Chap-3 — Current Electricity

Electric Current -

The flow of charge in conductor produce electric current.

The branch of physics which deals with the charges in motion is called Current Electricity

The rate of flow of Electric charge through any cross-section is called Electric current.

If Total charge flow in any conductor is Q in time T, Then electric current

$$\boxed{I = \frac{Q}{T}}$$

The unit of electric current is Coloumb per second (C/S) i.e. Ampere.

$$\boxed{1 \text{ Ampere} = \frac{1 \text{ Coloumb}}{1 \text{ second}}}$$

☆ Electric Current is Scaler Quantity

Current Density

The current flowing normally to unit cross-section area at any point of conductor is called current density at that point.

☆ It is denoted by j.

If I current flow normally at any point having cross-section area A then current density at that point —

$$\boxed{j = \frac{i}{A}}$$

☆ It is a vector quantity $(\vec{j})$

☆ Its unit is ampere/m^2

OHM'S LAW

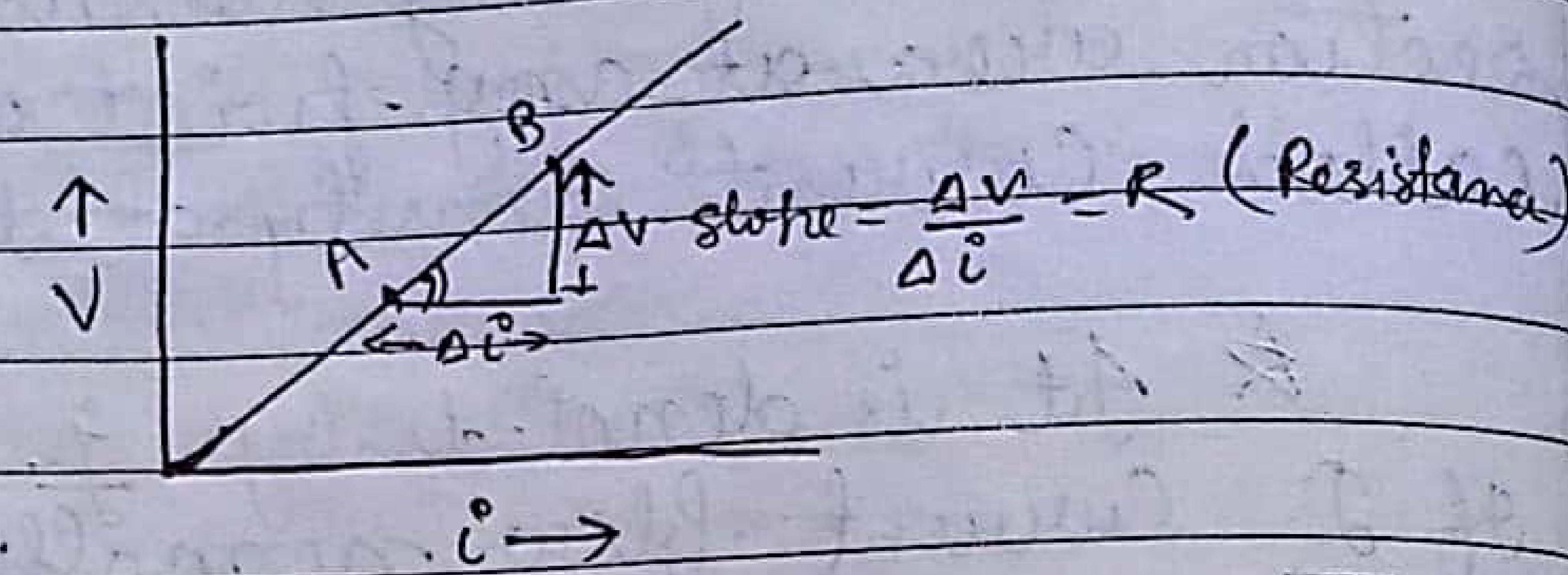
This law states that if the physical conditions like temperature are kept constant then applied voltage across a conductor will be directly proportional to the electric current flow in the conductor i.e.

$$V \propto i$$

or, $\boxed{V = Ri}$

where R is a constant which depend upon the length, shape & the nature of material of the conductor.

$$\left[R = \frac{V}{i}\right]$$



The S.I. unit of Resistance is Volt/amp i.e. called ohm (Ω)
↳ Latin symbol.

Dimensional formula of Resistane.

$$1\,ohm = \frac{1\,Volt}{1\,ampe}$$

$$= \frac{Joule/C}{amp}$$

$$= \frac{Joule}{C \times amp}$$

$$= \frac{ML^2T^{-2}}{ATA}$$

$$= \left[ML^2T^{-3}A^{-2}\right]$$

Electric Current In Conductors

The electric conduction in conductors

Can be explain by electronic theory

According to this theory every substances are made by atoms there is a nucleus and electrons in different orbit around the nucleus. The outer electron remove by some agitation these electrons are called Free electrons

When no electric field is applied on a solid conductor the free electron in them moves like molecules in a gas there is no certain direction for the velocities of electron Hence no current flow in it.

When an electric field is applied on a solid conductor then an electrical force is applied on every electrons by which they move in a particular direction, Therefore, an electric current flows opposite to the motion of electron in conductor.

In liquid and gases electric conduction take place by movement of both +ve and -ve ions. While in solid conductor electric conduction occurs by the movement of negative charge carriers i.e. electrons only.

There are some other material in which the electron will be bounded and they will not be accelerated even if the electric field is applied such materials are called insulators or dielectric for ex- wood, plastic, paper, rubber etc

Specific Resistance

The resistance of the Conductor depends on following factors —

i) $R \propto l$

ii) $R \propto \frac{1}{A}$

Combine i & ii

$R \propto \frac{l}{A}$

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

where ρ is a Constant which is known as Specific Resistance or Resistivity

It depends upon the nature of material

☆ The unit of Resistivity is ohm-m.

Effect Of Temperature on Resistance

The resistance of a Substance at temperature (t) is —

$$\boxed{R_t = R_o (1+\alpha t)}$$

where R_o = Resistance at 0°C

α = Temperature coefficient of Resistance

R_t = Resistance at t°C

1) **For Metal** - the value of α is +ve, therefore the resistance of metal increase when we rise temperature.

2) **For Insulator and Semiconductor** - The value of α is -ve, therefore, the resistance decreases when we rise the temperature.

3) **For Alloys** - The value of α is very small and it is different at different temperature.

Drift Velocity of free Electron

1) **Thermal velocity of free electron** - In a conducting body there are number of free electrons they moves just like gaseous molecule move in gas those velocity by which the free electron moves is called their thermal velocity.

2) **Average thermal velocity of free electron** - The average of thermal velocities of all free electrons is called average thermal velocity. for ex- If in a conductor there are n free electrons having thermal velocities u_1, u_2, u_3 ---- u_n then the average thermal velocity of free electron -

$$\boxed{\bar{u} = \frac{u_1 + u_2 + u_3 \text{ ---- } u_n}{n}}$$

3- **Drift velocity of free electron** - The average velocity with which the free electrons get drift towards the +ve end of the conductor under the influence of electric field applied across the conductor is called the drift velocity of free electron.

It is denoted by ~~Vd~~ (V_d)

4- **Mean free path of free electron** - The distance travel by free-electron b/w two successive collision with +ve ion is called Mean free path.

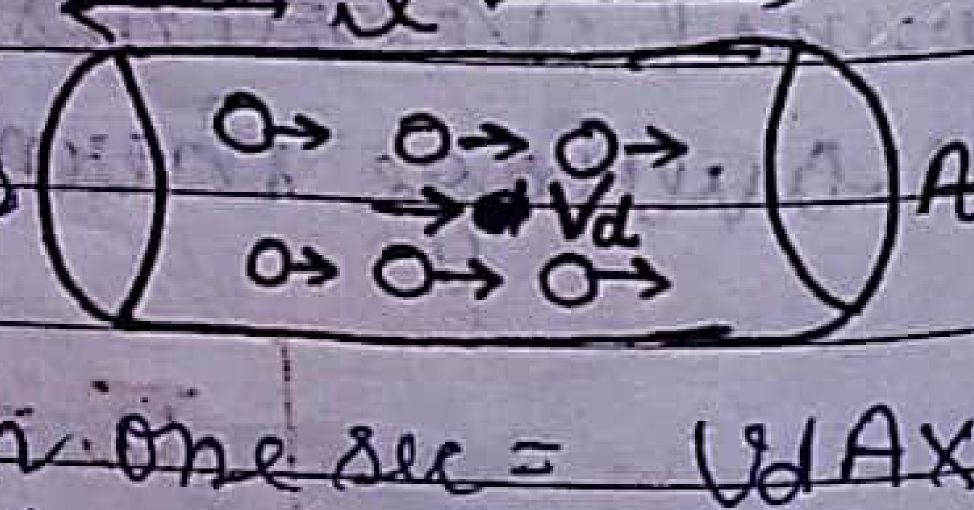
It is denoted by λ

5- **Relaxation Time** - The time taken b/w two successive collision is called relaxation time.

It is denoted by τ (Tough)

Imp

Relation between drift velocity and electric current



Let the no. of free electrons per unit volume = n

The total No. of free e^- in one sec = $V_d A \times n$

The total carrying charge in unit second = $nAV_d \times e$

Therefore, $[i = neAv_d]$

Current density & drift velocity

$$j = \frac{i}{A}$$

$$j = \frac{ne\cancel{A}v_d}{\cancel{A}}$$

$$\boxed{j = nev_d}$$

Imp ☆

Deduction Ohm's Law 100%

Let there is a conductor of length l and having cross-section are A there is n free electrons in per unit volume we applied V potential across the conductor there flow a current i.
If the drift velocity of electron is v_d.
then-

$$i = neAv_d \quad -①$$

Let the thermal velocities of free electrons are $u_1, u_2 \ldots\ldots u_n$

If the relaxation time of first electron is τ_1
Then the velocity accquired by electron-

$$v_1 = u_1 + a\tau_1$$

Similarly the velocity grain the other electrons will be $u_2 + a\tau_2, u_3 + a\tau_3 \ldots\ldots u_n + a\tau_n$

Therefore the drift velocity of free electrons

$$V_d = \frac{u_1 + a\tau_1 + u_2 + a\tau_2 + \cdots u_n + a\tau_n}{n}$$

$$V_d = \underbrace{\left(\frac{u_1 + u_2 \cdots u_n}{n}\right)}_{= 0} + a\left(\frac{\tau_1 + \tau_2 + \cdots \tau_n}{n}\right)$$

$$V_d = a\tau \quad \text{—— (ii)}$$

where $\tau = \left(\frac{\tau_1 + \tau_2 + \cdots \tau_n}{n}\right)$ average relaxation time

$$\therefore a = \frac{F}{m} = \frac{eE}{m} \quad \therefore E = \frac{V}{l}$$

$$a = \frac{eV}{ml}$$

from eq (ii)

$$V_d = \frac{eV}{ml} \times \tau$$

from eq (i)

$$i = neA \left(\frac{eV}{ml}\right)\tau$$

$$i = \left(\frac{ne^2A\tau}{ml}\right)V$$

$$\frac{V}{i} = \left(\frac{ml}{ne^2A\tau}\right) \quad \text{—— (iii)}$$

If temperature remain Constant

$$\boxed{\frac{V}{i} = \text{Constant}(R)}$$

This is Ohm's law.

Therefore Resistane (R) in Parameter

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

$\Rightarrow R \propto l$

& $R \propto \frac{1}{A}$

Conductance

The reciprocal of resistance is called Conductance of a conductor.

$$\boxed{G = \frac{1}{R}}$$

The S.I unit of Conductance is - Ω^{-1} or Siemen

Conductivity

The reciprocal of resistivity of a conductor is called Conductivity.

$$\boxed{\sigma = \frac{1}{\rho}}$$

The S.I unit of conductivity is $\Omega^{-1}-m^{-1}$

current density? conductivity electric field

Relation between J, σ and E

The resistivity of a conductor is also equal to the ratio of intensity of electric field and current density i.e.—

$$\rho = \frac{E}{j}$$

$$E = j\rho$$

$$\because \rho = \frac{1}{\sigma}$$

$$E = j \times \frac{1}{\sigma}$$

$$\boxed{j = \sigma E}$$

It is microscopic form of ohm's law.

Mobility

The magnitude of drift velocity of charge per unit electric field is called mobility of charge. It is denoted by μ

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

The unit of mobility is $m^2-v^{-1}-sec^{-1}$

For free Electrons drift velocity.

$$V_d = \frac{e\tau E}{m}$$

Therefore, $\mu_e = \frac{V_d}{E} = \frac{e\tau \cancel{E}/m}{\cancel{E}}$

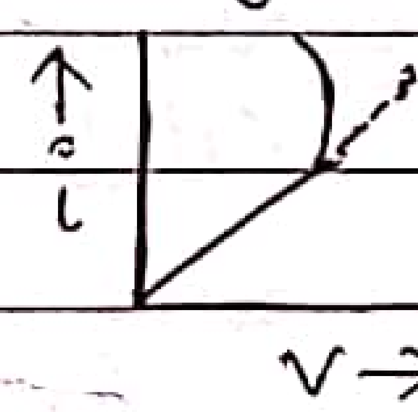
$$\boxed{\mu_e = \frac{e\tau}{m}}$$

Limitation of ohm's law

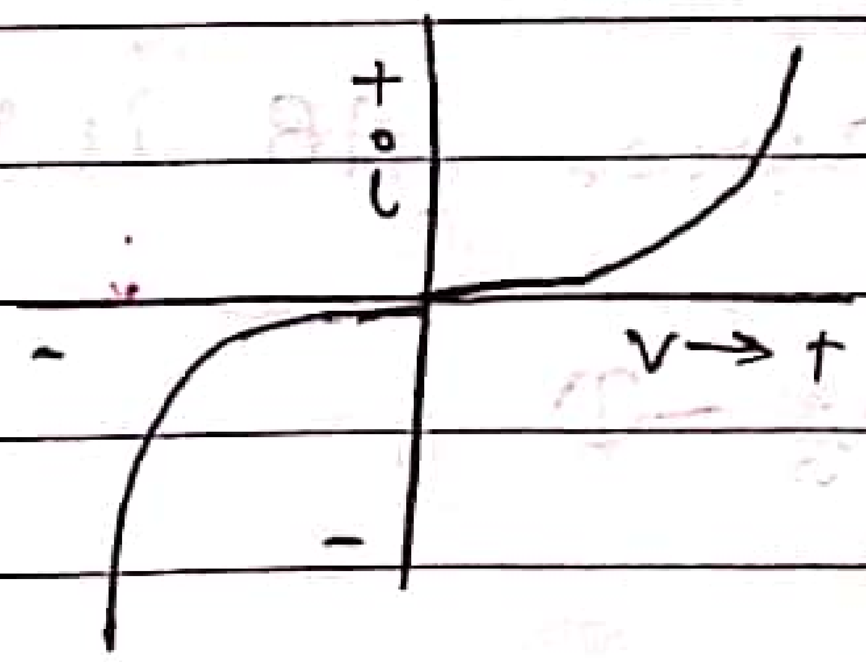
The devices which obey ohm's law are called Ohmic circuit and the devices which do not obey ohm's law that is called non-ohmic circuit

The limitations of ohm's law are followings

1) Potential difficence may vary non-linear with current.



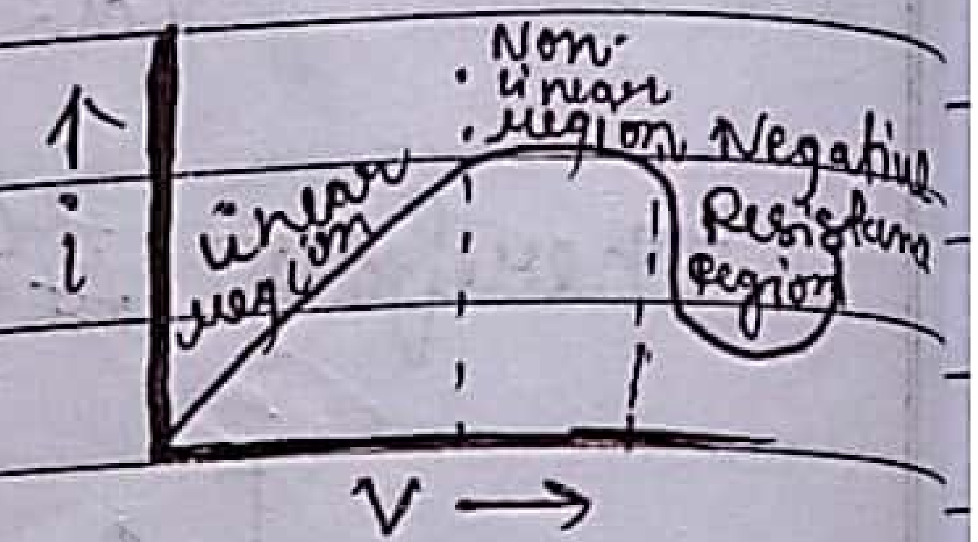
2)



The variation of current with p.d. may

depend upon the sign of p.d. applied.

iii) The relation b/w p.d. & current is not unique.



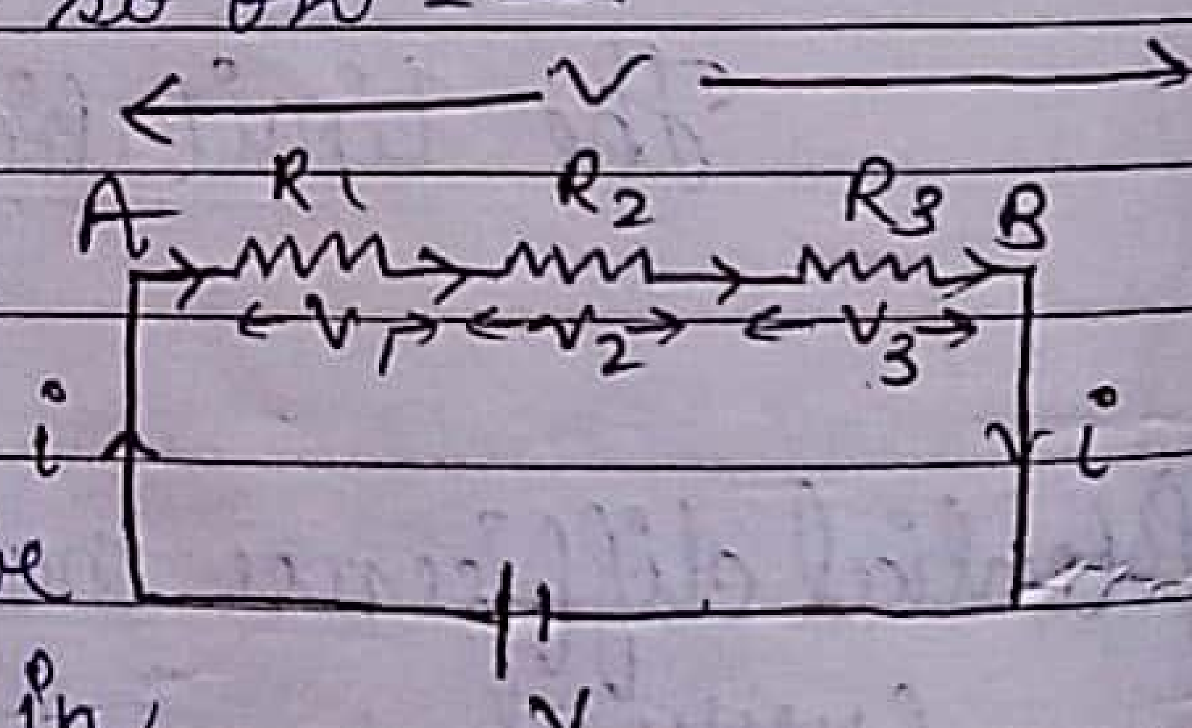
Combination of Resistors

Resistors can be combine in two form.

i) In Series

In this Combination the resistors are Combine end to end. i.e. Second end of first resistor is Connected to first end of second resistor and so on ---

☆ In series Combination of resister the potential across the resistors will be different while current in every resistor will be same.



Let, 3 resistors $R_1, R_2, \& R_3$ are Combined in series b/w A & B

Let, Potential across AB is V then

$$V = V_1 + V_2 + V_3 \quad -(1)$$

$$V_1 = iR_1$$

$$V_2 = iR_2$$

$$V_3 = iR_3$$

Let, equivalent resistance b/w A & B is R
Then $V = IR$
from eqn (1)

$$\cancel{I}R = \cancel{I}R_1 + \cancel{I}R_2 + \cancel{I}R_3$$

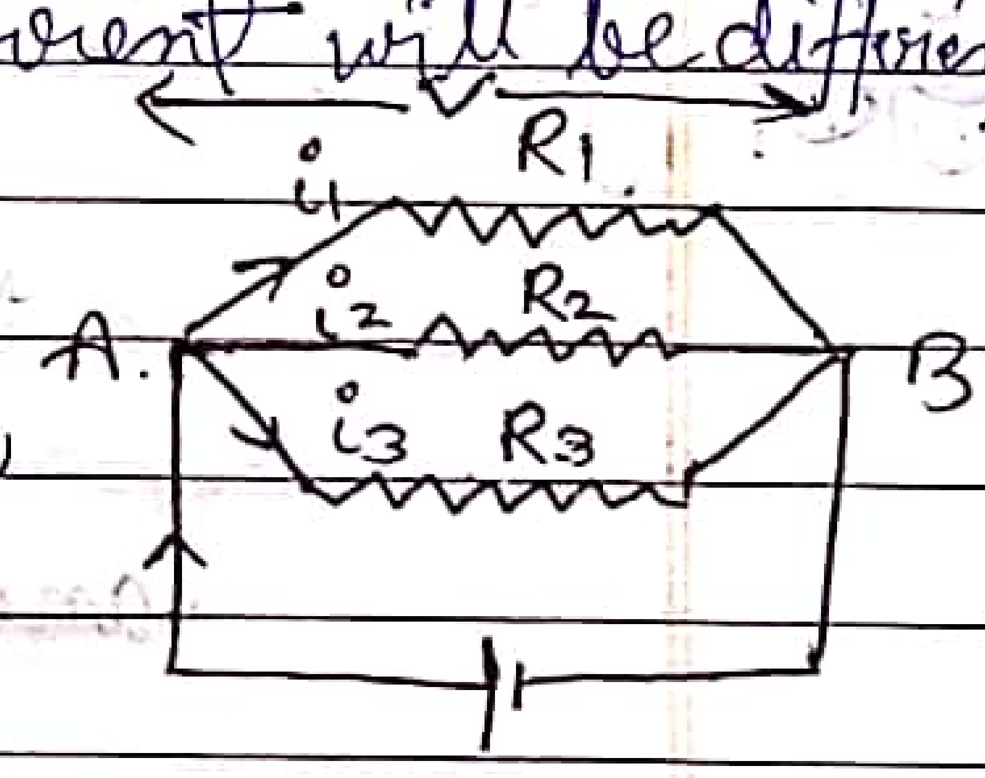
$$\boxed{R = R_1 + R_2 + R_3}$$

ii) In Parallel

In parallel combination one end of all resistors are combine at one point and another ends are combine at second point.

☆ In this combination the potential across every resistors will be same but current will be different.

Let, three resistors R_1, R_2, & R_3 are combined in parallel b/w A & B



The potential across AB is V
and the current in R_1 is i_1
in R_2 is i_2
& R_3 is i_3

Therefore, $i = i_1 + i_2 + i_3$ —(1)

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

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

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

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

from eq (1)

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

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

Electrical Energy & Power

Electrical Energy

The electrical energy is the total workdone by the source in maintaing the electric current in the given circuit for a specific time.

Let the Emf of Source is V
electromotive force
and i current flow in time t

If the charge carry is q

Then Work in flowing the current i =

$$W = qV$$

$$\because q = it$$

$$W = Vit$$

$$\therefore \boxed{\text{Electrical Energy } (E) = Vit}$$ 1st Formula

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$\because \quad V = iR$

Electrical Energy, $E = iR \times it$

$$\left[E = i^2 R t\right]$$ 2nd formula.

$\because \quad i = \frac{V}{R}$

$$E = \frac{V^2}{R^{\cancel{2}}} \times \cancel{R} t$$

$$\boxed{E = \frac{V^2 t}{R}}$$ 3rd formula

The S.I unit of the electrical energy is Joule

1 Joule = ~~V~~olt × amp × sec

[1 Joule = Watt-Sec]

Electrical Power

The work done in per unit time is called power.

$$P = \frac{W}{t} = \frac{Vi\cancel{t}}{\cancel{t}}$$

$$\left[P = Vi\right]$$ 1st formula

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

$$\left[P = i^2 R \right]$$ 2nd formula (series)

$$P = \frac{V^2 \cancel{t} / R}{\cancel{t}}$$

$$\left[P = \frac{V^2}{R} \right]$$ 3rd formula

The S.I unit of Electrical Power is <u>watt</u>

1 watt = 1 volt × 1 amp

1 watt → "The power of an electric circuit is 1 watt if 1 amp current is flow in it against the potential difference of 1 volt".

$$\left[\begin{array}{l} 1\,KW = 10^3\,W \\ 1\,MW = 10^6\,W \\ 1\,HP = 746\,W \end{array} \right]$$

Commercial unit of Electrical Energy

The commercial unit of electrical energy is Kilo-watt-hour is it also Called unit.

"(1 K-W-hr) 1 Kilo-watt-hour or 1 unit is the amount of electrical energy desipated in a hour in the circuit when the electrical Power of the circuit is 1 K-watt"

$$\boxed{1\,\text{Kwhr} = \frac{\text{Watt} \times \text{hour}}{1000}}$$

$$\{1\,\text{kwhr} = 3.6 \times 10^{6}\ \text{Joule}\}$$

Electric Cell

It is a device which convert chemical energy into electrical energy

Electromotive force of cell

The work done by the cell in moving unit testing charge through the whole circuit is call the e.m.f. of the cell.

If the workdone is W in flowing the charge q then emf of the cell :-

$$\boxed{E = \frac{W}{q}}$$

The S.I unit of emf is Joule/coulomb i.e also called volt

Internal Resistance of Cell

The resistance created by electrolyte of the cell to flow the current through it is called internal resistance of cell.

It is denoted by r

☆ The internal resistance of cell depend upon following factors

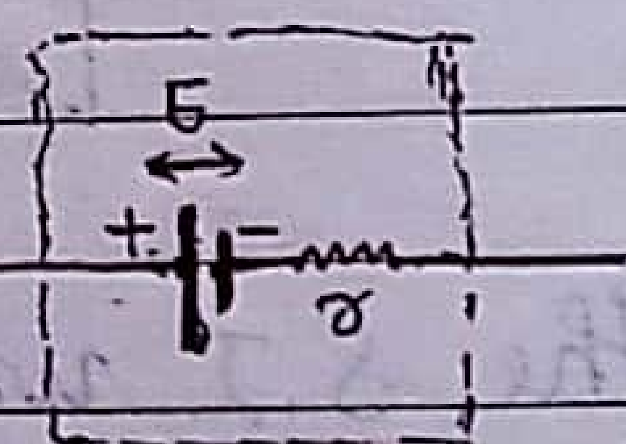
i. The internal resistance of cell is directly proportional to the distance b/w electrode of cell.

ii. The internal resistance of cell is inversely proportional to the area of electrode.

iii. Internal resistance of cell depend upon the concentration of electrolyte. If the concentration is more internal resistance will be more.

Terminal Potential Difference

The representation of cell is following

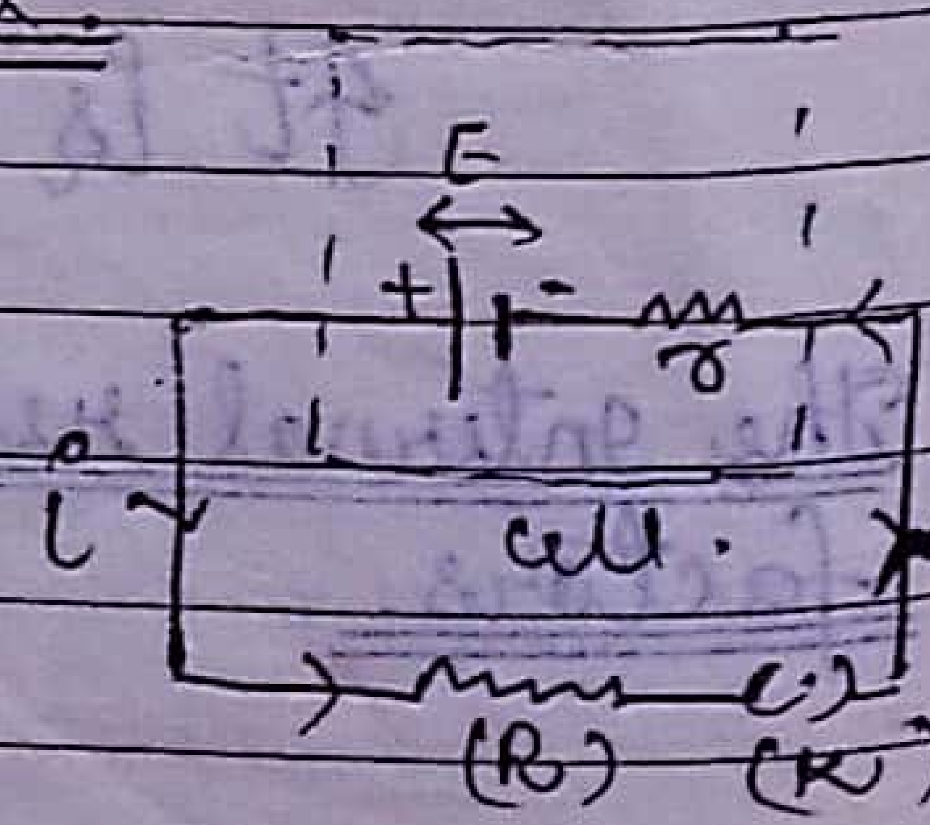


When a cell in close circuit i.e. when current is drawn from the cell the the potential difference b/w the two terminal of the cell is called terminal potential of the cell.

Relation b/w terminal potential (V), Emf of the cell (E) and Internal resistance (r) of a cell.

$i = \frac{\text{total e.m.f}}{\text{total Resistance}}$

$i = \frac{E}{R + r}$ — (1)



But By ohm's law

$$V = iR$$

$$i = \frac{V}{R} \quad - (2)$$

from (1) & (2)

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

$$ER = VR + Vr$$

$$Vr = (E-V)R$$

$$r = \frac{(E-V)R}{V}$$

$$\left\{ r = \left[\frac{E}{V} - 1\right] R \right\}$$

From eqn (1)

$$E = iR + ir$$

$$\because V = iR$$

$$[V = E - ir]$$

(1) If the cell is in close circuit i.e when the cell is given current then the terminal potential will be every time less then e.m.f of the cell. $V < E$

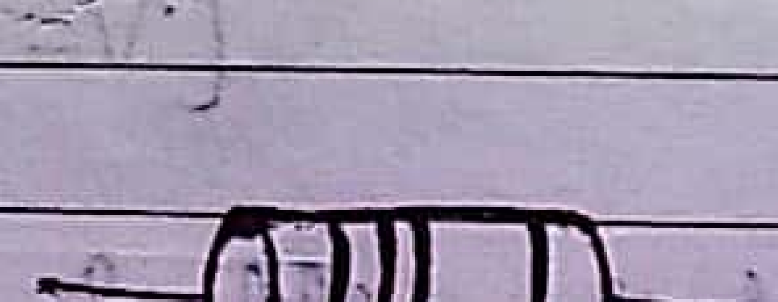
(2) If no current is drown from the cell i.e. cell is in an open circuit then e.m.f of the cell will be equal to the terminal potential diffence of the cell i.e. $V = E$.

Carbon Resistors

This resistance is based on colour code their value range from Kilo Ohm to mega ohm.
Their % accuracy is indicated by a Colour code printed on them.
The Colour code are following.
BBROY is Good Boy & Very Good wife.

B	Black	0
B	Brown	1
R	Red	2
O	orange	3
Y	yellow	4
G	Green	5
B	Blue	6
V	Violet	7
G	Grey	8
W	white	9

$$\left[\text{Resistane} = ab \times 10^{c} \pm d\% \right]$$



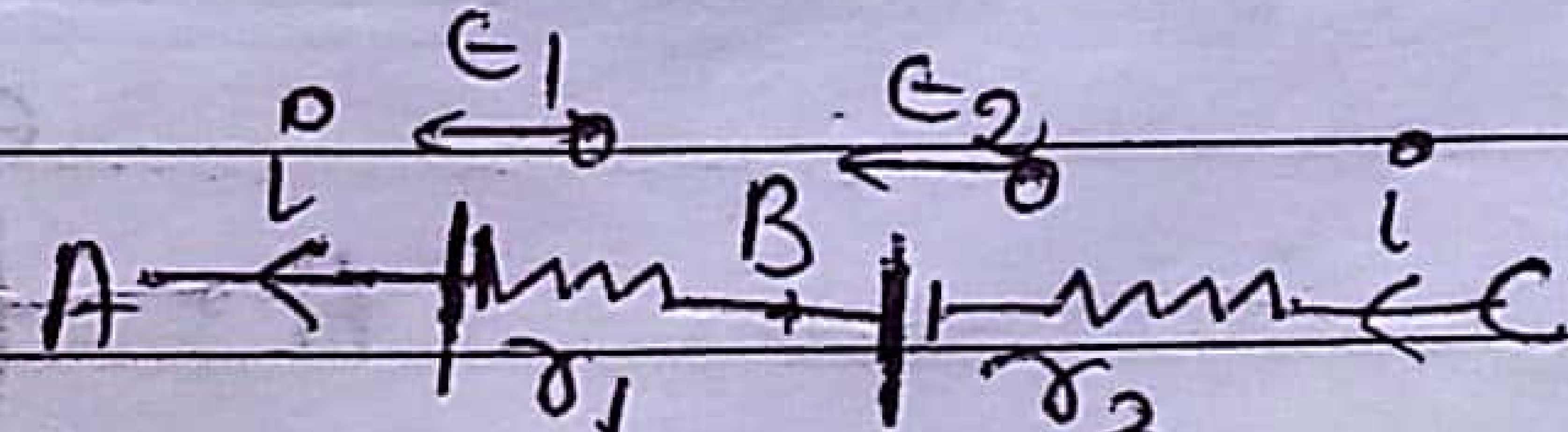
The forth colour band (d) represent the tolerance of resistance.
If d = Colourless 20%.

" d = Gold 5%.

" d = Silver 10%.

Combination of two cells in Series & Parallel

① In Series



Let two cells having emf ϵ_1 & ϵ_2 and internal resistance R_1 & R_2 are combine in series b/w A and C [the terminal potential b/w A and b]

$$V_{AB} = V_A - V_B = \epsilon_1 - ir_1$$

The Terminal potential b/w B & C

$$V_{BC} = V_B - V_C = \epsilon_2 - ir_2$$

Therefore the terminal potential b/w A&C

$$V_{AC} = V_{AB} + V_{BC}$$

$$\cancel{V_{AC} = (E_1+E_2) - i(r_1+r_2)}$$

$$V_{AC} = (E_1+E_2) - i(r_1+r_2)$$

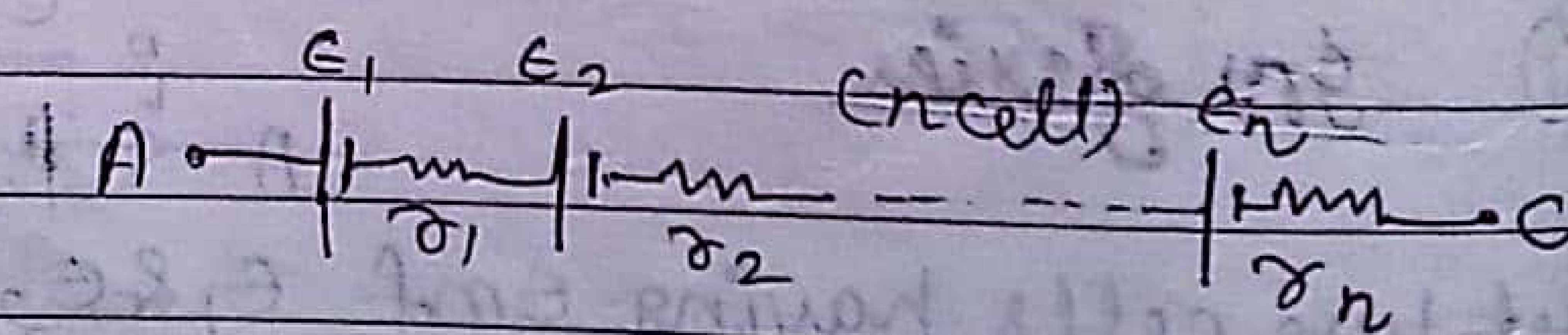
$$[V_{AC} = E_{eqv} - i r_{eqv}]$$

Therefore

$$\boxed{E_{eqv} = E_1 + E_2}$$

$$\boxed{R_{eqv} = r_1 + r_2}$$

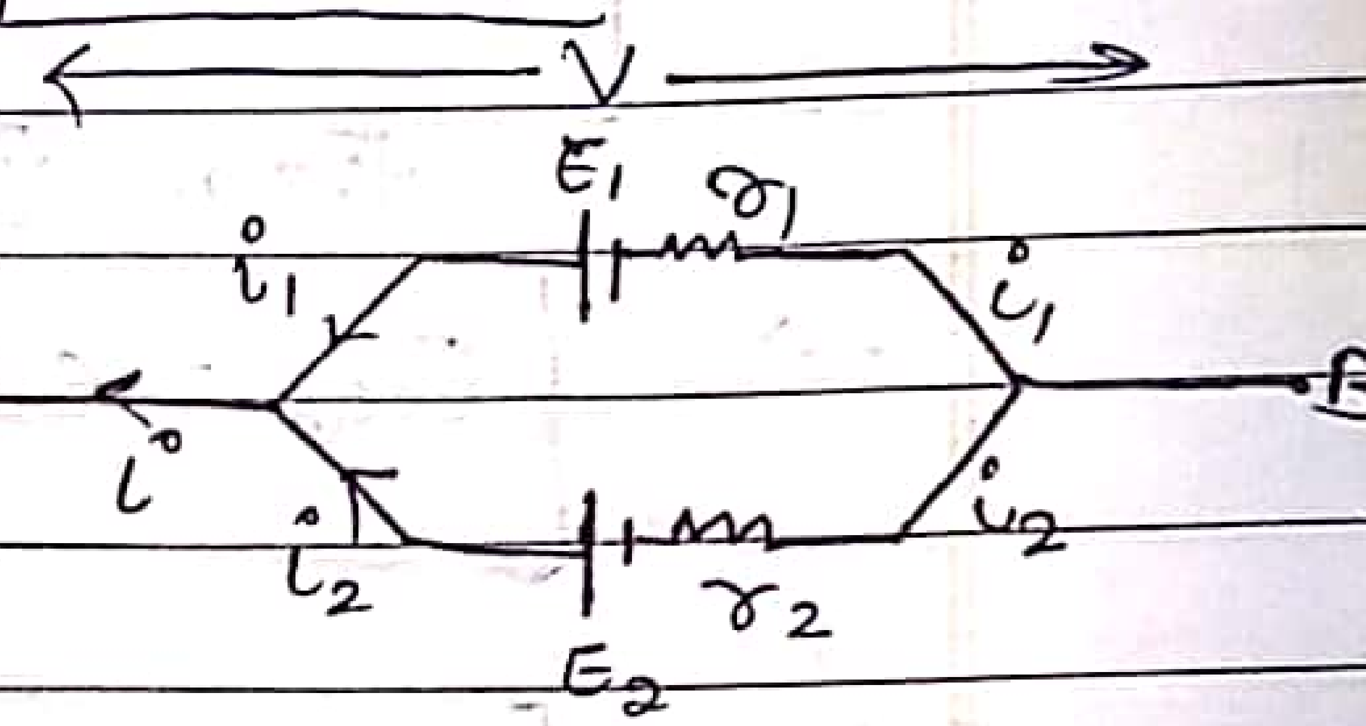
If there are n cell having Emf $E_1, E_2 \cdots E_n$ and internal resistance $R_1, R_2 \cdots R_n$ are Combine in series.



$$[E_{eqv} = E_1 + E_2 + \cdots E_n]$$

$$[R_{eqv} = R_1 + R_2 + \cdots R_n]$$

Combination of cells in Parallel



$i = i_1 + i_2$ — (1)

For First cell

$$V = E_1 - i_1 r_1$$

$$i_1 = \frac{E_1 - V}{r_1} = \frac{E_1}{r_1} - \frac{V}{r_1}$$

For Second cell

$$i_2 = \frac{E_2}{r_2} - \frac{V}{r_2}$$

From eqn (1)

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

$$i = \left(\frac{E_1}{r_1} + \frac{E_2}{r_2}\right) - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

$$i = \left(\frac{E_1 r_2 + E_2 r_1}{r_1 r_2}\right) - V\left(\frac{r_1 + r_2}{r_1 r_2}\right)$$

$$V\left(\frac{r_1 + r_2}{r_1 r_2}\right) = \frac{E_1 r_2 + E_2 r_1}{r_1 r_2} - i$$

$$V = \left(\frac{E_1 r_2 + E_2 r_1}{\cancel{r_1 r_2}}\right) \times \frac{\cancel{r_1 r_2}}{r_1 + r_2} - i\,\frac{r_1 r_2}{r_1 + r_2}$$

$$V = \left(\frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}\right) - i\left(\frac{r_1 r_2}{r_1 + r_2}\right) \quad \text{— (11)}$$

$$\boxed{V = E_{eqv} - i\, r_{eqv}} \quad \text{--- (iii)}$$

From (ii) & (iii)

$$\Rightarrow \boxed{E_{eqv} = \frac{\epsilon_1 r_2 + \epsilon_2 r_1}{r_1 + r_2}} \quad \text{(iv) 1st formula}$$

$$\Rightarrow \boxed{r_{eqv} = \frac{r_1 r_2}{r_1 + r_2}} \quad \text{(v) 2nd formula}$$

From eqn (v)

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

Eqn (iv) $\div$ (v)

$$\frac{E_{eqv}}{r_{eqv}} = \frac{\epsilon_1 r_2 + \epsilon_2 r_1}{\cancel{r_1 + r_2}} \times \frac{\cancel{r_1 + r_2}}{r_1 r_2}$$

$$\boxed{\frac{E_{eqv}}{r_{eqv}} = \frac{\epsilon_1}{r_1} + \frac{\epsilon_2}{r_2}}$$

If there are n cells having e.m.f $\epsilon_1, \epsilon_2 \text{ ---- } \epsilon_n$ and internal resistance $R_1, R_2 \text{ ---- } R_n$ Combined in parallel then —

$$\left[\frac{1}{r_{eqv}} = \frac{1}{r_1} + \frac{1}{r_2} + \text{------} + \frac{1}{r_n}\right]$$

$$\left[\frac{\epsilon_{eqv}}{r_{eqv}} = \frac{\epsilon_1}{r_1} + \frac{\epsilon_2}{r_1} + \dots\dots \frac{\epsilon_n}{r_n}\right]$$

imp

Kirchoff's Law

This law represent the distribution of current in any electrical circuit. Kirchoff's given two laws

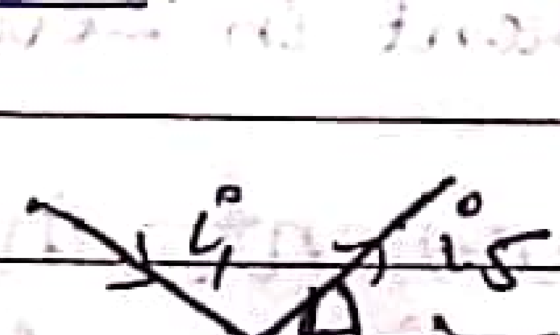
i) First law → This law states that algebric sum of currents meeting at any junction of circuit will be zero.

i.e. $[\Sigma i = 0]$

Let there are 5 currents meet at junction A i_1 & i_2 upcoming towards the juction while i_3, i_4 & i_5 are going away from the junction.

According to sign convension the currents incoming towards the junction will be taken +ve, & the currents going away the junction will be taken -ve.

$i_1 + i_2 - i_3 - i_4 - i_5 = 0$



$\Rightarrow \left[i_1 + i_2 = i_3 + i_4 + i_5\right]$

This law follow Conservation Law of charge ii Second law — According to this law the algebraic sum of multiplication of current & Resistance in any loop will be equal to the algebraic sum of E.m.f. of the cell.

NOTES → Sign Convensation → If the resistance is in direction of electric current then product of current and resistance will be taken +ve.

☆ The E.m.f. of the cell will be +ve if it is directed from -ve plate to +ve plate.

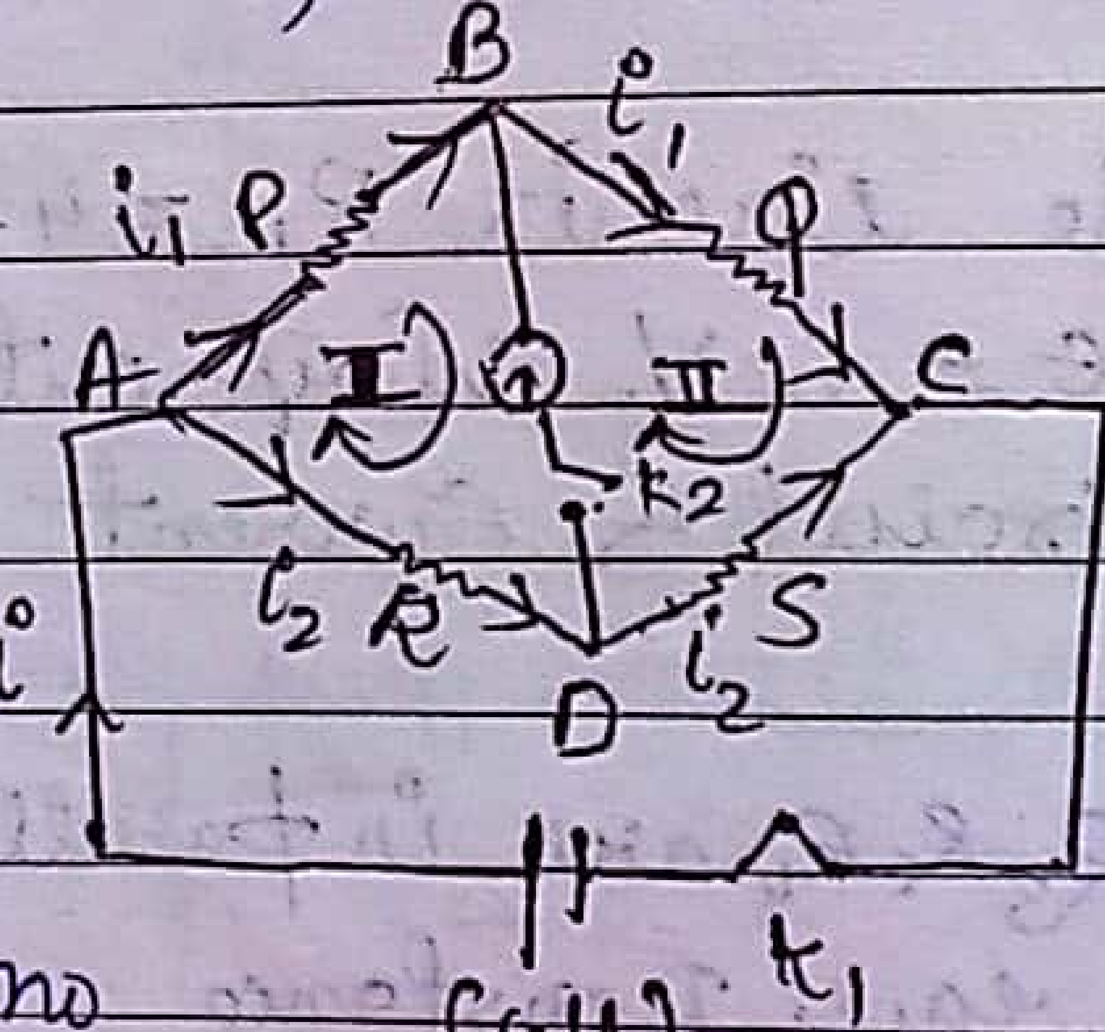
$$\left[\Sigma iR = \Sigma E \right]$$

Wheat Stone Bridge

An English Scienctist wheat stone construct a device by which we can calculate an unknown resistance.

Four resistances P, Q, ~~S~~ R, S are connected in series & converted in the from of ~~tetragonal~~ rectangle.

In diagonal BD and a diagonometer (G) and Key (K_2) are connected in another diagonal AC a cell and key (K_1) are connected



K_1 = Cell Key
K_2 = Galvano Key

Principle :-
Wheat stone arrange the resistance such type after which when we press Key K_1 & K_2 then there is no deflection in Galvanometer in this condition B & D ~~at~~ will be at same potential i.e. there will not flow any current in BD. then we say that Bridge is at Balanced position

In Balanced position —

$$\left[\frac{P}{Q} = \frac{R}{S}\right]$$

Proof :-
In closed mess (I)
$i_1 P - i_2 R = 0$

$$i_1 P = i_2 R \quad - (1)$$

In closed mess II

$$i_1 Q - i_2 S = 0$$
$$i_1 Q = i_2 S \quad - (2)$$

eq (I) ÷ eq (II)

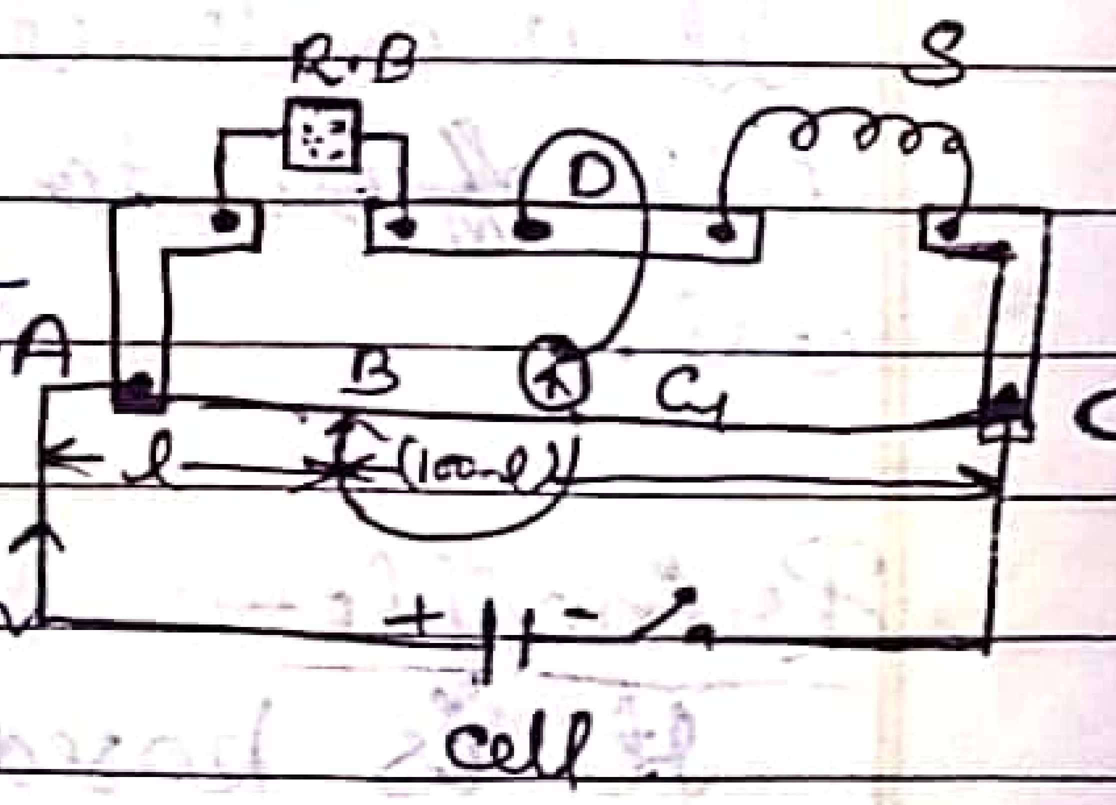
$$\left[\frac{P}{Q} = \frac{R}{S}\right]$$

P and Q are called ratio arm

R = Known arm
S = unknown arm

NOTE - wheat stone Bridge have more accuracy when every resistor will be at same order.

Metre Bridge



Metre Bridge is an instrument based upon balance wheat stone bridge to measure unknown resistance

Principle:-
It is constructed on the principle of balanced wheat

stone bridge i.e. when a wheat stone bridge is balanced —

$$\left[\frac{P}{Q} = \frac{R}{S}\right] \text{ — (1)}$$

Null deflection point
↓
Balanced

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

$$Q = \rho \frac{100-l}{A}$$

$$\frac{P}{Q} = \frac{l}{100-l}$$

from eq (1)

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

$$\left[S = R\left(\frac{100-l}{l}\right)\right]$$

Potentio metre

It is a device use to compare emf to two cells ~~off~~ or to measure internal resistance of a cell.

Principle—

It is based on the fact that fall of potential across any portion of a wire is directly proportional to the length i.e —

$$V \propto l$$

$$V = K l$$

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

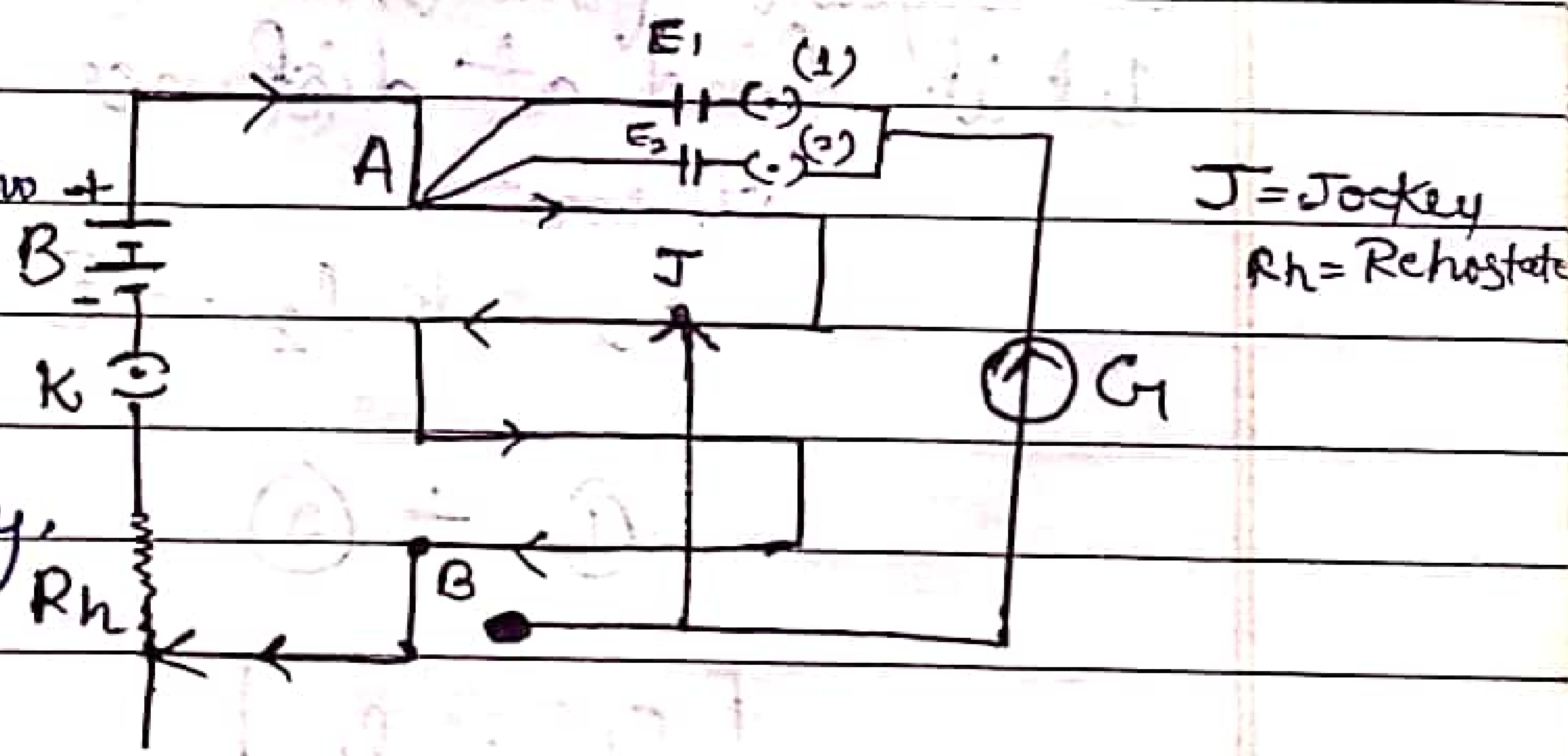
where K is a Constant which is calld potential Grediant

" The fall of potential per unit length is called potential Grediant.

Its unit is Volt/meter ~~or V/m~~ Volt/m

Application -

① To compare the e.m.f of two cell.



Let us Consider (2) two Cells of e.m.f. E_1 & E_2 which are to be compare, A battery, Keys, and Rehostate are Connected b/w terminal Point AB of Potentiometer.

The Positive end of both cell are Connected to terminal A & -ve terminal of both cells are connected to a double way key and it is Connected with Galvanometer & Galvnometer connected with Jockey (J)

First on the Keys (K) to flow a Constant Current in poentiometer.

and plug one kepton of double way key and two (2) off. And now side jockey from end A let at point J when we touch the jockey on wire there is no deflection in Galvanometer this is non-deflection position

Now measure the distance from A to J let it is l_1 then —

$$E_1 = K l_1 \quad \text{—} \ (1)$$

where K is potential gradient.

Now the plug (2) kept on and plug (1) off. & again find the non-deflection position let it find at distance l_2 from A then —

$$E_2 = K l_2 \quad \text{—} \ (2)$$

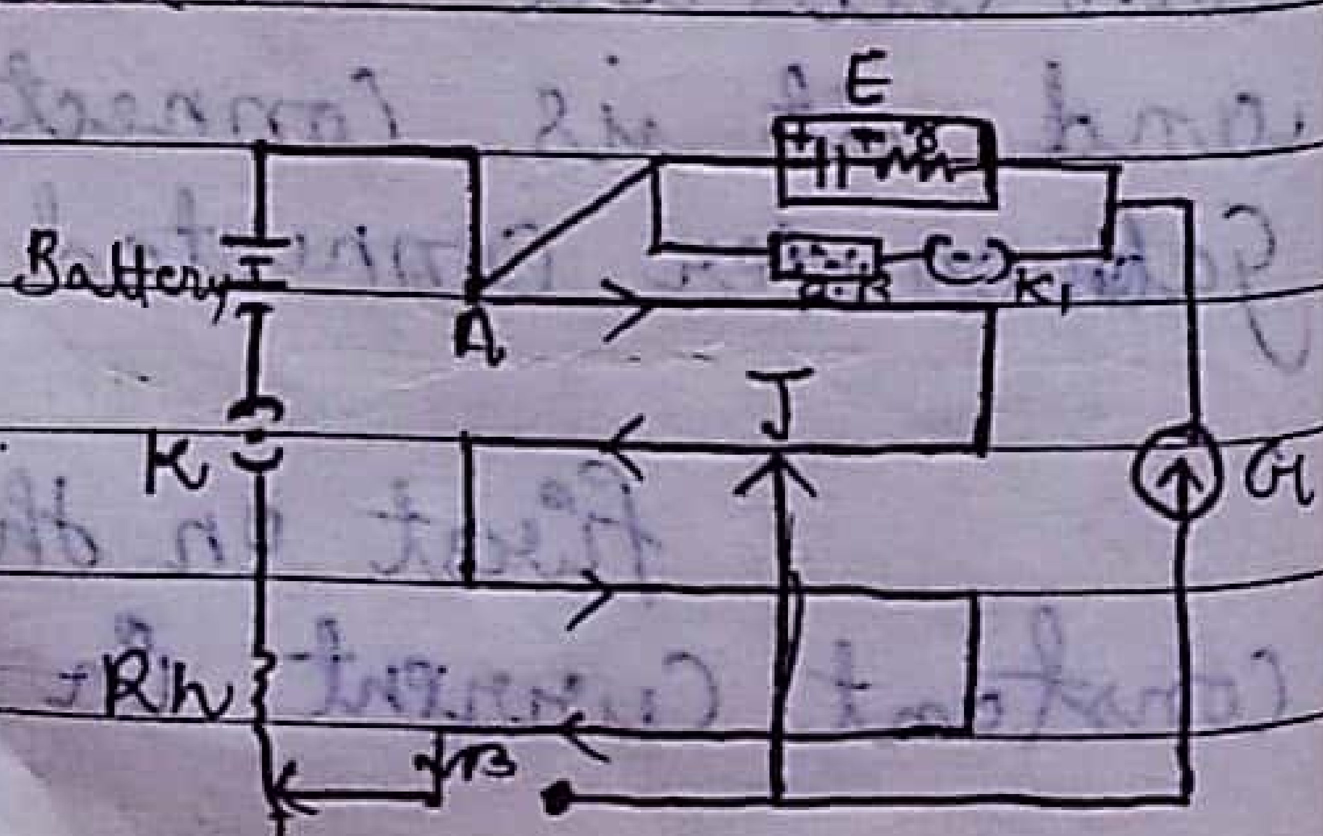
(1) ÷ (2)

$$\left[\frac{E_1}{E_2} = \frac{l_1}{l_2}\right]$$

(2) To measure internal resistance of a cell

To measure the internal resistance of the a cell

First a constant current is maintain



through potentiometer wire with the help of battery and Rehostate.

The ~~pulo~~ plug KEY(K_1) is Kept out & Jockey J is moved on the wire of potentiometer & find the find the non-deflection point. Let the distance of non-deflection point from end A is l_1 then —

$$E = Kl_1 \quad — (1)$$

Now, the plug key K_1 put in the circuit and a resitance R is taken from the resistance box & again find the non-deflection point.

Let in this position the distance of non-deflection point from ~~A~~ l_2 then terminal Potential b/w the electrodes of cell.

$$V = Kl_2 \quad — (2)$$

(1) ÷ (2)

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

The internal resistance of cell

$$r = R\left[\frac{E}{V} - 1\right]$$

$$r = R\left[\frac{l_1}{l_2} - 1\right]$$

~~Internal~~ Now put the value of $\frac{l_1}{l_2} = \frac{E}{V}$ & R in above equation we can find the internal resistance of cell.

$$r = R\left[\frac{l_1}{l_2} - 1\right]$$