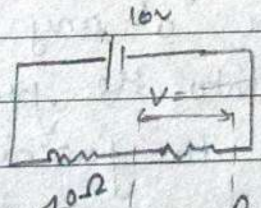
Find Potential at Junction.




$$V_m = \frac{\frac{20}{10} + \frac{10}{5} - \frac{10}{2}}{\frac{1}{10} + \frac{1}{5} + \frac{1}{2}} = \frac{\frac{100+100-250}{\cancel{50}}}{\frac{5+10+25}{\cancel{50}}} = \frac{-5\cancel{0}}{4\cancel{0}} = \frac{-5}{4} = -1$$

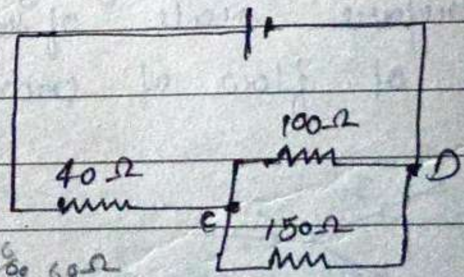
In the network shown below, Potential difference across CD i

(a) 4 V
(b) 6 V ✓
() 10 V
() 5 V




$\frac{60}{100} \times 10$

$R = \frac{150 \times 100}{150 + 100} = \frac{150 \times 100}{250}$, $\frac{300}{5}$ 60Ω

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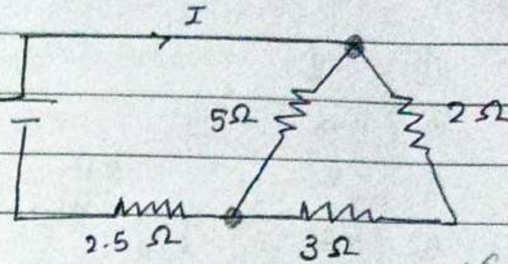
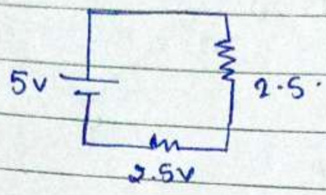
The current I through the cell in the network shown is

(a) 3 A
(b) 2 A
(c) 1 A ✓
(d) 4 A

$I = \frac{5V}{5} = 1$ Amp




$R = \frac{5 \times 5}{5+5} = \frac{25}{10}$

2.5Ω

## KIRCHOFF SECOND RULE LOOP RULE :→

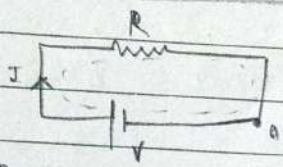
Algebraic sum of changes in potential around any closed loop involving resistor and cells in the loop is zero.

**Explanation :-**

We know that electric ~~field~~ Potential depend on the location of point. Therefore starting with any point if we come back to the same point the total change of potential must be zero.

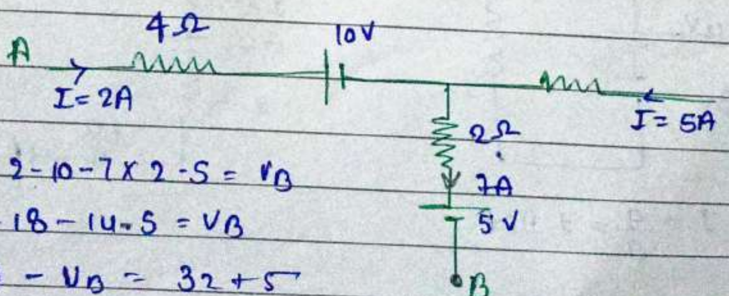
$V_A + V - IR = V_A$

$V - IR = 0$




sum. $\Sigma V - \Sigma IR = 0$

Find $V_A - V_B = ??$




$V_A - 4 \times 2 - 10 - 7 \times 2 - 5 = V_B$

$V_A - 18 - 14 - 5 = V_B$

$V_A - V_B = 32 + 5$

$= 37$ Volt

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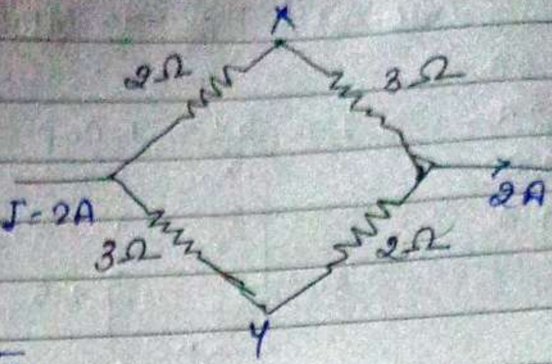
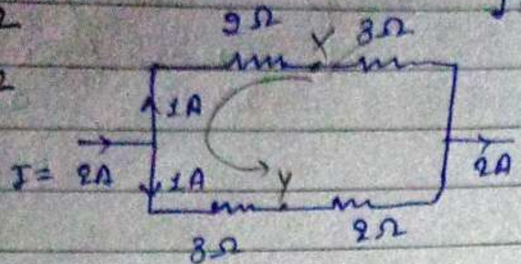
**Que** Find $V_x - V_y = ??$



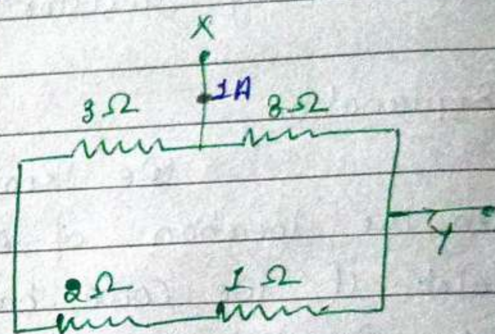

① 1
② −1
③ 2
④ −2




$V_x + I_1R_1 - I_2R_2 = V_y$

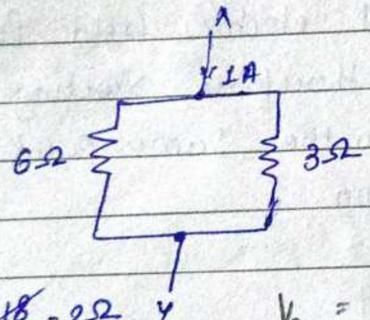
$V_x + 2\times1 - 3\times1 = V_y$

$V_x - V_y = +3 - 2 = 1$ Volt



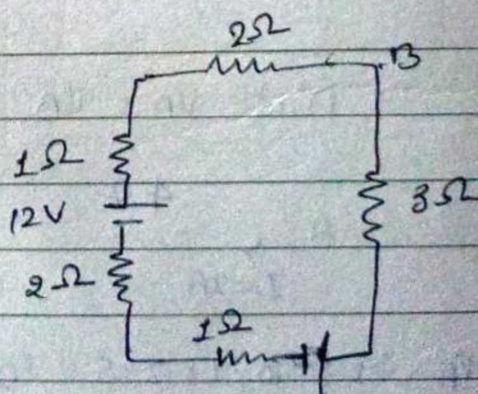

**Que** find $V_x - V_y = ??$

① 2 ✓
② 3
③ 6
④ 9

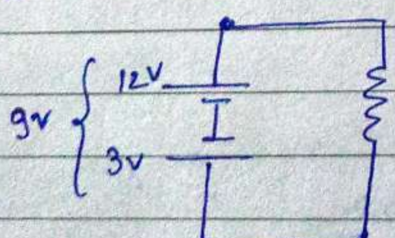



$R_{eq} = \frac{6\times3}{6+3} = \frac{18}{9} = 2\Omega$  $V_{AY} = 2\times1 = 2$ Volt

**Que** Potential difference $V_B - V_A$ in the network shown in




① 7V ✓
② 6V
③ 5V
④ 8V




$I = \frac{9}{9} = 1$ Amp

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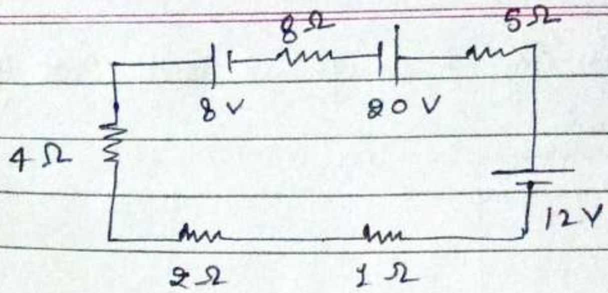
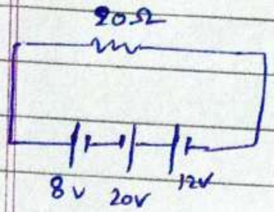
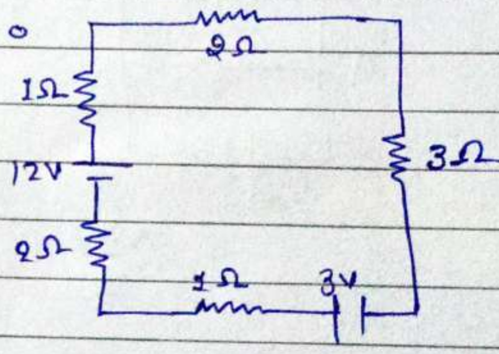



Potential difference $V_B - V_A$ in the network shown in

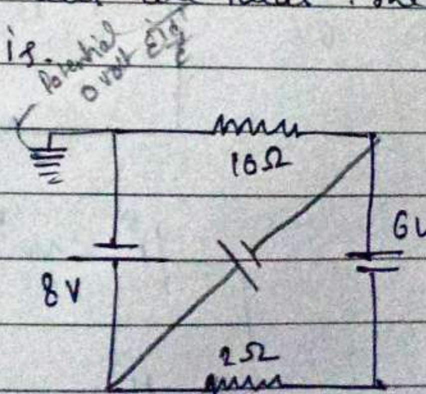
① 7V
② 6V
③ 5V
④ 8V

$$-2I - 3I - 3 - I - 2I + 12 - I = 0$$
$$-9I + 9 = 0$$
$$9 = 9I$$
$$I = \underline{1 \text{ Amp}}$$




In the Circuit Shown in figure all cells are ideal. the Current through 2 Ω resistor is.

① 5A
② 1A
③ 0.2A
④ Zero

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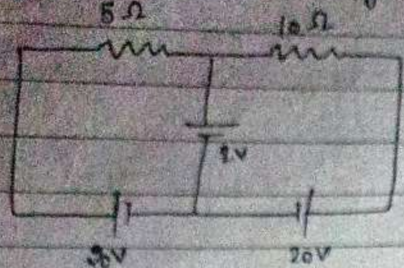
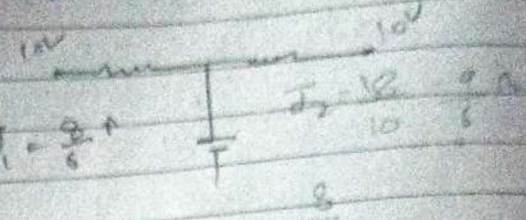
Find Current Passing through 2 Volt Battery ??

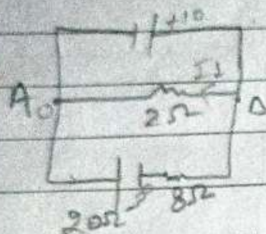


$I_1 = \frac{8}{6}$

$I_2 = \frac{12}{10}$

Find Current in given wire

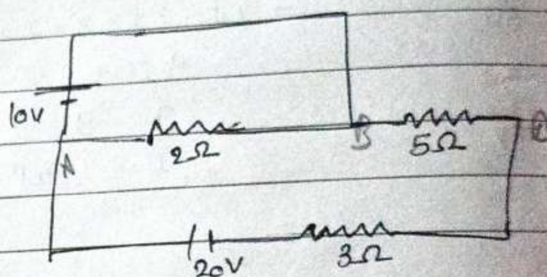



$I = \frac{10}{2} = 5$

$I = 5 + \frac{15}{4}$

$\frac{35}{4}$

$I_2 = \frac{30}{8} = \frac{15}{4}$



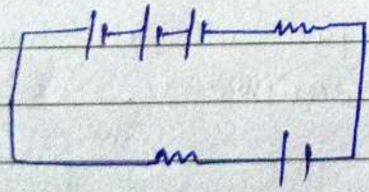

Que Reading of an ideal Voltmeter in the Circuit below is

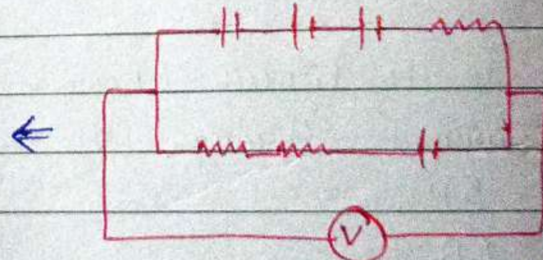
(a) Zero

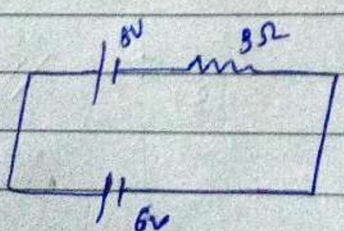
(b) 2V

(c) 4V

(d) 6V








$I = \frac{3}{3} = 1$ Amp

Ideal Voltmeter

R = Infinite

open wire

$V_A + 2 - 6 = V_B$

$\boxed{V_A - V_B = +4 \text{ Volt}}$

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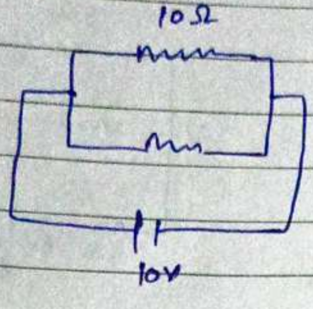
**Que** The potential difference b/w points A and B is.

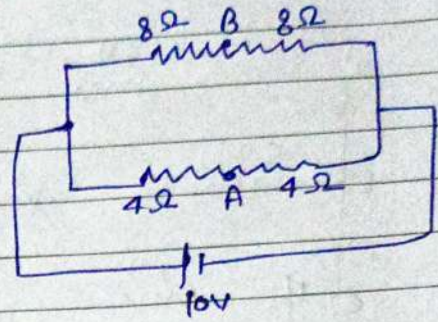
(1) $\frac{20}{7}$ V

(2) $\frac{20}{7}$ V

(3) $\frac{10}{7}$ V

(4) zero



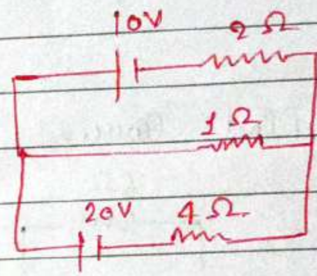

**Que** The Value of Current through 2 Ω resister is.

(a) 1.0 A

(b) 1.5 A

(c) 5.0 A

(d) 2.1 A



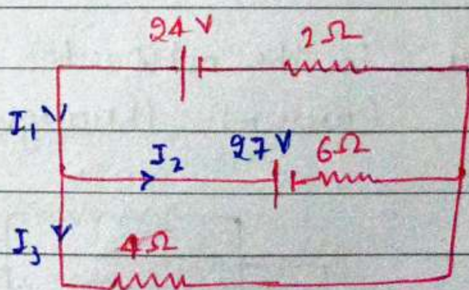

**Que** In given Circuit the Value of Currents $I_1$, $I_2$ and $I_3$

(a) 3A, $\frac{-3}{2}$ A, $\frac{9}{2}$

(b) A $\frac{9}{2}$ A, 3A, $\frac{-3}{2}$ A

(c) 5A, 4A, -3A

(d) 7A, $\frac{5}{4}$ A, $\frac{9}{2}$ A

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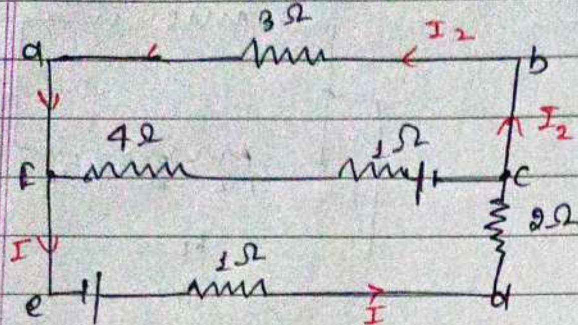
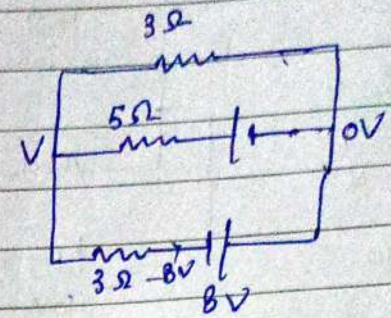
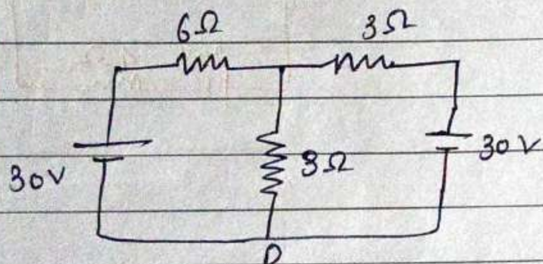
**Qu** In the network in given figure find $I_1$, $I_2$ and $I$.

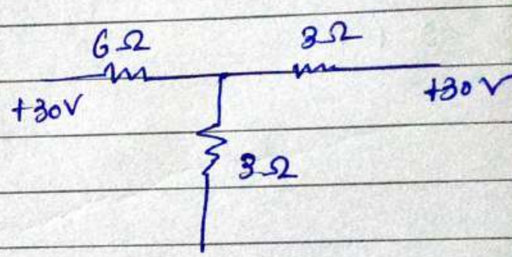


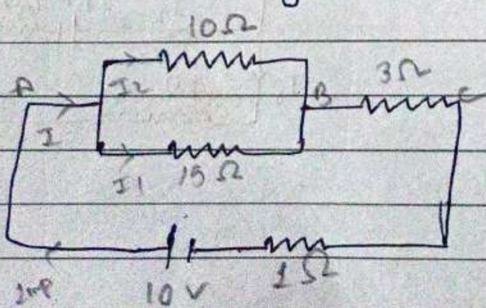

$$V = \frac{\frac{0}{3} + \frac{5}{3} - \frac{8}{3}}{\frac{1}{3} + \frac{1}{3} + \frac{1}{3}} = \frac{\frac{15-40}{18}}{\frac{10+3}{18}} = -\frac{25}{13} \text{ Volt}$$

**Qu** Find Current in BD Branch.

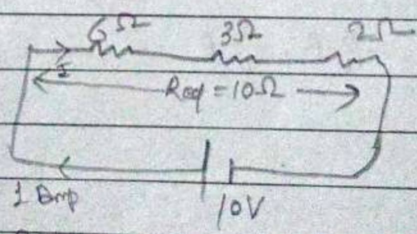



**Qu** In the network shown in the above figure find the Current through 3 Ω and 10 Ω resistance




$$R_{eq} = \frac{10 \times 15}{10 + 15} = \frac{150}{25} = 6\,\Omega$$




Current in 3 Ω ie 1 Ω

Current through 10 Ω $\Rightarrow I = \frac{V}{R} = \frac{6}{10} = \frac{3}{5}$ A

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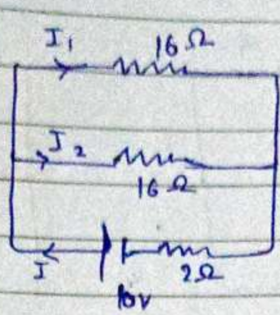
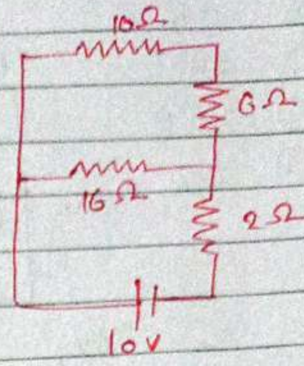
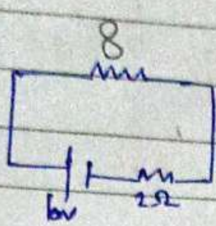
Que Current I in the network shown in figure is.

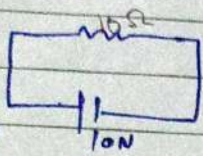
1. 1 A
2. 0.5 A
3. 2 A
4. 5A




I = Amp

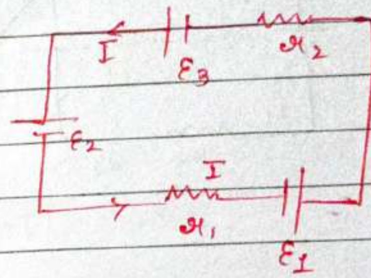


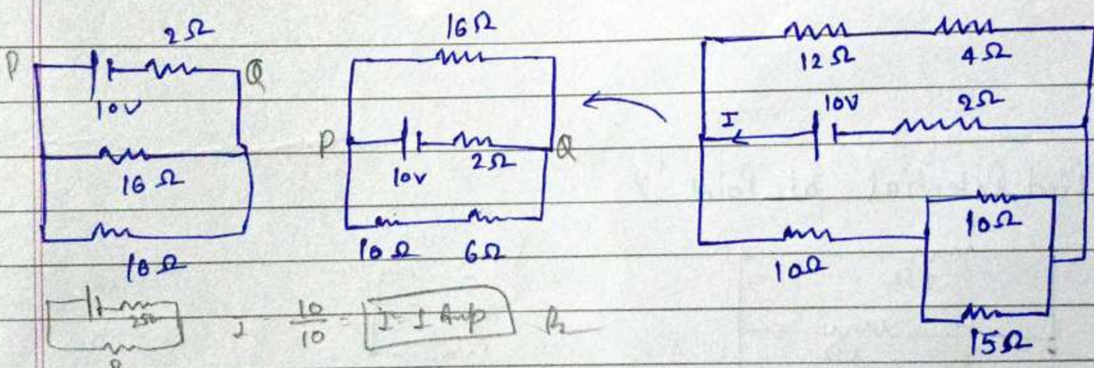

## M-2

$$I r_2 + \varepsilon_3 - \varepsilon_2 - I r_1 + \varepsilon_1 = 0$$

$$\varepsilon_1 - \varepsilon_2 + \varepsilon_3 = I(r_1 + r_2)$$

$$\boxed{I = \frac{\varepsilon_1 - \varepsilon_2 + \varepsilon_3}{r_1 + r_2}}$$




$I = \frac{10}{10} = \boxed{I = 1\ \text{Amp}}$

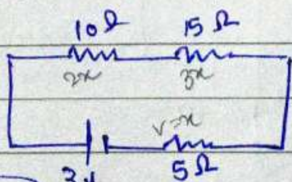
Que Potential difference across AB in the network shown in figure is

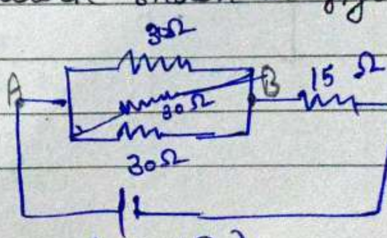
(a) 2V
(b) 3V
(c) 1V
(d) 1.5V

$6x = 3V$

$x = \frac{1}{2}$ volt

$\boxed{2x = 1\ \text{Volt}}$




(3V, 5Ω)

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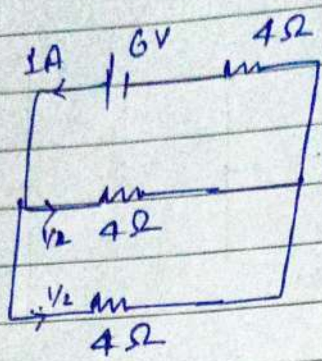
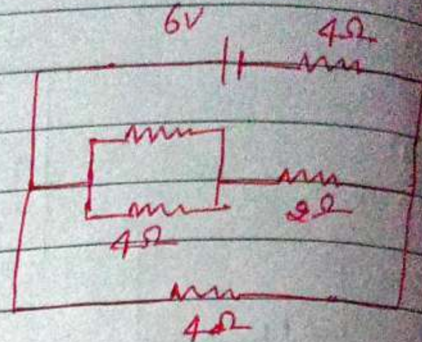
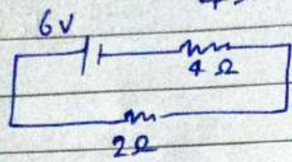
**Que** The Current I in the Circuit Shown below is

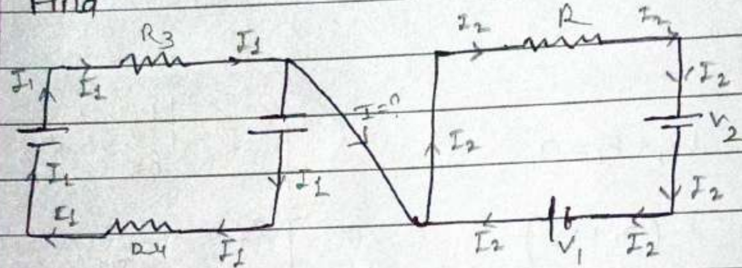
(a) 1A
(b) 2A
(c) 0.5 A
(d) Zero



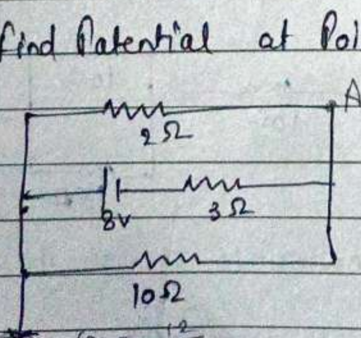




**Q.** Find

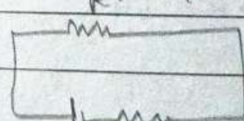



$\boxed{I = 0}$

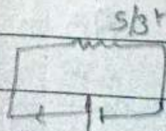
**Que** Find Potential at Point 'X'




$R = \frac{10\times 2}{10+2} = \frac{20}{12} = \frac{5}{3}\,\Omega$



$5/3 + 3 = \frac{14}{3}$




$I = \frac{8\times 3}{14} = \frac{24}{14} = \frac{12}{7}\,A$

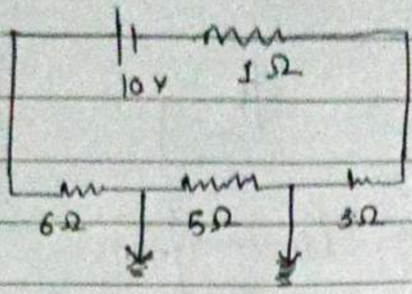
$6x = \frac{12}{7}$

$x = \frac{2}{7}$ Amp

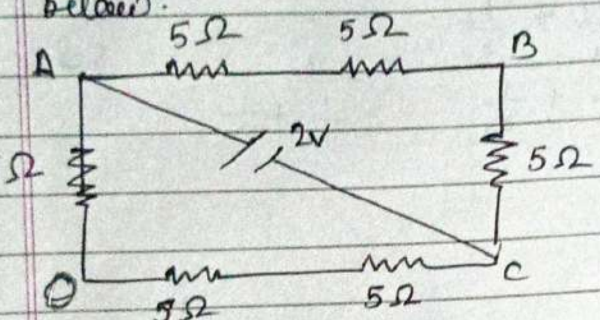
$0 - 10 \times \frac{2}{7} = V_A$

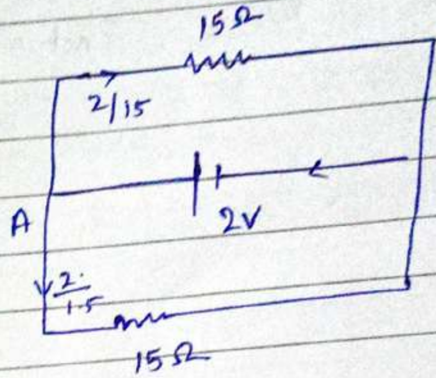
$-\frac{20}{7} = V_A$

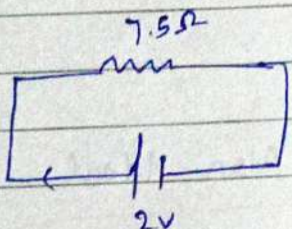
Find Current in the Circuit




Find the Potential difference b/w Points B and B in the figure below.

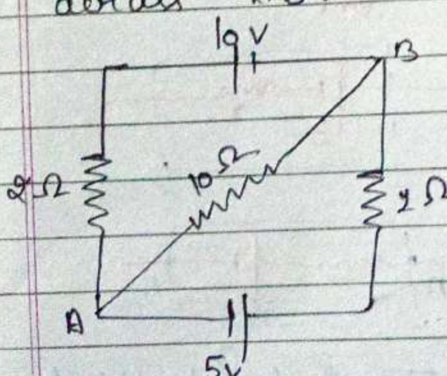


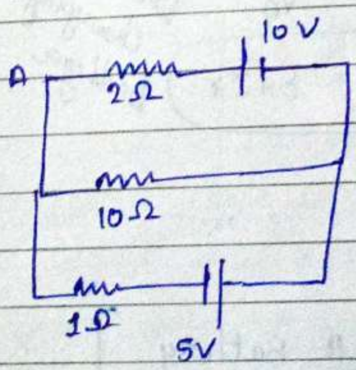



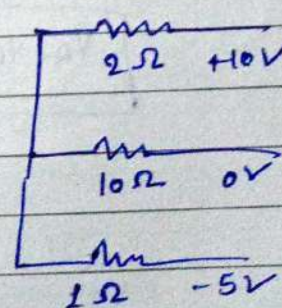




$$I = \frac{2V}{\left(\frac{15}{2}\right)} = \frac{4}{15} \text{ Amp.}$$

Find the Current through the 10 Ω resistance Connected across AB.

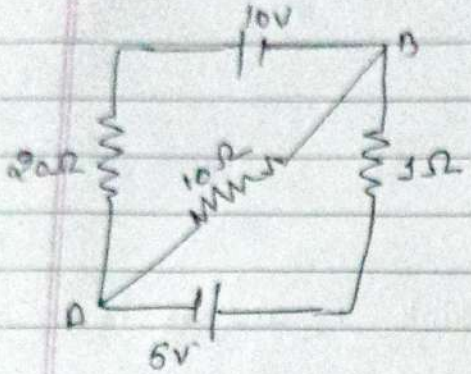


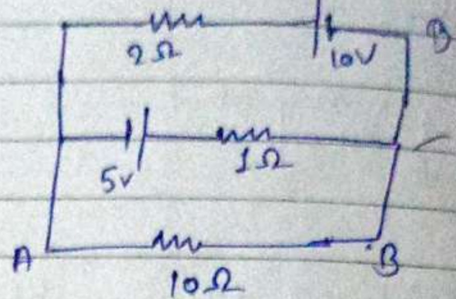




$$\frac{\frac{10}{2} - \frac{5}{1}}{\frac{1}{2} + \frac{1}{10} + \frac{1}{1}} = 0$$ across 10 Ω

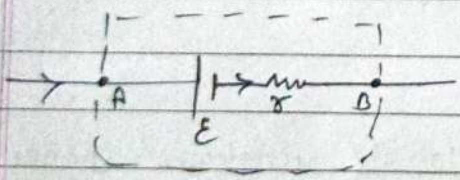
Que. Find the current through the 10 Ω resistance connected across AB.




$$\varepsilon_{net} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{\frac{10}{2} - \frac{5}{1}}{\frac{1}{1} + \frac{1}{2}} = 5.9 \approx 0$$

## Charging Battery

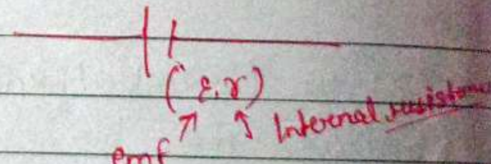


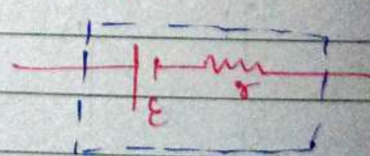

$V_A - \varepsilon - Ir = V_B$

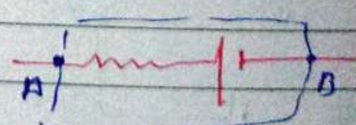
$$\boxed{V_A - V_B = V_{TP} = \varepsilon + Ir}$$

During charging badhega.

### Non-Ideal




[If Battery is not connected in any circuit $I = 0$] $V_{AB}$ = Terminal Potential of Battery = e.m.f

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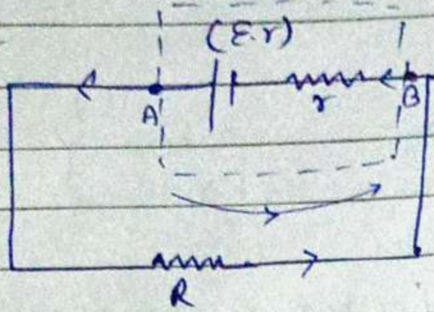
## Discharging of battery




$V_{TP} = \varepsilon.mf = \varepsilon$ ✗ No.

$V_A - \varepsilon + Ir = V_B$

$V_A - V_B = \boxed{V_{TP} = \varepsilon - Ir}$ during discharging

$$\boxed{V = \varepsilon - Ir}$$

Terminal potential diffⁿ across Battery during discharging

## Graph b/w V (Terminal Potⁿ) B/w I

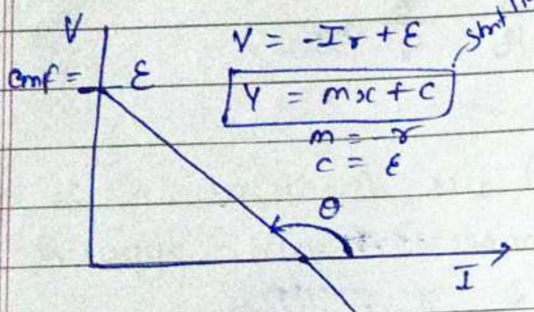
$V = \underset{const}{\varepsilon} - \underset{const}{Ir}$

$V = -Ir + \varepsilon$ straight line equatⁿ

$\boxed{Y = mx + c}$

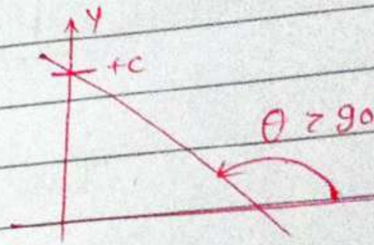
$m = -r$

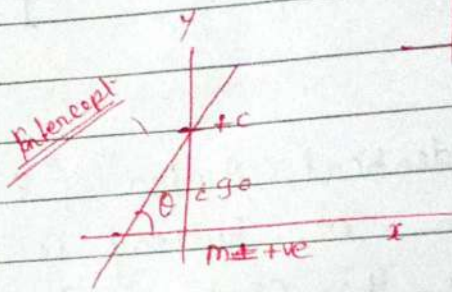
$c = \varepsilon$

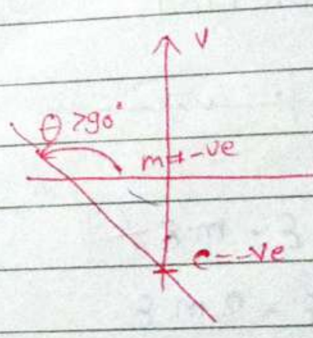


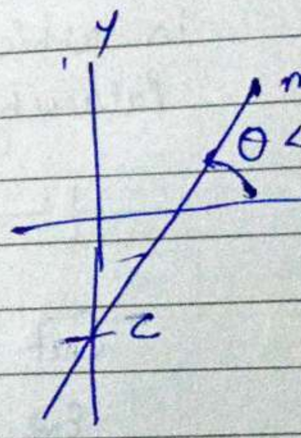

Slope = $\tan\theta = -r$

− Resistance Ro

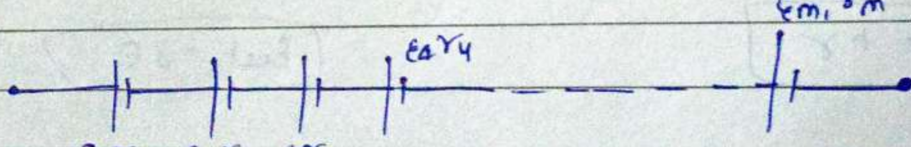


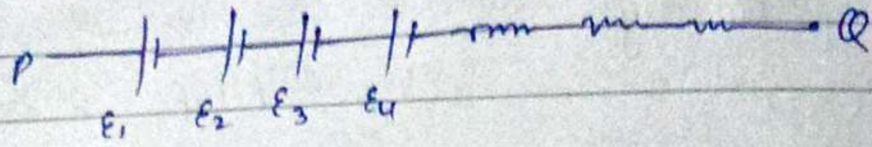



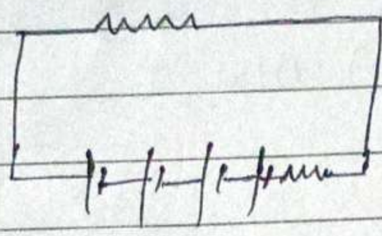

## Series Combination of Cell :→



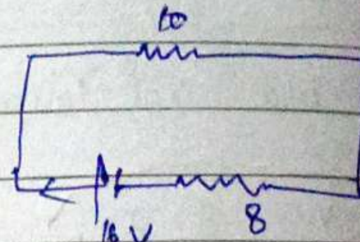



$$\left\{\begin{array}{l} \varepsilon_{net} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 + \varepsilon_4 + \cdots + \varepsilon_n \\ V_{in} = r_1 + r_2 + r_3 + r_4 \cdots + r_n \end{array}\right\}$$

4 - identical Battery is connected in series of e.m.f & Internal resistance $2\Omega$ through $10\Omega$ external resistance then find Current in external resist.

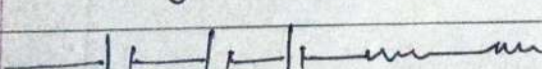


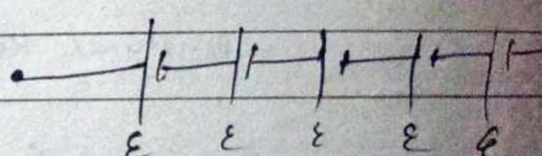
16V




$$I = \frac{16}{18} = \frac{8}{9} \text{ Amp}$$

In n- Identical Batter ($\varepsilon$.r) are Connected in series in which m buttery is Connected with opposite Palarity then find $\varepsilon_{net}$ & $r_{net}$



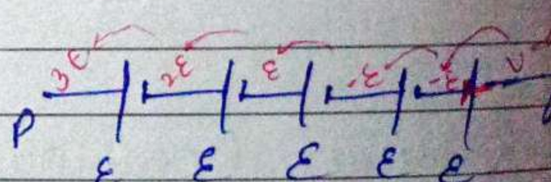



$\varepsilon_{net} = n\varepsilon - m\varepsilon$ ✗ wrong

$\varepsilon_{net} = n\varepsilon - 2m\varepsilon$

$\varepsilon_{net} = \varepsilon(n - 2m)$

$\boxed{r_{net} = nr}$




$\boxed{\varepsilon_{net} = 3\varepsilon}$

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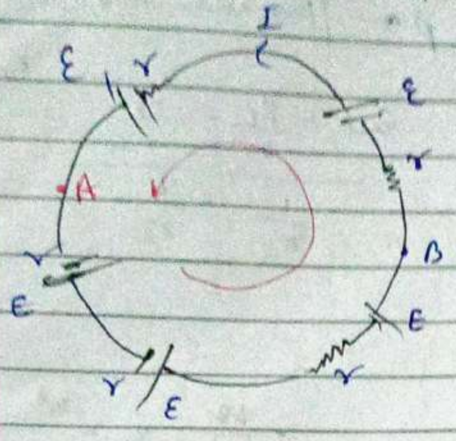
$I' = \frac{5\varepsilon}{5r} = \frac{\varepsilon}{r}$

Find Potentitial diffⁿ b/w A & B



$V_B - Ir + \varepsilon - Ir + \varepsilon = V_A$

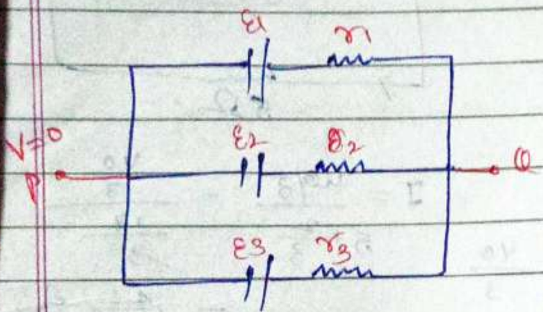
$V_B - 2Ir + 2\varepsilon = V_A$

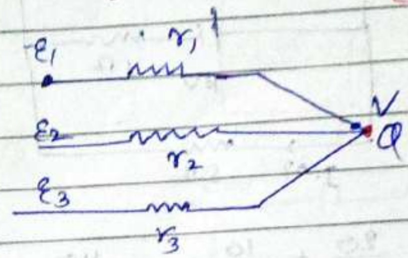
$V_B - \frac{2\varepsilon}{r} r + 2\varepsilon = V_A$

$\boxed{V_B = V_A}$

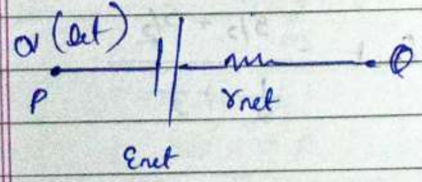
## Parallel Combination of Cell :-

$\boxed{\frac{1}{r_{net}} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}}$



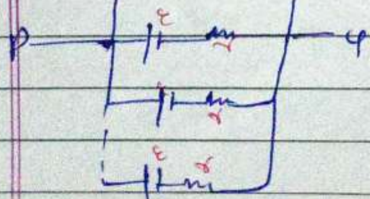


$$V_Q = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \frac{\varepsilon_3}{r_3}}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}}$$



$$\boxed{\varepsilon_{net} = V_Q - V_P = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + \frac{\varepsilon_3}{r_3}}{\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}}}$$

Que If n-Identical Battery $(\varepsilon, r)$ is connected in Parallel then $\varepsilon_{net}$ / r



$$\varepsilon_{net} = \frac{\frac{\varepsilon}{r} + \frac{\varepsilon}{r} + \frac{\varepsilon}{r} + \dots \frac{\varepsilon}{r}}{\frac{1}{r} + \frac{1}{r} + \frac{1}{r} + \frac{1}{r}}$$

$$\boxed{\varepsilon_{net} = \frac{\frac{n\varepsilon}{r}}{\frac{n}{r}} = \varepsilon}$$

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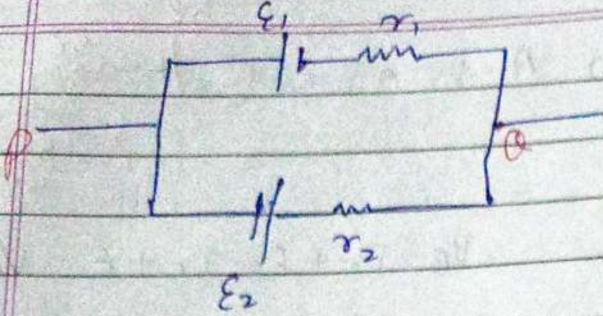
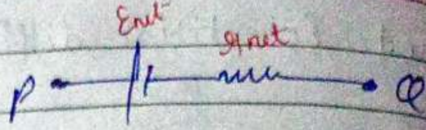
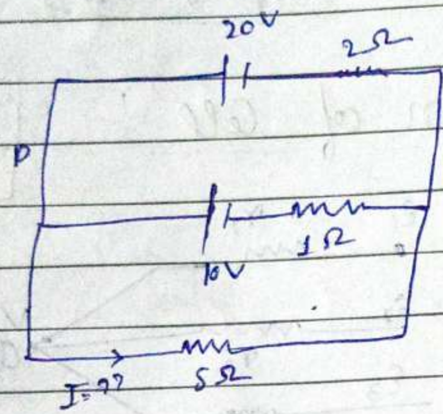


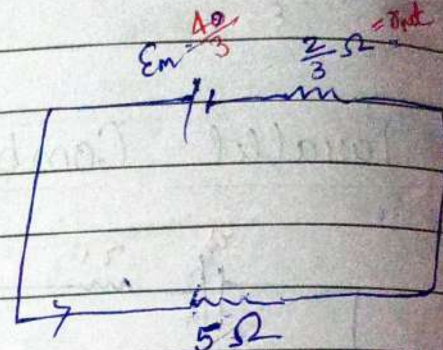




$$\varepsilon_{net} = \frac{\frac{\varepsilon_1}{r_1} - \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}}$$

$r_{net}$

Que find Current in ( 5 Ω)



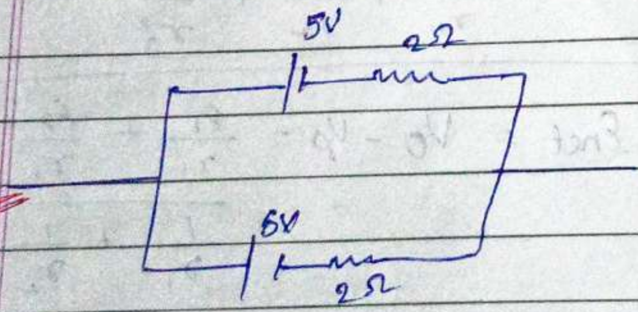




$$I = \frac{40/3}{5 + \frac{2}{3}} = \frac{\frac{40}{3}}{\frac{17}{3}}$$

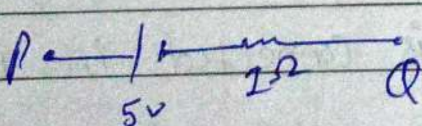
$$= \frac{40}{17} \text{ Ans}$$

$$\varepsilon_{net} = \frac{\frac{20}{2} + \frac{10}{1}}{\frac{1}{2} + \frac{1}{1}} = \frac{\frac{40}{2}}{\frac{3}{2}} = \frac{40}{3}$$

Qy




$$\varepsilon_{net} = \frac{5/2 + 5/2}{\frac{1}{2} + \frac{1}{2}}$$

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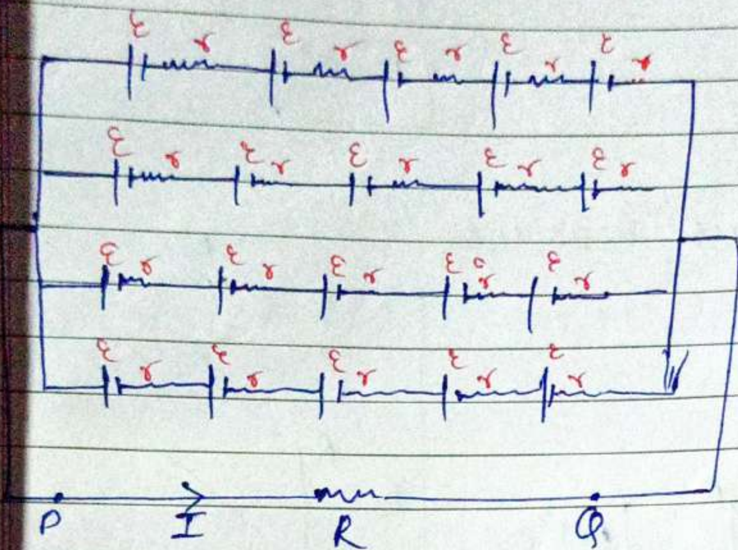
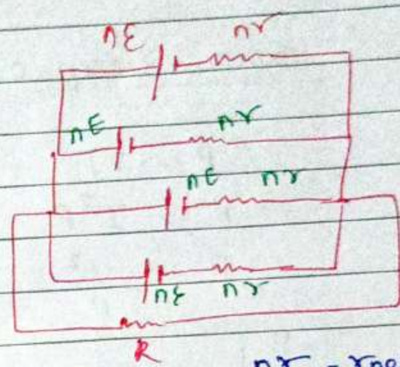
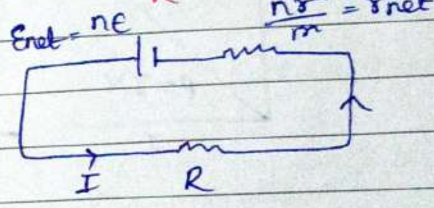
## Mixed grouping of cell :-

If n - Identical cell Connected in series and m - Such Combination connected in Parallel then find $E_{net}$ & $r_{net}$.




total cell = n × m



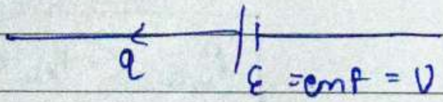




$$\boxed{I = \frac{nE}{\frac{nr}{m} + R}}$$

$$I = \frac{nE}{\frac{nr + mR}{m}}$$

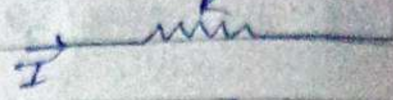
$$\boxed{I = \frac{nmE}{nr + mR}}$$ Ans

## Power Supply by the Battery




$$W = q\Delta V = qV$$

diffⁿ w.r.t time



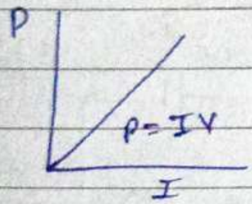

$$P = \frac{dW}{dt} = V\frac{dQ}{dt}$$

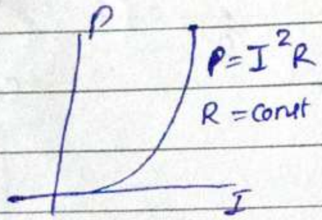
$$\boxed{P = IV}$$

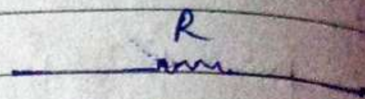
$$P = IV$$
$$= I(IR)$$
$$\boxed{P = I^2R}$$
$$\boxed{P = \frac{V^2}{R}}$$

## Power drop across resistance :-

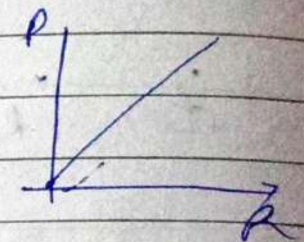
$$P = VI$$
$$P = I^2R$$
$$P = \frac{V^2}{R}$$

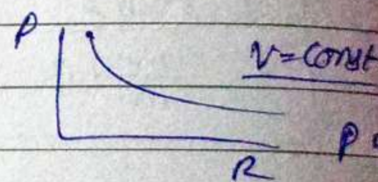


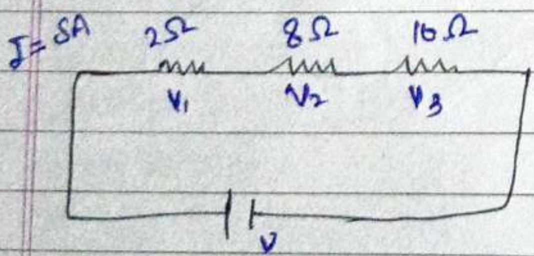




$$P = I^2R = \frac{V^2}{R}$$




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



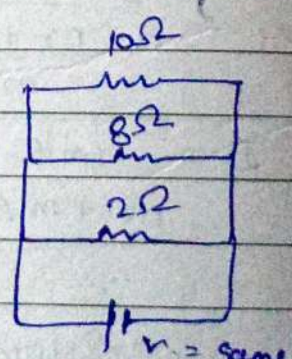

$$P \propto R$$

$$\boxed{\frac{P_1}{P_2} = \frac{R_1}{R_2}}$$

* In series combination

$$P_3 > P_2 > P_1$$

Que




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

$$\boxed{P_{10\Omega} < P_{8\Omega} < P_{2\Omega}}$$

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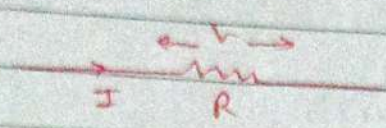
# Joule's Law of heating effect



$P = VI = I^2R = \frac{V^2}{R}$ → Heat loss per sec

H (Heat loss) $\propto I^2$

$H \propto R$

$H \propto t$

$\boxed{H = I^2Rt}$

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

$H = VIt$

$\frac{dH}{dt} = I^2R$

$\int dH = I^2R \int dt$

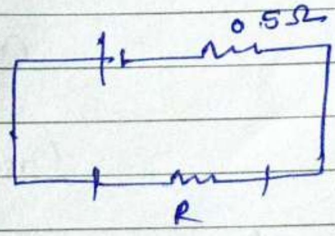
I = Variable: $H = R\int I^2 dt$

$\boxed{I = \text{const}}$

$\boxed{H = I^2Rt}$

Q. A battery of e.m.f 10 V and Internal resistance 0.5 Ω is Connected across a Variable resistance R. the Value of R which the power delivered in it is maximum is given by.

1. 0.5 Ω
2. 1.0 Ω
3. 2.0 Ω
4. 0.25 Ω

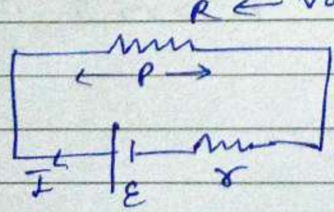


Maximum Power $th^m$

$\boxed{r_{in} = R}$

## Maximum Power theorem

R ← Variable External load Resistance



$P = I^2R$

$P = \left(\frac{\varepsilon}{R+r}\right)^2 R$

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

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

Power Supply by the battery to the external resistance will be max^m when Value of External R = r

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

# Power drop across 'R' Resistance

Power drop P will be max^m when $\frac{dP}{dR} = 0$

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$$P = \frac{\varepsilon^2 R}{(R+r)^2} \quad (\varepsilon \,\&\, r \text{ are const})$$

$$\left(\frac{dP}{dR}\right) = 0 = \varepsilon^2 \frac{d \frac{R}{(R+r)^2}}{dR}$$

$$0 = \frac{d\left(\frac{R}{(R+r)^2}\right)}{dR} = \frac{(R+r^2)\frac{dR}{dR} - R\,\frac{d}{}}{(R+r)^{2\times 2}}$$

$$(R+r)^2 - R\,2(R+r)(1) = 0$$

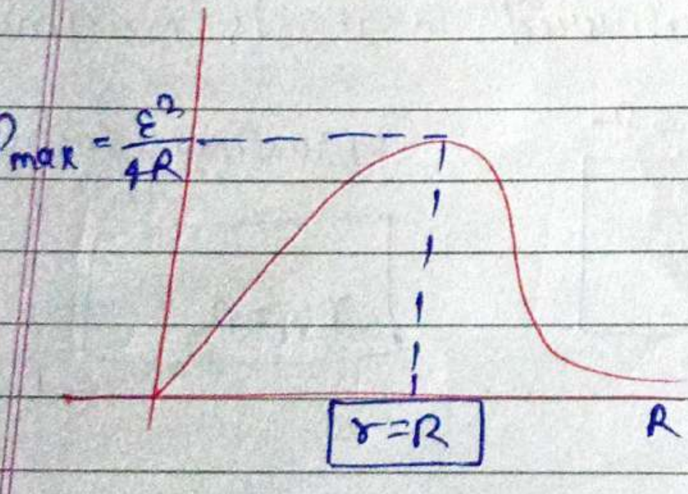
$$\cancel{(R+r)}^2 = 2R\,\cancel{(R+r)}$$

$$R + r = 2R$$

$$r = 2R - R = R$$

$$\boxed{r = R} \quad \text{Ans}$$

Draw graph b/w P and R




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

Case-1

$R = 0 \longrightarrow P =$

Case-2

$R <<< r$

$$P = \frac{\varepsilon^2 R}{r^2} \propto R$$

Case-3

$R >>>> r$

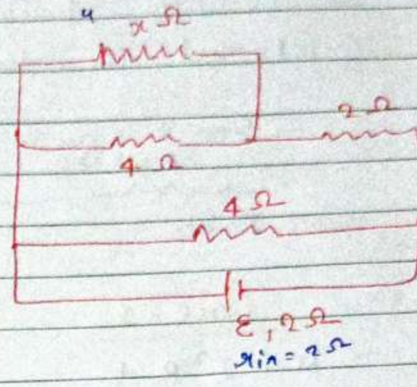
Find $x$ so that Power loss will be maximum in external Circuit.

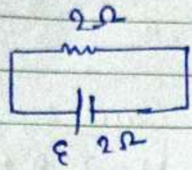
$2\Omega$

$4\Omega$

$8\Omega$

$3\Omega$




Find R so that Power Supplied by the battery is ma

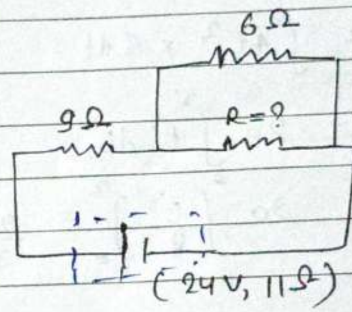
$$\frac{6 \times R}{6+R} = 2$$

$$6R = 12 + 2R$$

$$6R - 2R = 12$$

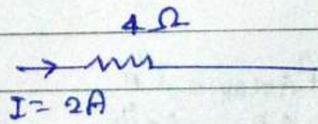
$$4R = 12$$

$$\boxed{R = 3\Omega}$$ Ans




Current 2 A is flowing through a Conductor of Resistance $4\Omega$ find the electrical Energy Consumed in 10 s.

$I = 2$ Amp




$$H = I^2 R t$$

$$(2)^2 \times 4 \times 10$$

$$4 \times 4 \times 10$$

$$\boxed{H = 160\,J}$$ Ans

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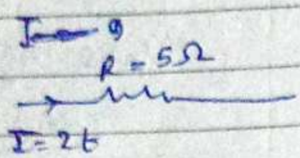
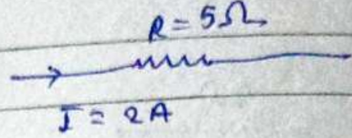
Current 2 A is is flowing through a Conductor of resistance 4 Ω find the electrical Energy Consumed in 10 s

Q. find heat loss in Both case in 2 s




const

Case - 1

$H = I^2 R t$

$dH = I^2 R\, dt$

$\int dH = \int 4t^2 \times 5\, dt$

$Heat = 20 \int_0^2 t^2\, dt =$

$20 \left[\frac{t^3}{3}\right]_0^2 = \frac{20}{3} \times 8 = \frac{160}{3}$ J

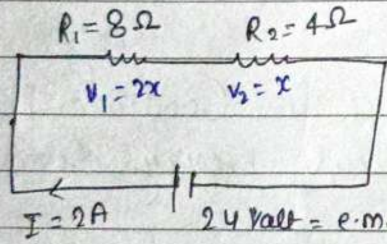
Case - 2

$H = I^2 R t$

$(2)^2 \times 5 \times 2$

$4 \times 10 = 40\ \Omega$

Qu




find Power loss in each resistance

(II) Power Scalar

$P_{net}$ Conn $= P_1 + P_2$

$P_{tot} = I^2 R_{eq} = (2)^2 \times 12$

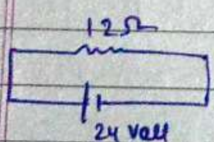
$\boxed{48\ \Omega}$

(III) $P_{total} = \frac{V^2}{R_{eq}}$

$\frac{24 \times 24}{12} = \boxed{48\ \Omega}$

(IV)

method - 1




$I = \frac{24}{12} = 2$

$\boxed{I = 2 amp}$

$Power_{across\ 8\Omega} = I^2 R$

$(2)^2 \times 8$

$4 \times 8 = 32\ \Omega$

$P_{across\ 4\Omega} = I^2 R$

$(2)^2 \times 4$

$= 16 W$

$\boxed{total\ power = 48 W}$

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Power Scalar $= P_1 + P_2$

$P_{total} = I^2 R_{eq} = (2)^2 \times 12$

$4 \times 12 = 48$ Watt

Method - 4

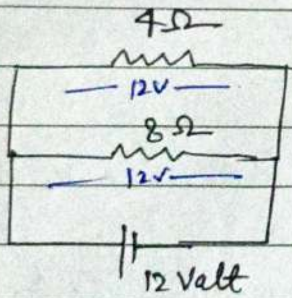
$x + 2x = 24$

$3x = 24$

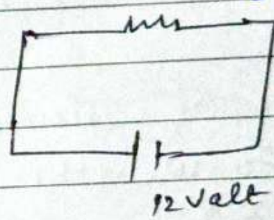
$x = 8$ Volt

$P_{4\Omega} = \frac{(8)^2}{4} = 16\,W$

$P_{8\Omega} = \frac{16 \times \cancel{16}^{2}}{\cancel{8}} = 32\,W$




$R = \frac{8 \times 4}{8+4} = \frac{32}{12}$




$P_{net} = \frac{V^2}{R_{eq}} = \frac{12 \times 12}{\frac{32}{12}}$

$\frac{\cancel{12}^{3} \times \cancel{12}^{6} \times \cancel{12}^{3}}{\cancel{32}_{\cancel{8}\,4}}$

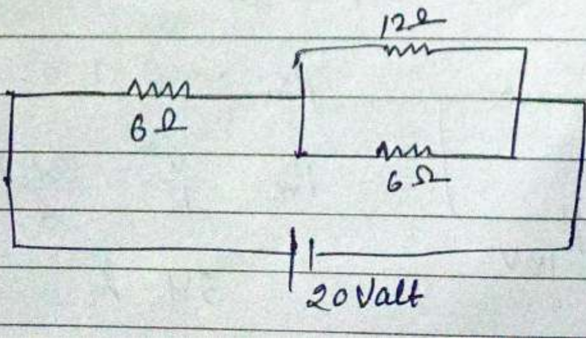
$18 \times 3 = 54\,W$

$P_{across\ 4\Omega} = \frac{12 \times \cancel{12}^{3}}{\cancel{4}} = 36\,W$

$P_{across\ 8\Omega} = \frac{\cancel{12} \times \cancel{12}^{3}}{\cancel{8}_{2}} = 18\,W$

$P_{total} = (18 + 36)$

$\boxed{54 \text{ Watt } P_2}$




Find Power loss in 12Ω Resistance?

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Que Power dissipated across the 8 Ω resistor in the Circuit shown here is 2 Watt. The Power dissipated in watt Units across the 3 Ω resistor is

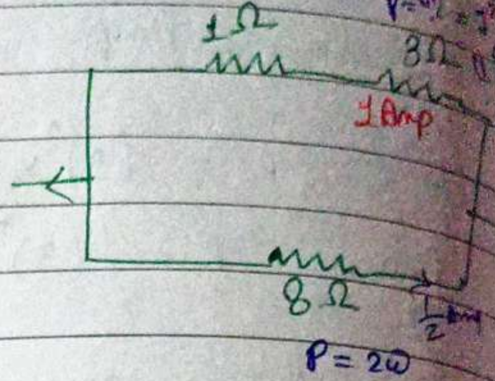
(1) 3.0 ✓
(2) 2.0
(3) 1.0
(4) 0.5

$I^2 = \frac{1}{4}$

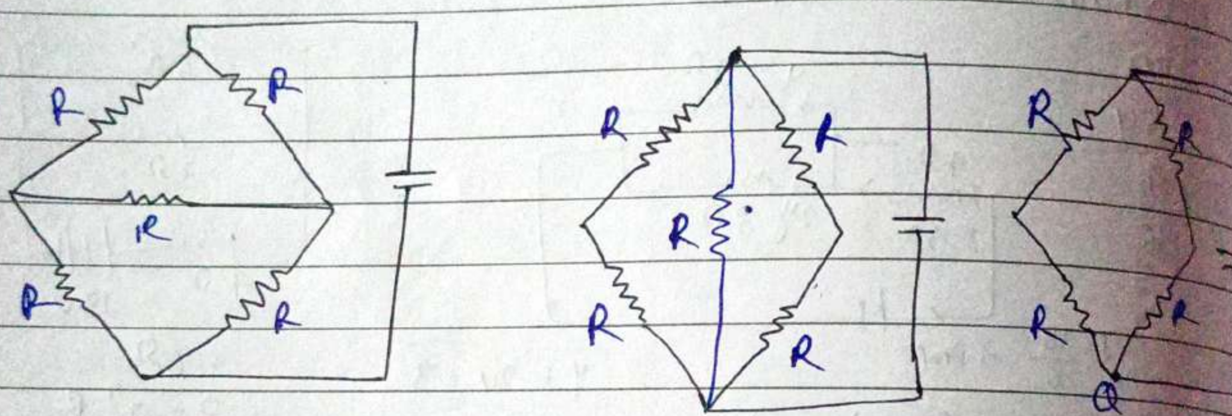
$I = \frac{1}{2}$ Amp

$P = I^2 R$

$2 = I^2 \times 8$ 4

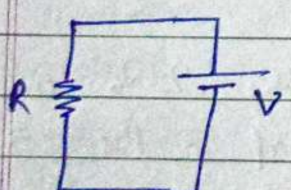



Que



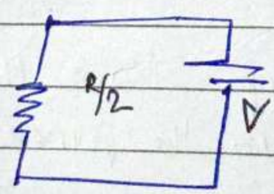

If all 5 - resistance are identical then compare power in each case

Case - 1



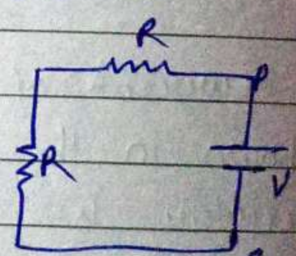

$\left\{ P_1 = \frac{V^2}{R} \right\}$

Case - 2




$P_2 = \frac{2V^2}{R}$

Case - 3




$P_3 = \frac{V^2}{2R}$

$\boxed{P_2 > P_1 > P_3}$

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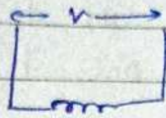
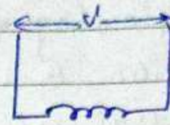
Qu. A heater boils certain amount of water in 15 minu[tes]. Another heater boils same amount of water in 10 minutes. time taken to boil same amount of water when both are used in parallel is.

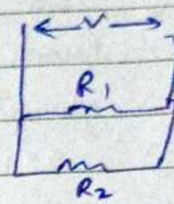
(1) 25 minute
(2) 6 minute
(3) 17 minute
(4) 12.5 minute



$R_1, H, t_1$



$R_2, H, t_2$




$$H = \frac{V^2}{R_1} t_1 \quad \text{(I)} \qquad H = \frac{V^2}{R_2} t_2 \quad \text{(II)}$$

$$\boxed{t = \frac{t_1 t_2}{t_1 + t_2} = \frac{15 \times}{15 +} \quad \text{MR} \quad \frac{150}{25}}$$

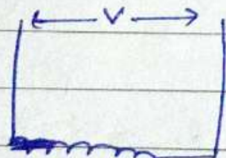
$$H = \frac{V^2}{R_{eq}} t, \quad H = V^2 t \cdot \left(\frac{1}{R_{eq}}\right) = V^2 t \left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

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

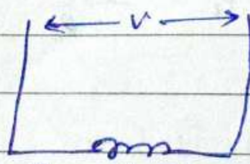
$$\cancel{H} = \frac{\cancel{H}}{t_1} t + \frac{\cancel{H}}{t_2} t = \quad t = \left(\frac{1}{t_1} + \frac{1}{t_2}\right) t = \boxed{\frac{1}{t}}$$

Qu. Two heater coil separately take 10 minute and 5 minu[tes] to boil certain amount of water. If both the coils are connected in series, the time taken will be.

(a) 15 min
(b) 7.5 min
(c) 3.33 min
(d) 2.5 min

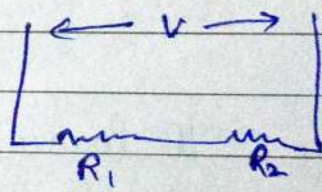


$R_1 \; H \; t_1$



$R_2 \; H \; t_2$

$\Rightarrow$




$$H = \frac{V^2}{R_1} t_1 \qquad H = \frac{V^2}{R_2} t_2$$

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

$$H = \frac{V^2}{R_{eq}} t = \frac{V^2 t}{R_1 + R_2} = \frac{\cancel{V^2} t}{\frac{\cancel{V^2} t_1}{H} + \frac{\cancel{V^2} t_2}{H}}$$

$$H = \frac{H t}{t_1 + t_2}$$

$$\boxed{t = t_1 + t_2}$$

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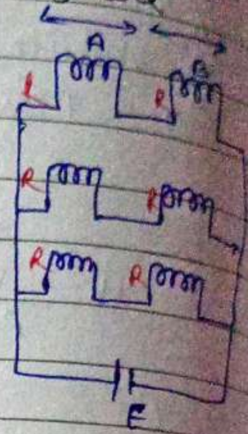
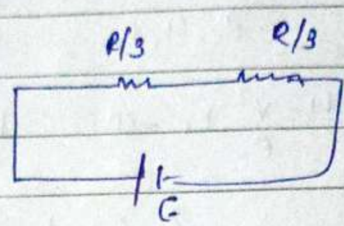
**Que** Six similar bulbs are connected as shown in the figure with a DC source of emf. and zero internal resistance, the ratio of power consumption by the bulbs when

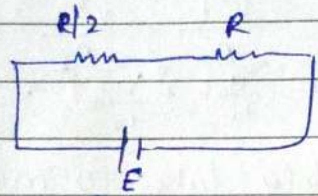
(i) All are glowing and (ii) In the situation when two from section A and one from section B are glowing will be




(a) 2 : 1
(b) 4 : 9
(c) 9 : 4 ✓
(d) 1 : 2




$$P_1 = \frac{3E^2}{2R} \quad —(i)$$



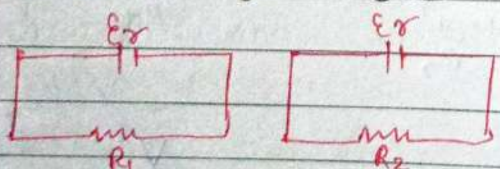

$$\frac{P_1}{P_2} = \frac{3E^2}{2R} \times \frac{3R}{2E^2}$$

$$\frac{9}{4}$$

$$R_1 = \frac{3R}{2}$$

$$P_2 = \frac{2E^2}{2R} \quad —(ii)$$

**Que** If power drop is same in $R_1$ and $R_2$ then find relation b/w $R_1$, $R_2$ and $r$. where battery is same in both case




$$P_1 = I^2 R_1 = \left(\frac{E}{R_1 + r}\right)^2 R_1 \qquad P_2 = \left(\frac{E}{R_2 + r}\right)^2 R_2$$

$$P_1 = P_2$$

$$\frac{E^2}{(R_1 + r)^2} R_1 = \frac{E^2}{(R_2 + r)^2}$$

$$\frac{R_1}{(R_1 + r)^2} = \frac{R_2}{(R_2 + r)^2}$$

$$R_1 (R_2 + r)^2 = R_2 (R_1 + r)^2$$

$$\sqrt{R_1}\,(R_2 + r) = \sqrt{R_2}\,(R_1 + r)$$

$$R_2\sqrt{R_1} + \sqrt{R_1}\,r = R_1\sqrt{R_2} + r\sqrt{R_2}$$

$$\boxed{r = \sqrt{R_1 R_2}}$$

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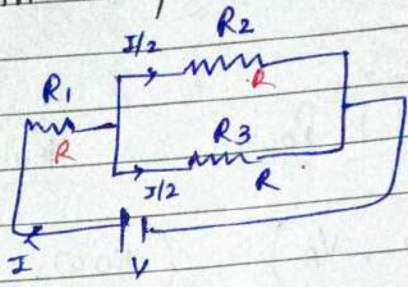
Que. Three Identical Resistance $R_1 = R_2 = R_3$ are connected as shown to a battery of constant e.m.f the power dissipated is.

(1) the least in $R_1$

(2) Greatest in $R_1$

(3) In the ratio 1:2 in resistance $R_1$ and $R_2$ respectively

(4) The same in $R_1$ and in the parallel combination of $R_2$ and $R_3$.



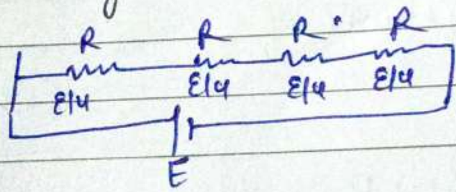

Que. Four equal resistance dissipated 5 W power together when connected in series to a battery of negligible. Internal resistance. the total power dissipated in these resistance when connected in parallel across the same battery would be.

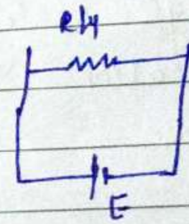
(1) 125 W

(2) 80 W

(3) 20 W

(4) 5 W




$P' = \frac{4E^2}{R} =$

$4[20W]$

$\boxed{= 80W}$

$R_{eq} = 4R$

$P = \frac{E^2}{4R} = 5$ Watt

An electric kettle takes 4. A current at 220 V. How much time will it take to boil 1 Kg of water from temperature 20°C ? the temp of boiling water is

1. 4.2 min

2. 6.3 min

3. 8.4 min

(4) 12.6 min.

$T_1 = 20°c$

$T_2 = 100°c$

$m = 1000\,gm$

$H = IVt = ms\Delta T$

$t_{in} = \frac{ms\Delta T}{IV} = \frac{1 \times 4.2 \times 10^3 \times ...}{... \times 220}$

$time = \frac{4.2 \times 10^3}{H}$

$S = 1\,cal/gm°c = \frac{4.2J}{10^{-3}\,kg°c}$

$= 4.2 \times 10^{-3}\,J/kg$

{ Rated Power & Rated Valtage }

$(P_R, V_R) = (50W, 220V)$

Bulb is Pure Resistance

$P_R = \frac{V_R^2}{R_{Bulb}}$

Rated Power and Rated Valtage only given to Calculated Resistance of Bulb.

$$\boxed{R_{Bulb} = \frac{V_R^2}{P_{Rated}}}$$

BOIB

$P_R, V_R \longleftrightarrow$ Rated Power, Rated Volt...

⇒ Pure Resistance

$P_R = \frac{V_R^2}{R_{bulb}}$

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

Rated Power and Rated Valtage only given to Calculate Resistance to Bulb.

$$\boxed{R_{bulb} = \frac{V_R^2}{P_{Rated}}}$$

$$P_{consumed} = \left(\frac{V_s}{V_R}\right)^2 P_{Rated}$$

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Que Two bulb are of (40 W, 200V) and (100 W, 200 V). then correct relation for their resistance is.

(a) $R_{40} < R_{100}$

(b) $R_{40} > R_{100}$ ✓

(c) $R_{40} = R_{100}$

(d) No relation can be predicted

Que An electric bulb is rated 60 W, 220 V. the resistance of its filament is.

(a) 870 Ω

(b) 780 Ω

(c) 708 Ω

(d) 807 Ω

$$R = \frac{V_R^2}{P_R} = \frac{220 \times \cancel{220}^{\,2}}{\cancel{60}_{\,3}} = \frac{220 \times 11}{3}$$

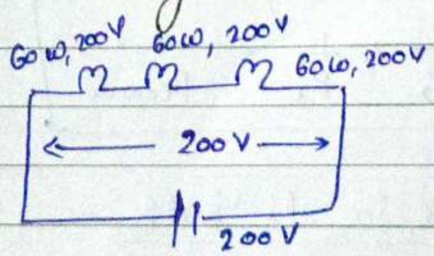
Que When three identical bulbs of 60 watt, 200 Volt rating are connected in series to a 200 Volt supply. The power drawn by them will be

(a) 60 Watt

(b) 180 Watt

(c) 10 Watt

(d) 20 Watt




$$\frac{1}{P_c} = \frac{1}{60} + \frac{1}{60} + \frac{1}{60} =$$

$$\frac{1}{P_c} = \frac{1}{20}$$

$$\boxed{P_c = 20 W}$$

$$P_{\substack{one\\bulb}} = \left(\frac{V_s}{V_R}\right)^2 P_R = \left(\frac{1}{3}\right)^2 \times 60 W$$

$$\frac{60W}{9} = \frac{60}{9} = P_{total} = \frac{60}{\cancel{9}_{3}} \times \cancel{3} = 2$$

Q4 A (100 W, 200V) bulb is connected to a 160 Volts supply. The Power Consumption would be

(a) 100 W (b) 125 W (c) 64 W (d) 80 W

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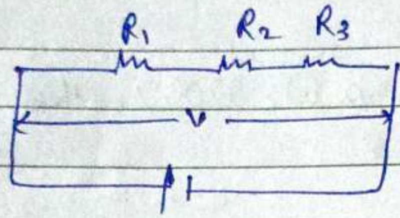
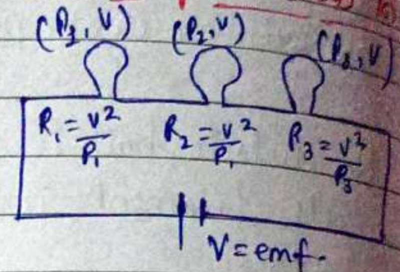
$$P_c = \left(\frac{V_s}{V_P}\right)^2 P_R = \left(\frac{160}{200}\right)^2 \times 100\,\omega$$

$$\frac{16}{25} \times 100 = 64\,\omega \quad B_2$$

## Series Combination of bulb (Power drop in Bulb in series) :-



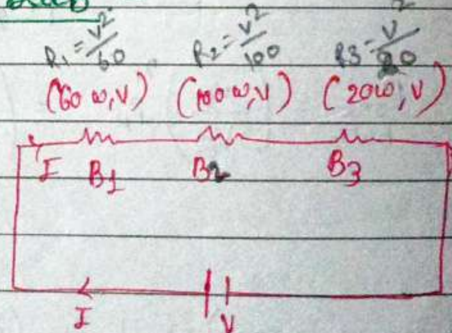

$$P_{cons} = \left[\frac{V^2}{R_{eq}}\right] = \frac{V^2}{R_1 + R_2 + R_3} = \frac{\cancel{V^2}}{\frac{\cancel{V^2}}{P_1} + \frac{\cancel{V^2}}{P_2} + \frac{\cancel{V^2}}{P_3}}$$

$$P_c = \frac{1}{\left(\frac{1}{P_1} + \frac{1}{P_2} + \frac{1}{P_3}\right)}$$

$$\boxed{\frac{1}{P_1} + \frac{1}{P_2} + \frac{1}{P_3} = \frac{1}{P_{consum}}}$$

Rated Power

## Current is same in all bulb :-




$$P_c = I^2 R_{Bulb}$$

$$P_{con.} \propto R_{bulb} \propto \frac{1}{P_{Rated}}$$

$$\boxed{P_{consumed} \propto \frac{1}{P_{Rated}}}$$

$$\boxed{B_3 > B_1 > B_2}$$

Brightness of Bulb

↳ Power Consumed by Bulb

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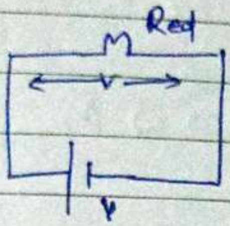
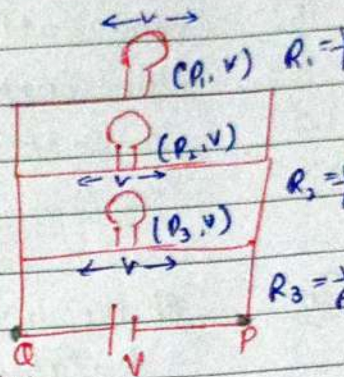
Parallel Combination of Bulb (Power drop in Parallel Combination) :-



$$\boxed{P_{total} = P_1 + P_2 + P_3}$$



# Compair their Brightness or Power consumed

$$P_{con} = \frac{V^2}{R_{Bul}} = V^2\left(\frac{1}{R_{eq}}\right)$$

# $P_{consumed} = \frac{V^2}{R_{Bulb}} \propto \frac{P_{Rated}}{V_{Rated}}$

$$P_{con} = V^2\left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right]$$

$$\boxed{P_{consumed} \propto P_{Rated}}$$

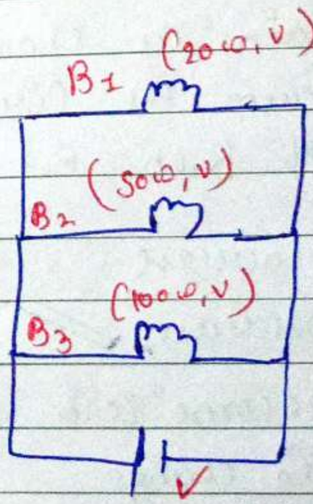
$$P_{con} = \cancel{V^2}\left[\frac{P_1}{\cancel{V^2}} + \frac{P_2}{\cancel{V^2}} + \frac{P_3}{\cancel{V^2}}\right]$$

$$\boxed{P_{con} = P_1 + P_2 + P_3}$$

Compair their Brightness

$P_{cons} \propto P_{Rated}$

$$\boxed{B_3 > B_2 > B_1}$$



Two 220 Volt, 100 Watt bulbs are Connected first In series and then In Parallel Each time the Combination is Connected to a 220 Volt ac Supply line. The Power drawn by the Combination in each case respectively will be

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(a) 50 Watt, 100 Watt
(b) 100 Watt, 50 Watt
(c) 200 Watt, 150 Watt
(d) 50 Watt, 200 Watt

$\frac{1}{P} = \frac{1}{P_1} + \frac{1}{P_2}$

$\frac{1}{P} = \frac{1}{100} + \frac{1}{100} = P = 50\,\omega$

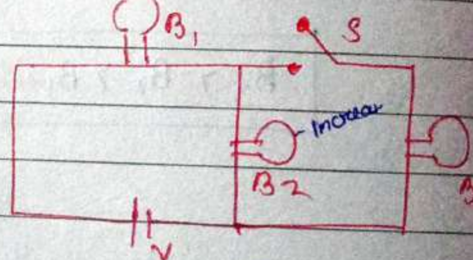
$P = P_1 + P_2 = 200\,\omega$

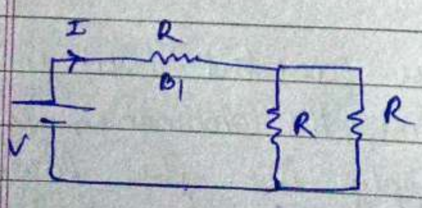
Qu. Of the two bulbs in a house hold circuit one glows brighter than the other which of the two bulbs has a large resistance?
(a) the bright bulb
(b) the dim bulb
(c) Both have the same resistance
(d) the brightness does not depend upon the resistance

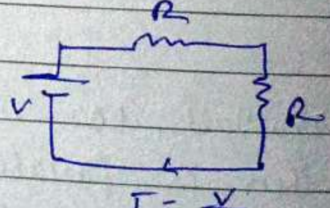
$P_{consum} = \frac{V^2}{R_{bulb}}$

Qu. Three Identical bulbs $B_1$, $B_2$, $B_3$ are connected to the main as shown in figure, If $B_3$ is disconnected from the circuit by opening switch S, then Incandescence of bulb $B_1$ will.

(a) Increase
(b) Decrease
(c) Become zero
(d) No change

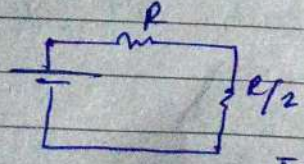



$I = \frac{V}{2R}$

$P' = I^2 R = \frac{V^2}{4R^2} = \boxed{R = \frac{V^2}{4R}}$




$I = \frac{V}{\frac{3R}{2}} = \left(\frac{2V}{3R}\right)$

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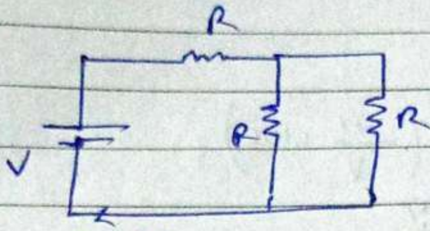
Three Identical bulbs are Connected as shown in figure when Switch S is closed the power Consumed in Bulb B is P. What will be the Power Consumed By the Same bulb when Switch S is Opened.

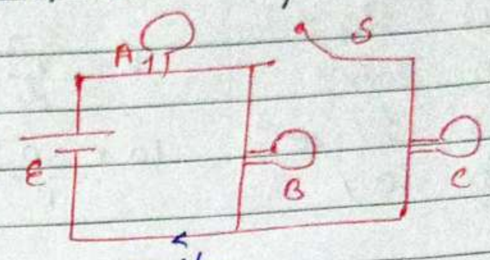
$\frac{9P}{4}$

$\frac{16P}{9}$

$\frac{9P}{16}$

$\frac{4P}{9}$




$I = \frac{2V}{3R}$

$P = I'^2 R$

$\left(\frac{V}{3R}\right)^2 \cdot R = \frac{V^2}{9R}$ — (1)

$I = \frac{V}{2R}$

$P' = I^2 R = \frac{V^2}{4R^2} R = \frac{V^2}{4R}$

$\boxed{P' = \frac{9P}{4}}$

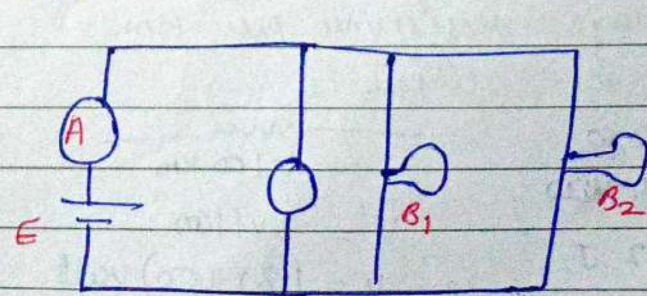
Two Identical bulbs are Connected in Parallel across an Ideal Source of emf. E the ammeter A and Voltmeter V are Ideal. If Bulb $B_2$ gets fused then

Reading of A will Increase but that of V will remain Same.

Reading of A will decrease but that of V will Increase

Reading of A will decrease but that of V will remain Same.

Reading of A will Increase and reading of V will also Increase.

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Que If Voltage across a bulb rated 220 Volt - 100 Watt drops by 2.5 % of its rated Value . the percentage of the rated Value by which the power would decrease is

(a) 20 %
(b) 2.5 %
(c) 5 % ✓
(d) 10 %

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

$10 \times \frac{\Delta P}{P} = 2\left(\frac{\Delta V}{V} \times 100\right)$

5 %

Que The Charge flowing through a resistance R Varies with time t as $Q = at - bt^2$ where a and b are positive Constant . the total heat produced in R is

(a) $\frac{a^3R}{2b}$
(b) $\frac{a^3R}{b}$
(c) $\frac{a^3R}{6b}$ ✓
(d) $\frac{a^3R}{3b}$

$Q = at - bt^2$

$\frac{dQ}{dt} = I = a - 2bt$

$I = 0 = a - 2bt$

$2bt = a$

$\boxed{t = \frac{a}{2b}}$

$dH = I^2 R dt$

$\int dH = \int (a - 2bt)^2 R dt$

$H = R \int (a-2bt)^2 dt$

$H = R \int (a-2bt)^2 dt =$

$R\left[\frac{(a-2bt)^3}{3 \times (-2b)}\right]_0^{\frac{a}{2b}}$

$\frac{R}{-6b}(0 - a^3)$

$\boxed{= \frac{a^3R}{6b}}$

Que Two Cities are 150 km apart. Electric Power is sent from One City to another City through Copper wires The fall of potential per km is 8 Volt and the average resistance per km is 0.5 Ω . the Power loss in the wire is

(1) 19.2 W
(2) 19.2 kW ✓
(3) 19.2 J
(4) 12.2 kW

$d = 150$ km

$V' = 8 V/km$

$V = (8 \times 150)$ volt

$R = 0.5 \times 150 = 75 \Omega$

$P = \frac{V^2}{R} = \frac{8 \times 8 \times 150 \times 150^2}{75}$

$64 \times 300$

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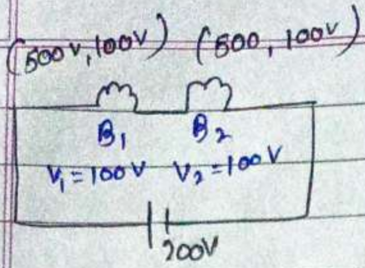
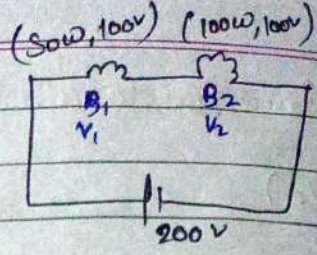
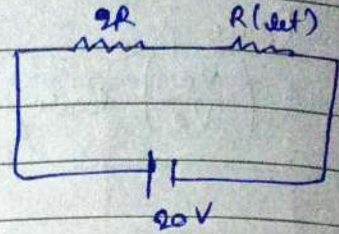



Which Bulb will fuse.

No Bulb will fuse

$P_{total}$ = 50W + 50W
100 Watt




$x + 2x = 200$
$3x = 200$
$x = \frac{200}{3} = V_2$
$V_1 = \frac{400}{3} = 133$

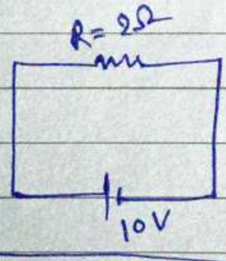
## GALVANOMETER

⇒ Use to detect current, not to measure current.
⇒ Very sensitive, measure small current
⇒ Produce large error when connected in circuit

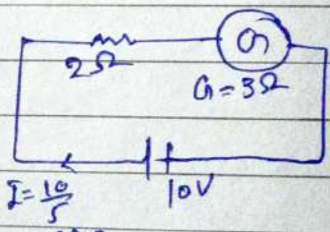
$I_G$ = Maximum current can measure =
$G$ = Resistance of galvanometer

We have two Problem → High sensitivity, → Error.

Galvanometer as Ammeter :- used to measure current




⇒




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

$I_{Reading} = 2$ Amp
Measured

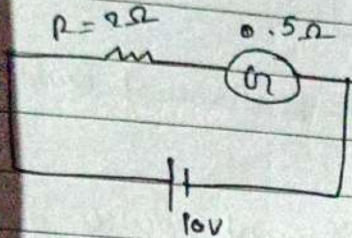
$\boxed{I = \frac{10}{2} = 5 \text{ Amp}}$

# Find % error in the reading of galvanometer

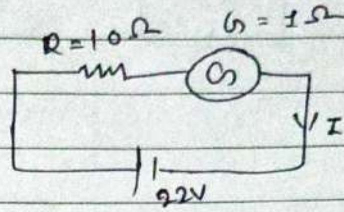
% error $= \dfrac{|I_m - I_T|}{I_T} \times 100$

$\dfrac{|2-5|}{\cancel{5}} \times \cancel{100}^{20} = 60\%$.

Qu




Qu



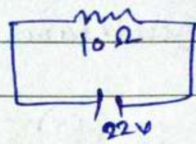

$I_{True} = 5$ Amp.

$I_m = \dfrac{10}{2.5} = 4$ Amp.

% error $= \dfrac{|I_T - I_m|}{I_T} \times 100$

$= \dfrac{1}{\cancel{5}} \times \cancel{100}^{20} = 20\%$.

Find % error in the reading of galvanameter.




$I = \dfrac{22}{10} = 2.2$ Amp

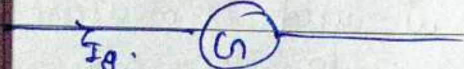
% error $= \dfrac{I_T - I_m}{I_T} \times 100$

$\dfrac{2.2-2}{2.2} \times 100$

$\dfrac{0.2}{2.2} \times 100$

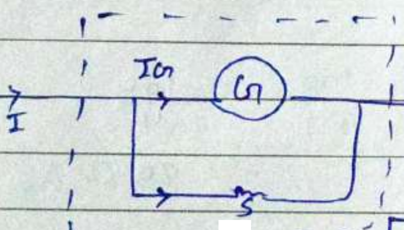
$\dfrac{100}{11} = \boxed{9\%}$

Qu **Conversion of galvanometer into Ammeter.**




Working Principle.

$\boxed{V_{ammeter} = V_G = V_{sunt}}$




$R_a = \dfrac{GS}{G+S}$
Resist of ameter.

Ideal ammeter

$R_{amm} = 0 \leftarrow$ Simple wire

$I_G G = (I - I_G) S$

If $I = n I_G$ — ①

* Capacity of Ammeter Increase by n times.

$\cancel{I_G} G = (n\cancel{I_G} - \cancel{I_G}) S$

$G = (n-1) S$

$\boxed{S = \dfrac{G}{n-1}}$

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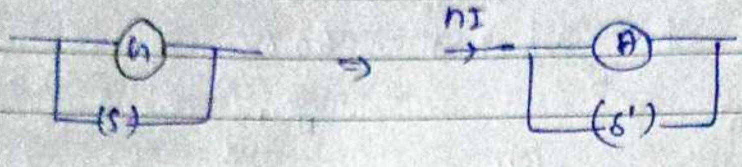
# Conversion of Ammeter into Ammeter

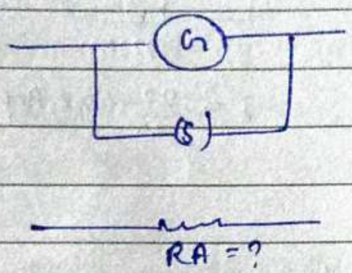


$$\boxed{S' = \frac{A}{n-1}}$$ — Resistance of Ammeter

PYQ

Qu In an ammeter 0.2% of main current passes through the galvanometer. If resistance of galvanometer is G, the resistance of ammeter will be

(1) $\frac{1}{499} G$
(2) $\frac{499}{500} G$
(3) $\frac{1}{500} G$
(4) $\frac{500}{499} G$

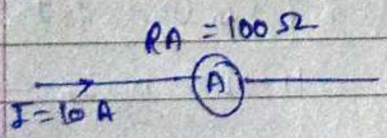


$I R_A = 0.2\% \, I G$

$R_A = \frac{0.2 G}{100} = \frac{2G}{100}$

$= \boxed{\frac{G}{500}}$ B

Qu Ammeter of resistance 100 Ω is used to measure 10 A. Find resistance of shunt if we want to measure 50 A.

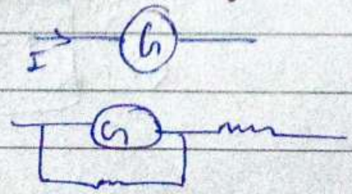


$S = \frac{A}{n-1} = \frac{100}{5-1} = \frac{100}{4}$

$= 25 \, \Omega$ Ans

Qu A galvanometer of resistance G is shunted by a resistance S ohm. To keep the main current in the circuit unchanged, the resistance to be put in series with galvanometer is

(a) $\frac{G}{(S+G)}$
(b) $\frac{G}{S+G}$
(c) $\frac{G^2}{S+G}$
(d) $\frac{SG}{S+G}$

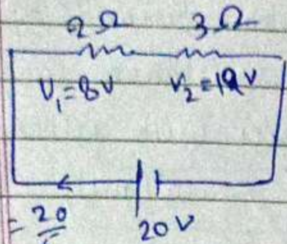


$\frac{GS}{G+S} + R = G$ , $R = G - \frac{GS}{G+S}$

$\frac{G^2 + GS - GS}{G+S}$

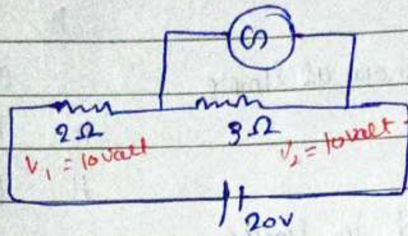
$R = \frac{G^2}{G+S}$

# Galvanometer As a Voltmeter




$I = \frac{20}{5}$
$= 4A$

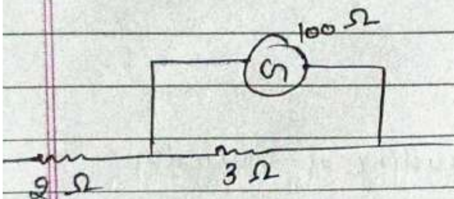
If we want to measure Potential drop across $3\Omega$, then we will use galvanometer Parallel with $3\Omega$ resistance.




$V_{measure} = 10$ volt

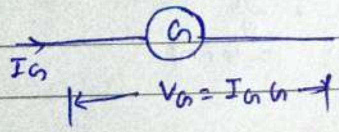
$\%\ error = \frac{V_T - V_R}{V_T} \times 100 = \frac{12-10}{12} \times 100$

$\frac{100}{6} = 16\%$




$\frac{100 \times 3}{103} = \frac{300}{105}$

## Conversion of galvanometer into Voltmeter




### Working Principle

$V_G = I_G G$ — (i)

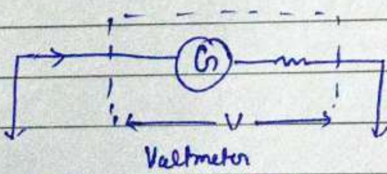
$V_{volt} = I_G (G+S)$ — (ii)

If $\boxed{V_{volt} = n V_G}$ — *

$I_G (G+S) = n I_G G$

$G + S = nG$

$$\boxed{S = nG - G = G(n-1)}$$




$\boxed{R_{volt} = G+S}$

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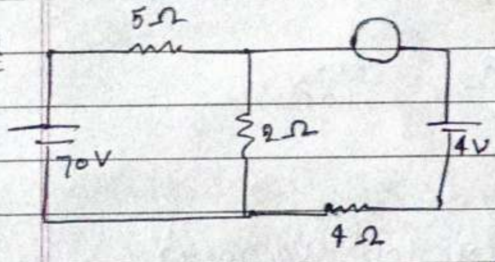
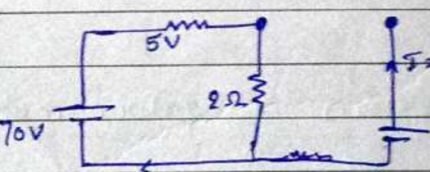
| Ammeter | Voltmeter |
| --- | --- |
| • Ammeter formed by adding small resistance connected in parallel with galvanometer | Voltmeter formed by adding large resistance connected in series with galvanometer |
| $\boxed{S = \frac{G}{(n-1)}}$ | $\boxed{S = G(n-1)}$ |
| # Ideal Ammeter behave as simple wire | # Ideal Voltmeter behave as open wire |
| # $R_{ideal\ ammeter} = 0$ | # $R_{ideal\ voltm} =$ Infinite |
| # Ammeter connected in series in circuit where current have to measure | # Voltmeter connected in parallel in circuit where potential have to measure. |

Qu




Find reading of Voltmeter = ?



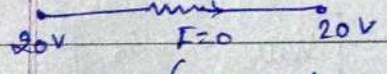

$I = \frac{70}{7}$

$= 10$ Amp.

$V_A - IR + 4 = V_B$

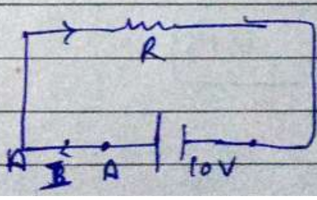
$V_A - V_B = IR - 4$

$20 - 4 = \boxed{16\ \text{volt}}$ Ans




Current must be zero.

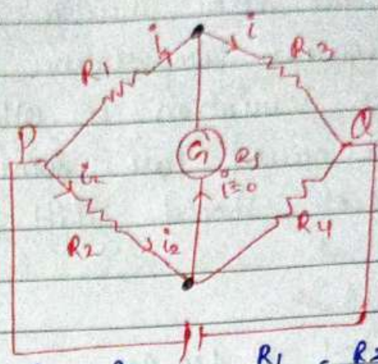
(20V) I may be (20V)
zero or may
not be zero.



# Wheatstone bridge

$I_G$ will be zero, only when $V_A = V_B$

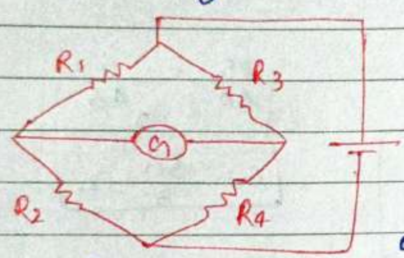
If $\boxed{\frac{R_1}{R_2} = \frac{R_3}{R_4}}$




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

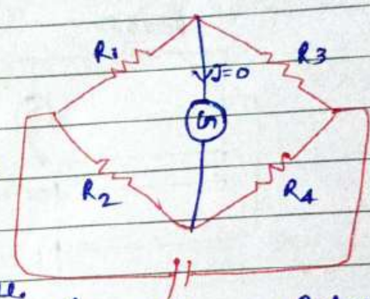
$\boxed{\frac{R_1}{R_3} = \frac{R_2}{R_4}}$

Balance Wheatstone Bridge




$\frac{R_1}{R_2} = \frac{R_3}{R_4}$ = same condn.

Interchange the position of Battery & galvanometer.



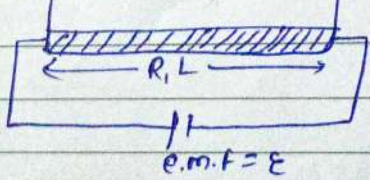

$\frac{R_1}{R_2} = \frac{R_3}{R_4}$ — Balance wheat Stone

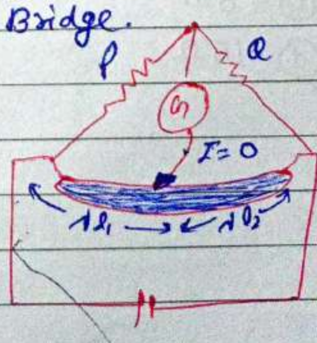
## Meter Bridge

An Instrument used to measure unknown resistance
Based on the Concept of wheat Stone Bridge.

$\frac{P}{\lambda l_1} = \frac{S}{\lambda l_2}$

$\boxed{\frac{P}{S} = \frac{l_1}{l_2}}$




Resistance Per Unit length $\lambda = \frac{R}{L}$

If $L = 1m = 100$ cm

then $\left(\frac{P}{S} = \frac{l_1}{100 - l_1}\right)$

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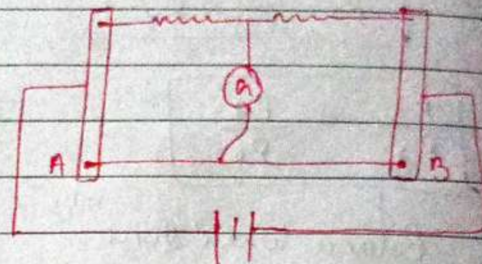
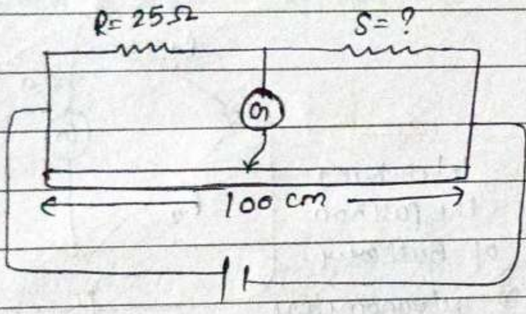
Qu In the meter bridge shown, the resistance X has a negative temperature Coefficient of resistance. Neglecting the Variation in other resistor, when Current is passed for some time, In the Circuit balance point Should Shift towards

(a) A
(b) B
(c) First A then B
(d) It will remain at C




Qu

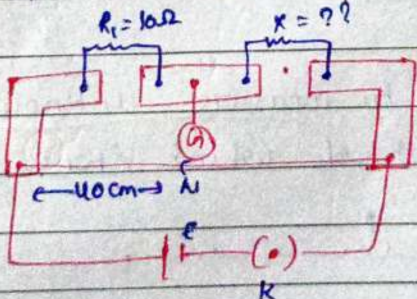



$$\frac{25}{\cancel{60}_{3}} = \frac{S}{\cancel{40}_{2}}$$

$$\boxed{S = \frac{50}{3}\,\Omega}$$

Qu In the meter bridge Experiment, the null point is obtained at N. the Value of unknown resistance X will

(a) 60 Ω
(b) 40 Ω
(c) 6 Ω
(d) 15 Ω




$$\frac{10}{40} = \frac{x}{60}$$

$$\frac{60}{4} = x$$

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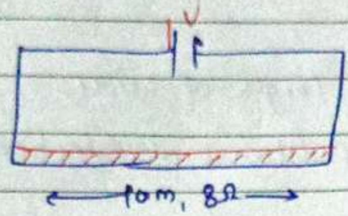
# Potentiometer Wire

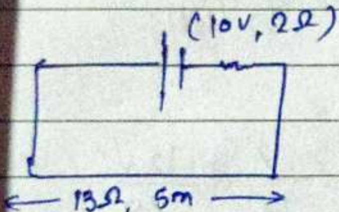
Potential drop in a metre - wire — Potential drop per unit length = $k$




Potential drop per unit length $= \frac{20}{10} = \boxed{2V/}$

$I = \frac{20}{8}$ Amp.

$V = IR = \frac{20}{8} \times 8 = 20$ Volt

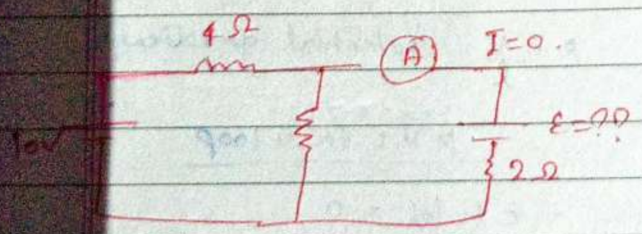



Potential drop per unit length $= \frac{V}{L} = \frac{26}{3 \times 5}$

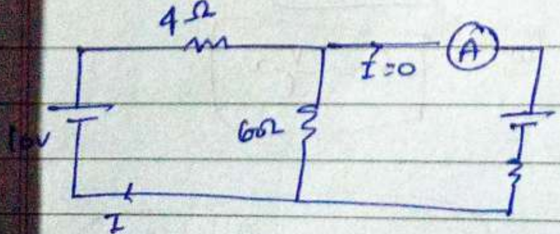
$= \frac{26}{15}$ V/

$I = \frac{10}{15} = \frac{2}{3}$ Amp.

$V_{(wire)} = IR = \frac{2}{3} \times 13 = \boxed{\frac{26}{2} \text{ Volt}}$




If current in ammeter is zero then find E.m.f of unknown Battery ??




KVL in loop

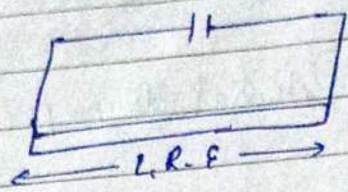
$0 + \varepsilon - IR = 0$

$\varepsilon = IR$

$1 \times 6 = \boxed{6 \text{ Volt}}$

Based on Potential gradient
Use to find

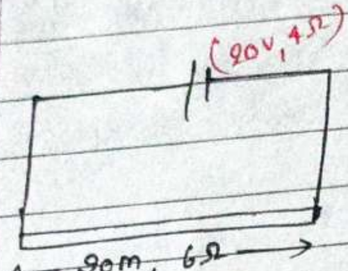
- e.m.f of cell
- Internal resistance
- ratio of e.m.f




L = length of wire

R = resistance of Potentiometer wire.

**Que**



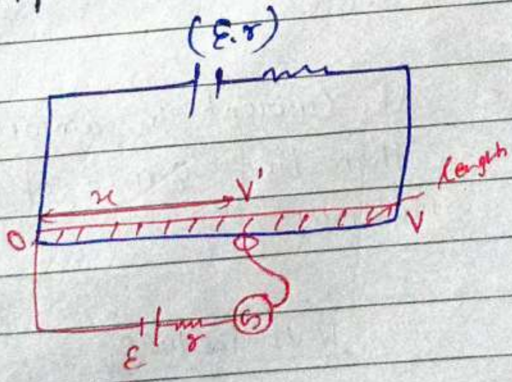

$I = \frac{20}{10} = 2$ Amp.

$V$ (wire) $= IR = 2 \times 6 = 12$ Volt

Potential drop per unit length $= \frac{V}{L} = \frac{12\,V}{20} = 0.6\ V/m$

## Application of Potentiometer Wire - To find emf

$K = \frac{V}{l}$ = Potential gradient

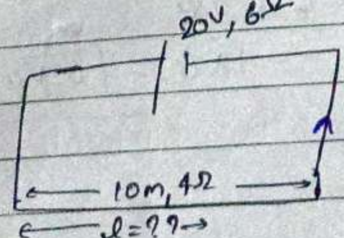



K.V.L in a loop

$-\varepsilon + Kl = 0$

$\boxed{\varepsilon = Kl}$

formula $\boxed{\varepsilon = \frac{V}{l}x}$




$I = \frac{20}{10}$

$I = 2A$

$V = IR$

$V = 2 \times 4 = 8$ volt

Ans Not Possible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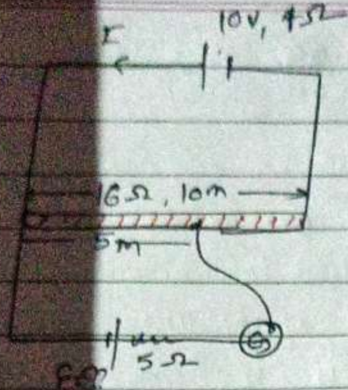
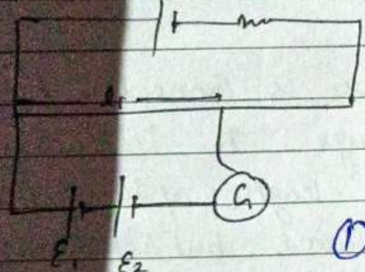



find EMF of Battery = ??

Not Possible
Balance Point can be find.

## Application - 2

To compare emf of Battery




when Both the battery is Connected with same Polarity then Balance Point is at $l_1$.

$k l_1 = \varepsilon_1 + \varepsilon_2$ — (I)

⇒ when Polarity 2nd Battery is re. then Balance Condition is at $l_2$

$k l_2 = \varepsilon_1 - \varepsilon_2$ — (II)

(I) / (II)

$$\frac{\varepsilon_1+\varepsilon_2}{\varepsilon_1-\varepsilon_2} = \frac{l}{l_2}$$

MR Ratta

$$\boxed{\frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1+l_2}{l_1-l_2}}$$

Q. Two cells of emf $\varepsilon_1$ and $\varepsilon_2$ are to be Compared in a Potentiometer ($\varepsilon_1 > \varepsilon_2$) when the Cells are used in Series Correctly. the balancing length obtained is 400 cm. When they are used in Series but $\varepsilon_2$ is Connected with reverse Polarities the balancing length obtained is 200 cm. Ratio of emf of Cells is

(1) 3 : 2 (b) 3 : 1 (3) 4 : 1 (4) 4 : 3

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$$\frac{\varepsilon_1}{\varepsilon_2} = \frac{(400+200)}{(400-200)} = \frac{600}{200} = \frac{3}{1} \quad ③$$

**Qu** Two cells of e.m.f $\varepsilon_1$ and $\varepsilon_2$ are joined in series and the balancing length of the Potentiometer wire is 625 cm. If the terminal of $\varepsilon_1$ are reversed the balancing length obtained is 125 cm. Given $\varepsilon_2 > \varepsilon_1$ the ratio $\varepsilon_1 : \varepsilon_2$ will be

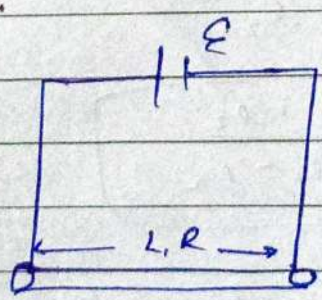
(1) 2 : 3
(2) 3 : 1
(3) 3 : 2
(4) 1 : 5

$$\frac{\varepsilon_2}{\varepsilon_1} = \frac{l_1 + l_2}{l_1 + l_2}$$

$$\frac{\varepsilon_2}{\varepsilon_1} = \frac{750}{500} = \frac{3}{2}$$

**Qu** A 10 m long Potentiometer wire is Connected to a Battery having a steady Voltage. A Leclanche Cell is Balanced at 4 m length of the wire. If the length is kept the same, but its Cross section is doubled. the null point will be obtained at.

(a) 8 m
(b) 4m
(c) 2m
(d) None




$$K = \frac{\varepsilon}{L}$$

## Application -3

To find Internal resistance of Cell

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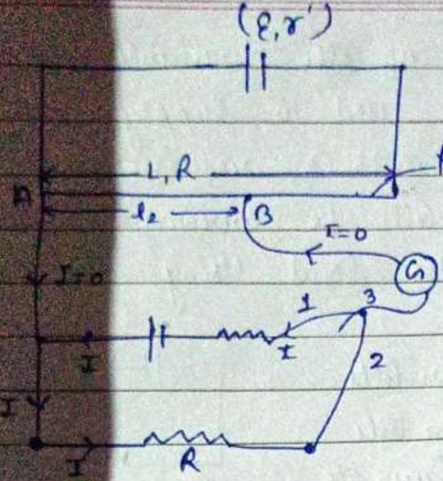



$1^{st}$ & $3^{rd}$ Key is connected.

If Balance Point is at $l_1$ then $\varepsilon = K l_1$ — (I)

Now $1^{st}$, $2^{nd}$ & $3^{rd}$ all are connected then Point is at $l_2$.

$IR = K l_2$ — (II)

$\frac{\varepsilon R}{R+r} = K l_2$ — (III)

(I) / (II)

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

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

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

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

Qu A Potentiometer Circuit is set up as shown. the Potential gradient across the potentiometer wire, is K Volt / cm and ammeter, Present in the Circuit, reads. 1.0 A when two way key is switched off. the balance points when the key b/w the terminal (i) 1 and 2 (ii) 1 and 3 is plugged in, are found to be at length $l_1$ cm and $l_2$ cm respectively. the magnitude, of the resistor R and X, in ohms are then equal respectively to.

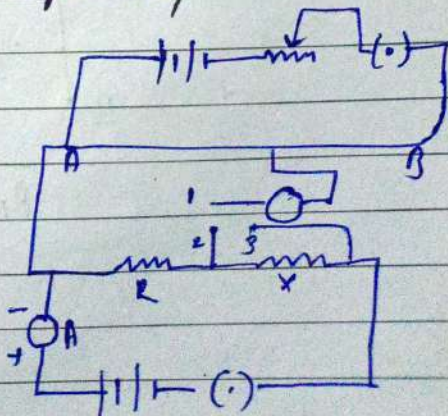
(a) $K(l_2 - l_1)$ and $Kl_2$
(b) $K(l_2 - l_1)$ and $Kl_1$
(c) $Kl_1$ and $K(l_2 - l_1)$
(d) $K(l_2 - l_1)$ and $Kl_1$

$\boxed{Kl_1 = 1 \times R}$ — (I)

$Kl_2 = 1(R + X)$ — (II)

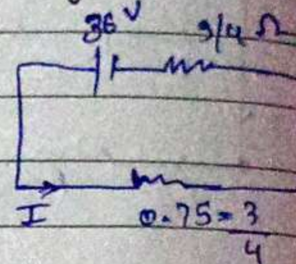
$Kl_2 = Kl_1 + X$

$K(l_2 - l_1) = X$



**Que** There are a large number of Cells available each marked ( 6V, 0.5 Ω ) to be used to supply Curr[ent] to a device of resistance 0.75 Ω requiring 24 Current. How should the Cells be arranged so [that] Power is transmitted to the load using minimum number of cells ?

(a) Six rows each Containing four Cells
(b) four rows each Containing Six Cells
(c) four rows each Containing four Cell
(d) Six rows each Containing Six Cells

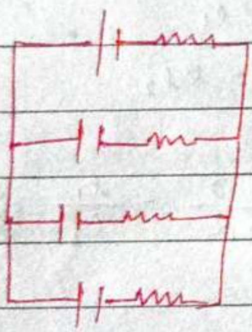


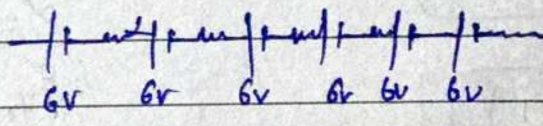

$$I = \frac{36}{\frac{3}{4}+\frac{3}{4}}$$

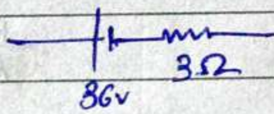
6

$\frac{36\,V}{6}$

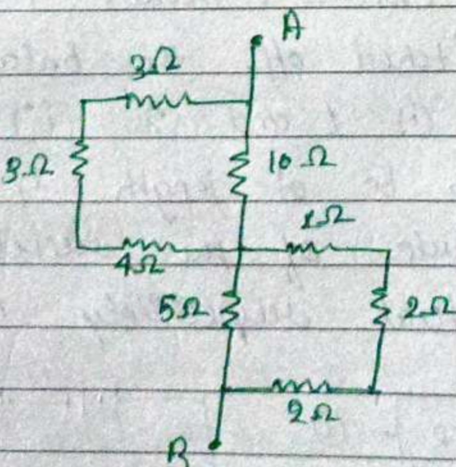
24






## Finding of equivalent Resistance




$R_{AB} = 7.8\ \Omega$

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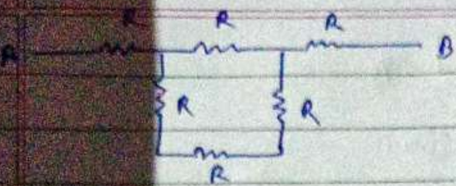
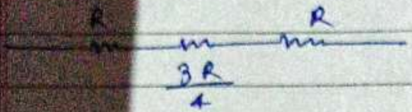
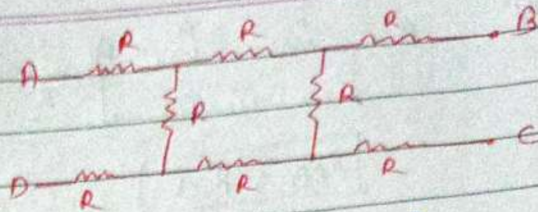
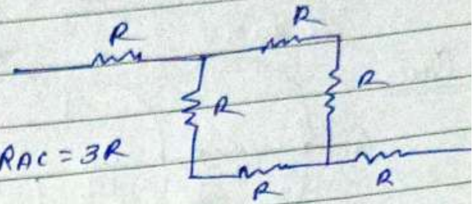


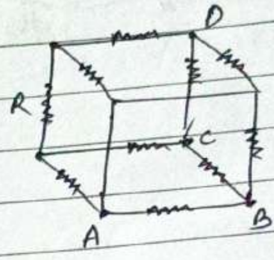

$R_{AB} = 2R + \frac{3R}{4} = \frac{11R}{4}$




$R_{AC} = 3R$

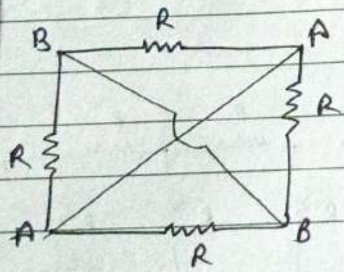
$\boxed{R_{AB} = \frac{7}{12}R}$ $\boxed{R_{AC} = \frac{3}{4}R}$

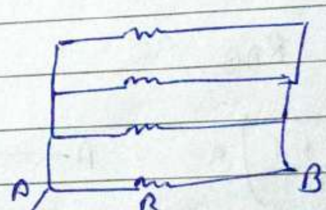
$\boxed{R_{AD} = \frac{5}{6}R}$




$\boxed{C_{AB} = \frac{12C}{7} \quad C_{AC} = \frac{4}{3}C \quad C_{AD} = \frac{6}{5}C}$

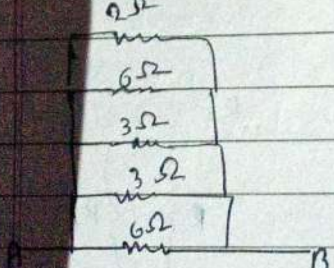
Q. Find $R_{AB}$ = ?



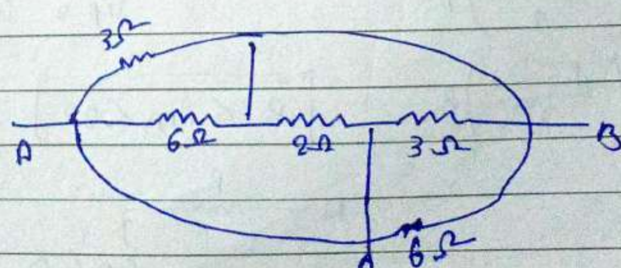




$R_{AB} = \frac{R}{4}$

Q.




$R_{AB} = \frac{2}{3}\Omega$

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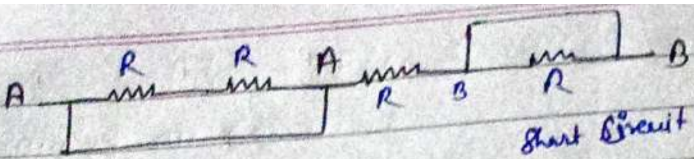
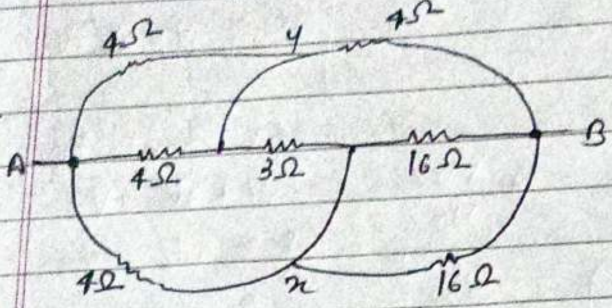
Qu



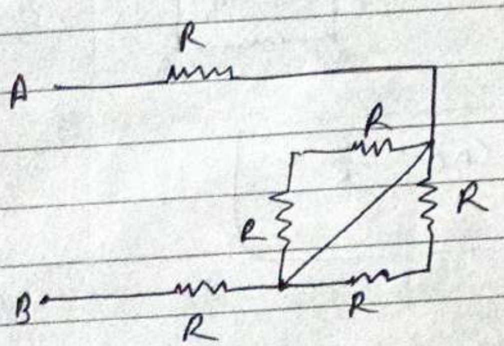

Short Circuit

$\boxed{R_{AB} = R\,\Omega}$

Qu




Qu




$\boxed{R_{AB} = 2R}$

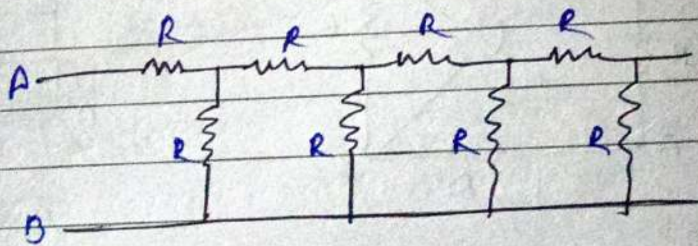
Qu Find $R_{AB} = ??$

(a) $\left(\frac{\sqrt{5}+1}{2}\right)R$

(b) $\left(\frac{\sqrt{5}-1}{2}\right)R$

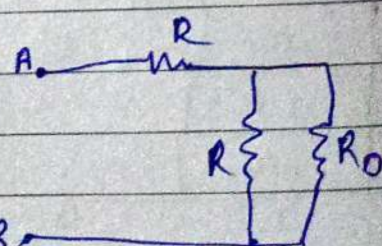
(c) $\left(\frac{\sqrt{3}+1}{4}\right)R$

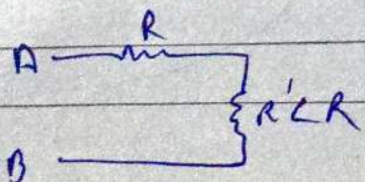
(d) $\left(\frac{\sqrt{3}-1}{2}\right)R$



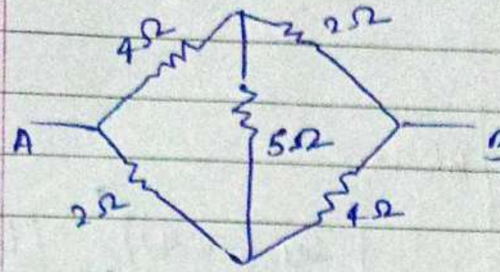

up to infinite

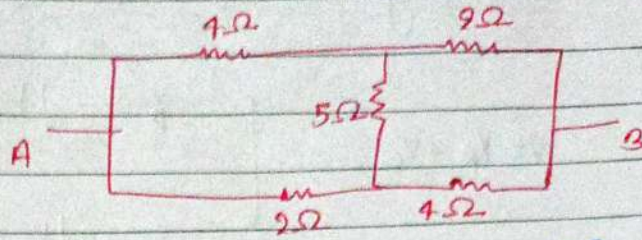
$\boxed{R < R_{AB} < 2R}$



# UnBalance Wheatstone Bridge. = Not in neet



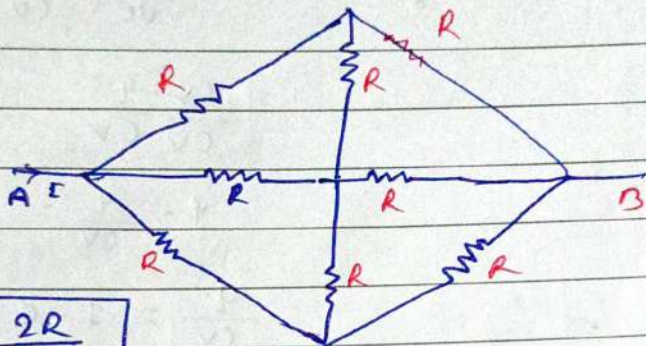




$R_{AB} = 3\Omega$

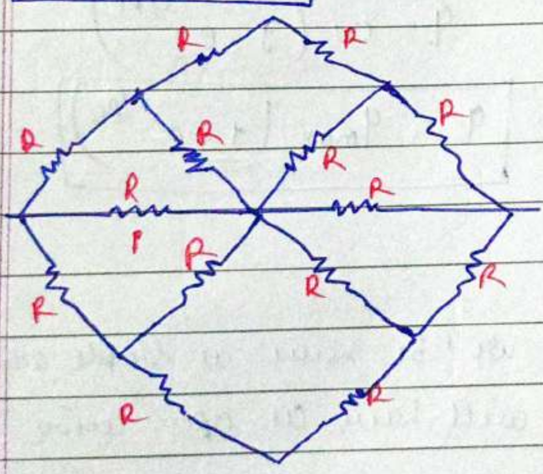
**MR*** assume It is balance wheat stone bridge then find $R_{AB}$ & your ans will be Just less than $R_{AB}$

$A_n = R_{AB} < 3\Omega$

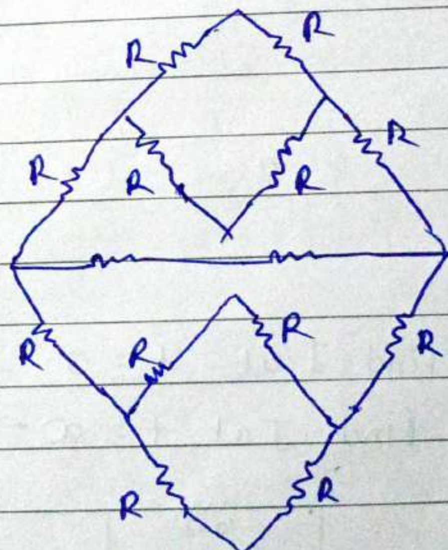
$= R = \frac{20}{7}\,\Omega$




$$\boxed{R_{AB} = \frac{2R}{3}}$$



⇒



$$R_{AB} = \frac{\frac{3R}{2} \times 2R}{\frac{3R}{2} + 2R} = \frac{\frac{6R^2}{2}}{\frac{7R}{2}}$$

$$\frac{6}{7}R$$

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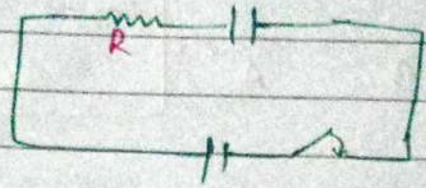
# D/C ⇒ R/C Circuit

## Charging or Capacitor :-

$V = V_R + V_C$



At t=0

at time 't'

$V = V_R + V_C$

$V = IR + \frac{q}{C}$

$IR = V - \frac{q}{C}$

$\frac{dq}{dt} R = \frac{CV - q}{C}$

$\int_0^q \frac{dq}{CV - q} = \int_0^t \frac{dt}{RC}$

$\left[\frac{-\log(CV-q)}{1}\right]_0^q = \left(\frac{t}{RC}\right)$

$\log(CV-q) - \log CV = -\frac{t}{RC}$

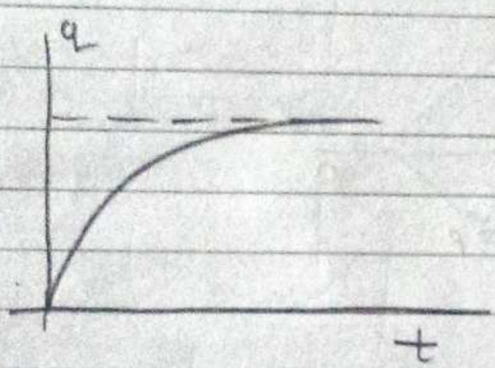
$\log_e\left(\frac{CV-q}{CV}\right) = -\frac{t}{RC}$

$\frac{CV}{CV} - \frac{q}{CV} = e^{-t/RC}$

$1 - \frac{q}{CV} = e^{-t/RC}$

$\frac{q}{CV} = 1 - e^{-t/RC}$

$q = CV\left(1 - e^{-t/RC}\right)$



at steady state

$t = \infty$

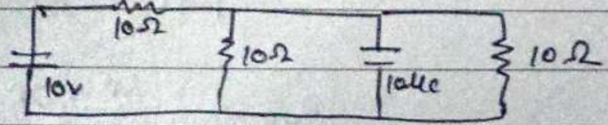
$q = q_{max} = CV$ ← does not depend on Resistance

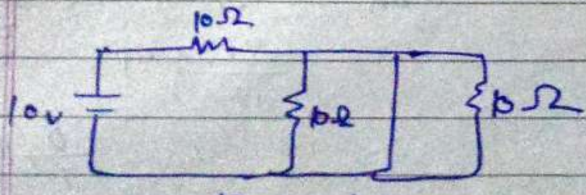
Imp $\boxed{q = q_{max}\left(1 - e^{-t/RC}\right)}$

(i) find I at $t = 0$ → Capacitor will be have as simple wire

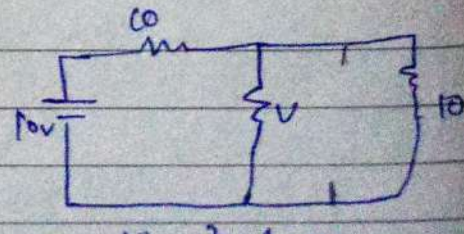
(ii) find I at $t = \infty$ → Capacitor will have as open wire

Q.





$I = \frac{10}{10} = 1$ Amp



$I = \frac{10}{15} = \frac{2}{3}$ Amp

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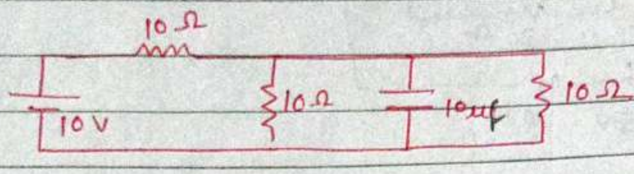
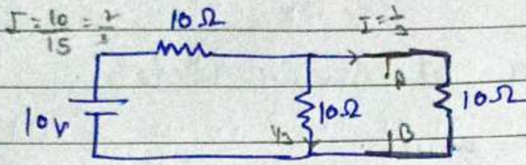
behave open wire

Q. Find charge on Capacitor in Steady State



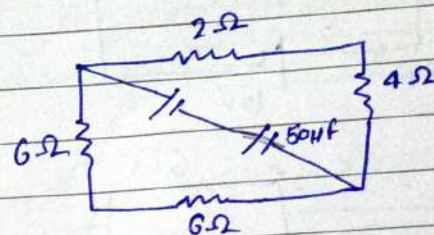

$q = CV = 10 \times \frac{10}{3} = \frac{100}{3}$ μc

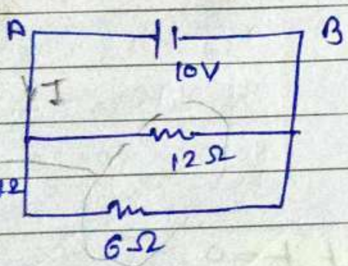
$V_{AB} = \frac{10}{3}$ Volt

Imp

Find Current at $t = 0$ and $t = \infty$ Steady State.

Capacitor will behave as simple wire at $t = 0$



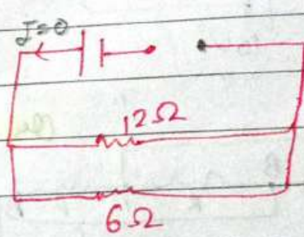




$\frac{12 \times 6}{12 + 6}$

$\frac{72}{18} = 4 \Omega$

$I = \frac{V}{R} = \frac{10}{4} = 2.5$ Amp

at Steady State → Capacitor open wire




Charge on Capacitor

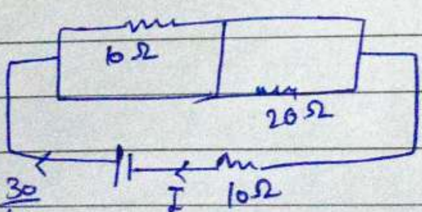
$V_{cap} = 10$ Volt

$q = CV = 50 \times 10$

$= 500$ μc

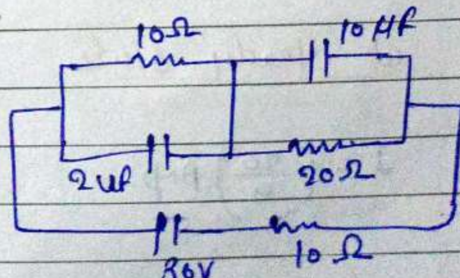
Q. Find Current at $t = 0$.

Imp Point Capacitor → Simple Wire




$I = \frac{30}{10}$

$= 3$ Amp

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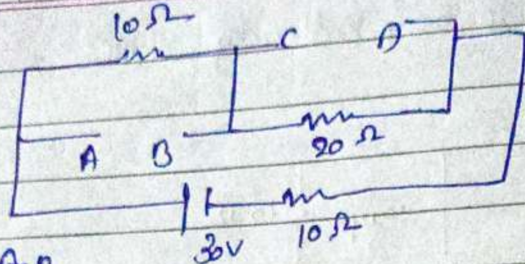
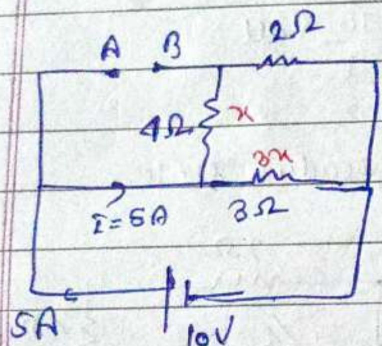
At Steady State.

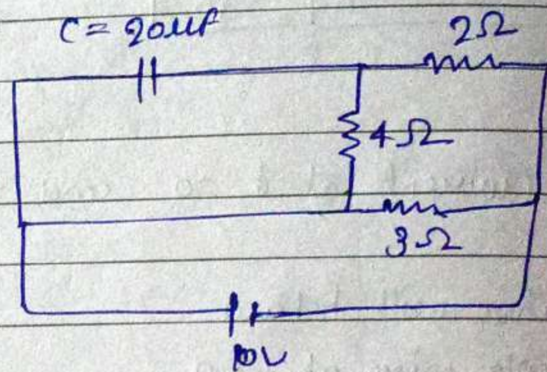


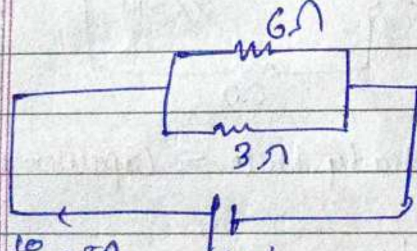

$I = \frac{30}{40} = \frac{3}{4}$ Amp

Find Charge on Capacitor at Steady State.




Steady State ⇐




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

$x = 2x = 5A$

$3x = 5A$

$x = \frac{5}{3}$ Amp

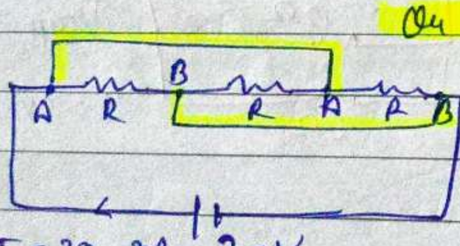
Potential diffⁿ across capacitor

$V_A - 4 \times \frac{5}{3} = V_B$

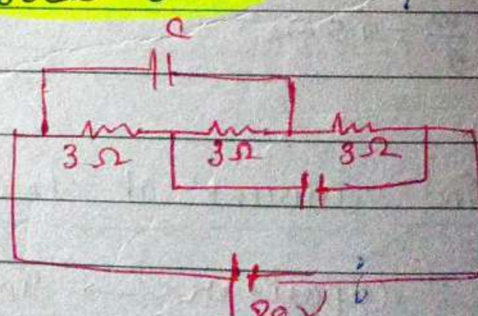
$V_A - V_C = V_C = \frac{20}{3}$

$q = CV = 20 \times \frac{20}{3} = \frac{400}{3}$

Q. Find Current t = 0




$I = \frac{20}{1} = 20$ Amp




at Steady State

$I = \left(\frac{20}{9}\right)$ Amp.

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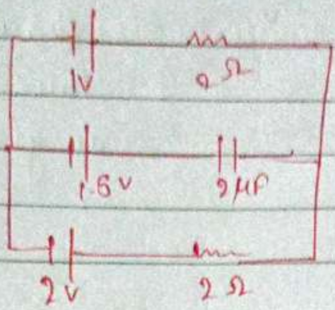
Q. The charge in the 2 μf capacitor at steady state is.

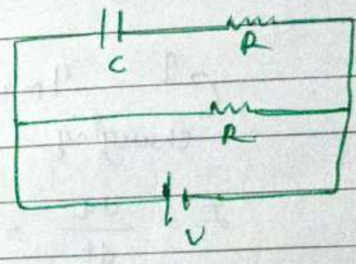
(1) zero
(2) 2 μc
(3) 4 μc
(4) 6 μc




Time Constant $\tau$ = Req C

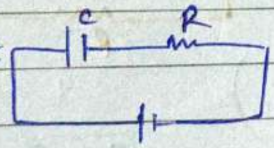
Short Circuit the battery and Calculate equivalent resistance along ends of capacitor $\boxed{\tau_{eq} = R_{q} C}$

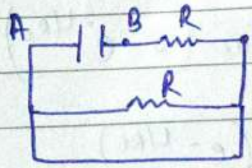
Find equivalent time Const of Circuit




$\tau$ = Req C

$\tau$=RC

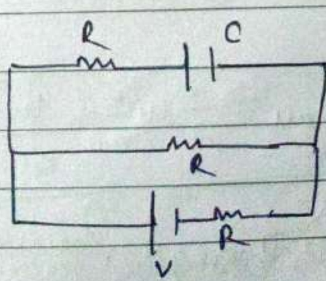


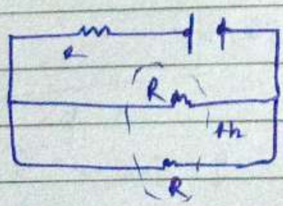




Req = R

$\boxed{\tau = RC}$

Q. Find equivalent time Constant




$R_{AB} = R + \frac{R}{2} = \frac{3R}{2}$

$\tau$ = Req C = $\frac{3RC}{2}$

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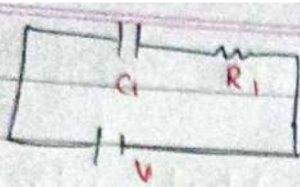
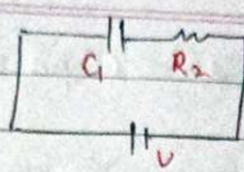
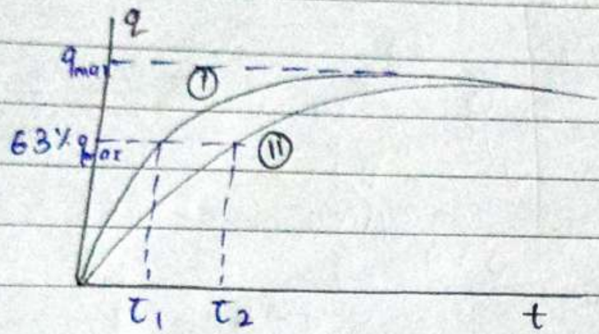
Que




Compare $C_1$ $C_2$ & $R$




Charge q / time (t) for both the circuit is give then compare $C_1$ $C_2$ and $R_1$ & $R_2$

$q_{max}$ same on both capacitor

$$q_{max} = C_1 V = C_2 V$$

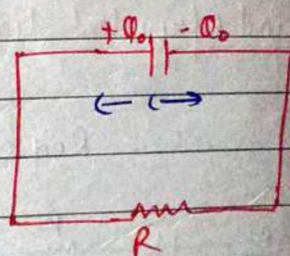
$$\boxed{q_{max} = C_1 = C_2}$$

$\tau_1 < \tau_2$

$R_1 C_1 < R_2 C_2$

$\boxed{R_1 < R_2}$

## Discharging of Capacitor :-




$$q_{charging} = q_{max}\left(1 - e^{-t/RC}\right)$$

$$I = \frac{dq}{dt} = q_{max}\left(0 - e^{-t/RC}\right)\left(-\frac{1}{RC}\right)$$

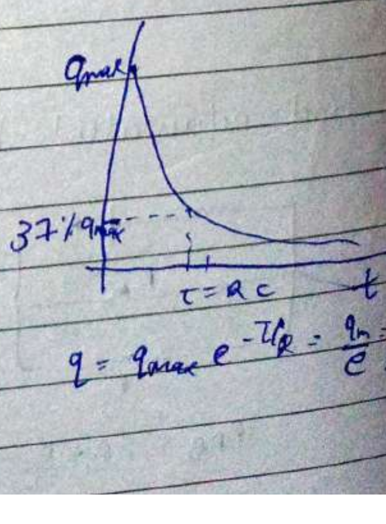
$$I = \frac{-\cancel{C}V}{R\cancel{C}}\left(e^{-t/RC}\right)$$

$$\boxed{I = I_{max}\, e^{-t/RC}}$$ charging

$q = q_{max} e^{-t/RC}$

$$\boxed{q = q_{max}\, e^{-t/RC}}$$

discharging




$q = q_{max} e^{-\tau/R} = \frac{q_m}{e} = \frac{q}{2 \cdot}$

$$\boxed{E_{loss} = \frac{1}{2} CV^2 = \frac{q_m^2}{2C}}$$

through Resistor

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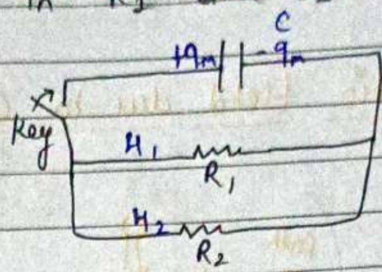
Qu Find Ratio of heat loss in $R_1$ and $R_2$




$$\boxed{\frac{H_1}{H_2} \propto \frac{R_2}{R}}$$

Ans

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

Parallel comb$^n$

$V$ = same

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

$H_1 + H_2 = \frac{q_{max}^2}{2C}$

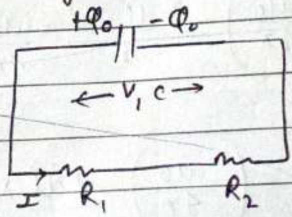
$H_1 + \frac{R_1 H_1}{R_2} = \frac{q_{max}^2}{2C}$

$H_1 \left(\frac{R_2 + R_1}{R_2}\right) = \frac{q_m^2}{2C}$

$H_1 = \frac{R_2}{R_1 + R_2}\left(\frac{q_m^2}{2C}\right)$

$H_2 = \frac{R_1}{R_1 + R_2}\left(\frac{q_m^2}{2C}\right)$

Qu Find Ratio of Heat loss ~~through~~ $R_1$ & $R_2$




$H = I^2 R t$

$H \propto R$

$$\boxed{\frac{H_1}{H_2} = \frac{R_1}{R_2}}$$

Ans

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