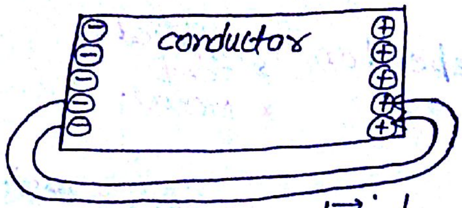
*** Electrodynamics

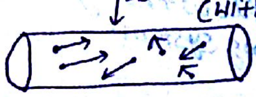
CURRENT ELECTRICITY

$\longrightarrow \vec{E}_{ext}$



$|\vec{E}_{in}| = |\vec{E}_{ext}|$

Electric field inside the conductor will be non-zero.



A/R Due to thermal speed free e^- performed a random motion / brownian motion so net disp. of change remain zero. So current is zero.

|1| → Free e^- density (n) → No. of free e^- in unit volume of metal $(n = 10^{28}\ e^-/m)$.
* Depend on nature of metal. (Highest in silver).

|2| → Thermal speed (V_T) → Speed of free e^- due to surrounding temp.

K.E of one free e^-

$$\frac{1}{2} M V_T^2 = \frac{3}{2} KT$$

$$* \ V_T = \sqrt{\frac{3KT}{M}} \propto \sqrt{T}$$

* At room temp. $V_T = 10^5\ M/sec$.

Ex → copper $n = 10^{29}/m^3$

$U_{Thermal} = 10^6\ m/sec$
$= 1000\ km/sec$.

* Net velocity of an e^-

$$\boxed{\vec{V}_{net} = \vec{V}_{thermal} + \frac{e(-\vec{E})}{m} t}$$

t = time b/w two successive collision.

$$* \langle \vec{V}_{net} \rangle = \langle \vec{V}_{thermal} \rangle^{0} + \left\langle \frac{e(-\vec{E})}{m} t \right\rangle$$

$$\vec{V}_{drift} = 0 + \frac{e(-\vec{E})}{m} t$$

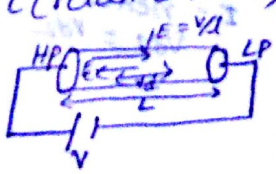
|3| → Relaxation time (τ) → It is average free time b/w two conjugative collision. $\left[\tau = 10^{-14}\ sec \quad 1\ sec = 10^{14}\right]$ * also depend on metal.

A/R AIIMS NOTE → |i| → on ↑ temp. relaxation time ↓, hence drift speed ↓.

|ii| → Physical significance of Resistance –
The resistance offered by a conductor is due to collision of e^-s with atoms of the lattice. So, on ↑ temp., resistance should also ↑.

|4| → Mean free path → (λ) ⇒ distance covering in τ (relative time)

$$\boxed{\lambda = 10 \text{Å}}$$



|5| → Drift velocity (V_d) → After applying battery free e^- aquired almost velocity.

AIIMS A/R

* Drift speed $\approx 10^{-3}$ m/sec / 10^{-4} m/sec / 0.1 mm/sec. or, 10^{-2} cm/sec

* $$\boxed{\begin{aligned} \vec{V}_{drif} &= \frac{-e\vec{E}\tau}{m} \\ V_d &= \left(\frac{e\tau}{M}\right)E \\ V_d &= \left(\frac{e\tau}{M}\right)\left(\frac{V}{l}\right) \end{aligned}}$$

τ → Mean free time or, Relaxation time or, Avg. time b/w two callision.

* V_d depend on → * Applied E
  * Temp.
  * Metal.

|6| → Mobility (μ) → It is drift velocity for unit applied electric field.

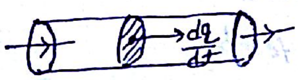
$E \longrightarrow V_d$

$1 \longrightarrow \frac{V_d}{E}$

$$\boxed{\mu = \frac{V_d}{E} = \frac{e\tau}{M}}$$

|7| → Electric current (I): → It is rate of change flow through cross sectional area of current carrying system.

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

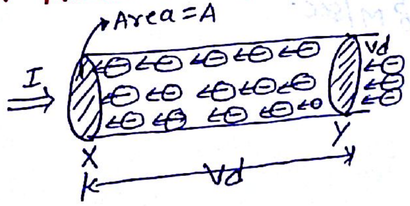


⇒ current → scalar quantity

** unit → M.K.S ⇒ C/sec, Amp.
→ C.G.S ⇒ Ab.Amp, Biot (Bi)

$$\boxed{1\ Ab.A = 10\ Amp}$$

*** # Relation b/w current (I) & drift speed (V_d) →



n = no. of free e's per unit volume.

No. of e^- in volume XY $= AV_dn$

Charge crossing per sec $= A \times V_d ne = I$

* $$\boxed{I = neAV_d}$$

#

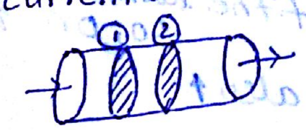
* $$\boxed{I = \frac{dq}{dt} = \frac{q}{T} = qf = \frac{q\omega}{2\pi} = \frac{qv}{2\pi r}}$$

EX → calculate equivalent current in 1 orbit of H-atom.

$$I = \frac{ev}{2\pi r} = \frac{1.6\times10^{-19}\times 2.2\times 10^{6}}{2\times\pi\times 0.059\times 10^{-10}\,m} \simeq 0.96\,mA \pm 1\,mA.$$

* current carrying conductor always neutral.
  $E_{outside} = 0$, $E_{inside} \neq 0$ (due to battery)

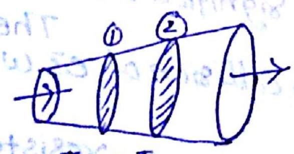
* current at each point of conductor is same irrispective cross-sectional Area.



$I_1 = I_2$

$I = neAV_d$

$V_{d1} = V_{d2}$



$I_1 = I_2$

$I = neAV_d$

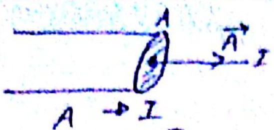
$$\boxed{V_d \propto \frac{1}{A}}$$

$A_1 < A_2$

$V_{d1} > V_{d2}$

** * Area का change V_d पर होता है! I पर नहीं!

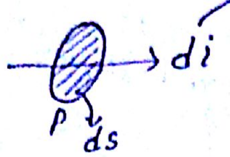
8 → current density (J) →



$A \to I$

$1 \to \frac{I}{A}$

$\boxed{J = I/A}$



⊥r current passing through ds

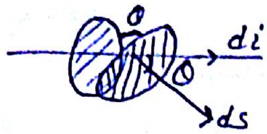
$$\boxed{J = \frac{di}{ds}}$$

direction

↳ Direction is along the Direction of current at that point.

NOTE → (i) → unit $= \frac{Amp}{m^2}$

(ii) → If Area 'ds' is not ⊥r



$$j = \frac{di}{ds\cos\theta}$$

$$di = j\,ds\cos\theta$$

$$* \boxed{di = \vec{J}\cdot\vec{ds}}$$

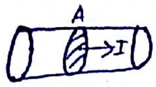
$$i = \int di = \int \vec{J}\cdot\vec{ds}$$

$I = \oint \vec{J}\cdot d\vec{A}$] → current is flux of current density.

$q = \oint \vec{E}\cdot d\vec{A}$] → charge is flux of Electric density.

] comparision.

In conductor →



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

$$J = \frac{I}{A} = ne\left(\frac{e\tau}{M}\right)E$$

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

$J = \sigma E$ *

$\boxed{\vec{J} = \sigma\vec{E}}$ ⇒ vector form/Microform of ohms Law.

9 → conductivity of specific conductance (σ) →

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

$$\text{Temp} \uparrow \propto \frac{1}{\tau\downarrow} \propto \frac{1}{\sigma\downarrow}$$

10 → Resistance (R) → tendency of current carrying system to oppose the charge flow.

$V = IR$, $R = \frac{\text{Applied voltage}}{\text{Resultant current}}$]*

* scalar
* unit → ohm(Ω)

Resistance of conductor →

$$I = neAv_d$$

$$= neA\left(\frac{e\tau}{M}\right)\frac{V}{l}$$

$$\frac{V}{I} = \frac{M}{ne(e\tau)}\frac{l}{A}$$

$$\boxed{R = \left(\frac{M}{ne^2\tau}\right)\frac{l}{A} \qquad R = \frac{\rho l}{A}}$$ → रोली ऊँमाना A

11 → Resistivity or, Sp. Resistance (ρ) →

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

* unit = $\Omega \times M$
* Temp ↑, τ ↑, R ↑

AIPMT 2002 * Resistance (R) depend on length/Area but Resistivity (ρ) doesn't depend on this both parameter.

Ohm's Law

In conductor at const temp. current is $\propto$ applied voltage so, resistance Remain const.

$$\left[\begin{array}{l} V \propto I \\ \frac{V}{I} = \text{const} \\ R = \text{const} \end{array}\right] \rightarrow \text{means ohm's voltage.}$$

$$I = A V_d n e$$

$$\frac{I}{A} = V_d n e = \frac{e^2 n E}{m}\tau$$

$$* \boxed{\vec{J} = \frac{e^2 n \vec{E}}{m}\tau}$$

$$* \boxed{\frac{|\vec{E}|}{|\vec{J}|} = \frac{m}{e^2 \tau n} = \rho\,(\text{Resistivity})}$$

|i|* → ρ is a property of material. (ऐसा कोई तार नहीं जिसका कोई R नहीं।)

AIIMS |ii| → on ↑ temp.

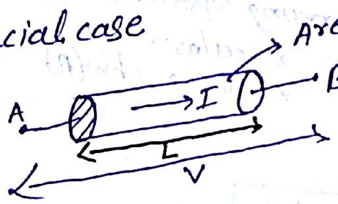
|a| → For conductor ↑ as τ decreases.

AMU 2016 |b|* → For semiconductor ↓
→ τ ↓
→ n ↑
→ $n\tau$ ↑se.

|iii| → $\rho_T = \rho_0(1+\alpha\Delta T)$

α = Temp. coefficient of resistivity.
ΔT = Rise in temp.

|iv| → Special case



$$E = \frac{V}{L}$$

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

$$\frac{E}{J} = \frac{m}{e^2\tau n} = \rho$$

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

$$\frac{V}{I} = R\,(\text{Resistance})$$

* Resistance depends on material as well as physical dimensions.
* conductivity $(\sigma) = \frac{1}{\text{Resistivity}\,(\rho)}$
* conductance $= \frac{1}{\text{Resistance}\,(R)}$
* unit –
  Resistance → ohm(Ω)
  Resistivity → ohm-meter
  conductivity → mho-m^{-1}
  conductance → mho or, Siemen.

Dependance of conductor Resistance :→

AIPMT

$$\boxed{\begin{array}{l} R = \frac{\rho l}{A} \times \frac{l}{l} \\ R = \frac{3 l^2}{\text{vol}} \end{array}}$$

Scanned by CamScanner

~~[illegible]~~
Length (l) →

|i| → If $A = \text{const} \Rightarrow R = \frac{\rho l}{A} \Rightarrow R \propto l$

|ii| → If ~~volt~~ vol const $\Rightarrow R = \frac{\rho l^2}{vol} = R \propto l^2$

Cross section Area (A) →

|i| → If $l = \text{const} \Rightarrow R = \frac{\rho l}{A} \Rightarrow R \propto \frac{1}{A} \propto \frac{1}{r^2}$

|ii| → If $vol = \text{const} \Rightarrow R = \frac{\rho(vol)}{A^2} \Rightarrow R \propto \frac{1}{A^2} \propto \frac{1}{A^4}$

|iii| → Temp.

|iv| → Metal.

! * Streaching, compressing, Melting, Moulding, Bending Means $vol = \text{const}$.

EX → Resistance of conducting wire is 'R' calculate Resistance If -

|i| → Its length become 'n' times by streaching it -

$\Rightarrow l' = nl$ (vol. const), $R \propto l^2$, $R' = n^2 R$.

|ii| → If radis become $\frac{r}{n}$ times by streaching it -

$r' = r/n$

vol = const (bcoz wire streached)

$R \propto \frac{1}{r^4}$, $R' = n^4 R$

|iii| → If wire is folded into 'n' layer.

vol = const. | $R' = \frac{R}{n^2}$

$l' = l/n$

$R \propto l^2$

Imp
Small % change at const vol:

|i| → If $\Delta l = x\%$ then $\Delta R = 2x\%$

|ii| → If $\Delta A = x\%$ then $\Delta R = -2x\%$

|iii| → If $\Delta r = x\%$ then $\Delta R = -4x\%$

*Trick

$R \propto l^2$

$R \propto \frac{1}{A^2} \propto A^{-2}$

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

EX → *Streaching a wire l 2% ↑

R 4% ↑

* By compressing a metablock crosssection area by 1% → R = 2% ↓

EX → $P = I^2 R$

If $\Delta I = x\% \Rightarrow \Delta P = 2x\%$

|i| → If I → 1% ↓

P → 2% ↓

|ii| → If I_{bulb} = 0.5% ↓

P → 1% ↓

EX → r → 1% ↑

$F = \frac{kq_1 q_2}{r^2}$ $f = r^{-2}$

$F = -2x = -2\%$ ↓

Dependance of Resistance on temp. →

In conductor

Temp ↑ ⇒ τ ↓ ⇒ ρ ↑ ⇒ Resistance ↑

⇒ Resistance temp. const (α)

|i| → $\alpha = \frac{\Delta R / R}{\Delta t}$

|ii| → unit → per unit temp.
per °c
per K

|iii| → If α (high) = More variation in Resistance.
If α (Low) = Less " " "

|iv| → If α (⊕ve) ⇒ Temp ↑ ⇒ R ↑ ⇒ metal.
If α ⊖ve ⇒ Temp ↑ ⇒ R ↓ ⇒ semiconductor.
If α = zero ⇒ Temp ↓ ⇒ R = const ⇒ Insulator.

|v| → $R_{t_2} = R_{t_1}[1 + \alpha (t_2 - t_1)]$
If Reference temp. = 0°c
$R_t = R_0 \, [1 + \alpha(t)]$

Take care →

Temp. should be in °c This Relation valid for small temp. change. Reference temp. taken in 0°c or, 20°c

Imp
If series Resistance is independent of temp. then $\alpha = 0$

$\alpha_{series} = 0$

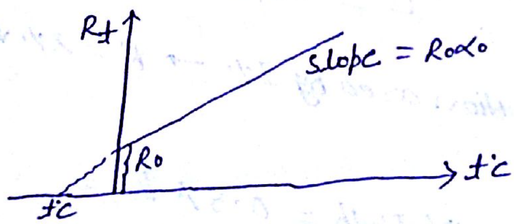
$0 = \frac{R_1\alpha_1 + R_2\alpha_2}{R_1 + R_2}$

$R_1\alpha_1 = -R_2\alpha_2$

$\frac{R_1}{R_2} = -\frac{\alpha_2}{\alpha_1}$

* This condition one wire should be conductor other should be semiconductor.

Graph: → Resistance v/s temp.



$R_c = R_0(1 + \alpha_0 t)$
$R_t = R_0 + (R_0\alpha_0)\,t$

axis ↓ $y = c + mx$ ↑ slope ↓ axis.

* [If $t > t_c$ ⇒ $R \neq 0$ = conductor
If $t \leq t_c$ ⇒ $R = 0$ = super conductor

Some special materials: —

|i| → Heating element → * High MP, High resistivity
* Nichrome
* $\rho_{Alloy} > \rho_{metal}$.

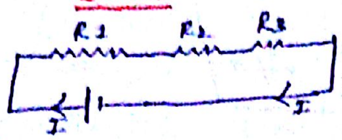
|ii| → Standard Resistance → * Small (α)
* $\alpha_{alloy} < \alpha_{metal}$
* Best alloy is magninin, constantum, evertum.

** |iii| → Fused wire → * It is used to protect the ckt from excess current.
Imp * Always connected in series at the starting of ckt.
* MP small
* Made of Sn + Pb
63% 37%
* current capacity (I)
$I \propto r^{3/2}$, $I \propto l^0$

CIRCUIT

|1.|→ Grouping of Resistance →

Series



* current ⇒ same
* $R_{net} = R_1 + R_2 + R_3$
* $R_{eq} > R_1$

  $R_{eq} > R_2$

  $R_{eq} > R_3$

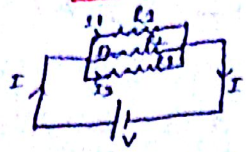
* voltage distribution

  $V = \underbrace{I}_{same} R$

  $\boxed{V \propto R}$

  $V_1 : V_2 : V_3 = R_1 : R_2 : R_3$

Parallel



* current ⇒ different in ||
* V = same
* $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

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

  $R_{eq} < R_1$

  $R_{eq} < R_2$

  $R_{eq} < R_3$

* current distribution

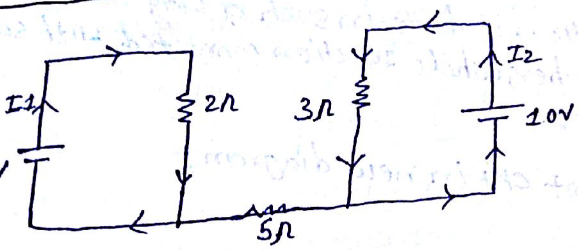
  $\cancel{V} = IR$

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

  $I_1 : I_2 : I_3 = \frac{1}{R_1} : \frac{1}{R_2} : 1/R_3$

*** LOGIC ⇒ जिसमे Resistance कम उसमे voltage कम !**

IIT EX →

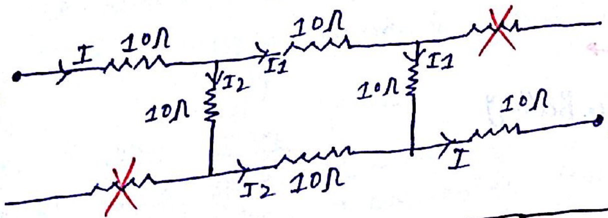


$I_{5\Omega} = ? = zero.$

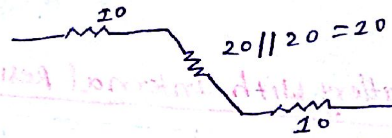
!

*** current अपना रास्ता repeat नही करता !!**

EX →



⇒



$R_{AB} = 10 + 10 + 10 = 30\Omega$

!

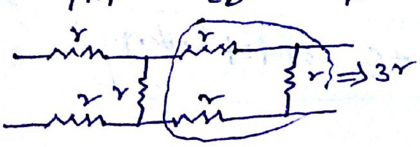
*** current का Flow उसी direction मे जाता है जिसमें wo अपनी आखरी मंजिल तक पहुँचता है।**

Short trick → consider Ist two block only get their Resistance after that.

|i|→ $R_{eq} \le R_{approx}$ [R = Resistance] [R for Resistance R for Reduce]

|ii|→ $C_{eq} \ge C_{approx}$ [C = capacitor]

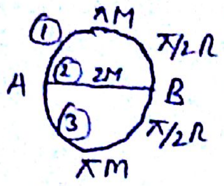
EX →



$*R_{eq} = r + \frac{3r}{4} + r = \frac{11r}{4} = 2.75r$

*R_{eq} is slightly less than 2.75r

EX→ Find equivalent Resistance of given ckt Made up of conducting wire.



radius = 1M

Resistance = $\frac{1}{2}$ Ω/M

circumference of circle $(2\pi M) = 2\pi$ → ① $= \pi$, ③ $= \pi$

$$R_{AB} = \frac{2}{\pi} + \frac{2}{\pi} + 1$$
$$= \frac{4+\pi}{\pi}$$
$$\frac{1}{R_{AB}} = \frac{4+\pi}{\pi}$$

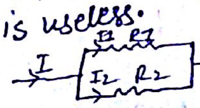
$$\boxed{R_{AB} = \frac{\pi}{\pi+4}}$$

Current अपना रास्ता Repeat नहीं करता!

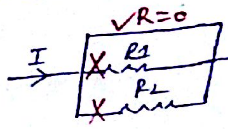
short circuit :→

(i)→ R=0 path

(ii)→ Total current passed through ckt path so component passes through short ckt path is useless.



$$\boxed{R_{eq} = \frac{R_1R_2}{R_1+R_2}}$$

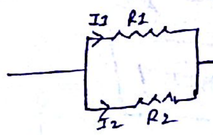


short ckt $\boxed{R_{eq} = 0}$

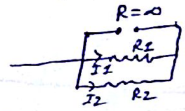
open circuit →

(i)→ $R = \infty$

(ii)→ In this case current is zero, bcoz problem is ∞ Resistance.



$R_{eq} = \frac{R_1R_2}{R_1+R_2}$



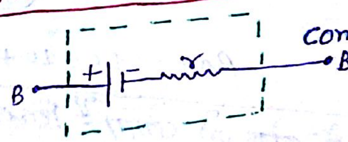
$R_{eq} = \frac{R_1R_2}{R_1+R_2}$

point potential method :→ It is usefull in ckt having direct wires (component free path).

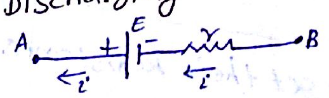
(i)→ Numbering of all junction is done in such a way that different junction should have number, while junction connected with same wire have same number.

(ii)→ Rearrange the component ckt in new diagram.

Battery with Internal Resistance →

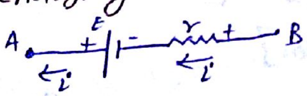


* During Discharging



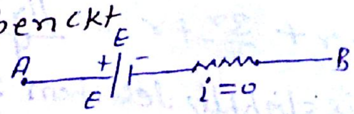
$\boxed{V_A - V_B = +E - ir < \text{Emf of Battery}}$

* During charging



$\boxed{V_A - V_B = +E - ir > \text{Emf of Battery}}$

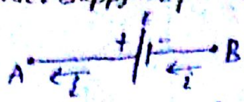
* When open ckt



$\boxed{V_A - V_B = +E = \text{Emf of battery}}$

NOTE →

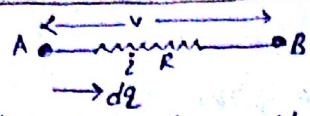
(i) → Power supplied/consumed by Battery.



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

* Work done by battery in time 'dt' $= (dq)E = dw$
* Rate of work done $\left(\frac{dw}{dt}\right) = E\frac{dq}{dt} = Ei = P_{supplied}$.
* During charging $\boxed{P_{consumed} = Ei}$

(ii) → Heat lost in a Resistance : → (Joule Heating).



If 'dq' charge passes through 'R' from 'A' to 'B'

Energy Lost by (dq) :

$$P_{loss} = \frac{dH}{dt} = V\cdot\frac{dq}{dt} = Vi$$

$$\boxed{P_{loss} = Vi = i^2R = \frac{V^2}{R}}$$

Heat los in time 't'

$$\boxed{H = Pt = i^2Rt}$$

$$\boxed{P = H/t}$$

Kirchoff Law → KCL, KVL

(i) → First law/current law/Junction law (KCL) : →

→ Based on charge conservation.

→ At any junction alsebric sum or, all current or, charges is always zero, It means current towards junction is exactelly equal to current leaving the junction.

$\Rightarrow \boxed{\Sigma Q = 0 \quad \Sigma I = 0 \;\Big|\; \Rightarrow \text{Incoming} = \ominus ve \quad \text{While outgoing } \oplus ve}$

(ii) → Second law/voltage law/Loop law (KVL) : →

→ Based on Energy conserbation.

→ In a close loop summation of all p.d is allways zero.

$\boxed{\Sigma PD = 0}$

Sign conversion →

observer

(i) → $\oplus$ to $\ominus$ → $\ominus$ve

(ii) → $\ominus$ to $\oplus$ve → $\oplus$ve

(iii) → $-|\,|^{+}_{E}-$ → $-E$

(iv) → $-|\,|_{E}-$ → $+E$

(v) → $-^{+}|\,|^{-}-$ → $-V$

(vi) → $-^{-}|\,|^{+}-$ → $+V$

(vii) → $\xrightarrow{I}\,{}^{+}R^{-}$ → $-IR$

(viii) → ${}^{-}R^{+}\xleftarrow{I}$ → $+IR$.

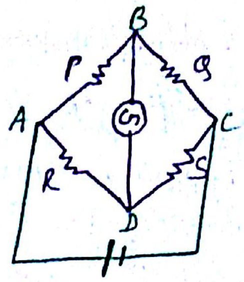
Symmetrical line Method : →

→ Draw the ⊥ bisector line joining the terminals points. This symmetrical line should draw the ckt in two mirror image.

→ Strech the ckt along symmetrical line in such way that all junction on symmetrical line are Removed.

Scanned by CamScanner

Circuit Based on Wheat stone Bridge →



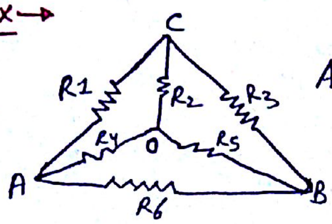
Case-I → Balance Bridge →

If $\boxed{\frac{P}{Q} = \frac{R}{S}}$, $\boxed{V_B = V_D}$

$\boxed{I_{middle} = 0}$

AIIMS ***

Ex →



All Resistance same value = ?

If Battery Applied that B/W

$A \& O \Rightarrow I_{R3} = 0$	$A \& B \Rightarrow I_{R2} = 0$
$B \& O \Rightarrow I_{R1} = 0$	$B \& C \Rightarrow I_{R4} = 0$
$C \& O \Rightarrow I_{R6} = 0$	$A \& C \Rightarrow I_{R5} = 0$

Case-I → unbalance Bridge →

If $\frac{P}{Q} \neq \frac{R}{S}$ $V_B \neq V_D$ $\Rightarrow I_{middle} \neq 0$

* If $\frac{P}{Q} > \frac{R}{S} \Rightarrow V_B < V_D$

Battery side also same A/c to diagram.

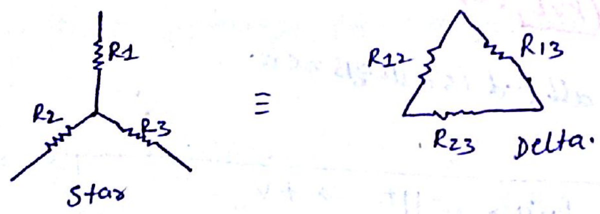
* If $\frac{P}{Q} < \frac{R}{S} \Rightarrow V_B > V_D$

* For gating equivalent Resistance KVL & star delta method used.

* short circuit → In unbalanced bridge is also eleminated the middle arm & get Resultant which is approx. ***

$\boxed{\begin{array}{l} (i) \rightarrow R_{eq} \leq R_{approx} \\ (ii) \rightarrow C_{eq} \geq C_{approx} \end{array}}$

*** Star — delta Method.



* Star to Delta →

$$\boxed{\begin{array}{l} R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3} \\ R_{13} = R_1 + R_3 + \frac{R_1 R_3}{R_2} \\ R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1} \end{array}}$$

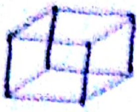
* Delta to Star →

$$\boxed{\begin{array}{l} R_1 = \frac{R_{12} R_{13}}{(R_{12} + R_{23} + R_{13})} \\ R_2 = \frac{R_{22} + R_{23}}{(R_{12} + R_{23} + R_{13})} \\ R_3 = \frac{R_{23} R_{13}}{(R_{12} + R_{23} + R_{13})} \end{array}}$$

NOTE → About Wheat Stone Bridge —

* Battery arm & Galvenometer are Interchangeable.
* Battery key (K_1) is made on First then Galvenometer key is opened to avoid the effect of Induced current.
* Battery is Most sensitive when all four Resistance are of same value.

Cube



Each side = Resistance (R)

* $R_{main\ diagonal} = \frac{5}{6}R = 0.82$
* $R_{face\ diagonal} = \frac{3}{4}R = 0.75$
* $R_{side} = \frac{7}{12}R = 0.58$

Each side = capacitor (C)

* $C_{main\ diag} = \frac{6}{5}C$
* $C_{face\ diag} = \frac{4}{3}C$
* $C_{side} = \frac{12}{7}C$

AIIMS 2018

CELL

chemical energy into electrical energy.

* internal resistance of cell
* practically $r \neq 0$
* ideally $r = 0$

* Pri-cell → non-Rechargable, chemical Rxn irreversible, High 'r'.
* Sec-cell → Rechargable, chemical Rxn Reversible, Low 'r'.

EMF of cell (E)

* It is work done by cell in a Rotating unit charge in complete circle.
* It is PD b/w cell terminal when current with cell is zero.
* All Printed or, mentioned value are EMF only.

Terminal voltage (V)

|1| → It is PD b/w cell terminal when current with cell is non-zero.

$V = E - IR$ [Discharging]

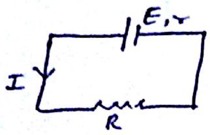
$V = E + IR$ [charge]

NOTE → Terminal voltage may be more, less or, equal to emf.

|2| → cell is open ckt.

$R = \infty$, $I = 0$ $\boxed{V = E}$

cell ckt →



|i| → $I_{ckt} = \frac{E}{R+r}$

|ii| → $I_{max} = \frac{E}{r}$ [When Load Resistance 'R' = 0]

|iii| → $V = E - Ir$

|iv| → $r = \left(\frac{E-V}{V}\right)R$

|v| → * Power at load $(P) = I^2R$
* Power in ckt $(P) = I^2(R+r)$
* $P_{load} = I^2R = \left(\frac{E}{R+r}\right)^2 R$

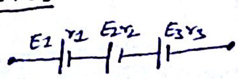
|vi| → P_{max} $\frac{dP}{dR} = 0$ $\boxed{R = r}$

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

NOTE → * $r = 0$ then $I_{max} = E^2/R$
* $R = r$ then $P_{max} = E^2/4R$

Grouping of cell

|1| → Series →



$$\boxed{\begin{aligned} E_{net} &= E_1 + E_2 + E_3 \\ r_{net} &= r_1 + r_2 + r_3 \end{aligned}}$$

NOTE → If Load Resistance (R) is very-very large than total internal Resistance then series grouping of cell is prefered.

Case-I → If $R <<< nr$ → $I = \frac{nE}{nr} = \frac{E}{r}$

case-II → $R >>> nR$ → $I = \frac{nE}{R} = n\left(\frac{E}{R}\right)$

Imp * If one Battery, say E_3 is connected with terminals is Reversed.

$$\boxed{\begin{aligned} E_{equi} &= E_1 + E_2 - E_3 \\ r_{equi} &= r_1 + r_2 + r_3 \end{aligned}}$$

* If N-Batteries each having different emf & their emf are proportional to their internal Resistance i.e $\boxed{E \propto r}$

Scanned by CamScanner

(2) → Parallel →

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

r_{net} = || equivalent of all 'r'

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

$$r_{net} = \frac{r_1 r_2}{r_1 + r_2}$$

NOTE → Here E_{net} is b/w E_1 & E_2 only in this case.

$E_{net} = \frac{20+10}{3} = \frac{30}{3} = 10V$

** → If || cell in same polarity →

(i) → E_{net} b/w E_1 & E_2.

(ii) → If EMF of each cell is same then E_{net} is equal to EMF of one cell.

case-I → If $R >>> \frac{r}{n} \Rightarrow I = E/R$

case-II → If $r/n >>> R \Rightarrow I = nE/r$

** If $E_1 = E_2 = E_3 = E$

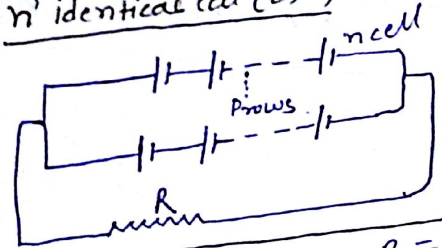
$r_1 = r_2 = r_3 = r$

$E_{eq} = E$

$r_{eq} = r/3$

Symetrical Mixed Grouping →

'n' identical cell (E, r) →



$$I = \frac{nE}{R + \frac{nr}{P}}$$

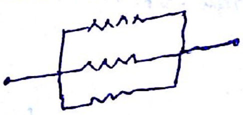
* For Pmax $= R = \frac{nr}{P}$

$\frac{R}{r} = \frac{n}{P}$

* Imax $= \frac{R}{r} = \frac{n}{P}$

n- identical resist.

$H = \frac{V^2}{R} t \propto \frac{1}{R}$



$$\frac{H_{series}}{H_{parallel}} = \frac{R_{parallel}}{R_{series}} = \frac{R/n}{nR} = \boxed{1 : n^2}$$

**
* Temp. change $H = ms\Delta\theta$ * Phase change $H = mL$ * $L_{water} = 540$ cal/gm

* $S_{water} = 1$ cal/gm°C * $L_{ice} = 80$ cal/gm

BULB

→ Rated values (V_R & P_R) →

Ex → Bulb (100W, 220 volt)

$V_R = 220V$

$P_R = 100W$

* If $V_{actual} = 220V$, $P_{actual} = 100W$ ⇒ Perfect.
* If $V_{actual} < 220V$, $P_{actual} < 100W$ ⇒ Down
* If $V_{actual} > 220$, → fused.

* Resistance of Bulb (R_B) → This is always calculated using Rated value only.

(i) → $\boxed{R_B = \frac{V_R^2}{P_R}}$

(ii) → In India (V_R = same)

$\boxed{R_B \propto \frac{1}{P_R}}$

Ex → $R_{100W} < R_{60W} < R_{40W}$

* Actual power consumption of Bulb →

$$\boxed{P_{actual} = I^2_{Actual} R_B = \frac{V^2_{actual}}{R_B}}$$

$$\boxed{\text{Brightness} \propto P_{actual}}$$ *

Case-I → Bulb in series →

$$\text{Brightness} \propto P_{actual} \; (= I^2 R_B)$$
$$\propto R_B$$
$$\propto \frac{1}{P_R}$$

NOTE → * In series bulb of less Rated power is more bright.
* Bulb with higher Poutput will glow more.
* Bulb $\bar{c}$ higher Resistance will glow more.

Case-II → Bulb in Parallel →

$$\text{Brightness} \propto P_{actual} \left(\frac{V^2}{R_B}\right)$$
$$\propto \frac{1}{R_B}$$
$$\propto P_R$$

NOTE → * Bulb of less rated power is less bright.
* Bulb $\bar{c}$ lower Resistance will glow more.

$\boxed{\begin{array}{l} P_{Total} = \Sigma P \text{ (parallel)} \\ P_{Total} = \Sigma 1/P \text{ (series)} \end{array}}$