/04/2023

1. ELECTROSTATIC

* **Charge** :-

→ The fundamental property that define electrical and magnetic properties of an object.

→ There are two types of charges

① +ve charge (Proton) (p^+)

② -ve charge (Electron) (e^-)

→ Denoted by Q/q

→ Unit :- Coulomb (C)

→ Dimension :- [AT] $(\because q = It)$

→ Some other units :- Stat coulomb → esu unit.
electrostatic

ab coulomb → emu unit.
↓
electromagnetic

$1C = 3 \times 10^9$ s.c

* **Properties** :-

→ Charge is a scalar quantity.

→ Minimum charge in nature :- 1.6×10^{-19} C i.e. charge of $1e^-$.

→ Charge is transferable.

→ Charge is always associate with mass but mass may or may not have charge.

→ Charge is quantaised.

→ The no. of e^- always an integral multiple of whole number.

$$\boxed{Q = ne}$$

where n = integer/ no. of e^-

$e = 1.6 \times 10^{-19}$ C

Ex:- Calculate the charge of an object having 20 electrons.

Ans. $Q = ne$

$= 20 \times 1.6 \times 10^{-19} C$

$= 32 \times 10^{-19} C$.

Q. How many e^-s are there in $10^{15} C$ of charge?

Ans:- Given, $Q = 10^{15}$

$n = \frac{Q}{e} = \frac{10^{15}}{1.6 \times 10^{-19}} = 0.625 \times 10^{34}$

*. Charged body:-

→ If an object is either rich of e^-s or deficiency of e^-s is called as charged body.

→ -vely charged → rich of e^-s

→ +vely charged → deficient of e^-s.

* Method of charging:-

⊛ friction:-

When one object is rubbed over another then transfer of charge takes place.

→ Ex:- When glass rod rubbed over silk cloth then e^-s from glass rod ~~to~~ transfer to silk cloth.

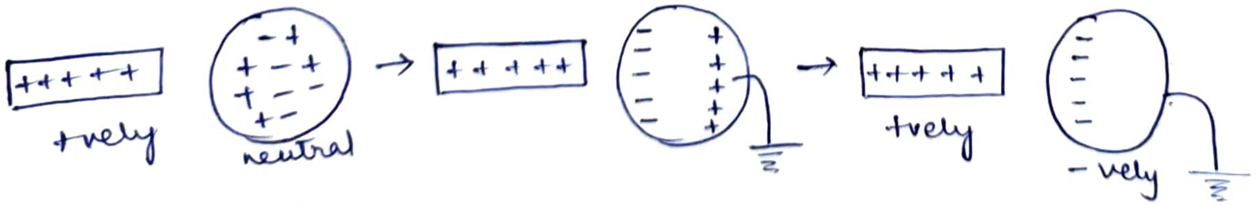
glass rod → +vely

Cloth → -vely.

⊛ Due to less value of work function(ϕ_0), glass rod release e^-s easily.

⊛ Induction:-

→ Charging of object by a charged object without even contact.



→ In induction, always opposite nature charge induces i.e. -ve induces +ve and +ve induces -ve

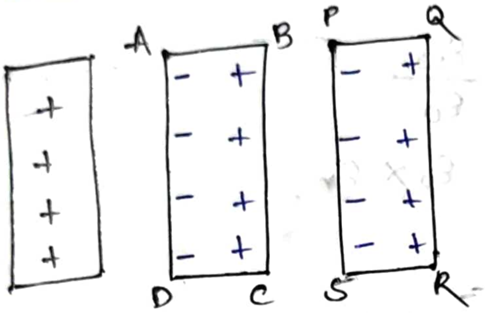
Conduction :-

→ The transfer of charge takes place depending upon the potential difference when both objects are in contact to each other.

→ e⁻s travels from lower potential to higher potential.

→ The transfer of charge takes place until the potential equalise and the amount of charge loss by an object is equal to amount of charge gained by an another one.

Q.



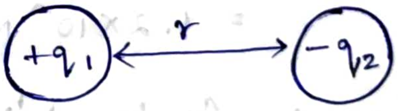
(1) (2) (3)

Fig. 1, 2, 3 are conduction, if conductor 1 is charged with +ve charge then what type of charge induced on QR side of conductor 3.

Ans. On QR side +ve charge will induce.

* Coulomb's Law :-

It states that electrostatic force of attraction or repulsion depends on the product of magnitude of both charges and inversely depend on square of the distance between them and act along the line joining them.



$F \propto q_1 q_2$ —— ①

$F \propto \frac{1}{r^2}$ —— ②

Combining eqⁿ ① & ②.

$F \propto \frac{q_1 q_2}{r^2}$

$\Rightarrow F = K \frac{q_1 q_2}{r^2}$

where $K = \frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \; Nm^2/C^2$.

ε_0 = permittivity in free space

$= 8.85 \times 10^{-12} \; C^2/Nm^2$

ε ★. Permitivity :-

→ Permitivity is denoted by ε (epsilon)

→ Permitivity in free space = ε_0.

→ relative $\boxed{\varepsilon_r = \frac{\varepsilon}{\varepsilon_0}}$ (ε_r is also dielectric constant)

Coulomb's ~~free~~ force in water medium.

$$F_w = \frac{1}{4\pi \varepsilon_w} \frac{q_1 q_2}{r^2}$$

(force in water)

$$\varepsilon_r = \frac{\varepsilon_w}{\varepsilon_0}$$

$$\Rightarrow \varepsilon_w = \varepsilon_0 \times \varepsilon_r .$$

$$F_w = \frac{1}{4\pi \varepsilon_0 \varepsilon_r} \frac{q_1 q_2}{r^2}$$

$$= \frac{1}{\varepsilon_r} \times \frac{1}{4\pi \varepsilon_0} \frac{q_1 q_2}{r^2}$$

$$\boxed{F_w = \frac{1}{\varepsilon_r} \times F_{free\ space}}$$

[∵ force will be decreased]

Q. Calculate the Coulomb's force in a medium of constant 2.5 if force in space is 3×10^{10} N ?

Ans. $F = \frac{1}{\varepsilon}$ Given :- ~~F~~ $\varepsilon_r = 2.5$

$F_{space} = 3 \times 10^{10}$ N.

$$F_{medium} = \frac{3 \times 10^{10}}{2.5}$$

$$= 1.2 \times 10^{10} \text{ N}.$$

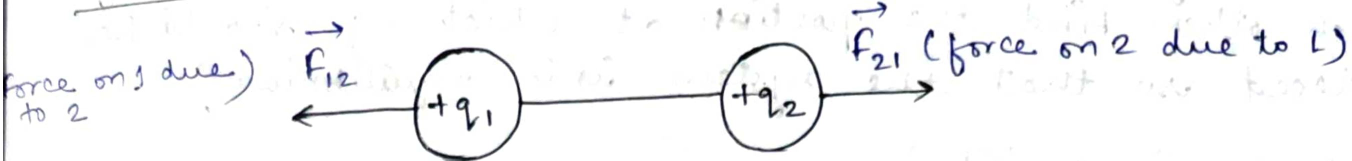
★ Properties of Coulomb's force :-

→ Electrostatic force is more strong than gravitational force

→ Electrostatic force may be attractive or repulsive.

→ Electrostatic force depends on medium.

* Coulomb's force in vector form :-



$\vec{F}_{12}$ = force of 1 due to 2 = $\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{|\vec{r}_{21}|^2}\hat{r}_{21}$

$\hat{r}_{21} = \frac{\vec{r}_{21}}{|\vec{r}_{21}|}$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{|\vec{r}_{21}|^2}\frac{\vec{r}_{21}}{|\vec{r}_{21}|}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{|\vec{r}_{21}|^3}\vec{r}_{21}$$

$\vec{F}_{21}$ = force of 2 due to 1 = $\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{|\vec{r}_{12}|^{\cancel{2}3}}\vec{r}_{12}$

$\hat{r}_{12} = \frac{\vec{r}_{12}}{|\vec{r}_{12}|}$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{|\vec{r}_{12}|^2}\frac{\vec{r}_{21}}{|\vec{r}_{12}|}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{|\vec{r}_{12}|^3}\vec{r}_{12}$$

Q:- What happened to coulomb's force if the charge doubled in magnitude and distance between them reduces to $\frac{1}{3}$ times?

Ans:- $F_0 = K\frac{q_1q_2}{r^2}$

$q_1 \rightarrow 2q_1$

$q_2 \rightarrow 2q_2$

$r \rightarrow r/3$

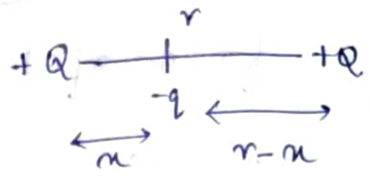
$F_{new} = K\frac{2q_1 2q_2}{(r/3)^2}$

$= 4 \times 9 \, K\frac{q_1q_2}{r^2}$

$$\boxed{F_{new} = 36 F_0}$$

Q. Two charges each of +Q is placed at a distance r from each other. Find the position at which −q should be placed so that the system is in equilibrium?

Ans. To be in equilibrium,
force on −q at both side will be equal.



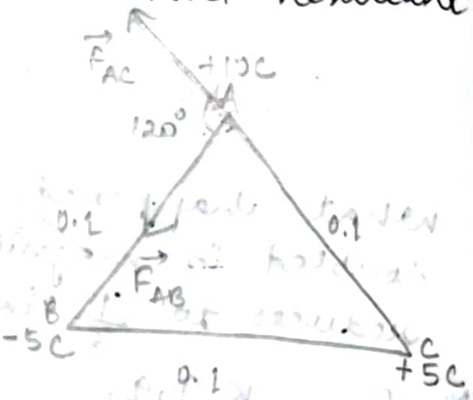
$$\frac{KQq}{x^2} = \frac{KQq}{(r-x)^2}$$

$\Rightarrow x^2 = (r-x)^2$

$\Rightarrow 2x = r$

$\Rightarrow \boxed{x = \frac{r}{2}}$

Q. Three charges 10C, 5C and −5C are placed at corners of an equilateral triangle of side 0.1 m. Find resultant force on 10C?



Ans. $\vec{F}_{AB} = K\frac{5\times10}{(0.1)^2}$ along AB.

$= \frac{9\times10^9\times5\times10}{10^{-2}}$ along AB

$= 45\times10^{12}$ N.

Similarly,

$\vec{F}_{AC} = K\frac{10\times5}{(0.1)^2}$ along AC

$= \frac{9\times10^9\times10\times5}{10^{-2}}$ along AB.

$= 45\times10^{12}$ N.

$$\vec{F}_R = \sqrt{F_{AB}^2 + F_{AC}^2 + 2F_{AB}F_{AC}\cos120^\circ}.$$

$= 45\times10^{12}$ N.

*. Test charge $(+q_0)$:-

→ It is a small positive charge having negligible mass and a unit +ve charge.

→ It is used to determine force and electric field due to a charge.

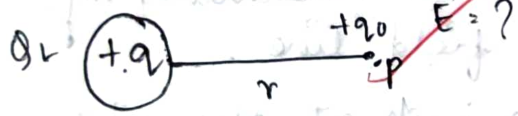
* Electric field :-

→ The region or area around a charge where the electrostatic force of attraction or repulsion remain effective.

→ The force per unit charge is called it's electric field.

$$\boxed{\vec{E} = \frac{\vec{F}}{q}} \quad \text{(or)} \quad \boxed{\vec{E} = \frac{\vec{F}}{q_0}}$$

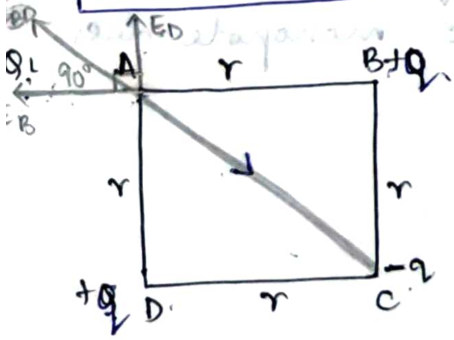
Electric field



$$\vec{E} = \frac{\vec{F}}{q_0} = \frac{\frac{Kq q_0}{r^2}}{q_0}$$

• B

$$\boxed{\vec{E} = \frac{Kq}{r^2}}$$ →(Formula)



Find $\vec{E}$ at A?

Ans↓ $\vec{E}_O = \frac{Kq}{r^2} = \vec{E}_D$

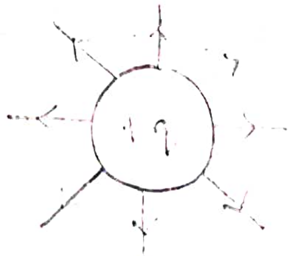
$$\vec{E}_{B,D} = \sqrt{E_B^2 + E_D^2 + 2E_BE_D\cos 90^\circ}$$
$$= \sqrt{2\left(\frac{Kq}{r^2}\right)^2}$$
$$= \sqrt{2}\,\frac{Kq}{r^2}$$

$$E_C = \frac{Kq}{(\sqrt{2}r)^2} = \frac{Kq}{2r^2} = \frac{1}{2}\frac{Kq}{r^2}$$

$$E_{net} = E_{BD} - E_C$$
$$= \left(\sqrt{2} - \frac{1}{2}\right)\frac{Kq}{r^2}$$

*. Electric Field Lines :-

→ These are imaginary hypothetical lines drawn to represent the electric field and it's direction.



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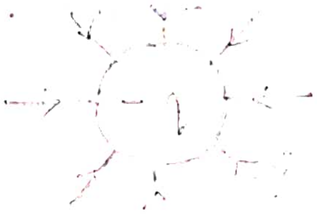

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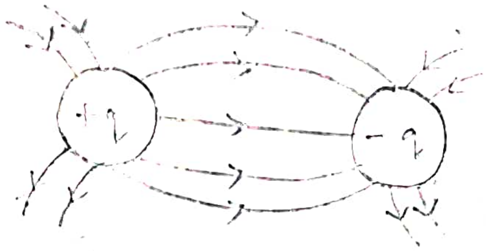


→ The direction of $\vec{E}$ is +ve to −ve.

* Properties :-

- These lines never form closed curve.
- The direction of Electric field can be determined by ploting tangent at any point on field line.
- $\vec{E}$ line never ~~so~~ cross each other. As at the point of crossing, two direction will be found which is not possible.
- The relative strength of charge is proportional to the number of lines.
- If $\vec{E} = 0$, then there will be no field lines.
- Electric monopole excist but magnetic monopole does not excist

1. Linear charge density (λ) :-

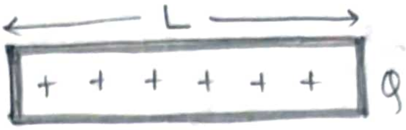
$\lambda = \frac{Q}{L} \Rightarrow Q = \lambda L$

In derivative form.

$\lambda = \frac{dq}{dl} \Rightarrow dq = \lambda dl$

$\vec{E} = \frac{KQ}{r^2}$ (or) $\int \frac{Kdq}{r^2}$

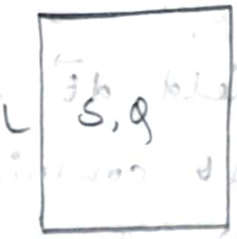
$= \frac{K\lambda L}{r^2}$ (or) $\int \frac{K\lambda dl}{r^2}$



2. Surface charge density (σ) :-

$\sigma = \frac{Q}{S}$ (or) $\frac{dq}{ds}$

$\vec{E} = \frac{K\sigma S}{r^2}$ (or) $\int \frac{K\sigma ds}{r^2}$



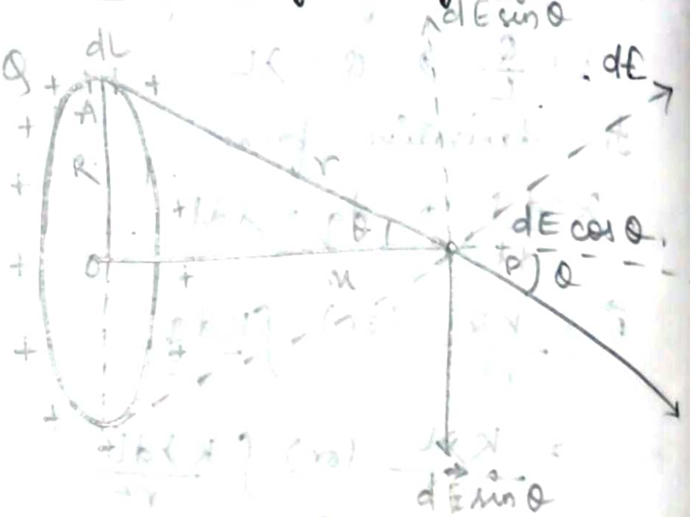
3. Volume charge density (ρ) :-

$\rho = \frac{Q}{V}$ (or) $\frac{dq}{dV}$

$\vec{E} = \frac{K\rho v}{r^2}$ (or) $\int \frac{K\rho dv}{r^2}$

* $\vec{E}$ at a point on axis due to charged ring :-

$r^2 = R^2 + x^2$



A ring of radius R having charge Q is taken P be the point of observation at a distance x from centre of ring.

Electric field $d\vec{E}$ has two components $dE\cos\theta$ and $dE\sin\theta$

Only $dE\cos\theta$ contribute to $\vec{E}$.

$$\vec{E} = \int dE\cos\theta$$

$\because \boxed{E = \frac{Kdq}{r^2}}$

$$= \int \frac{Kdq}{r^2}\cos\theta$$

$$= \frac{K}{r^2}\cos\theta\int dq$$

$$= \frac{K}{r^2}\cos\theta\, Q$$

In ΔAOP
$R^2 + x^2 = r^2$
and $\cos\theta = \frac{x}{r}$

$$\Rightarrow \vec{E} = \frac{K}{R^2+x^2} \times \frac{x}{r} \times Q.$$

$$\Rightarrow \vec{E} = \frac{K}{R^2+x^2} \times \frac{x}{(R^2+x^2)^{1/2}} \times Q$$

$\boxed{r = (R^2+x^2)^{1/2}}$

$$= \frac{KxQ}{(R^2+x^2)^{3/2}}$$

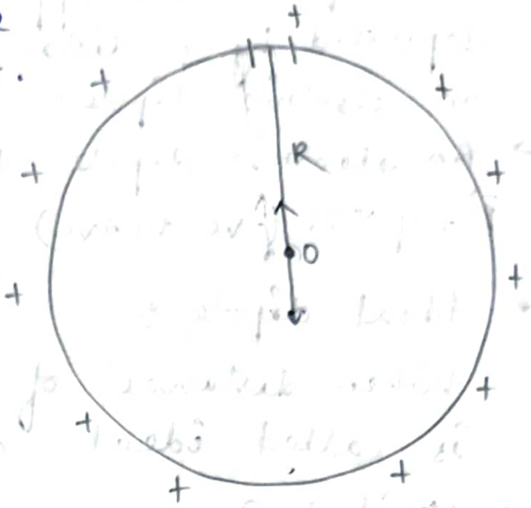
neglect R as x>>>R

$$E = \frac{KxQ}{x^{\cancel{2}\times 3/\cancel{2}}} = \frac{K\cancel{x}Q}{x^{\cancel{3}2}} = \frac{KQ}{x^2}$$

* $\vec{E}$ at a centre due to charged ring :-

At centre there will be opposite $\vec{E}$ due to each point and it's opposite point. So, they cancelled each other.

Hence $\boxed{\vec{E}_{centre} = 0}$



Q. Find $\vec{E}$ at a distance of 10^{-1}m from a charged ring of radius 10^{-4}m. having linear charge density $\frac{7}{22} \times 10^{5}$ c/m.

Ans. Given,

$x = 10^{-1}$ m

$R = 10^{-4}$ m.

$\Rightarrow \frac{Q}{L} = \lambda = \frac{7}{22} \times 10^{5}$ c/m

$\boxed{\because \Rightarrow Q = \lambda \times L \Rightarrow \lambda \times 2\pi R = \frac{\cancel{7}}{\cancel{22}} \times 10^{5} \times 2 \times \frac{\cancel{22}}{\cancel{7}} \times 10^{-4} \\ = 200\ C}$

$\vec{E} = \frac{K.Q}{x^2}$

$= \frac{9 \times 10^{9} \times 200}{10^{-2}}$

$= 180 \times 10^{11}$ N/C.

Q. An $\vec{E}$ of 100×10^{10} N/C is observed at a distance of 3×10^{-1} from a ring. Find it's charge.

Ans. $\vec{E} = 100 \times 10^{10}$ N/C $\quad \because E = \frac{KQ}{x^2}$

$x = 3 \times 10^{-1}$

$Q = ?$

$\Rightarrow Q = \frac{E \times x^2}{K} = \frac{100 \times 10^{10} \times \cancel{9} \times 10^{-2}}{\cancel{9} \times 10^{9}}$

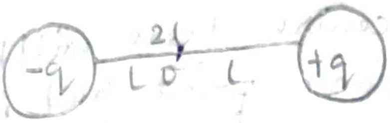
$= \frac{100 \times 10^{-8}}{10^{9}}$

$= 100 \times 10^{-1}$

$= 10$ C.

* **Electric dipole :-**

The equal and opposite charge separated by a distance constitute an electric dipole.



→ An electric dipole has dipole moment given by $\vec{P} = q \times 2l$ (-ve to +ve)

* **Ideal dipole :-**

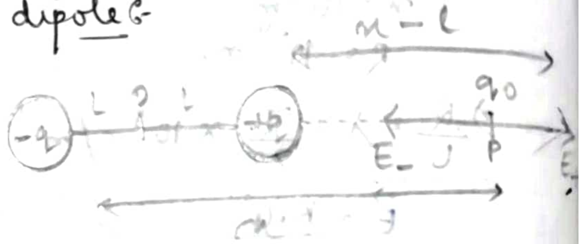
When distance of separation is neglected then dipole is called ideal dipole.

→ Unit :- Cm

→ Dim^n :- $[AT][L]$

$= [ATL]$

* $\vec{E}$ at axial point due to dipole :-



An electric dipole of -q and +q having 2l separation is taken. Let P be the point of observation at a distance x from centre of dipole 'O'.

∴ E_+ be the electric field due to +q charge.

$$\vec{E}_+ = \frac{kq}{(x-l)^2} \text{ along OP}$$

$$\vec{E}_- = \frac{kq}{(x+l)^2} \text{ along PO}$$

$$E_{net} = E_+ - E_- \text{ along OP}$$

$$= \frac{kq}{(x-l)^2} - \frac{kq}{(x+l)^2} \text{ along OP}$$

$$= kq\left(\frac{1}{(x-l)^2} - \frac{1}{(x+l)^2}\right) \text{ along OP}$$

$$= kq\left(\frac{(x+l)^2 - (x-l)^2}{(x^2-l^2)^2}\right) \text{ along OP}$$

$$= kq \times \frac{4xl}{(x^2-l^2)^2} \text{ along OP}$$

For ideal dipole $r >>> l$,
l neglected

$$\Rightarrow \vec{E}_{net} = \frac{kq \times 4\cancel{r}l}{r^{\cancel{4}3}} \text{ along OP}$$

$$\Rightarrow \vec{E}_{net} = \frac{kq\, 2l \times 2}{r^3} \text{ along OP} \quad \therefore \boxed{p = q \times 2l}$$

$$\Rightarrow \boxed{\vec{E}_{net} = \frac{2kp}{r^3} \text{ along OP}}$$

Q. find $\vec{E}$ at a distance 10^{-1} m from a dipole of $-10\mu C$ an
$+10\mu C$ separation 10^{-4} m at axial position ?

Ans:- $q = 10 \times 10^{-6}$ C.

$2l = 10^{-4}$

$p = 10 \times 10^{-6} \times 10^{-4} = 10^{-9}$ cm.

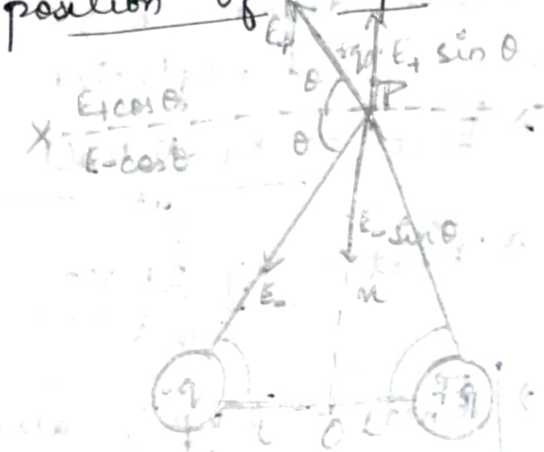
$r = 10^{-1}$ m.

$$\Rightarrow \vec{E}_{net} = \frac{2kp}{r^3}$$

$$= \frac{2 \times 9 \times \cancel{10^{9}} \times \cancel{10^{-9}}}{10^{-3}}$$

$$= 18 \times 10^3 \text{ N/C}.$$

* $\vec{E}$ at a point on equatorial position of a dipole :-



$$E_+ = \frac{kq}{(\sqrt{x^2+l^2})^2} = \frac{kq}{x^2+l^2}$$

$$E_- = \frac{kq}{(\sqrt{x^2+l^2})^2} = \frac{kq}{x^2+l^2}$$

Here $|\vec{E_+}| = |\vec{E_-}| = \vec{E}$ (say).

Now $E_+ \sin\theta$ and $E_- \sin\theta$ cancelled each other.

Now only $\cos\theta$ component will contribute to net $\vec{E}$.

$$\vec{E}_{net} = E\cos\theta + E\cos\theta \text{ along PX}$$

$$= 2E\cos\theta \text{ along PX.}$$

$$= 2 \times \frac{kq}{(x^2+l^2)} \times \frac{l}{\sqrt{x^2+l^2}} \text{ along PX.}$$

$$= \frac{2kql}{(x^2+l^2)(x^2+l^2)^{1/2}} \text{ along PX}$$

$$= \frac{2kql}{(x^2+l^2)^{3/2}} \text{ along PX} \quad [\because 1+\tfrac{1}{2} = \tfrac{3}{2}]$$

Here for ideal dipole,

$x >>> l$ i.e. l neglected.

$$\Rightarrow \vec{E}_{net} = \frac{2kql}{(x^{\cancel{2}})^{3/\cancel{2}}} \text{ along PX}$$

$$\Rightarrow \boxed{\vec{E}_{net} = \frac{k\vec{P}}{x^3} \text{ along PX}}$$

→ Direction of $\vec{E}_{net}$ in equatorial case is opposite to dipole direction.

→ $\boxed{\vec{E}_{axial} = 2 \times \vec{E}_{equatorial}}$

Q:- Find $\vec{E}$ at equatorial position ~~of~~ at a distance 10^{-1} m of a dipole of $-2\mu C$ and $+2\mu C$ separated by 3×10^{-3} m.

Ans:- $x = 10^{-1} m$

$q = 2\mu C = 2\times10^{-6}$ C.

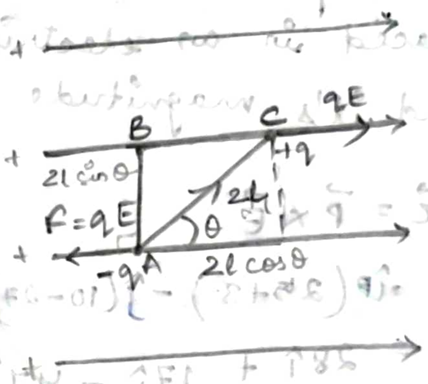
$2l = 3\times10^{-3}$ m.

$P = q \times 2l = 2\times10^{-6} \times 3\times10^{-3} = -6\times10^{-9}$ Cm.

$$E = \frac{KP}{x^2} = \frac{9\times10^{9}\times6\times10^{-9}}{(10^{-1})3} = 54\times10^{3} N/C.$$

* Torque on a dipole placed in an electric field :-

A dipole is placed at an angle θ with $\vec{E}$.



Torque = Force × ⊥r distance

$= qE \times AB$

$= qE \times 2l \sin\theta$; $(AB = 2l\sin\theta)$

$= P \times E \sin\theta$

$$\boxed{\vec{\tau} = \vec{P}\times\vec{E}}$$

Case-I dipole placed ⊥r to $\vec{E}$

$\theta = 90°$

i.e. $\tau = PE \sin 90$

$= PE$ (max^m).

Case-II dipole placed ||l to $\vec{E}$

$\theta = 0°$

$\tau = PE \sin 0$

$= 0$ (minimum).

Q:- A dipole of +6 μC and −6 μC separated by 0.001 m is placed in an electric field 3×10^3 N/C at an angle 30°. find torque on the dipole ?

Ans. Given,

$q = 6\cancel{2}\,\mu C = 6\cancel{2} \times 10^{-6}\,C$

$2l = \cancel{3 \times 10^3}\ 0.001 = 10^{-3}$

$\tau = PE \sin\theta$

$= q \times 2l \times E \sin\theta$

$= 6 \times 10^{-6} \times \cancel{10^{-3}} \times 3 \cancel{\times 10^3} \times \sin 30$

$= \overset{9}{\cancel{18}} \times 10^{-6} \times \frac{1}{\cancel{2}}$

$= 9 \times 10^{-6}$ Nm.

Q:- The dipole moment of a dipole is $\vec{P} = 2\hat{i} + 5\hat{j} + 3\hat{k}$ is placed in an electric field $\vec{E} = 9\hat{i} - \hat{j} + 5\hat{k}$. find torque and it's magnitude ?

Ans:- $\vec{\tau} = \vec{P} \times \vec{E}$

$$\begin{array}{ccc} + & - & + \\ \end{array}$$
$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 2 & 5 & 3 \\ 9 & -1 & \cancel{3}5 \end{vmatrix}$$

$= \hat{i}(25+3) - \hat{j}(10-27) + \hat{k}(-2-45)$

$= 28\hat{i} + 17\hat{j} - 47\hat{k}$.

$|\vec{\tau}| = \sqrt{28^2 + 17^2 + (-47)^2}$

Q:- If a dipole of dipole moment P is placed anti parallel to $\vec{E}$ then find expression for $\vec{\tau}$?

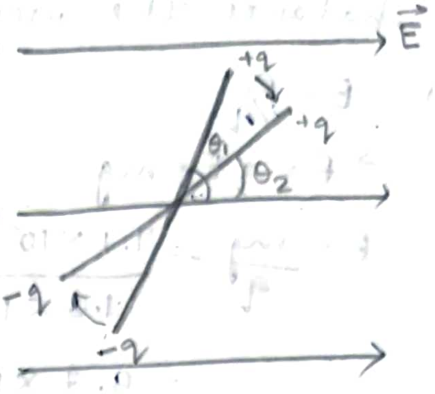
Ans:- $\vec{\tau} = \vec{P} \times \vec{E}$

$= PE \sin\theta$

$= PE \sin 180°$

$\boxed{\tau = -PE}$

* **Energy of a dipole placed in $\vec{E}$:**



The amount of workdone required to rotate dipole from θ_1 to θ_2 is stored as potential energy of the dipole

$$\boxed{U \text{ (or) } W = -PE(\cos\theta_2 - \cos\theta_1)}$$

* When $\theta_1 = 90°$
i.e. dipole is $\perp^r$ to $\vec{E}$
and $\theta_2 = \theta$

$$U \text{ (or) } W = -PE(\cos\theta - \overset{0}{\cancel{\cos 90}})$$

$$\boxed{U = -PE\cos\theta}$$

Q: What will be minimum energy of a dipole placed in a $\vec{E}$?

Ans: When $\theta = 0$
i.e. $U = -PE\cos 0 = -PE$

Q: What will be maximum energy of a dipole placed in a $\vec{E}$?

Maximum, $\theta = 180$

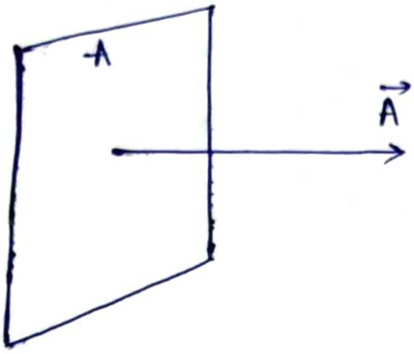
$$U = -PE\cos 180$$
$$= -PE(-1)$$
$$= PE.$$

26/04/2023

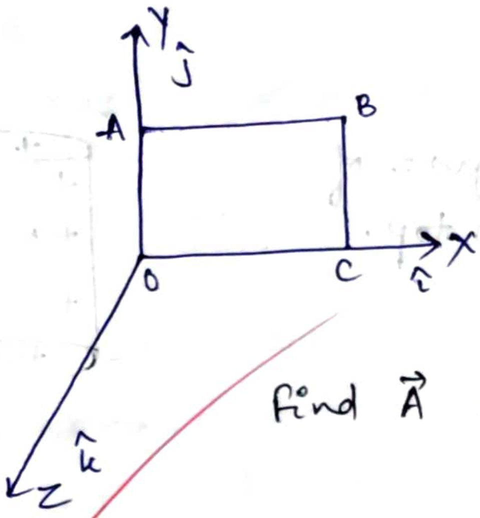
*. Area Vector :-

→ The perpendicular drawn to the area gives area vector of that area or object.

→



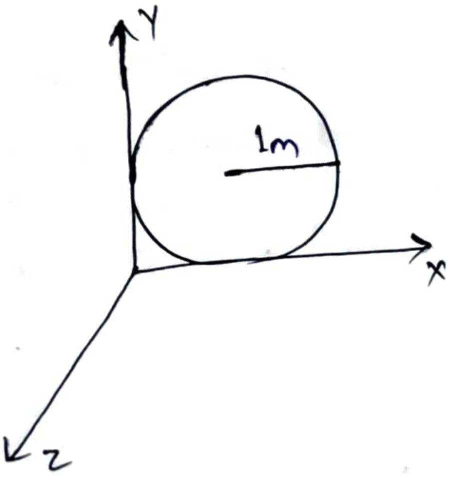
→ Ex:-



find $\vec{A}$ of ABCO sheet?

Ans:- $\vec{A} = \overset{(l \times b)}{(AB \times BC)} (-\hat{k})$.

Q:-



Find area vector of the object?

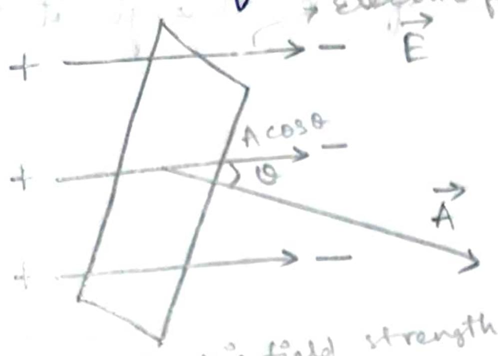
Ans:- $A = \pi r^2 = 3.14 \times 1^2$
$= 3.14 \text{ m}^2$

$\vec{A} = 3.14 \hat{k}$.

1. Electric Flux :-

→ The no. of electric field line passing through area.

→



i.e. $\phi \propto E$ and

$\phi \propto A$

→ electric field strength
→ ∠ bet^n them

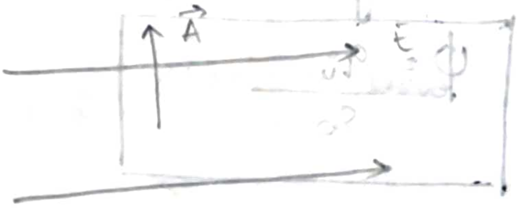
$\phi = EA\cos\theta$

→ Area of the object

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

$$\boxed{\phi = \int \vec{E}\cdot d\vec{A}}$$

i) **Minimum :-** [object orientation will be parallel but ∠ will be 90°]



$\phi = 0$

$0 = EA\cos\theta$

$\Rightarrow \cos\theta = 0$

$\Rightarrow \theta = 90°$ ~~($\parallel^l$ case)~~.

~~(object held $\perp^r$ to $\vec{E}$)~~.

Unit = $\phi = EA$

$= \frac{F}{q} A$

$= Nm^2/C$

Dim^n $= \frac{M^1L^1T^{-2}}{AT} \times L^2$

$= [M^1L^3T^{-3}A^{-1}]$

ii) **Maximum flux :-**

when $\theta = 0°$

i.e. $\phi = EA\cos\theta$

$= EA\cos 0°$

$= EA$.

Q:- A circular object of radius 0.2m is placed in an $\vec{E} = 7\times10^2$ at an angle 60°. find flux through it ?

Ans:- $\phi = \vec{E}\cdot\vec{A}$

$= EA\cos\theta$

$= \cancel{7}\times10^2 \times \frac{\overset{11}{\cancel{22}}}{\cancel{7}} \times (0.2)^2 \times \frac{1}{\cancel{2}}$

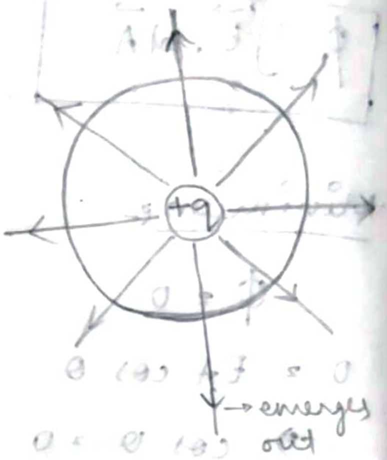
$= 0.04 \times 11 \times 10^2$

$= 44\ Nm^2/C$.

* Imp Gauss Law :-

→ Total electric flux through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times the charge inside.

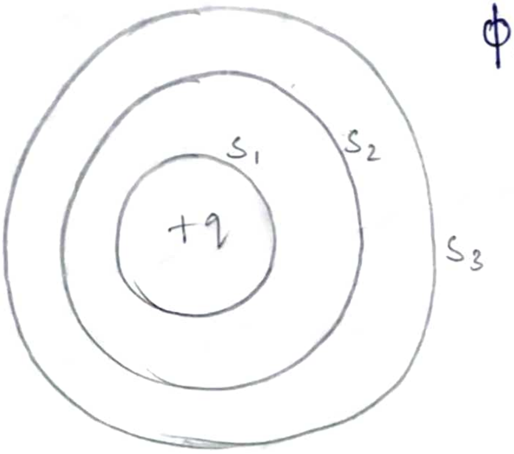
$$\boxed{\phi_{enclosed} = \frac{q_{in} \rightarrow \text{inside}}{\varepsilon_0}}$$



→ flux depend on charge inside.

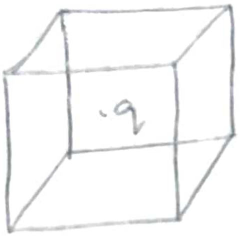
→ Flux will not depend on radius/ ~~or~~ ~~side~~ size of surface.

→ $\phi_{S_1} = \phi_{S_2} = \phi_{S_3} = \frac{q}{\varepsilon_0}$



→ The objects like cylinders, cube and sphere are known as gussian surface because they obey gauss law.

→

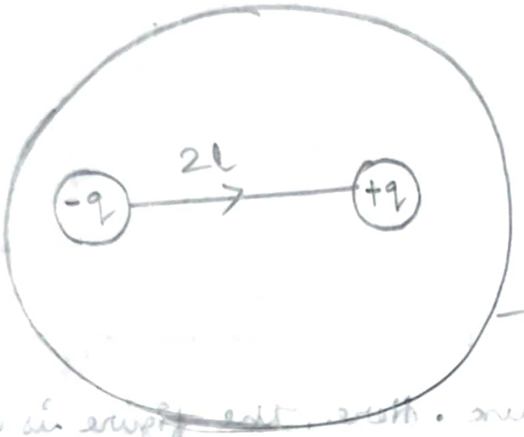


$\phi = \frac{q}{\varepsilon_0}$

$\phi = \frac{q}{\varepsilon_0}$

$\phi_{\text{for each face}} = \frac{q}{6\varepsilon_0}$.

Q:-



Find ϕ ?

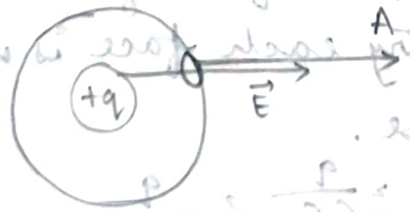
Ans:- $\phi = \frac{q_{in}}{\varepsilon_0} = \frac{-q+q}{\varepsilon_0} = \frac{0}{\varepsilon_0} = 0$.

⊛ Property of Gaussian Surface :-

→ It should be symmetry about charge.

→ $\vec{E}$ should be symmetry uniform.

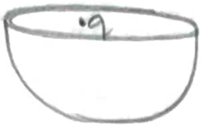
→



$\vec{E}$ and $\vec{A}$ should be parallel.

→ There should not be point charge on the gussian surface.

Q QL

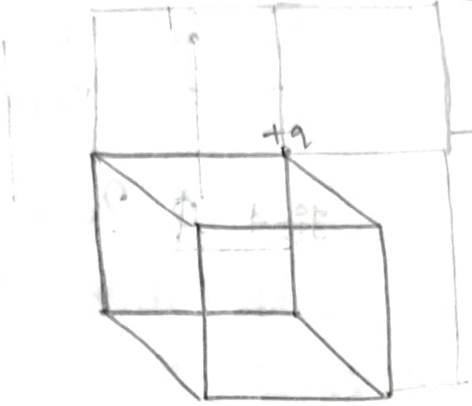


hemisphere. $\phi = ?$

Ans. For full sphere, $\phi = \frac{q}{\varepsilon_0}$

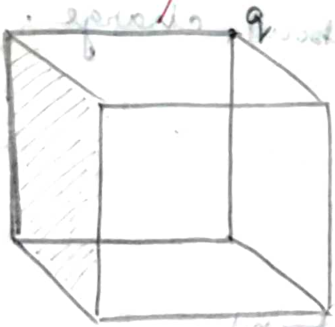
For hemisphere, $\phi = \frac{q}{2\varepsilon_0}$.

QL



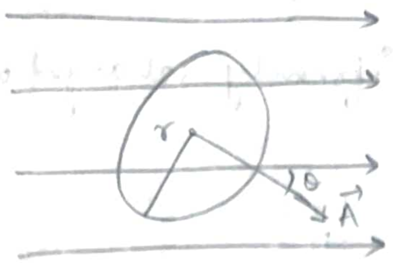
$\phi = \frac{q}{\varepsilon_0}$ for total flux. Here, the figure is not symmetry we have to make it symmetry by placing 8 cube.
So, q/ε_0 will divided within 8 and
ϕ through each cube $= \frac{q}{8\varepsilon_0}$.

QL



We know flux through each face of a cube is $\frac{q}{6\varepsilon_0}$
Now after marking symmetry each face is made up of 4 small faces of cube.
So, ϕ through each face $= \frac{\frac{q}{6\varepsilon_0}}{4} = \frac{q}{24\varepsilon_0}$.

Q:



$\theta = 60°$, $r = 0.2\,m$, $E = 7 \times 10^2\, N/C$.
find ϕ ?

Sol: $\phi = \int E.dA = \vec{E}.\vec{A}$

$= EA \cos\theta$

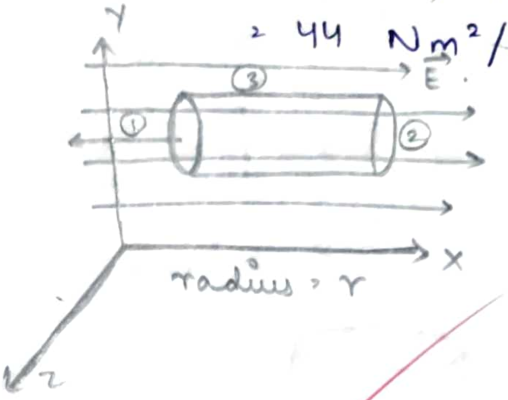
$= 7 \times 10^2 \times \pi r^2 \times \cos 60°$

$= \cancel{7} \times 10^2 \times \frac{22}{\cancel{7}} \times (2 \times 10^{-1})^2 \times \frac{1}{2}$

$= 22 \times \overset{2}{\cancel{4}} \times 10^2 \times 10^{-2} \times \frac{1}{\cancel{2}}$

$= 44\ Nm^2/C$

3:



$\phi_1 = \vec{E}.\vec{A}_1 = E\pi r^2 \cos 180$

$= -E\pi r^2$

$\phi_2 = \vec{E}.A_2 = E\pi r^2 \cos 0$

$= E\pi r^2$

$\phi_3 = \vec{E}.\vec{A}_3 = E A_3 \cos 90°$

$= 0$

$\phi_{net} = \phi_1 + \phi_2 + \phi_3 = -E\cancel{\pi r^2} + E\cancel{\pi r^2} + 0$

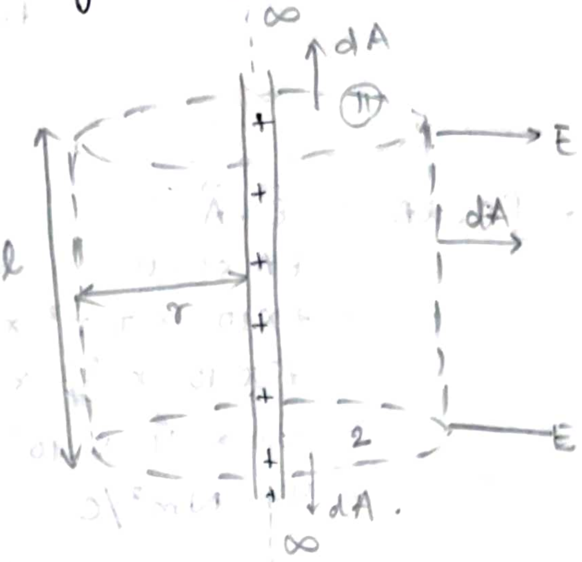
$= 0$

NOTE:- Net flux through any closed surface in a uniform electric field is always zero.

28/04/2023

✱. $\vec{E}$ due to an infinite long uniformly charged wire.

$q = \underset{\text{density}}{\lambda} \times \overset{\text{particular length}}{l}$



Cylindrical gaussian surface have 3 surface.
2 flat surface will not contribute any flux as

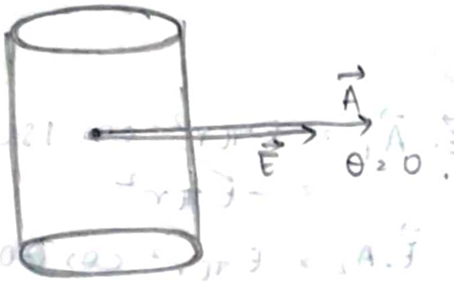
$E.\vec{A} = EA \cos 90 \ (\theta = 90°)$

$\phi = 0$

$q = \underset{\text{density}}{\lambda} \times l \to$ particular length

Flux through the curved surface = $\vec{E}.\vec{A} = EA\cos\theta$ $(\theta = 0°)$

$\phi = EA$



$\to \phi = \frac{q_{in}}{\varepsilon_0} = EA$

$= \frac{\lambda \times l}{\varepsilon_0} = E 2\pi r l$

$$\boxed{E = \frac{\lambda}{2\pi r \varepsilon_0}}$$

$\to E \propto \frac{1}{r}$.

$\to$

Graphical representation of distance of line charge.

Q. An infinite line charge produce field of 9×10^4 N/C at a distance 0.02 m. Calculate the linear charge density?

Ans. Given, $E = 9\times10^4$ N/C

$r = 0.02$ m.

$\lambda = ?$

$$E = \frac{\lambda}{2\pi\varepsilon_0 r}$$

$$= \frac{2\lambda}{4\pi\varepsilon_0 r}$$

$$E = \frac{1}{4\pi\varepsilon_0} \times \frac{2\lambda}{r}$$

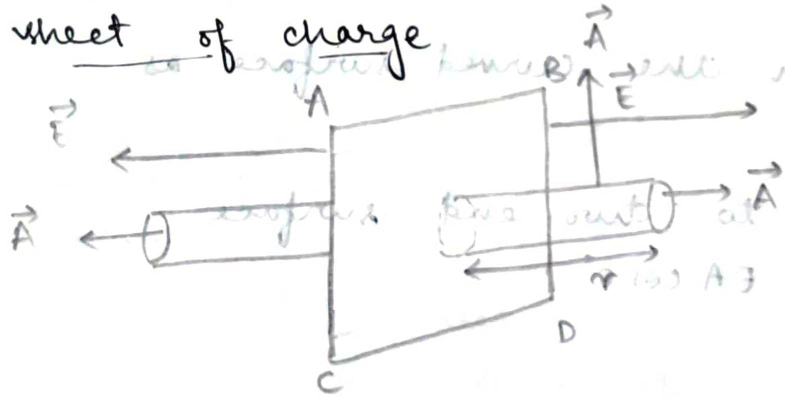
$$\Rightarrow \cancel{9}\times10^4 = \cancel{9}\times10^9 \times \frac{2\cancel{\pi}\lambda}{2\times10^{-2}}$$

$$\Rightarrow \lambda = \frac{2\times10^{-2}\times10^4}{2\times10^9}$$

$= 10^{-7}$ C/m.

[charge/length (Lamba)]

*. Electric field due to an infinite non-conducting flat sheet of charge



charged density

$$\left[\begin{array}{l} \therefore \sigma = q/A \\ \Rightarrow q = \sigma A \end{array}\right]$$

For curved surface no flux will be considered

$\phi = EA\cos 90° = 0$

For two surface at the end, we consider flux

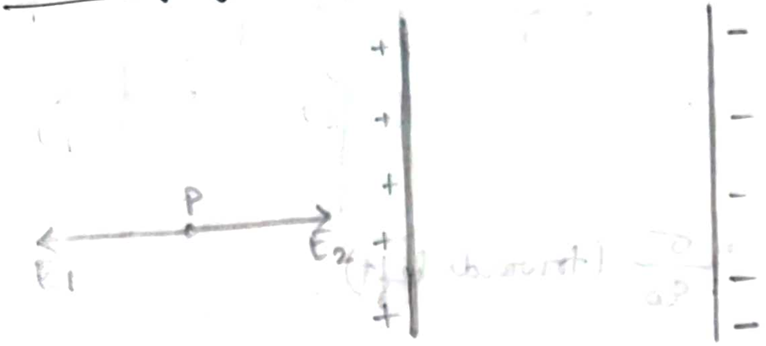
i.e. $\phi = EA\cos 0° + EA\cos 0°$

$= 2EA$.

4/05/2023

Imp *. Electric field due to two plane parallel and oppositely charged sheets :-

a) Point lying outside :-



At P, due to sheet 1, Electric field

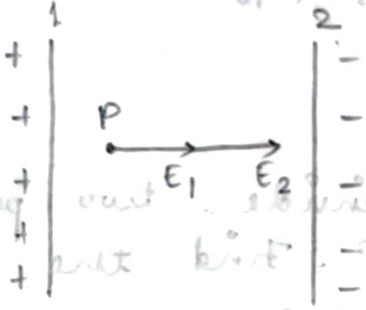
$E_1 = \frac{\sigma}{2\varepsilon_0}$ towards left.

and due to sheet 2,

$E_2 = \frac{\sigma}{2\varepsilon_0}$ towards right.

So, $E_{net} = E_1 - E_2 = \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$

b) Point lying inside :-



Electric field due to 1,

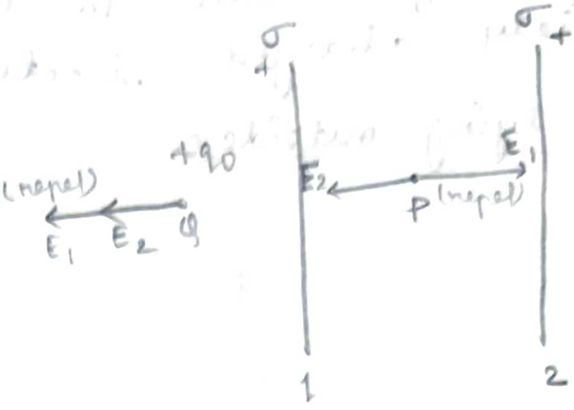
$E_1 = \frac{\sigma}{2\varepsilon_0}$ towards right.

due to sheet 2,

$E_2 = \frac{\sigma}{2\varepsilon_0}$ towards right.

$E_{net} = E_1 + E_2 = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$

Q. Find $\vec{E}$ outside and inside for same charged parallel plate of density σ_+ ?



Ans. at P

$$E_{net} = E_2 - E_1$$

$$= \frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0} = 0$$

at Q : $E_{net} = E_1 + E_2$

$$= \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}$$ (towards left).

Q. A 2μC charge is placed inside two opposite parallel plate having density 8.85×10^{-7} C/m². Find force on that charge?

Ans. Given,

$\sigma = 8.85 \times 10^{-7}$ C/m²

$q = 2 \times 10^{-6}$ C

$$F = qE = \frac{q\sigma}{\varepsilon_0} = \frac{2\times10^{-6} \times 8.85 \times 10^{-7}}{8.85 \times 10^{-12}}$$

$$F = 2\times10^{-13} \times 10^{12}$$

$$= 2\times10^{-1}$$

$$= 0.2 \text{ N}.$$

Q. An electron is placed inside two parallel plate of density 17.7×10^{-8} C/m². Find the acceleration with which e⁻ will move.

Ans. $F = qE = \frac{q\sigma}{\varepsilon_0}$

$$= \frac{1.6 \times 10^{-19} \times \overset{2}{\cancel{17.7}} \times 10^{-8}}{\cancel{8.85} \times 10^{-12}}$$

$$= 3.2 \times 10^{-15} \text{ N}.$$

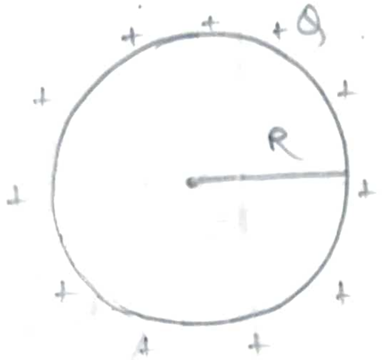
$[\because F = ma]$ $a = \frac{F}{m} = \frac{3.2 \times 10^{-15}}{9.1 \times 10^{-31}} = \frac{32}{91} \times 10^{16} = \frac{320}{91} \times 10^{15} = 3.5 \times 10^{15}$ m/s².

2/05/2023

*. $\vec{E}$ due to spherical shell :-

→ When a spherical shell is charged, the charges will lie on the surface.

→



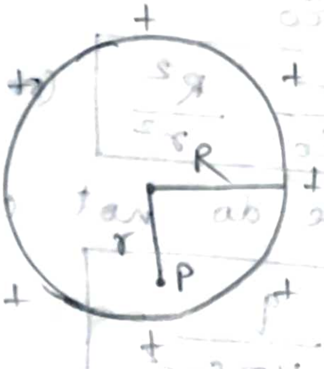
→ $\boxed{\sigma = \frac{Q}{4\pi R^2}}$

i) Inside point :-

Imp

$\phi = \frac{q_{in}}{\varepsilon_0} = \vec{E}\cdot\vec{A}$

$\Rightarrow \frac{q_{in}}{\varepsilon_0} = EA\cos\theta$



Here, $q_{in} = 0$

i.e $E = 0$

ii) On surface of shell

Imp

Here $r = R$

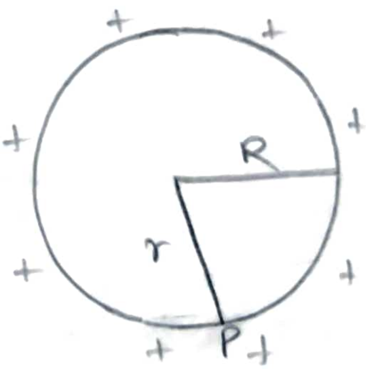
We know

$\phi = \frac{q_{in}}{\varepsilon_0} = \vec{E}\cdot\vec{A}$

(Here $\theta = 0°$ as $\vec{A}$ $\parallel$ $\vec{E}$)

$\phi = \frac{q_{in}}{\varepsilon_0} = E\underline{A} \rightarrow$ P point area

$= \frac{\sigma \times 4\pi R^2}{\varepsilon_0} = E \times 4\pi r^2$

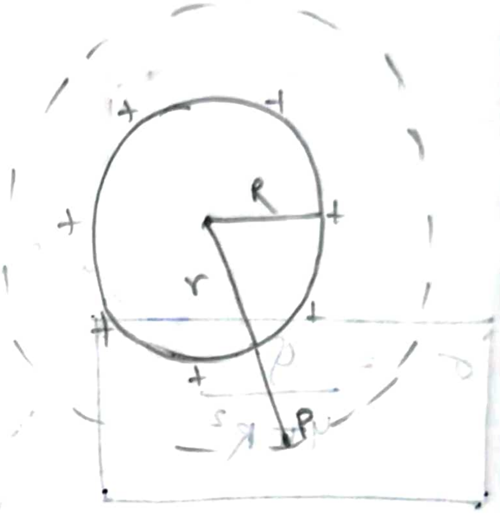


$$\Rightarrow E = \frac{\sigma}{\varepsilon_0}\frac{R^2}{r^2}$$

Here, r = R

$$\boxed{E = \frac{\sigma}{\varepsilon_0}}$$

iii) Outside point :-



We know,

$$\phi = \frac{q_{in}}{\varepsilon_0} = \vec{E}\cdot\vec{A}$$

$$\Rightarrow \frac{\sigma \times 4\pi R^2}{\varepsilon_0} = E\cdot A$$

$$= \frac{\sigma \times 4\pi R^2}{\varepsilon_0} = E \times 4\pi r^2$$

$$\Rightarrow \boxed{E = \frac{\sigma}{\varepsilon_0}\frac{R^2}{r^2}}$$ (or)

If we do not consider density

$$\checkmark\ \boxed{E = \frac{q}{4\pi\varepsilon_0 r^2}}$$

4/05/2023

2. Electrostatic Potential & Capacitance

*. Electric Potential :-

→ In electrostatic, we get the idea about electric potential i.e. flow of charge depends on potential of two points.

→ i.e. charge flows from higher potential to lower potential.

→ In qualitative way,
we can say, electric potential is the quantity which determines the direction of flow of charge.

*. Physical concept :-

Suppose a test charge brought from infinite to a point in an electric field.

Then there must be some interaction energy between the field and the test charge (q_0)
i.e. given as U.

In the above case, we are bringing the charge, we must have to do some work done.

Thus, potential at any point in an electric field is defined as the work done in moving a unit positive charge from infinite to that point.

Q. Given as

Ans
$$\boxed{V = \frac{W}{q_0}}$$

(or) for any charge $\boxed{V = \frac{W}{q}}$

Q. A charge of 2C taken from infinity to a point is an electric field, if work done in that case is 20 J. find potential at that point?

Ans. Given,

$W = 20 J$

$q = 2 C$

So, $V = \frac{W}{q} = \frac{20}{2} = 10 J/C$.

NOTE :-

→ Electric potential is a scalar quantity.

→ Always consider the sign that given in question. Lt,-

→ This work is against electric force.

→ That W in path independent because $f_{electrostatic}$ is conservative.

*. Unit :-

⊛ In SI :-

$$V = \frac{W}{q} = \frac{J}{C} = V \text{ (Volt)}$$

or $\boxed{\text{Volt (V)} = JC^{-1}}$ ✓

⊛ In CGS :-

a) esu unit :-

$$\text{Stat volt} = \frac{\text{erg}}{\text{stat coulomb}}$$ ✓

b) emu unit :-

$$\text{ab volt} = \frac{\text{erg}}{\text{ab coulomb}}$$ ✓

*. Relations :-

→ 1 volt = $\frac{1}{300}$ stat volt → bigger

→ 1 volt = 10^8 ab volt → Smaller

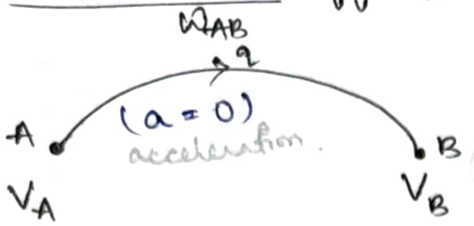
→ 1 stat volt = 3×10^{10} ab volt.

*. Dimension :-

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

$$= \frac{[M^1 L^2 T^{-2}]}{AT} = [M^1 L^2 T^{-3} A^{-1}]$$

*. Potential Difference



Workdone in moving a charge from point A ~~of~~ of at potential V_A to point B ~~at~~ of potential V_B is W_{AB}.

So, potential difference is given as.

$$V_B - V_{AB} = \frac{W_{AB}}{q_0}$$

(or) $V_B - V_A = \frac{W_{AB}}{q}$.

i.e. potential difference between any two points in an electric field is defined ~~of~~ as the work done in moving a unit positive charge from one point to another against the electric field.

Q. Workdone in moving a charge of 2C between two points having potential +20V & xV is 200J. find x?

Ans. Given :-

$q = 2C$

$V_B = +20$; $V_A = x$

$W = 200$ J.

$$\frac{W_{AB}}{q} = V_B - V_A$$

$$\Rightarrow \frac{\cancel{200}^{100}}{\cancel{2}} = 20 - x$$

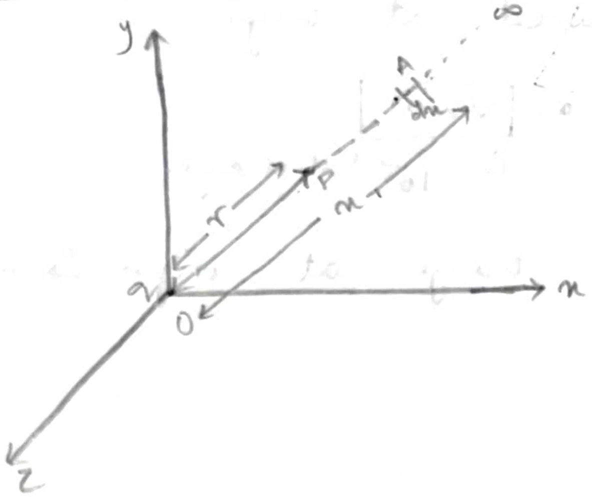
$$\Rightarrow 100 = 20 - x$$

$$\Rightarrow x = 20 - 100$$

$$\Rightarrow \boxed{x = -80}$$

5/05/2023

* Electric Potential due to a point charge :-



Now bring that test charge from infinity to point P. Suppose we first calculate the small work done for a small displacement dx which is at a distance x from origin.

So,

$$dw = \vec{E}\cdot dx = E\,dx\,\cos 180^\circ$$
$$= -E\,dx.$$

$$\Rightarrow dw = \frac{-Kq}{x^2}\,dx \qquad \left[E = \frac{Kq}{x^2} \text{ at point } A\right]$$

$$\Rightarrow W = \int_0^W dw = -\int_\infty^r \frac{Kq}{x^2}\,dx$$

$$\Rightarrow W = -Kq\int_\infty^r \frac{dx}{x^2}$$

$$= -Kq\left[\frac{-1}{x}\right]_\infty^r$$

$$= -kq\left(\frac{-1}{r} + \frac{1}{\infty}\right)$$

$$\boxed{W = +\frac{Kq}{r}}$$

or $$\boxed{W = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}}$$

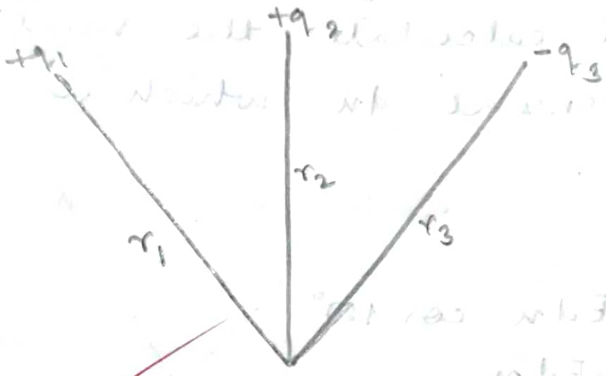
i.e. potential at point P at distance r from a point charge q placed at origin.

So, $\boxed{V = \frac{Kq}{r}}$ as $\boxed{V = W}$ for $q_0 \to$ test charge.

NOTE:- If that point charge at origin is $-q$, then

$$\boxed{V = \frac{-Kq}{r}}$$

* Potential due to a system of charge :-



$$V_1 = \frac{+kq_1}{r_1}$$

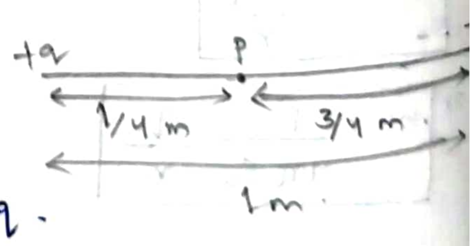
$$V_2 = \frac{+kq_2}{r_2}$$

$$V_3 = \frac{-kq_3}{r_3}$$

$$V_P = V_1 + V_2 + V_3$$

$$\boxed{V_P = K\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} - \frac{q_3}{r_3}\right)}$$

Q: Find V at point P in ~~the~~ line joining two charges +q and −3q at 1m apart.

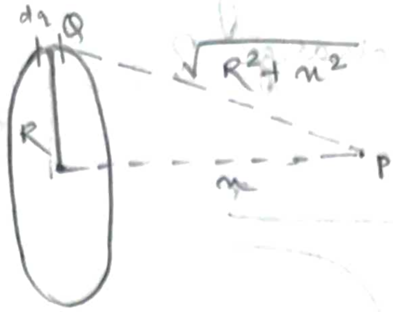


Ans: V_P due to $+q = \frac{Kq}{r} = \frac{Kq}{1/4} = 4kq$.

V_P due to $-q = \frac{-K3q}{r} = \frac{-K3q}{3/4} = \frac{-4K3q}{3} = -4kq$.

So, net V at P $= 4kq - 4kq = 0$.

*. Potential V on axis of charged ring :-



Consider a small charge dq for a small part of ring.
λ will not be consider as distance from each point ~~as~~ is same.

$$dv = \frac{K\,dq}{\sqrt{R^2+x^2}}$$

$$\Rightarrow V = \int \frac{K\,dq}{\sqrt{R^2+x^2}} = \frac{KQ}{\sqrt{R^2+x^2}}$$ ✓

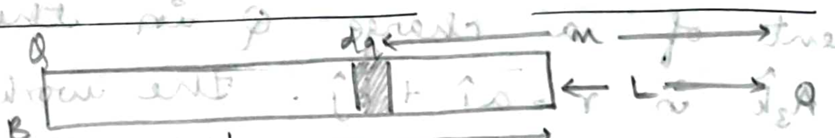
i) at centre, $x = 0 \Rightarrow V = \frac{KQ}{\sqrt{R^2}}$

$$\boxed{V = \frac{KQ}{R}}$$

ii) for a long distance point,
$x >> R$ $\Rightarrow V = \frac{KQ}{\sqrt{x^2}}$

So, $\boxed{V = KQ/x}$

* Potential V on axial line due to charged rod :-



Here $\lambda = Q/L$

For dq, $\int dv = \int_{L}^{2L} \frac{K\,dq}{x} = \int_{L}^{2L} \frac{K\lambda\,dx}{x}$

$$\Rightarrow V = K\lambda \int_{L}^{2L} \frac{dx}{x} = K\lambda[\ln x]_{L}^{2L} = K\lambda(\ln 2L - \ln L)$$

$$\Rightarrow V = K\lambda \ln\left(\frac{2\cancel{L}}{\cancel{L}}\right)$$

$$\Rightarrow V = K\lambda \ln 2$$

$$\Rightarrow \boxed{V = \frac{1}{4\pi\varepsilon_0}\,\frac{Q}{L}\,\ln 2}$$ [∴ ln converted to $\log_e$]

or $$\boxed{V = \frac{Q}{4\pi\varepsilon_0 L}\log_e 2}$$

Potential due to charged sphere :-

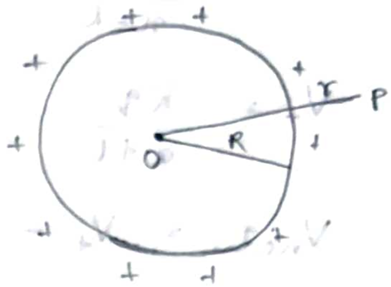
Hollow charged sphere :-

Outside point :-

Charges are situated on the surfaces.

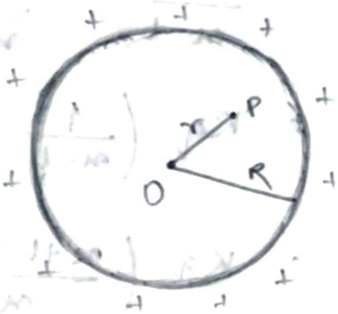
$V_p = \frac{KQ}{r}$

$V_{surface} = \frac{KQ}{R}$



) Inside point :-

$V_p = \frac{KQ}{R}$



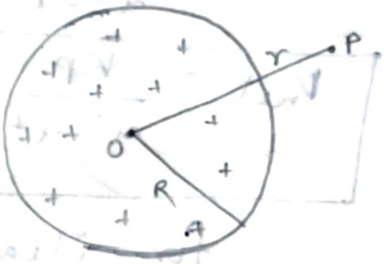
. Solid charged sphere :-

) Outside point :-

$\rho = \frac{m}{V} = \frac{Q}{V}$

$V_p = \frac{KQ}{r}$ (Same as hollow sphere)

$V_{surface} = \frac{KQ}{R}$



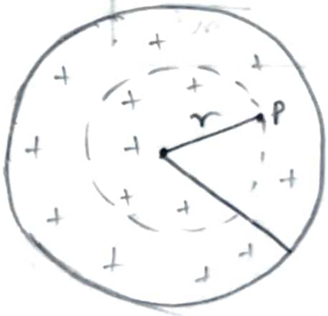
) Inside point :-

$\rho = \frac{m}{V} = \frac{Q}{V}$

$V_p = \frac{KQ}{R}\left(\frac{3}{2} - \frac{r^2}{R^2}\right)$

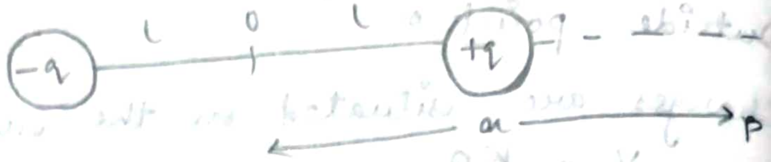
at centre $r = 0$

$V_{centre} = \frac{3KQ}{2R}$



3 *Imp **Potential due to dipole :-**

a) **On axial point :-**



V_+ due to +q

$$= \frac{Kq}{x-l}$$

$$V_- = \frac{Kq}{x+l}$$

$$V_{net} = V_+ - V_-$$

$$= \frac{Kq}{x-l} + \frac{Kq}{x+l}$$

$$= Kq\left(\frac{1}{x-l} + \frac{1}{x+l}\right)$$

$$= Kq\left(\frac{x+l - x+l}{x^2 - l^2}\right)$$

$$= \frac{Kq2l}{x^2 - l^2}$$

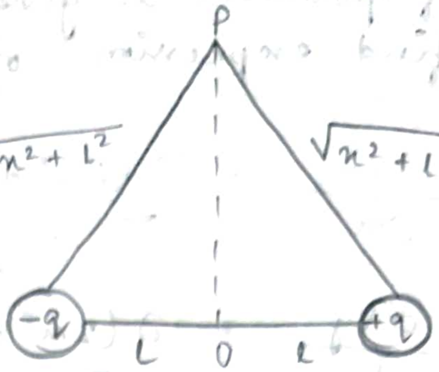
$$\boxed{V_{net} = \frac{Kp}{x^2 - l^2}}$$

for ideal dipole

$x >> > l$ i.e. $l^2 = 0$

$$\boxed{V_{net} = \frac{Kp}{x^2}}$$

b) On equatorial point :-



$$V_+ = \frac{Kq}{\sqrt{x^2+l^2}}$$

$$V_- = \frac{-Kq}{\sqrt{x^2+l^2}}$$

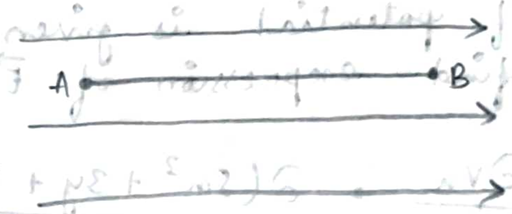
$$V_{net} = \frac{-Kq}{\sqrt{x^2+l^2}} + \frac{Kq}{\sqrt{x^2+l^2}} = 0$$

*. Relation between $\vec{E}$ and V :-

$F = qE$

$$\boxed{V_B - V_A = -\vec{E}\cdot\Delta\vec{r}}$$

- Vector concept :-



$\vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}$

$\Delta r = \partial x\hat{i} + \partial y\hat{j} + \partial z\hat{k}$

$\Rightarrow \partial V = -F\cdot\partial r$

$= -(E_x\hat{i} + E_y\hat{j} + E_z\hat{k})\cdot(\partial x\hat{i} + \partial y\hat{j} + \partial z\hat{k})$

$= -(E_x\partial x + E_y\partial y + E_z\partial z)$

- Const. derivative
$\Rightarrow \frac{d(xy)}{dx} = x\frac{dy}{dx} + y\frac{dx}{dx}$
- Partial derivative
$\Rightarrow \frac{\partial(xy)}{\partial x} = y\frac{\partial x}{\partial x}$

$\Rightarrow \partial V_x = -E_x\partial x$

$\partial V_y = -E_y\partial y$

$\partial V_z = -E_z\partial z$

$\Rightarrow E_x = \frac{-\partial V_x}{\partial x}$

$E_y = \frac{-\partial V_y}{\partial y}$

$E_z = \frac{-\partial V_z}{\partial z}$

$\Rightarrow \vec{E} = E_x\hat{i} + E_y\hat{j} + E_z\hat{k}$

$$\boxed{\vec{E} = \left(\frac{-\partial V_x}{\partial x}\right)\hat{i} + \left(\frac{-\partial V_y}{\partial y}\right)\hat{j} + \left(\frac{-\partial V_z}{\partial z}\right)\hat{k}}$$

Imp

3. Q:- If potential is given as $V = 2x^2 + 3y^3 + 4z$ then find expression of $\vec{E}$ at $(1,2,0)$

A Ans:- $\frac{\partial V_x}{\partial x} = \frac{\partial(2x^2 + 3y^3 + 4z)}{\partial x} = 4x$

$$\frac{\partial V_y}{dy} = \frac{\partial(2x^2 + 3y^3 + 4z)}{\partial y} = 9y^2$$

$$\frac{\partial V_z}{\partial z} = \frac{\partial(2x^2 + 3y^3 + 4z)}{\partial z} = 4$$

$$\vec{E} = -4x\hat{i} - 9y^2\hat{j} - 4\hat{k}$$

at $(1,2,0)$

$$\vec{E} = -4 \times 1\hat{i} - 9 \times 2^2\hat{j} - 4\hat{k}$$

$$= -4\hat{i} - 36\hat{j} - 4\hat{k}$$

Imp

Q:- If potential is given as $V = 5x^3 + 3y + 4z^2$ then find expression of $\vec{E}$ at $(2,1,1)$

Ans $\frac{\partial V_x}{\partial x} = \frac{\partial(5x^3 + 3y + 4z^2)}{\partial x} = 15x^2$

$$\frac{\partial V_y}{\partial y} = \frac{\partial(5x^3 + 3y + 4z^2)}{\partial y} = 3$$

$$\frac{\partial V_z}{\partial z} = \frac{\partial(5x^3 + 3y + 4z^2)}{\partial z} = 8z$$

$$\vec{E} = -15x^2\hat{i} - 3\hat{j} - 8z\hat{k}$$

at $(2,1,1)$

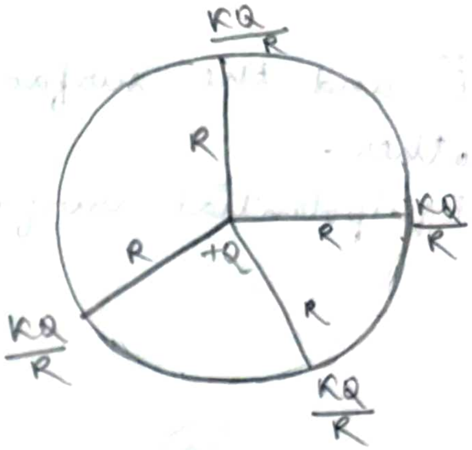
$$\vec{E} = -15(2)^2\hat{i} - 3\hat{j} - 8 \times 1\hat{k}$$

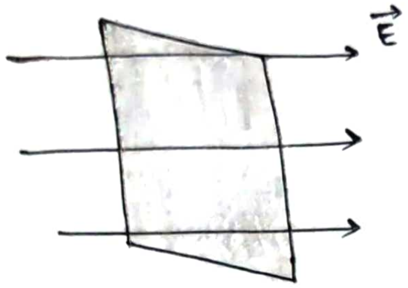
$$= -15 \times 4\hat{i} - 3\hat{j} - 8\hat{k}$$

$$= -60\hat{i} - 3\hat{j} - 8\hat{k}.$$

Equipotential Surface :-

- The surface on which potential is same at all points.
- For a point charge the equipotential surface is spherical.





ans. This is a equipotential surface which held $\perp^r$ to $\vec{E}$.

2. Properties of equipotential surface :-

Workdone

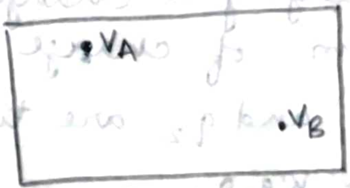
$W = \Delta V \times q$

$\left(\Delta V = \frac{W}{q}\right)$

$= (V_B - V_A) q$

$= 0 \times q$

$= 0$



$V_A = V_B$

On equipotential surface the workdone is zero.

⇒ We know

$W = 0$

$\Rightarrow F.S = 0$

$\Rightarrow qE.S = 0$ $(F = qE)$

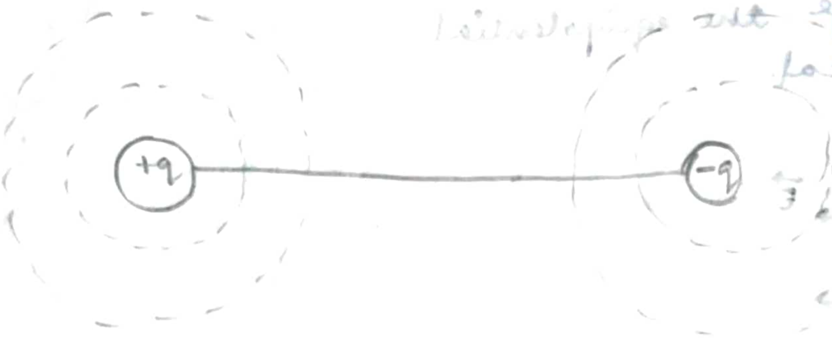
$\Rightarrow qES\cos\theta = 0$

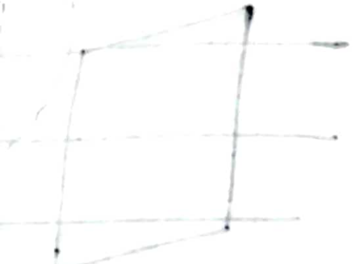
$\Rightarrow \theta = 90^\circ$.

3. → $\vec{E}$ and the surface (or) displacement is $\perp^r$ to each other.

→ Equipolential surface never cross each other.

A



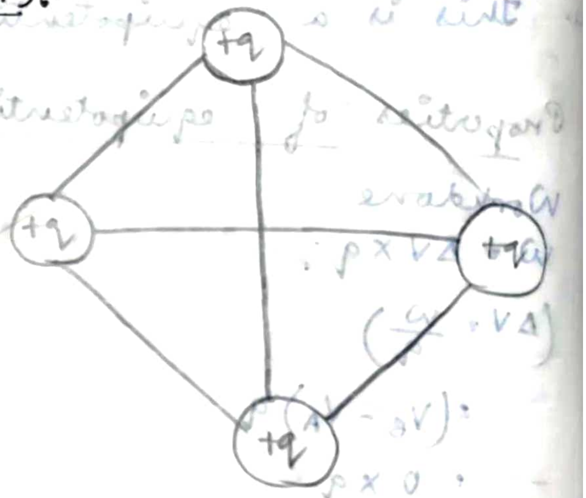


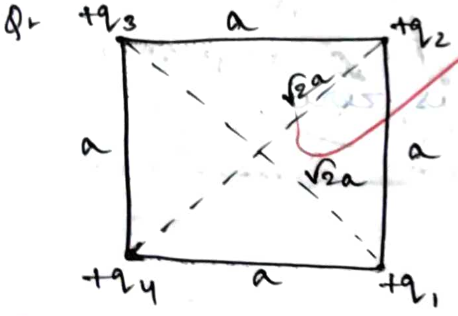
*. Electrostatic potential Energy (EPF):-

→ It is the amount of workdone is bringing a change to near a system of change.

→ If q_1 and q_2 are two charges then

$$U = \frac{Kq_1q_2}{r}$$





find U_{12}, U_{23}, U_{34}, U_{14}, U_{13}, U_{24} ?

Ans:- $U_{12} = \frac{Kq_1q_2}{a}$ $U_{14} = \frac{Kq_1q_4}{a}$

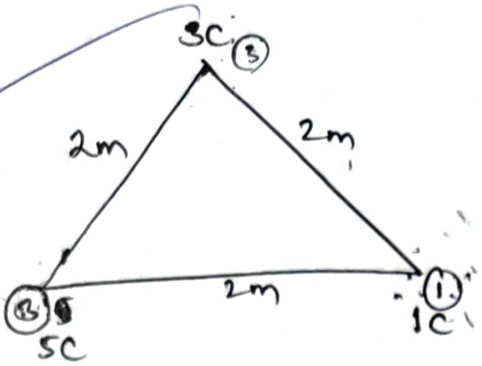
$U_{23} = \frac{Kq_2q_3}{a}$ $U_{13} = \frac{Kq_1q_3}{\sqrt{2}a}$

$U_{34} = \frac{Kq_3q_4}{a}$ $U_{24} = \frac{Kq_2q_4}{\sqrt{2}a}$

$$U_{total} = \frac{Kq_1q_2}{a} + \frac{Kq_2q_3}{a} + \frac{Kq_3q_4}{a} + \frac{Kq_1q_4}{a} + \frac{Kq_1q_3}{\sqrt{2}a} + \frac{Kq_2q_4}{\sqrt{2}a}$$

$$= \frac{K}{a}\left(q_1q_2 + q_2q_3 + q_3q_4 + q_1q_4 + \frac{q_1q_3}{\sqrt{2}\cancel{a}} + \frac{q_2q_4}{\sqrt{2}}\right)$$

Q L



find $U_{total} = ?$

Ans $U_{12} = \frac{K\times1\times3}{2} = \frac{3K}{2}$

$U_{23} = \frac{K\times3\times5}{2} = \frac{15K}{2}$

$U_{31} = \frac{K\times5\times1}{2} = \frac{5K}{2}$

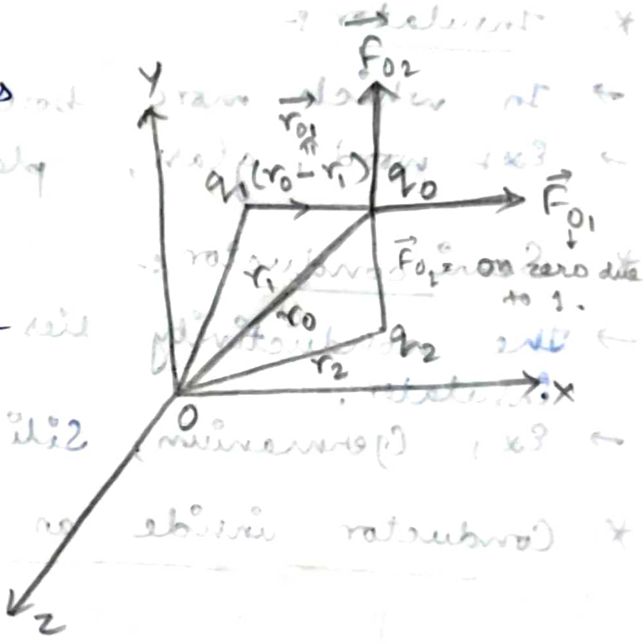
$U_{total} = \frac{3K+15K+5K}{2} = \frac{23K}{2} = \frac{23}{2}\times9\times10^9$

$= 103.5\times10^9 J.$

*. Superposition principle :-

Suppose there are i no. of charges $q_1, q_2 \dots q_i$ having position vector $r_1, r_2 \dots r_i$

For i no. of charges force will be $\vec{F}_{0i}$



$$\vec{F}_{01} = \frac{1}{4\pi\varepsilon_0}\frac{q_0q_1}{(r_{01})^2}\hat{r}_{01}$$

$$\vec{F}_{02} = \frac{1}{4\pi\varepsilon_0}\frac{q_0q_2}{(r_{02})^2}\hat{r}_{02}$$

$$\vec{F}_{0i} = \frac{1}{4\pi\varepsilon_0}\frac{q_0q_i}{(r_{0i})^2}\hat{r}_{0i}$$

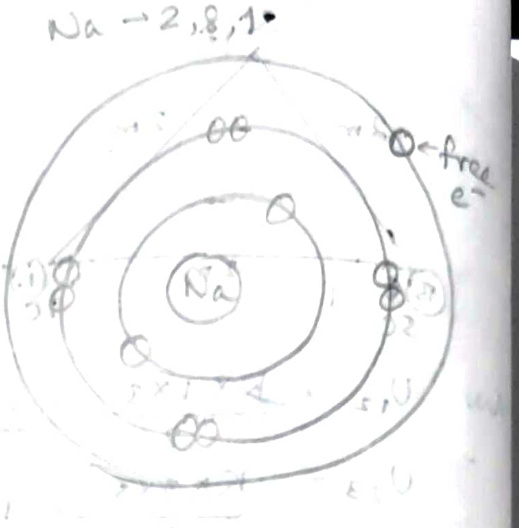
Total force of q_0

$$\vec{F} = \sum_{i=1}^{n}\frac{1}{4\pi\varepsilon_0}\frac{q_0q_i}{(r_{0i})^2}\hat{r}_{0i}$$

3. * **Free electron :-**

→ e^- which are present in outer orbit.

→ These free e^- carry electricity



* **Bound electrons :-**

→ e^- which are tightly bounded to nucleus.

* **Conductor :-**

→ The substance in which more no. of free e^-s than bound e^-s.

→ Ex:- iron, copper, silver.

* **Insulator :-**

→ In which more bound e^-s than free e^-s

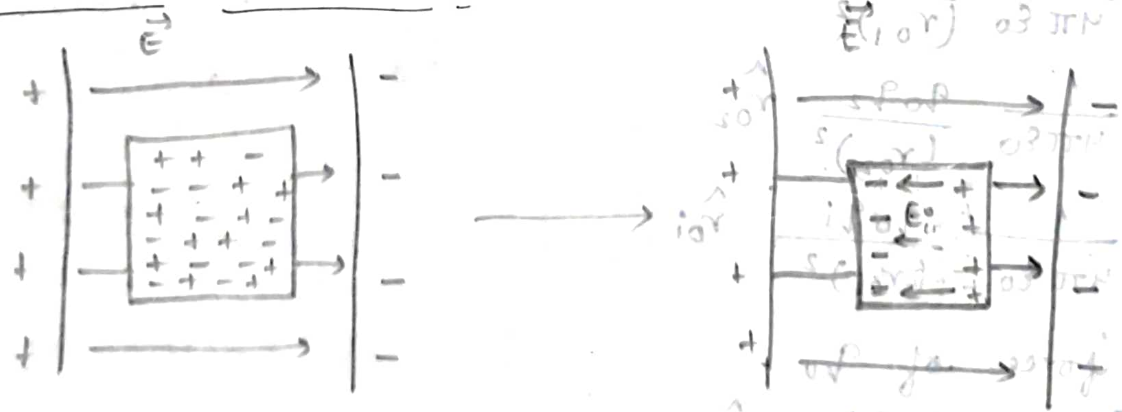
→ Ex :- wood, glass, plastic etc

* **Semi conductor :-**

→ The conductivity lies in between conductor & insulator.

→ Ex :- Germanium, Silicon.

* **Conductor inside an $\vec{E}$:-**



$$E_{final} = \vec{E} - \vec{E_i}$$

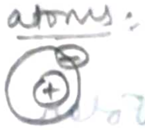
→ when a conductor is placed inside an $\vec{E}$ then positive charges of conductor gathers near the negative side of $\vec{E}$ and vice-versa.

→ After that, inside conductor an internal $\vec{E}$ (E_i) develop in opposite direction as compared to external electricfield.

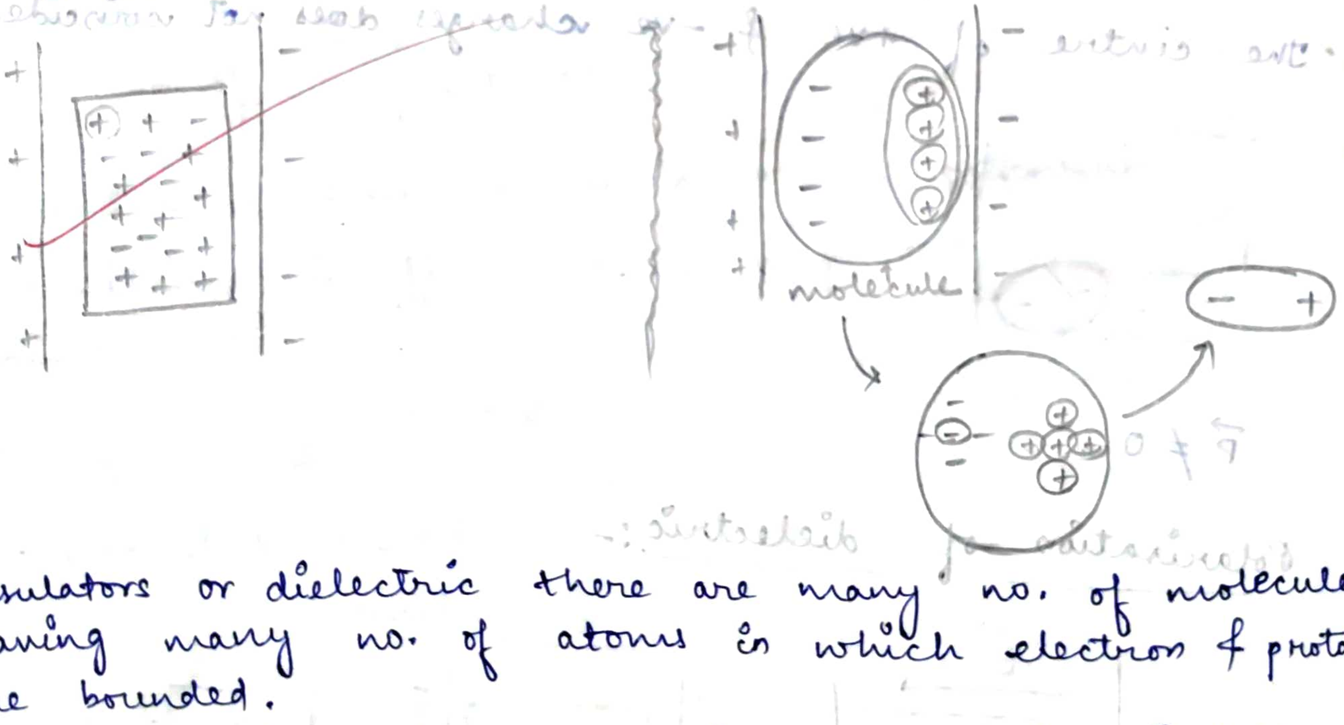
$$\vec{E}_{final} = \vec{E} - \vec{E}_i$$

→ when external $\vec{E}$ is in equilibrium with internal $\vec{E}$ then it seems that there will be no $\vec{E}$ inside the conductor.

*. Insulator in an $\vec{E}$:-



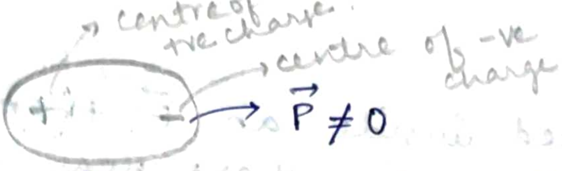
→ It is also known as dielectric.



→ Insulators or dielectric there are many no. of molecules having many no. of atoms in which electron & proton are bounded.

→ when the dielectric placed in an electric field then positive & negative charges separated and make groups.

→ the positive charge group & the negative charge group have centre of +ve charge & -ve charge respectively.

→ 

molecule of dielectric

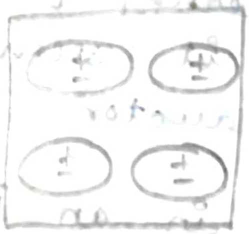
→ Each molecule have dipole moment i.e $\vec{P} \neq 0$.

*. Dielectrics are divided into 2 categories

1) Non- polar dielectric:

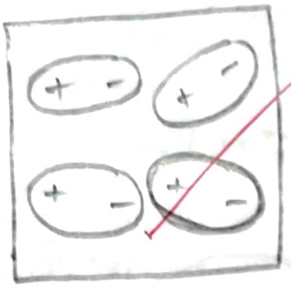
→ In this type the centre of +ve & -ve charges approximately coinside.

→ $\vec{P} = 0$.



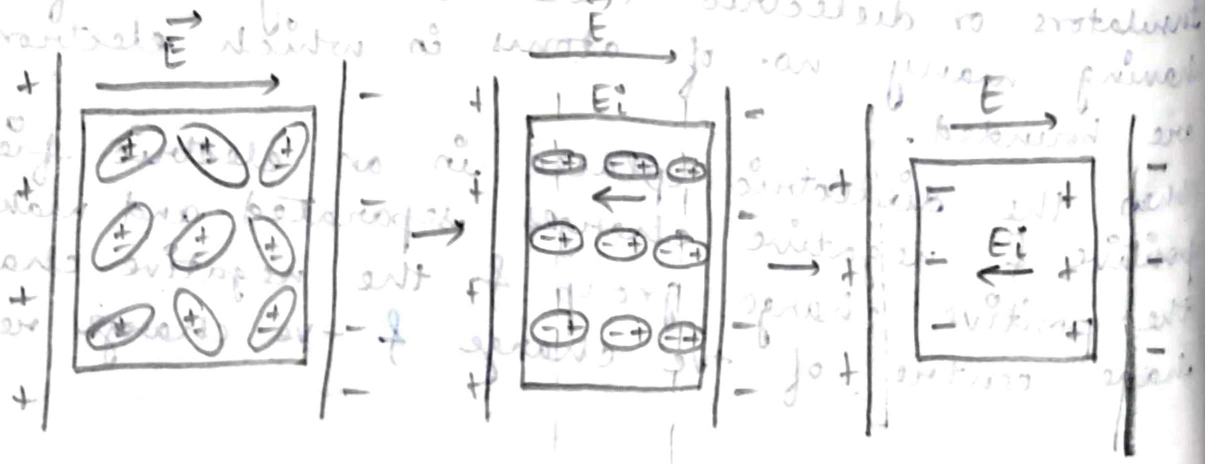
2) Polar dielectric :

→ The centre of +ve & -ve charges does not coinside.

→ 

$\vec{P} \neq 0$.

*. Polarisation of dielectric :-



→ When a non-polar dielectric is placed inside an $\vec{E}$ the molecules which are randomly oriented are now oriented in a regular manner.

→ The +ve & -ve charges of each molecule neutralize each other & finally -ve charge induce in the +ve side of the electric field & vise-versa. Then an internal electricfield developed inside the dielectric.

Hence, this process is called polarisation.

→ The polarisation is depends on the ~~ex~~ strength of the external electricfield.

*. Capacitance :-

→ The ability to store charge w.r.t. potential.

$Q \propto V$ — potential.

$\Rightarrow Q = CV$

$\Rightarrow C = \frac{Q}{V}$ = capacitance.

→ Capacitance means, charge per unit potential.

→ Capacitance is fixed for a capacitor.

Unit :

$C = \frac{Q}{V} = \frac{C}{\text{Volt}}$ = farad.

esu → stat farad

emu → ab farad.

~~taf~~ $1F = 9 \times 10^{11}$ S.F (stat farad)

$1F = \frac{1}{10^9}$ ab.F

Dim^n : $\frac{Q}{V}$

$= \frac{AT}{M^1L^2T^{-3}A^{-1}} = [M^1L^{-2}T^4A^2]$

3 *. Capacitance of an isolated sphere :-

Imp

$C = 4\pi\varepsilon_0 r$ ↳ radius.

$\frac{1}{9\times10^9}$

For earth,

$r_e = 6.4 \times 10^3$ km

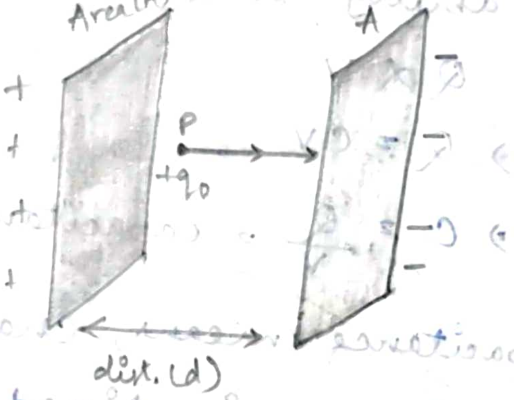
$= 6.4 \times 10^6$ m.

$\Rightarrow C = \frac{\cancel{} \times 6.4 \times 10^6}{9 \times 10^9} = \underline{\underline{711\,\mu F}}$

Numerical Imp

*. (v) Parallel plates capacitor :-

→ Two parallel plates of area A and separated by d are charged to +ve & −ve respectively.



$\vec{E}$ at P is $\vec{E} = \frac{\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0} = \frac{\sigma}{\varepsilon_0}.$

(due to parallel plate) (Chp-1)

The relation between V & E & d is

$V = -Ed.$

$$\boxed{V = -\frac{\sigma d}{\varepsilon_0}}$$

$E = -\frac{dv}{dt}$

$\Rightarrow E = -\frac{V}{d}$

$\Rightarrow V = -Ed$

and capacitance

$$C = \frac{Q}{V} = \frac{Q}{\frac{\sigma d}{\varepsilon_0}} = \frac{Q\varepsilon_0}{\sigma d}$$

We know,

$\sigma = \frac{Q}{A}$

$$C = \frac{\cancel{Q}\varepsilon_0}{\frac{\cancel{Q}}{A} d} = \frac{\varepsilon_0 A}{d}$$

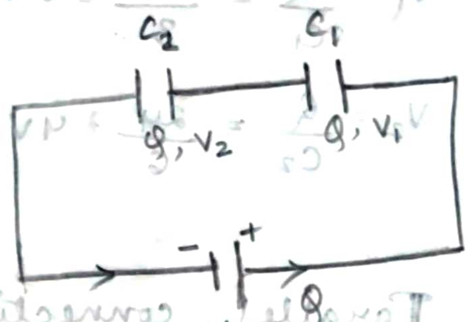
Q1- If area of a parallel plate capacitor doubled and separation decrease to half then find change in capacitance.

Ans- $C' = \frac{\varepsilon_0 A'}{d'} = \frac{\varepsilon_0 2A}{d/2} = \frac{4\varepsilon_0 A}{d} = 4C$

$4C - C = 3C$

*. Combination of capacitor :-

⊛ Series connection :-



Potential ← V

flow of current +ve to -ve

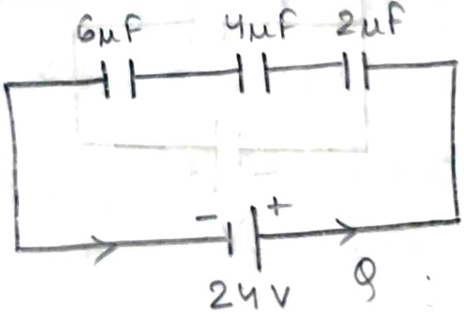
→ In series Q is constant at all capacitor.

$V = V_1 + V_2$

$\Rightarrow \frac{Q}{C_{eq}} = \frac{Q}{C_1} = \frac{Q}{C_2}$

$$\Rightarrow \boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}}$$

Q-



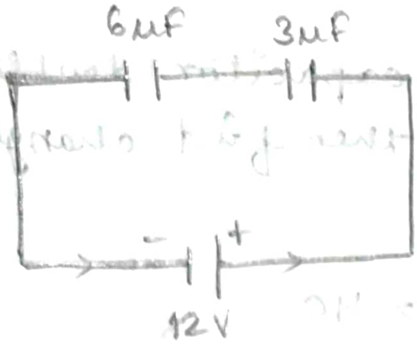
Find $C_{eq} = ?$ and $Q = ?$

Ans- $\frac{1}{C_{eq}} = \frac{1}{2} + \frac{1}{4} + \frac{1}{6} = \frac{6+3+2}{12} = \frac{11}{12}$

$\Rightarrow C_{eq} = \frac{12}{11}$ μF.

$Q = C \times V$ [$\because C = \frac{Q}{V}$]

$= 24 \times \frac{12}{11} = \frac{288}{11} = 26.1$ μC.
(microcoulomb)

3 Q:- 

Find Potential drop at each capacitor ?

Ans:- $C_{eq} = \frac{1}{3} + \frac{1}{6} = \frac{2+1}{6} = \frac{3}{6} = 2$

$Q = C \times V$

$= 2 \times 12 = 24\ \mu C.$

$V_1 = \frac{Q}{C_1} = \frac{24}{3} = 8V$

$V_2 = \frac{Q}{C_2} = \frac{24}{6} = 4V.$

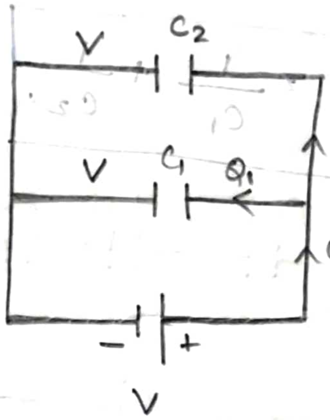
*. **Parallel connection:-**

→ $Q = Q_1 + Q_2$

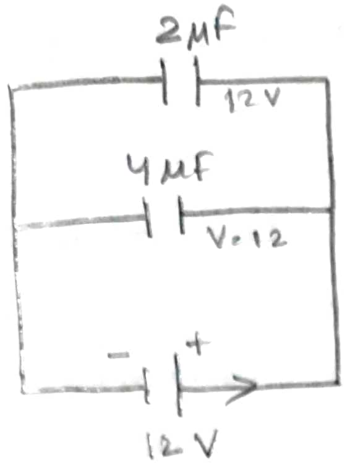
→ V is constant

⇒ $C_{eq} \times V = C_1 \times V + C_2 \times V$

⇒ $\boxed{C_{eq} = C_1 + C_2}$



Q2



Find charge on each capacitor?

Ans: $C_{eq} = 2 + 4 = 6\mu F$

$Q = C \times V = 6 \times 12 = 72\ \mu C.$

$Q_1 = C_1 \times V = 4 \times 12 = 48 \mu C$

$Q_2 = C_2 \times V = 2 \times 12 = 24\ \mu C.$

*. **Mixed connections-**

Ex:- C_1 & C_2 are in series.

$$\frac{1}{C_{12}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2}$$

$C_{12} = 2\ \mu F$

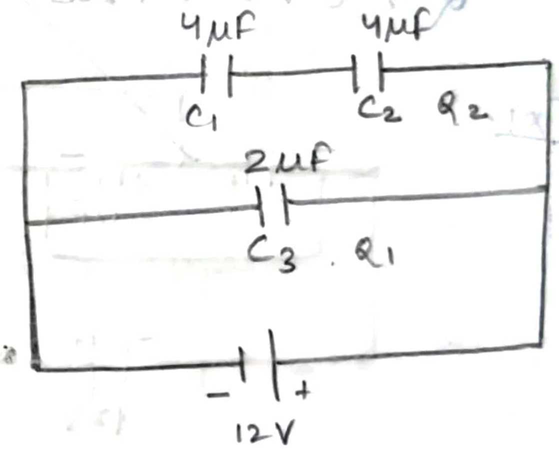
C_{12} & C_3 are in parallel

So, $C_{eq} = 2 + 2 = 4\mu F.$

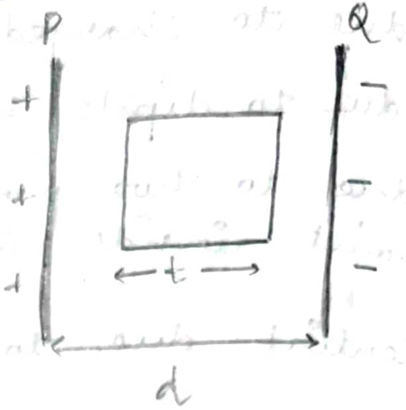
$Q = 4\mu F \times 12 = 48\ \mu C.$

$Q_1 = C_1 V = 2 \times 12 = 24\ \mu C$

$Q_2 = C_2 V = 2 \times 12 = 24.\ \mu C.$



* imp Conductor inside a parallel plate capacitor :-



Suppose a conductor of thickness t is placed inside a parallel plate capacitor separated by distance d of area A.

It is partially filled.

$\vec{E}$ is due to the distance, $(d-t)$

$$\boxed{C = \frac{\varepsilon_0 A}{d-t}}$$

When it is full filled then

$d = t$

$$C = \frac{\varepsilon_0 A}{0} = \infty.$$

Capicitance infinite mean charge conduct ~~from~~ from one plate to another plate.

Q!. Find change in capacitance when a conductor of thickness 0.1×10^{-2} m is placed inside of a capacitor of area $0.225\ cm^2$ and distance 0.5 cm.

Ans. $\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/Nm^2$.

$A = 0.225\ cm^2 = 0.225 \times (10^{-2})^2 = 0.225 \times 10^{-4}\ m^2$.

$d = 0.5\ cm = 0.5 \times 10^{-2}\ cm$

$t = 0.1 \times 10^{-2}\ m$.

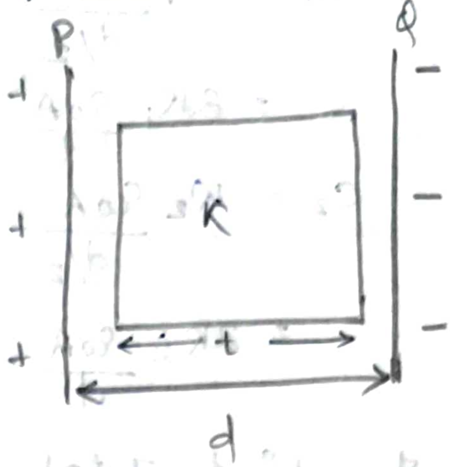
$$C = \frac{8.85 \times 10^{-12} \times 0.225 \times 10^{-4}}{(0.5 - 0.1) \times 10^{-2}}$$

$$= \frac{1.99 \times 10^{-16}}{0.4 \times 10^{-2}} = 4.8 \times 10^{-14}\ c^2/Nm^2.$$

Imp

* Dielectric or insulator inside a capacitor :-

A dielectric of constant K & thickness t is placed inside a capacitor of area A and separation d.



The electric field decreases when dielectric introduced.

$$E = \frac{E_0}{K}$$

$$\boxed{C = \frac{\varepsilon_0 A}{d - t + t/K}}$$

When the parallel plates are full filled

$d = t$

$$C = \frac{\varepsilon_0 A}{d - d + d/K}$$

$$= \frac{\varepsilon_0 A}{d/K} = K\frac{\varepsilon_0 A}{d} = K C_0$$

original capacitance.

Q1. If capacitance increased to 1.5 times when dielectric introduced then find dielectric constant ?

Ans. $C = 1.5\, C_0$

$C = K \times C_0$

$\Rightarrow 1.5\, \cancel{C_0} = K \cancel{C_0}$

$\Rightarrow \boxed{K = 1.5}$

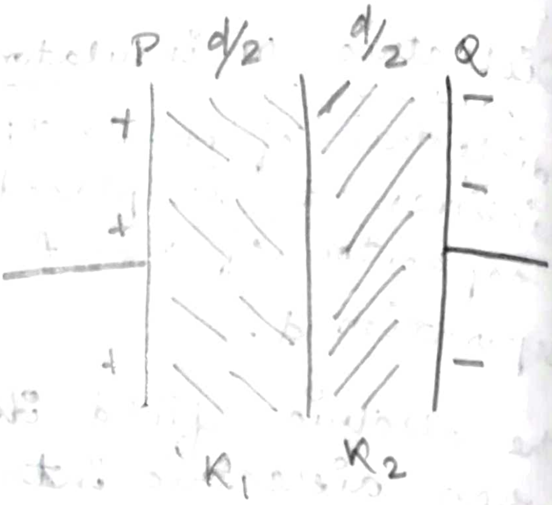
Imp

1 * $C_1 = K_1 \frac{\varepsilon_0 A}{d/2}$

$= 2K_1 \frac{\varepsilon_0 A}{d}$

$C_2 = K_2 \frac{\varepsilon_0 A}{d/2}$

$= 2K_2 \frac{\varepsilon_0 A}{d}$



To find Total capacitance is in series

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$\frac{1}{C_{eq}} = \frac{1}{2K_1 \frac{\varepsilon_0 A}{d}} + \frac{1}{2K_2 \frac{\varepsilon_0 A}{d}}$$

$$= \frac{1}{\frac{\varepsilon_0 A}{d}} \left(\frac{1}{2K_1} + \frac{1}{2K_2} \right)$$

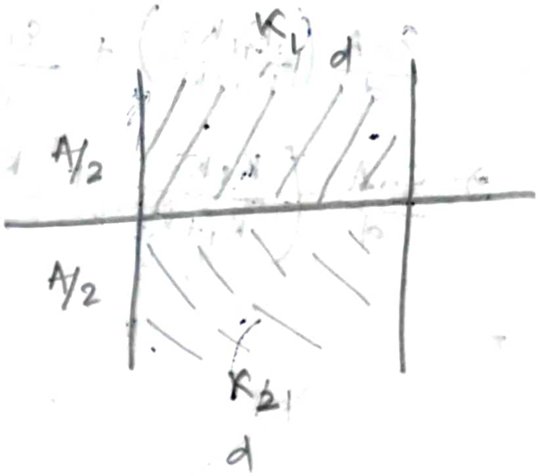
$$= \frac{d}{\varepsilon_0 A} \left(\frac{\cancel{2}K_2 + \cancel{2}K_1}{\cancel{4}_2 K_1 K_2} \right)$$

$$= \frac{d}{\varepsilon_0 A} \left(\frac{K_1 + K_2}{2K_1 K_2} \right)$$

$$C_{eq} = \frac{\varepsilon_0 A}{d} \left(\frac{2K_1 K_2}{K_1 + K_2} \right)$$

$$K_{eq} = \frac{2K_1 K_2}{K_1 + K_2}$$

*. This is a parallel connection.

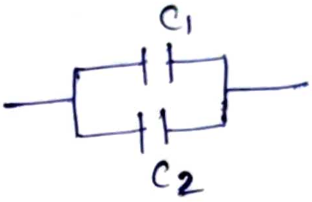


$$C_1 = \frac{\varepsilon_0 A/2}{d} K_1$$

$$C_2 = \frac{\varepsilon_0 A/2}{d} K_2$$

$$C_{eq} = C_1 + C_2$$

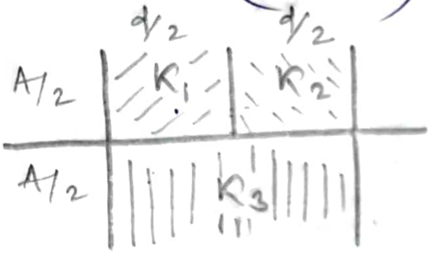
$$= \frac{\varepsilon_0 A}{d} \times \frac{K_1}{2} + \frac{\varepsilon_0 A}{d} \times \frac{K_2}{2}$$

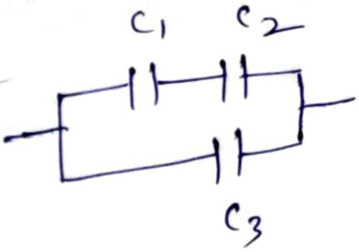


$$= \frac{\varepsilon_0 A}{d}\left(\frac{K_1}{2} + \frac{K_2}{2}\right)$$

$$= \frac{\varepsilon_0 A}{d}\left(\frac{K_1 + K_2}{2}\right)$$

Q:-





Find C_{eq} = ?

find K_{eq} = ?

Ans:- $C_1 = \frac{\varepsilon_0 A/2}{d/2} K_1 = \frac{\varepsilon_0 A}{d} K_1$

$$C_2 = \frac{\varepsilon_0 A/2}{d/2} K_2 = \frac{\varepsilon_0 A}{d} K_2$$

$$\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2}$$

$$= \frac{d}{\varepsilon_0 A K_1} + \frac{d}{\varepsilon_0 A K_2}$$

$$= \frac{d}{\varepsilon_0 A}\left(\frac{1}{K_1} + \frac{1}{K_2}\right)$$

$$= \frac{d}{\varepsilon_0 A}\left(\frac{K_1 + K_2}{K_1 K_2}\right)$$

$$C_{eq} = \frac{\varepsilon_0 A}{d}\left(\frac{K_1 K_2}{K_1 + K_2}\right)$$

*. Energy stored in a capacitor :-

Potential energy of a capacitor is defined as the amount of workdone in charging the capacitor.

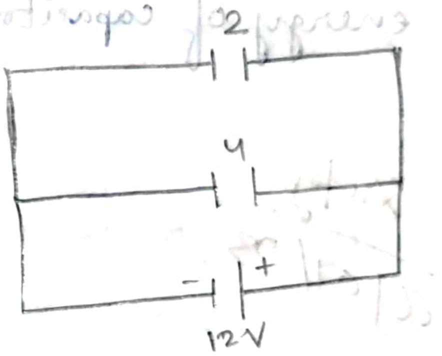
* There are 3 formula to find energy

$W = \frac{1}{2} CV^2$ → for parallel connection

$= \frac{1}{2} \frac{Q^2}{C}$ → for series connection

$= \frac{1}{2} QV$ → where capacitance is unknown

Q :-

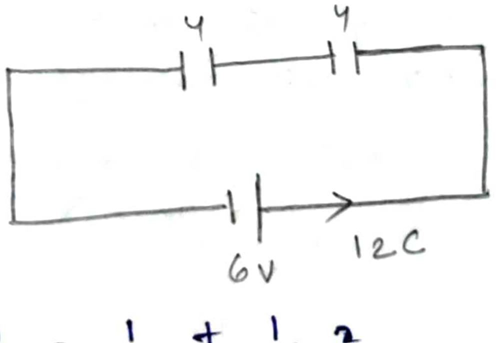


find energy of each capacitor.

Ans :- $W_1 = \frac{1}{2} C_1 V_1^2 = \frac{1}{2} \times 2 \times (12)^2 = 144$ J

$W_2 = \frac{1}{2} C_2 V_2^2 = \frac{1}{2} \times 4 \times (12)^2 = 288$ J

Q :-



Ans :- $\frac{1}{C_{eq}} = \frac{1}{4} + \frac{1}{4} =$

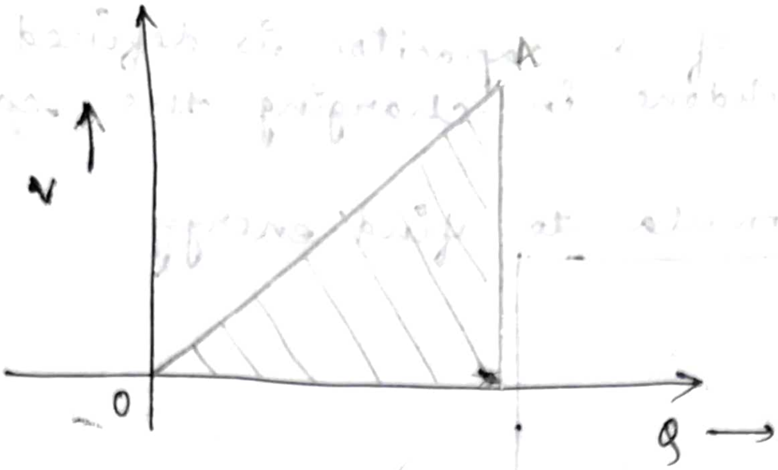
$\Rightarrow C_{eq} = 2$

$\Rightarrow \frac{1}{2} \times \frac{12^2}{4} = \frac{1}{\cancel{2}} \times \frac{\overset{72}{\cancel{144}}}{4} = 18$ J

$\Rightarrow W_1 = 18$ J

$\Rightarrow W_2 = 18$ J

*. Graph :-



$$\text{Area} = \frac{1}{2} \times Q \times V$$

$$= \frac{1}{2} QV = \text{Energy}$$

Area under Q ~ V graph gives energy of capacitor.

06/07/23

3. Current Electricity

*. Electric current :-

→ The flow of charge with respect to time.

$$\boxed{I = \frac{q}{t}}$$

$$I_{avg} = \frac{\Delta q}{\Delta t} = \frac{q_2 - q_1}{t_2 - t_1}$$

$$I_{instant} = \frac{dq}{dt}$$

→ Unit :- $C/_{sec}$

→ Dim^n :- [A]

→ Current divided on path dependeds. but direction cannot be divide, So, current is not considered ~~by~~ as vector.

→ Current can be added algebrically.

*. Average Current :-

$$I_{avg} = \frac{\Delta q}{\Delta t}$$

*. Instantaneous current :-

$$I_{instant} = \frac{dq}{dt}$$

Q: If charge is given as a function of time i.e. $q = 2t + 5t^2 C$ find current at $t = 2 sec$?

Ans:- $q = 2t + 5t^2$

$$I_{instant} = \frac{dq}{dt} = \frac{d}{dt}(32t + 5t^2)$$

$$= 2 + 10t$$

at time, $t = 2$

$I = 2 + 10 \times 2 = 22$ A.

Q: If current in a conductor is given as $3t^2 + 10$ A. Then find amount of charge flows from $t = 1$ to 2sec.

Ans: $I = 3t^2 + 10$

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

$$\Rightarrow \int dq = \int I dt$$

$$\Rightarrow q = \int_1^2 (3t^2 + 10) dt$$

$$= 3\left[\frac{t^3}{3}\right]_1^2 + 10[t]_1^2$$

$$= \cancel{3} \times \left(\frac{2^3}{\cancel{3}} - \frac{1^3}{\cancel{3}}\right) + 10$$

$$= 8 - 1 + 10 = 17 C.$$

14/07/2023

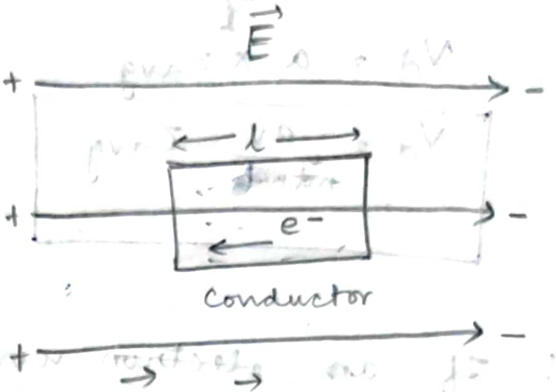
Imp

* Drift Velocity :-

→ Electrons move inside a conductor when placed in an electric field with some velocity.

→ They collide with each other as there are n no. of e⁻s.

→ Due to that their actual velocity decreases and that average velocity with ~~&~~ which e⁻s move is called, drift velocity.



$\vec{V}_d = \vec{a} \times \underbrace{time}_{\text{relaxcation time}}$

↓ velocity

$= \tau_{avg}$ (tao)

We know $\vec{E}$ is given as

$$E = -\frac{V}{l} \quad \text{—} \quad ①$$

Force on one e⁻ is

$$F = -eE \qquad \left[\because F = qE \atop = -eE\right]$$

$$= -e \times -\frac{V}{l}$$

$$= \frac{eV}{l} \xrightarrow{} \text{Potential}$$

$$\Rightarrow ma = \frac{eV}{l}$$

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

Average relaxcation time

$$\tau_{avg} = \frac{\tau_1 + \tau_2 + \dots + \tau_n}{n}$$

Finally drift velocity

$V_d = a \times \tau_{avg}$

$$\boxed{V_d = \frac{ev}{ml} \tau_{avg}}$$

Q: If an ~~electron~~ conductor is placed in an electric field 9.1×10^{-2} N/C with $\tau_{avg} = 2 \times 10^{-14}$ sec. Find a drift velocity?

$e = 1.6 \times 10^{-19}$

$m = 9.1 \times 10^{-31}$

Ans. $\tau_{avg} = 2 \times 10^{-14}$ sec

$e = 1.6 \times 10^{-19}$

$m = 9.1 \times 10^{-31}$

$E = 9.1 \times 10^{-2}$

$$V_d = \frac{eE}{m} \tau_{avg}$$

$$= \frac{1.6 \times 10^{-19} \times 9.1 \times 10^{-2}}{9.1 \times 10^{-31}} \times 2 \times 10^{-14}$$

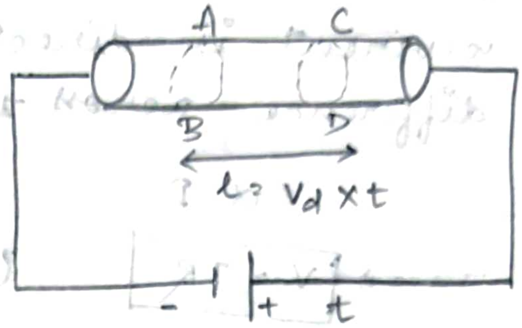
$$= 3.2 \times 10^{-19} \times 10^{-2} \times 10^{-14} \times 10^{31}$$

$$= 3.2 \times 10^{-35} \times 10^{31}$$

$$= 3.2 \times 10^{-4} \text{ m/s}.$$

*. Relation between V_d and I :-

Let n be the no. of electrons is unit volume,
So,
total electron will be



$N = n \times \text{volume}$

$= n \times A \times L$

$= n \times A \times V_d$

$q = Ne = neAV_d t$

charge,

$I = \frac{q}{t}$

$= \frac{nAV_d \cancel{t} e}{\cancel{t}}$

$= \boxed{nAV_d e}$

*. Mobility (μ) :-

The drift velocity per unit electric field.

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

$$\frac{M/s}{N/C} = \frac{Mc}{N sec}.$$

17/07/2023

*. Ohm's law :-

→ "For a conductor, at a given temperature the current is directly proportional to potential difference across the conductor."

$$V \propto I$$

$$\Rightarrow \boxed{V = IR} \quad (R = \text{Resistance})$$

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

We know

$$I = nAV_d e$$

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

$$I = nA\frac{e^2V}{ml}\tau$$

$$\Rightarrow \frac{V}{I} = \frac{ml}{nAe^2\tau} \qquad \left[\because \frac{V}{I} = R\right]$$

$$\Rightarrow \boxed{R = \frac{ml}{nAe^2\tau}}$$

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

$$\Rightarrow \boxed{R = \underset{\text{resistivity}}{\rho}\frac{l}{A}}$$

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

→ const. for a given wire.

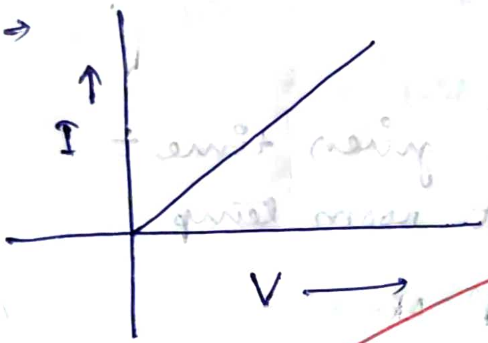
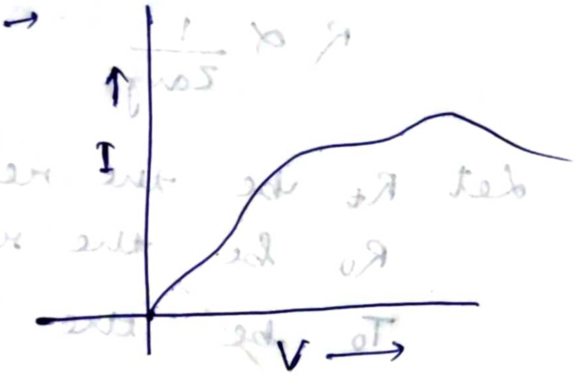
Q: If length of a wire doubled and area become half then what happened to Resistance ?

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

$l' \rightarrow 2l$

$A' \rightarrow A/2$

$R' = \frac{\rho l'}{A'} = \frac{\rho 2l}{A/2} = \frac{4\rho l}{A} = 4R.$

*. Ohmic conductor	Non-ohmic conductor
→ Obey ohm's law	→ do not obey ohm's law
→ 	→ 

*. Resistance (R) :-

→ It is the opposition offered by conductor to the flow of current.

→ $R = \frac{V}{I}$

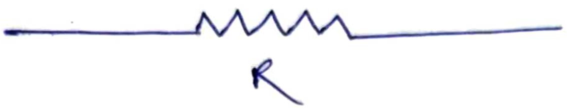
→ unit :- ohm (or) Ω

→ Dim^n :- $\frac{V}{I} = \frac{W}{q} = \frac{W}{It}$

$\Rightarrow \frac{W}{I^2 t} = \frac{M^1 L^2 T^{-2}}{A^2 T^1} \Rightarrow [M^1 L^2 T^{-3} A^2]$

→ The device that provide resistance is called resistor.

→



*. Variation of resistance with temperature :-

→ When temp. increases the collision rate increases which cause decrease in relaxation time.

So, when relaxation time decreases then resistance increases i.e.

$$\uparrow R \propto \frac{1}{\tau_{avg}\downarrow}$$

Let R_t be the resistance at given time t

R_0 be the resistance at room temp.

T_0 be the room temp.

T be the given temp.

$$R_t = R_0(1+\alpha(T-T_0))$$

where α = temp. coefficient of resistance

$$\boxed{\alpha = \frac{R_t - R_0}{R_0(T-T_0)}}$$

Unit = $\overset{\text{Kelvin}}{K^{-1}}$ (or) $\overset{\text{Celcius}}{C^{-1}}$

*. Resistivity & ρ conductivity :-

→ $R = \underset{\substack{\downarrow \\ \text{resistivity}}}{\rho} \frac{l}{A}$

⇒ $\boxed{\rho = \frac{RA}{l}}$

Unit = ohm m.

④ Conductivity :-

→ Reciprocal of resistivity

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

Unit :- $\text{ohm}^{-1}\ m^{-1}$

$= \text{siemen}\ m^{-1}$

$= \text{mho}\ m^{-1}$

*. Imp

Current density (J) :-

→ Current per unit area of cross section for a conductor in the direction of current flow.

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

⇒ $\boxed{I = \vec{J} \cdot \vec{A}}$

Unit :- $\underset{\substack{\downarrow \\ \text{Area}}}{A}\ \underset{\substack{\downarrow \\ \text{mtr}}}{m}^{-2}$

imp

*. Relation between $\vec{J}$ and $\vec{E}$:-

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

ohm law, $V = IR$

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

$$\Rightarrow J = \frac{V}{RA}$$

∴ Relⁿ betⁿ E & V :-

$$E = \frac{V}{l} \Rightarrow V = El$$

$$\Rightarrow J = \frac{El}{RA}$$

$$= \frac{E}{RA/l} \rightarrow \rho$$

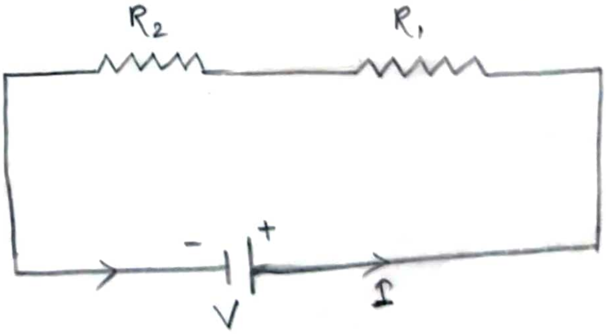
$$= \frac{E}{\rho}$$

$$\Rightarrow \boxed{J = \sigma \cdot E}$$

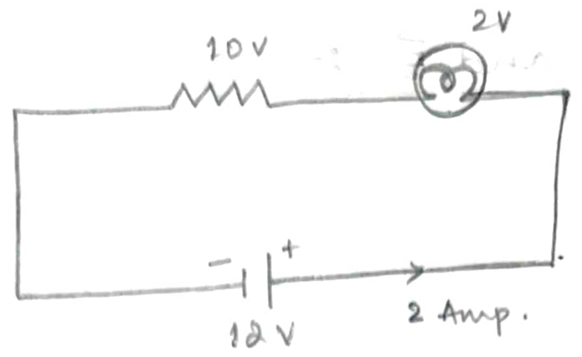
*. Series connection of resistor :-

→ $R_{eq} = R_1 + R_2$

→ I remain constant.



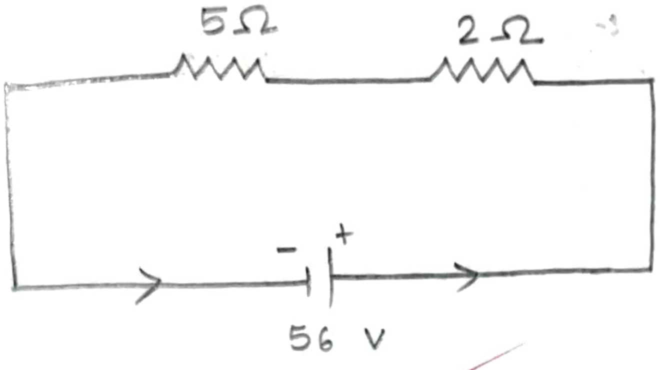
Q↳



$V = IR$

$R = \frac{V}{I} = \frac{10}{2} = 5\Omega$

Q↳



Find $R_{eq} = ?$

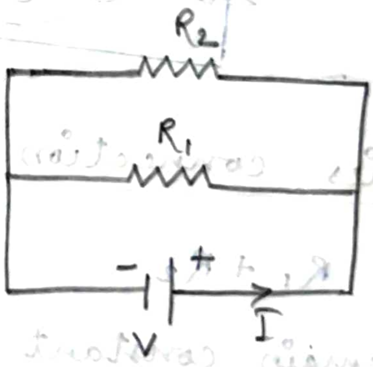
$R_{eq} = R_1 + R_2 = 7\Omega$

$I = \frac{V}{R} = \frac{56}{7} = 8 A.$

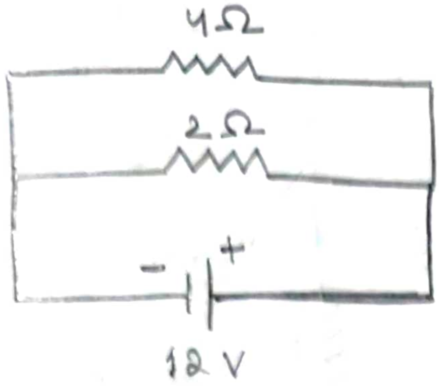
*. Parallel connection :-

→ $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2}$

→ V constant.



Q:



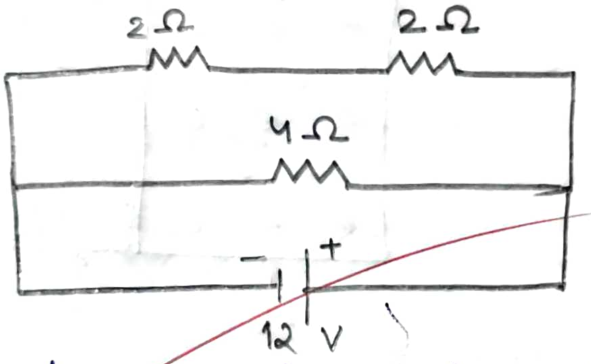
Ans: $\frac{1}{R_{eq}} = \frac{1}{2} + \frac{1}{4} = \frac{2+1}{4} = \frac{3}{4}$

$R_{eq} = \frac{4}{3}\ \Omega$

$I = \frac{V}{R} = \frac{12}{4/3} = 9A$.

*. Mixed connection :-

Q:



Ans: $\frac{1}{R_{eq}} = \frac{1}{4} + \frac{1}{4} = \frac{2}{4} = \frac{1}{2}$

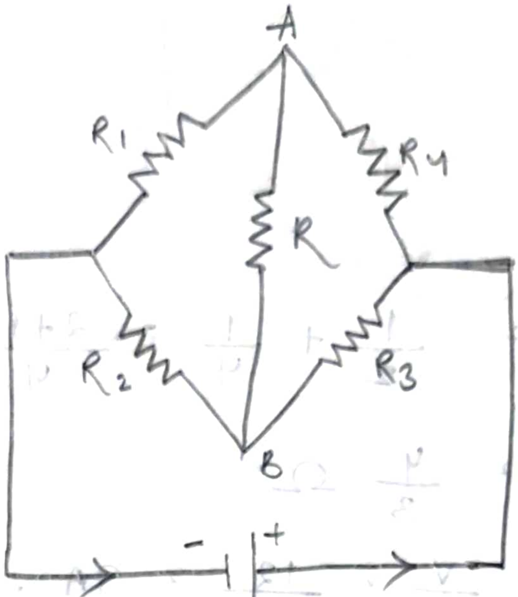
$R_{eq} = 2$

$I = \frac{V}{R} = \frac{12}{2} = 6A$

*. Wheat stone bridge :-

If $\frac{R_1}{R_2} = \frac{R_3}{R_4}$, then

R is neglected.



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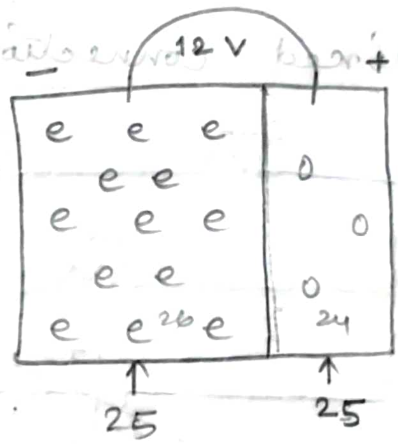
*. Emf (Electro motive force) :-

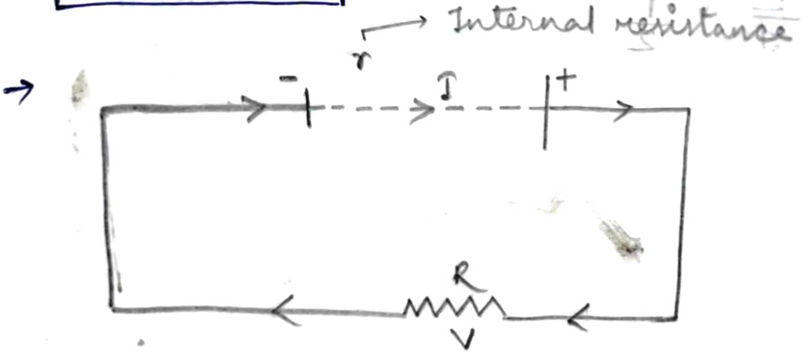
→ Emf is the actual potential when battery is not connected.

→ Emf responsible for motion of charges.

→ $\boxed{Emf = \frac{W}{q}}$



→



$EMF = V + \textcircled{Ir}$ → Potential consumed by internal resistance of battery.

→ EMF > Potential (V)

→ EMF is the cause, V is the effect.

$V = Emf - Ir$

$\boxed{V = E - Ir}$

Q: Emf of a battery is given as 12 V, when the circuit is closed it's potential reading out to be 11.75V. Find the potential resisted by battery?

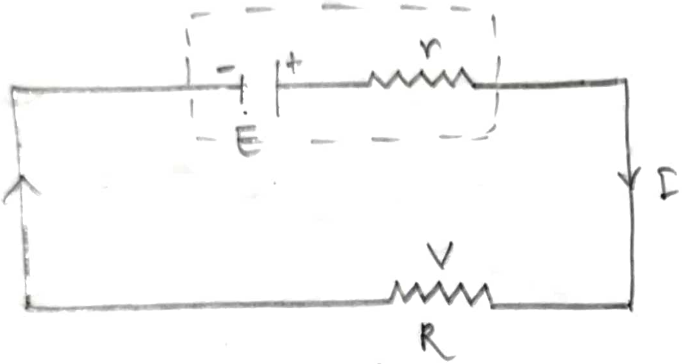
Ans: $E = V + Ir$

$Ir = E - V$

$= 12 - 11.75\ V$

$= 0.25\ V$

*.



$\Rightarrow E = V + Ir$

$V = IR$

$\Rightarrow E = IR + Ir$

$\Rightarrow E = I(R + r)$

$\Rightarrow \boxed{I = \frac{E}{R+r}}$

Q: A battery marked as 24V when connected to 4Ω resistor it's potential reading is 11.60 V, current is given as 2A. Find internal resistance & Req?

Ans: $E = 24V$

$R = 4\Omega$

$V = 11.6$

$I = 2$

$r = ?$

$\Rightarrow E = V + Ir$

$\Rightarrow Ir = E - V$

$= 12 - 11.6$

$= 0.4$

$\Rightarrow r = \frac{0.4}{I} = \frac{0.4}{2} = \boxed{0.2\ \Omega}$

$\Rightarrow R_{eq} = R + r$

$= 4 + 0.2$

$= 4.2\ \Omega$

21/07/2023

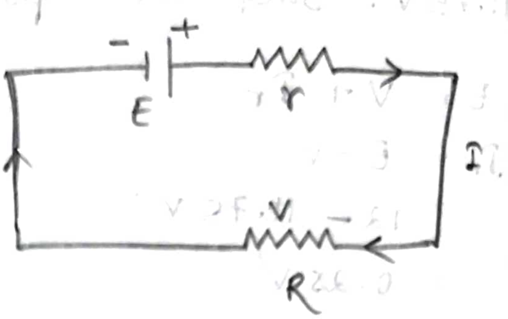
*. Internal Resistance :-

$V = E - Ir$

$\Rightarrow E = V + Ir$

$= IR + Ir$

$= I(R+r)$



$$\Rightarrow \boxed{I = \frac{E}{R+r}} \quad — ①$$

Put I,

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

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

$\Rightarrow V = E\left(\frac{R+\cancel{r}-\cancel{r}}{R+r}\right)$

$$\Rightarrow \boxed{V = \frac{ER}{R+r}} \quad — ②$$

$\Rightarrow V(R+r) = ER$

$\Rightarrow VR + Vr = ER$

$\Rightarrow Vr = ER - VR$

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

$$\Rightarrow \boxed{r = \left(\frac{E-V}{V}\right) R}$$

$E = V + Ir$

$\frac{E-V}{I} = r$

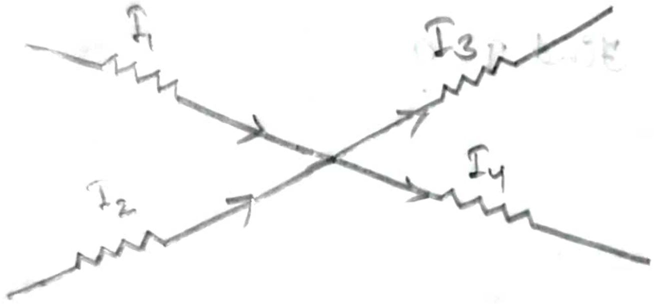
*. Kirchhoff's Law :-

⊛ KCL (Kirchhoff's Current Law) :-

→ Current entering to a junction is equal to current leaving the junction.

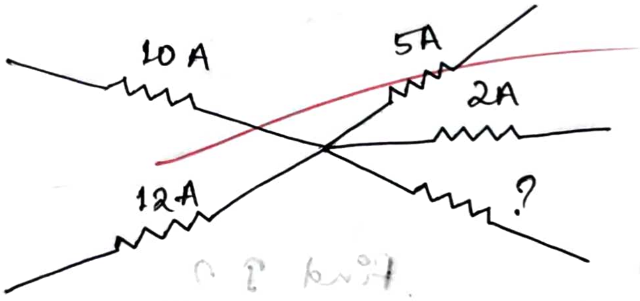
→ It works on the principle of conservation of charge.

→



$$\boxed{I_1 + I_2 = I_3 + I_4}$$

Q:-



Ans:- $I_1 + I_2 = I_3 + I_4 + I_5$

⇒ $10 + 12 = 5 + 2 + x$

⇒ $22 = 7 + x$

⇒ $22 - 7 = x$

⇒ $15 = x$

⇒ $x = 15\text{ A}$

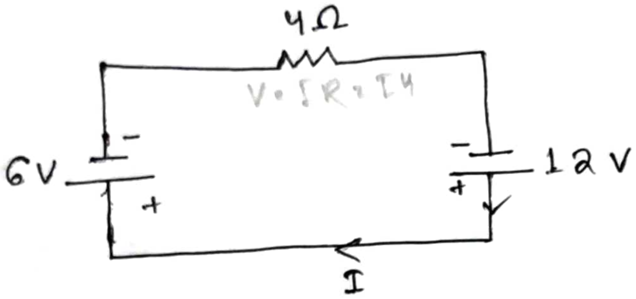
*. KVL (Kirchhoff's Voltage Law):-

→ In a closed circuit, the sum of potential is zero

$$\boxed{\Sigma \Delta V = 0}$$

→ $V_1 + V_2 + \dots + V_n = 0$

Q1



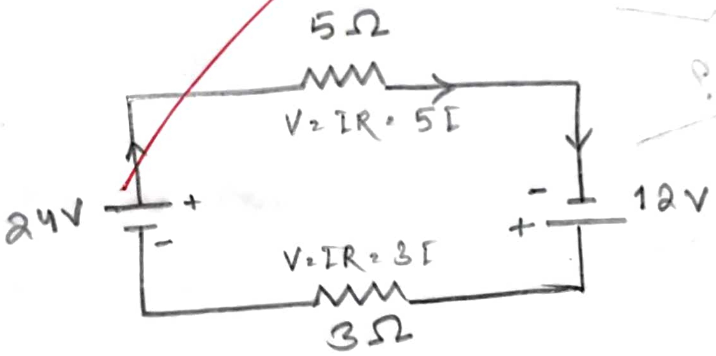
Find $I = ?$

Ans:- $12 - 6 = V_R = 0$

$\Rightarrow 6 - 4I = 0$

$\Rightarrow I = \frac{6}{4} = \frac{3}{2} = 1.5\ A$.

Q1



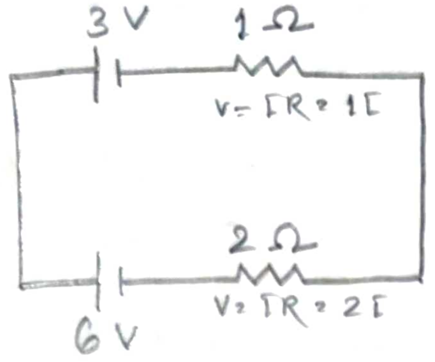
Find I ?

Ans:- $24 + 12 - 5I - 3I = 0$

$\Rightarrow \cancel{-}8I = \cancel{-}36$

$\Rightarrow I = \frac{36}{8} = 4.5\ A$.

Q:-



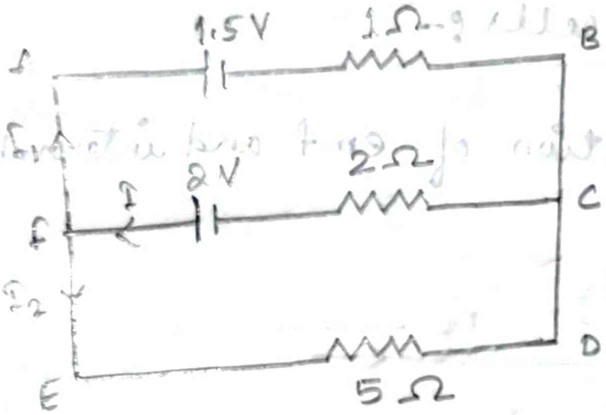
find I ?

Ans:- $6 - 3 - 1I - 2I = 0$

⇒ $3I = 3$

⇒ $I = 1\ A.$

Q:



Find I ?

Ans:- For ABCDEFA,

⇒ $1.5 - I_1 \times 1 - 5I_2 = 0$ — ①

for DEFC,

⇒ $2 - 5I_2 - 2I = 0$ — ②

⇒ $1.5 - I_1 - 5I_2 = 0$ — ①

$2 - 5I_2 - 2I = 0.$ $[\because I = I_1 + I_2]$

⇒ $2 - 5I_2 - 2I_1 - 2I_2 = 0$

⇒ $2 - 7I_2 - 2I_1 = 0$ — ②.

$2 \times (1.5 - I_1 - 5I_2) = 0$

$2 - 7I_2 - 2I_1 = 0$

$- \quad + \quad -$

$3 - 2I_1 + 2I_1 - 10I_2 + 7I_2 = 0$

⇒ $1 - 3I_2 = 0$

⇒ $\boxed{I_2 = \frac{1}{3}}$

$2 - \frac{7}{3} - 2I_1 = 0$

$\Rightarrow -\frac{1}{3} - 2I_1 = 0$

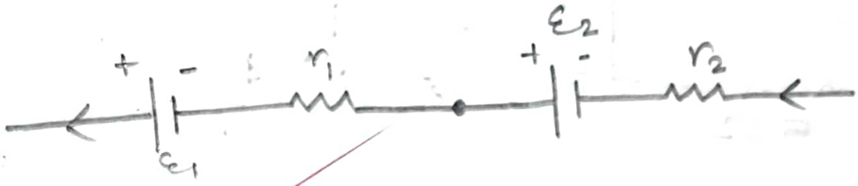
$\Rightarrow I_1 = -\frac{1}{6}$

$\Rightarrow I = \frac{1}{3} - \frac{1}{6}$

$= \frac{1}{6}$ A.

*. Series combination of cells :-

→ A cell is a combination of emf and internal resistance.



$r_{eq} = r_1 + r_2$

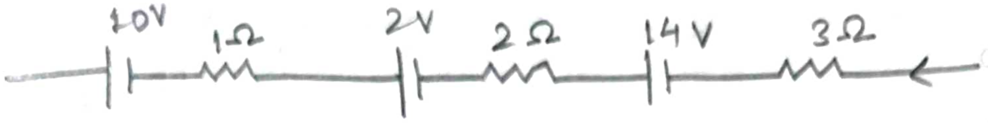
$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2$

→

$r_{eq} = r_1 + r_2 + r_3$

$\varepsilon_{eq} = \varepsilon_2 + \varepsilon_3 - \varepsilon_1$

Q.



find $r_{eq} = ?$

$\varepsilon_{eq} = ?$

Ans. $r_{eq} = r_1 + r_2 + r_3 = 1\Omega + 2\Omega + 3\Omega$

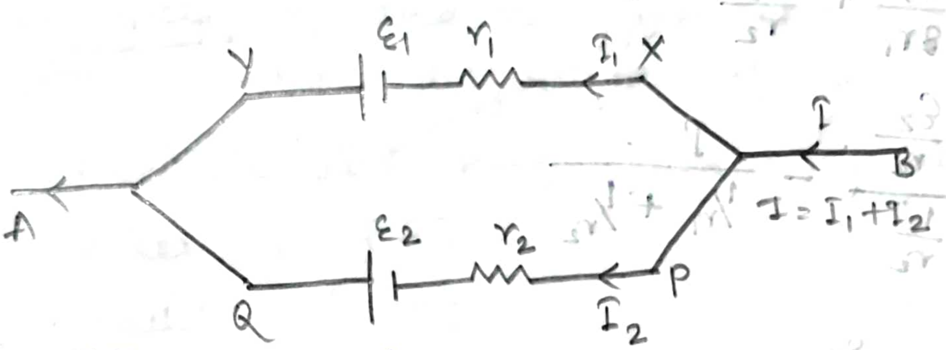
$= 6\Omega$

$\varepsilon_{eq} = \varepsilon_1 + \varepsilon_2 + \varepsilon_3 = (10 + 2 + 14)V$

$= 26\ V$

Imp

* Parallel combination of cells :-



For XY component :-

$V = E - Ir$

$\rightarrow V = \varepsilon_1 - I_1 r_1$

$\Rightarrow \boxed{I_1 = \frac{\varepsilon_1 - V}{r_1}}$

For PQ component :- .

$\Rightarrow V = B\,\varepsilon_2 - I_2 r_2$

$\Rightarrow \boxed{I_2 = \frac{\varepsilon_2 - V}{r_2}}$

We know

$I = I_1 + I_2$

$$\Rightarrow I = \frac{\varepsilon_1 - V}{r_1} + \frac{\varepsilon_2 - V}{r_2}$$

$$\Rightarrow I = \frac{\varepsilon_1}{r_1} - \frac{V}{r_1} + \frac{\varepsilon_2}{r_2} - \frac{V}{r_2}$$

$$\Rightarrow I = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} - \left(\frac{V}{r_1} + \frac{V}{r_2}\right)$$

$$\Rightarrow I = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} - V\left(\frac{1}{r_1} + \frac{1}{r_2}\right)$$

$$\Rightarrow V\left(\frac{1}{r_1} + \frac{1}{r_2}\right) = \frac{\varepsilon_1}{8r_1} + \frac{\varepsilon_2}{r_2} - I$$

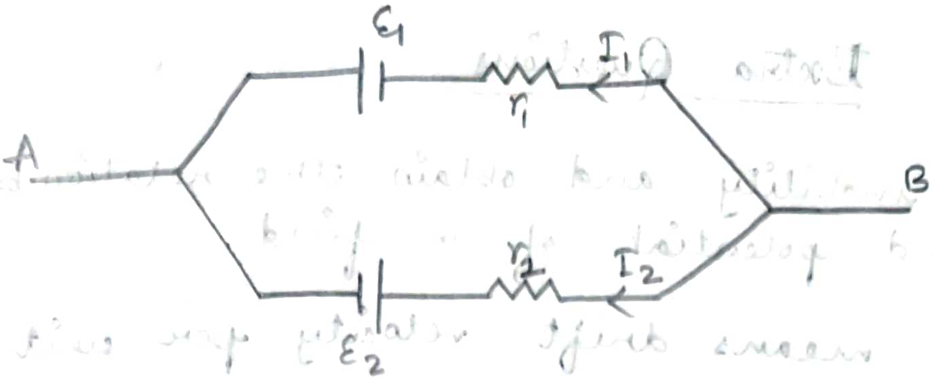
$$\Rightarrow V = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} - \frac{I}{1/r_1 + 1/r_2}$$

$[\therefore V = E - Ir]$

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

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2}$$

Q:



Ans:
$$\varepsilon_{eq} = \frac{\frac{\varepsilon_1}{r_1} - \frac{\varepsilon_2}{r_2}}{1/r_1 + 1/r_2}$$

$$r_{eq} = \frac{1}{r_1} + \frac{1}{r_2}$$

Q: Two cells of emf ε_1 & ε_2 having internal resistances r_1 and r_2 are connected through a ~~pottos~~ potential difference of V. [5]

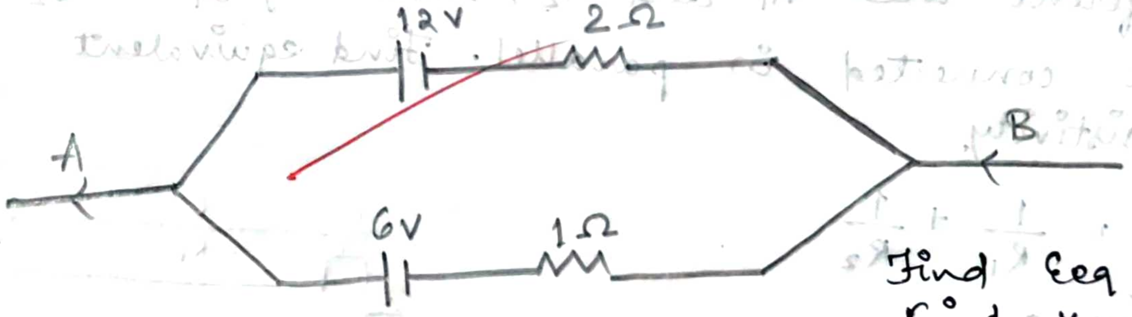
1) Find equivalent emf when connected in:

a) Series [2]

b) parallel [3]

Ans: Derivation of series & parallel from notes.

Q:



Find ε_{eq} = ?
Find r_{eq} = ?

Ans: Given :-

$\varepsilon_1 = 12\,V$; $\varepsilon_2 = 6V$

$r_1 = 2\Omega$; $r_2 = 1\Omega$

$$\varepsilon_{eq} = \frac{\frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2}}{\frac{1}{r_1} + \frac{1}{r_2}} = \frac{\frac{12}{2} + \frac{6}{1}}{\frac{1}{2} + 1} = \frac{12}{3/2} = \frac{24}{3} = 8\,V$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} = \frac{1}{2} + \frac{1}{1} = \frac{1+2}{2} = \frac{3}{2}$$

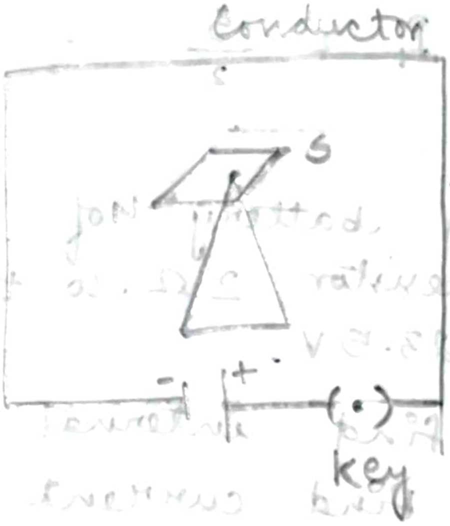
$$r_{eq} = \frac{2}{3}$$

25/07/23

27/07/2023

4. Magnetic Effect Of Electric Current

*. Oersted Experiment :-

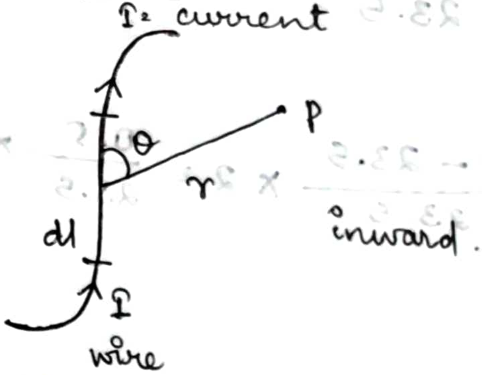


→ When current flow, the needle deflect. When current increases the deflection increases.

→ If current is reserved deflection also reeserved.

→ Due to electric current there is a magnetic effect.

*. Biot - Savart law :-



A wire is taken in which current I is flowing. Take a small cross section dl and at a distance r. we have find magnetic field.

Magnetic field = $d\vec{B} = \frac{\mu_0}{4\pi} = \frac{i(d\vec{l} \times \vec{r})}{r^3}$

where, μ_0 = permiability in frees space.

$$= \frac{\mu_0}{4\pi} = 10^{-7} \text{ N/A}^2$$

$$\Rightarrow d\vec{B} = \frac{\mu_0}{4\pi} \frac{idl\, r \sin\theta}{r^3}$$

$$\boxed{= \frac{\mu_0}{4\pi} \frac{idl \sin\theta}{r^2}}$$

⊛ unit of magnetic field :- $\frac{N}{A^2} = \frac{A \times m}{m^2}$

$= \frac{N}{Am}$ or Tessla or weber/m^2.

⊛ Dimension $= \frac{[M^1 L^1 T^{-2}]}{[A][L^1]} = [M^1 T^{-2} A^{-1}]$.

*. Case - I (Maximum) :-

$\theta = 90$ sin 90 = 1

$$dB = \frac{\mu_0}{4\pi} \frac{(idl)}{r^2}$$

$$= \frac{\mu_0}{4\pi} \frac{idl}{r^2}$$ i.e. equatorial position.

*. Case II = (Minimum) :-

$\theta = 0$ $\sin \theta = 0$

$$dB = \frac{\mu_0}{4\pi} \frac{idl}{r^2} \sin 0$$

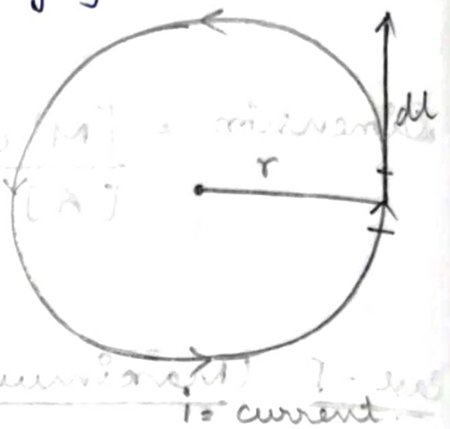
$= 0$ i.e. axial point.

31/07/202

Imp

* *. Magnetic field at the centre of coil carrying current

A circular coil of radius r carrying current i is placed.
dl be the small cross section which is $\perp^r$ to the radius.



$\theta = 90°$.

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{i dl \sin\theta}{r^2}$$

Put $\theta = 90°$

$$\Rightarrow d\vec{B} = \frac{\mu_0}{4\pi} \frac{i dl}{r^2}$$

Magnetic field due to whole coil.

$$\int_0^B dB = \int_0^{2\pi r} \frac{\mu_0}{4\pi} \frac{i dl}{r^2}$$

$$\Rightarrow B = \frac{\mu_0}{4\pi} \frac{i}{r^2} [l]_0^{2\pi r}$$

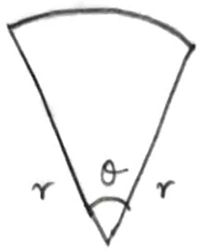
$$= \cancel{B} \frac{\mu_0}{\cancel{4\pi}_{2}} \frac{i}{r^{\cancel{2}}} \times \cancel{2\pi r} = \frac{\mu_0 i}{2r}$$

For N no. of circle (or) turns

$$\boxed{B = \frac{\mu_0 N i}{2r}}$$

NOTE :- $2\pi = \frac{\mu_0 N i}{2r}$

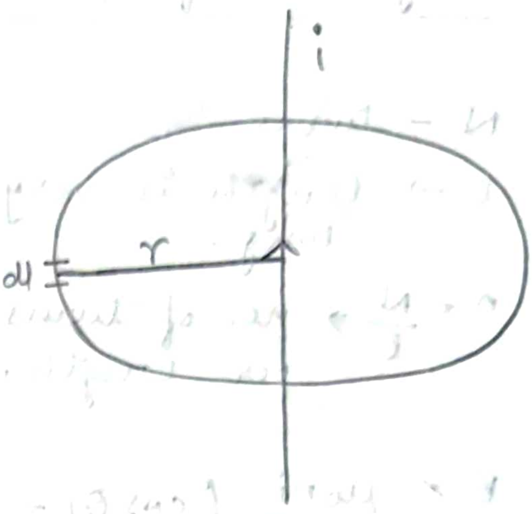
$$\Rightarrow \boxed{B = \frac{\theta}{2\pi} \frac{\mu_0 N i}{2r}}$$



*. Ampere's law :-

→ It states that magnetic field around a conductor is given as μ_0 times the current.

$\int B.dl = \mu_0 I_{inside}$



*. B for a straight conductor :-

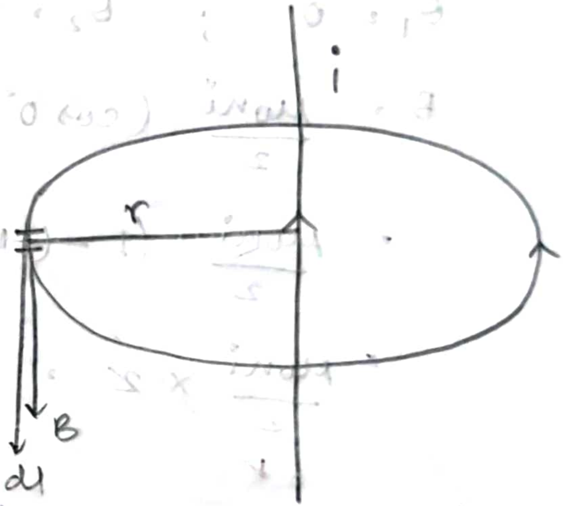
⇒ $\int B.dl \cos\theta = \mu_0 I$.

⇒ $\int B dl \cos 0 = \mu_0 I$

⇒ $B \int dl = \mu_0 I$

⇒ $B \times 2\pi r = \mu_0 I$

⇒ $\boxed{B = \frac{\mu_0 I}{2\pi r}}$



Q:- Find magnetic field at 1m from a wire carrying current 5A.

$\left[\therefore \frac{\mu_0}{4\pi} = 10^{-7} \quad \mu_0 = 4\pi \times 10^{-7} \right]$

Ans:- $r = 1m$

$I = 5A$

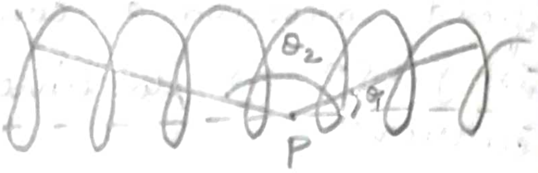
$B = \frac{\mu_0 I}{2\pi r}$

$= \frac{10^{-7} \times \overset{2}{\cancel{4}}\cancel{\pi} \times 5}{\cancel{2} \times \cancel{\pi} \times 1}$

$= 10 \times 10^{-7}$ T

1/08/2023

*. Magnetic field due to a solenoid :-



N - turns

l → length is very long.

$n = \frac{N}{l}$ → no. of turns per length.

$$B = \frac{\mu_0 n i}{2} (\cos\theta_1 - \cos\theta_2)$$

For infinitely long solenoid

$\theta_1 = 0$; $\theta_2 = 180$

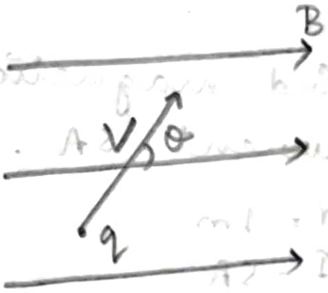
$$B = \frac{\mu_0 n i}{2} (\cos 0^\circ - \cos 180^\circ)$$

$$= \frac{\mu_0 n i}{2} (1 - (-1))$$

$$= \frac{\mu_0 n i}{\cancel{2}} \times \cancel{2} = \mu_0 n i .$$

*. Force on a charge placed in a magnetic field :-

When a charge q is moving ~~with velocity~~ in a magnetic field B with velocity v at angle θ.



Here, direc^n will be inward.

$$F = q(\vec{v} \times \vec{B})$$

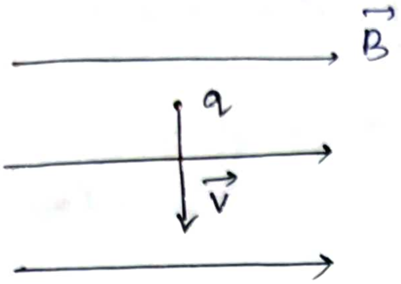
$$\boxed{F = qvB \sin\theta}$$

→ Place your fingers in $\vec{V}$ direction and curl towards $\vec{B}$ then thumb will give the direction of force.

- Maximum, when $\sin\theta = 1$
  $\theta = 90°$

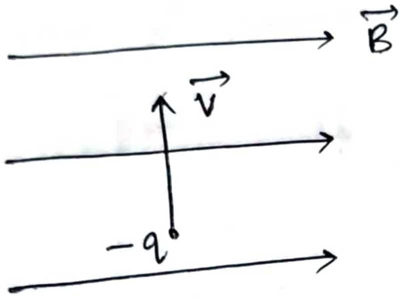
- Minimum, when $\sin\theta = 0$
  $\theta = 0°$.

Q:-



direction outward.

Q:-



direction outward (because of − symbol)

Lorentz force :-

When a charge q is placed under influence both magnetic and electric field.

$\vec{F}_{elec} = q\vec{E}$

$\vec{F}_{mag} = q(\vec{v} \times \vec{B})$

The resultant force will be $q\vec{E} + q(\vec{v} \times \vec{B})$

$$\vec{F} = q(\vec{E} + (\vec{v} \times \vec{B}))$$

Q2

$\vec{B}$ inward.

Find expression for Radius? Time period and frequency?

θ = 90° as the (inward) magnetic field & velocity is in ⊥r.

Ans: $f_{mag} = qVB \sin 90$

$= qVB$

$f_{centripetal} = \frac{mv^2}{r}$

$f_{mag} = f_c$

$\Rightarrow qVB = \frac{mv^2}{r}$

$\Rightarrow r = \frac{mv^2}{qVB} = \frac{mV}{qB}$

$T = \frac{2\pi r}{V}$

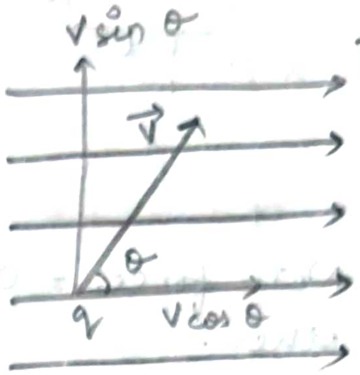
$= \frac{2\pi \cancel{r}}{\frac{qB\cancel{r}}{m}} = \frac{2\pi m}{qB}$

$f = \frac{1}{T} = \frac{qB}{2\pi m}$

4/08/2023

Imp

*. Helical path of charge in magnetic field :-

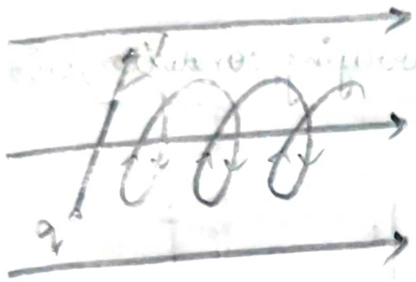


→ V cos θ component responsible for forward motion.

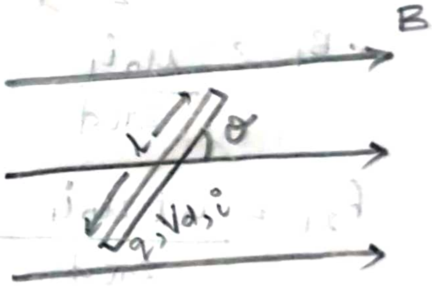
→ V sin θ responsible for upward motion.

→ So the paths become spiral/ helical.

→



* Imp Force on a current carrying conductor in a magnetic field :-



V_d = drift vel,
i = current
q = charge

Force on a charge placed in magnetic field

$F = q(\vec{V} \times \vec{B})$

$= qVB \sin\theta$

$= eV_dB \sin\theta$

For n no. of e^{-}s

$F = neV_dB \sin\theta \times \underbrace{l \times A}_{Vol^m}$

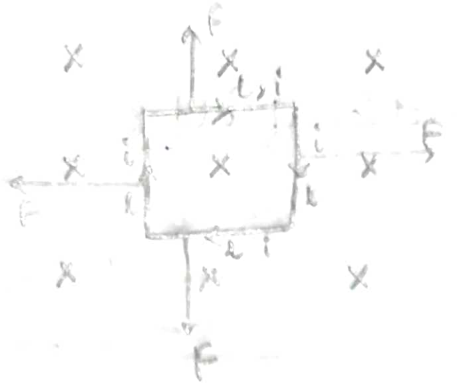
$= \underbrace{nAV_de}\, lB \sin\theta$

$\boxed{F = ilB \sin\theta}$

$\Rightarrow \boxed{F = i(\vec{l} \times \vec{B})}$

x = denotes magnetic field inward.

Q.



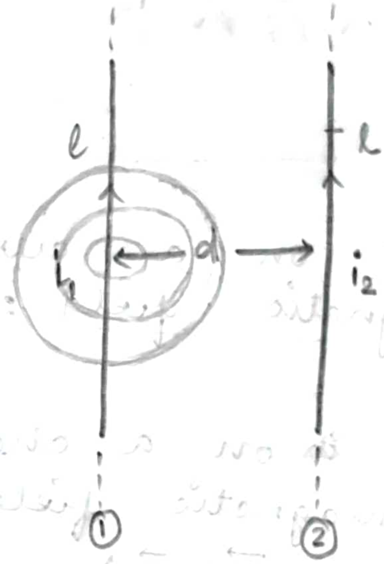
Find net force on the loop ?

Ans. Net force = 0 as opposite side force cancel each other.

[Long type]

***. Force between two long current carrying conductor/wire**

Force on wire 2 is due to the magnetic field of wire 1.



$F_{21} = i_2 l B_1 \sin\theta$

$\cancel{= i_2 l}$ $\theta = 90°$

$= i_2 l B_1$

$B_1 = \frac{\mu_0 i_1}{2\pi d}$ [∴ from Ampere's law]

$F_{21} = \frac{i_2 l \mu_0 i_1}{2\pi d} = \frac{\mu_0 i_1 i_2 l}{2\pi d}$

$\Rightarrow \boxed{\frac{F_{21}}{l} = \frac{\mu_0 i_1 i_2}{2\pi d}}$ towards left.

Similarly

$\Rightarrow \frac{F_{12}}{l} = \frac{\mu_0 i_1 i_2}{2\pi d}$ towards right.

So, $\frac{F_{21}}{\cancel{l}} = -\frac{F_{12}}{\cancel{l}}$

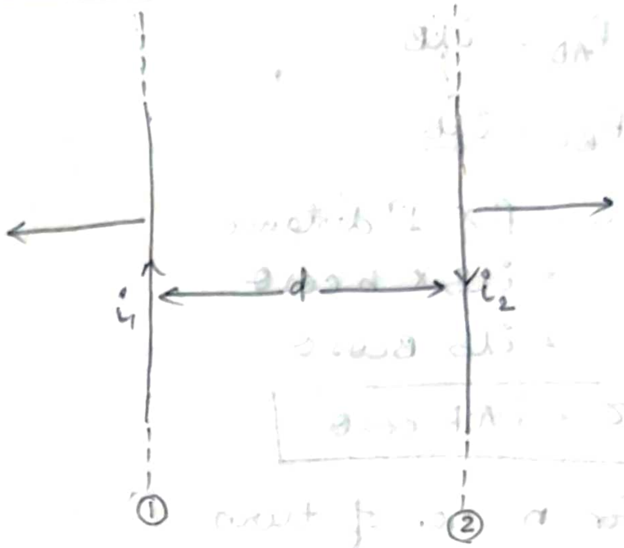
$\Rightarrow \boxed{F_{21} = -F_{12}}$

*. When current is opposite in both sides:-

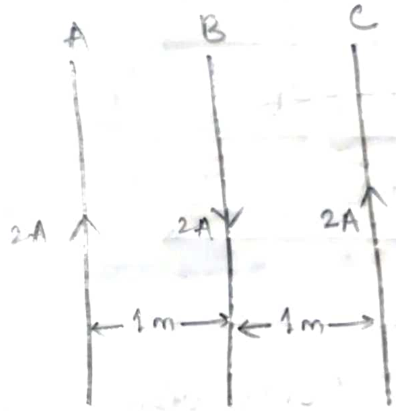
→ $\frac{F_{12}}{l} = \frac{\mu_0 i_1 i_2}{2\pi d}$ towards left

→ $\frac{F_{21}}{l} = \frac{\mu_0 i_1 i_2}{2\pi d}$ towards right

→ opposite current repel each other.



Q1



Find force on wire B.

Ans. Force on B due to A

$F_{BA} = \frac{\mu_0 i_1 i_2 \times 2}{2(2\pi d)}$ towards right

$= \frac{10^{-7} \times 2 \times 2 \times 2}{1}$ towards right

$= 8 \times 10^{-7}$ N towards right.

Force on B due to C.

$F_{BC} = \frac{\mu_0 i_1 i_2 \times 2}{2(2\pi d)}$ towards left.

$= \frac{10^{-7} \times 2 \times 2 \times 2}{1}$ towards left

$= 8 \times 10^{-7}$ N towards left

$= F_{net} = F_{BA} - F_{BC} = 0.$

*. Torque on a coil in a Magnetic field :-

→ $f_{AD} = ilB$

→ $f_{BC} = ilB$

→ $\tau = f \times \perp^r$ distance

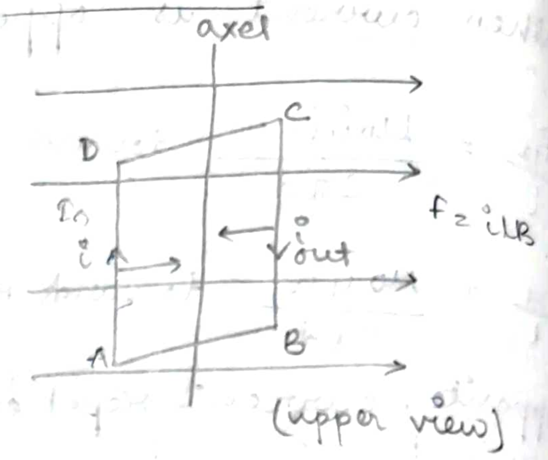
$= ilB \times b \cos\theta$

$= ilb\, B\cos\theta$

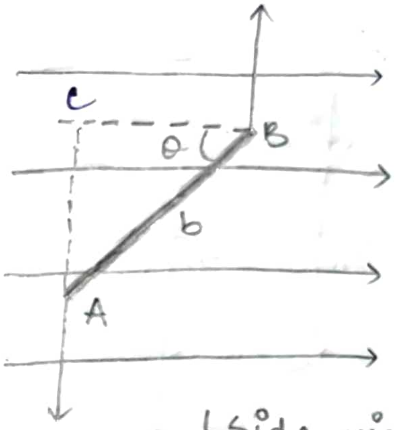
$$\boxed{\tau = iAB\cos\theta}$$

→ For n no. of turn

$$\boxed{\tau = niBA\cos\theta}$$



(upper view)



(side view)

*. If we consider area vector

$\theta \to 90-\theta$

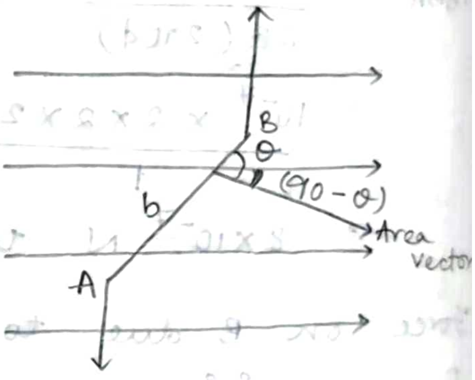
$\tau = niBA\cos\theta$

$= niBA\cos(90-\theta)$

$= niBA\sin\theta$

$\tau = nmB\sin\theta$ [$\because iA = \vec{m}$ magnetic moment]

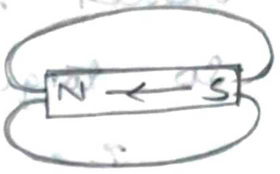
$$\boxed{\tau = n(\vec{m} \times \vec{B})}$$



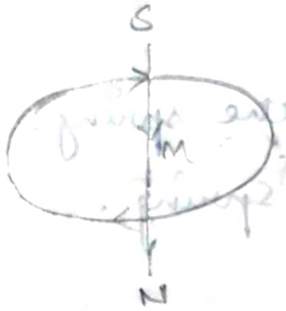
*. Magnetic moment :-

$\vec{M} = i\vec{A}$

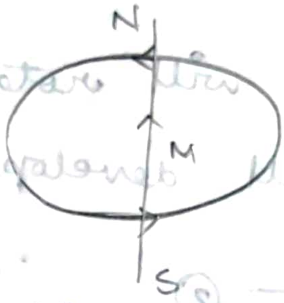
→ Magnetic moment direction from south to north. (inside direcⁿ will be considered i.e S → N)



→

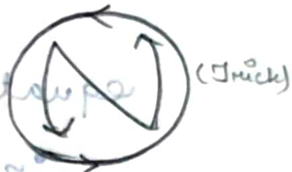


(in clockwise)



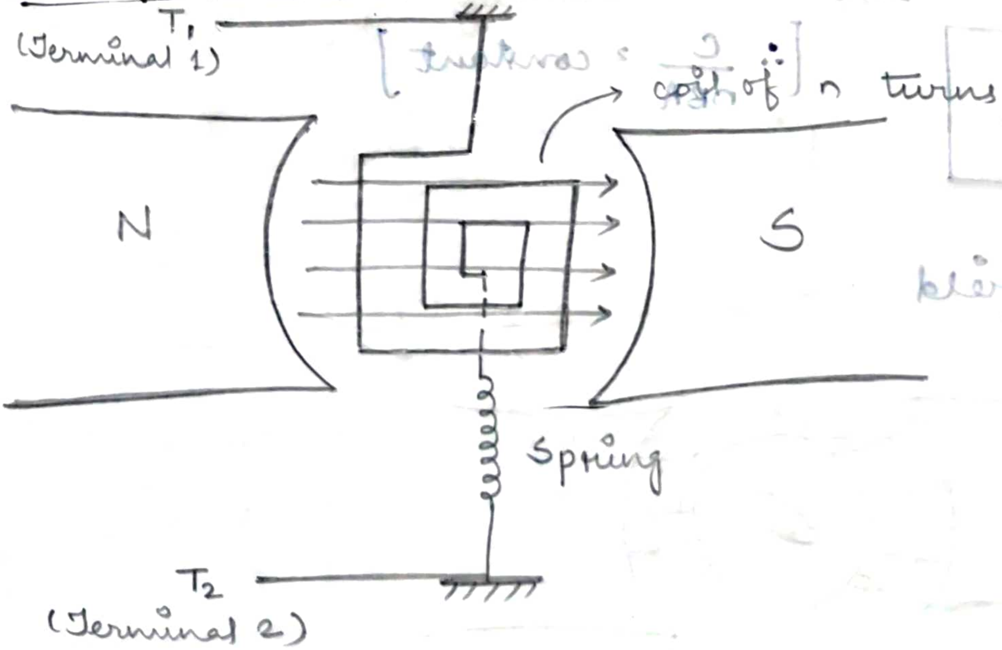
(in anti-clockwise)

→ When current is anti-clockwise then upper part North pole & lower part south pole.



→ When current is clockwise, then upper part → South pole & lower part → north pole.

*. Moving coil Galvanometer :-



- → A coil of n turns is connected to a spring.
- → Placed between north and south pole.
- → So torque on that coil will be

$$\tau = niBA \sin\theta \quad \text{——} \quad ①$$

- → When coil rotate, it will rotate the spring.
- → So, restoring force will develop is spring.

$$\boxed{\tau = C\phi} \quad \text{——} \quad ②$$

where, C = torsional couple per twist.
ϕ = angle of twist.

equating eqⁿ ① & eqⁿ ②

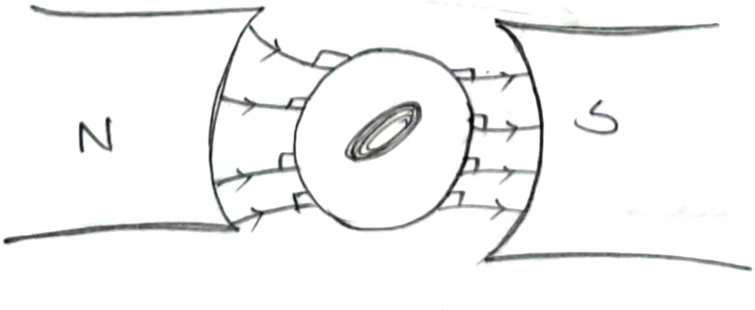
$$niBA \sin\theta = C\phi$$

$$\Rightarrow i = \frac{C\phi}{nBA \sin\theta}$$

$$\Rightarrow i = \frac{C}{nBA} \times \frac{\phi}{\sin\theta}$$

$$\Rightarrow \boxed{i \propto \frac{\phi}{\sin\theta}} \qquad \left[\because \frac{C}{nBA} = \text{constant}\right]$$

- → Radial field



$\theta = 90°$.

→ due to radial field θ always 90. i.e magnetic field $\perp^r$ to soft iron material.

$$\theta = 90^\circ$$

$$i = \frac{C}{nBA} \frac{\phi}{\sin\theta}$$

$$\sin 90 = 1$$

$$i = \frac{C}{nBA} \phi$$

$$\Rightarrow i = K\phi$$

where, K = reducing factor.

→ Current required to deflect a unit value.

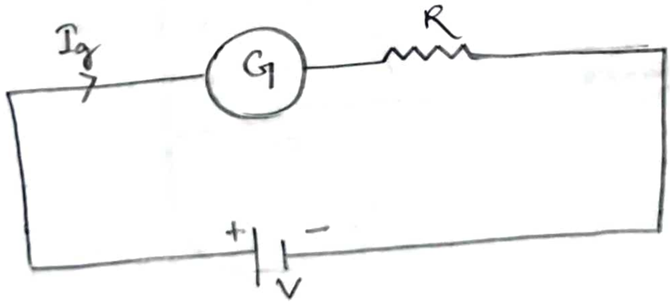
$$i = \frac{C}{nBA} \phi$$

$$\Rightarrow \phi = \frac{nBA}{C} i$$

$$\Rightarrow \boxed{\frac{\phi}{i} = \frac{nBA}{C}}$$

(high resistance req.)

imp ★. Conversion of galvanometer to voltmetre :-



→ G = resistance of Galvanometre

→ $\boxed{R + G = \frac{V}{I_g}}$ [$\therefore R = \frac{V}{I}$, ohm's law]

$$\Rightarrow \boxed{R = \frac{V}{I_g} - G}$$

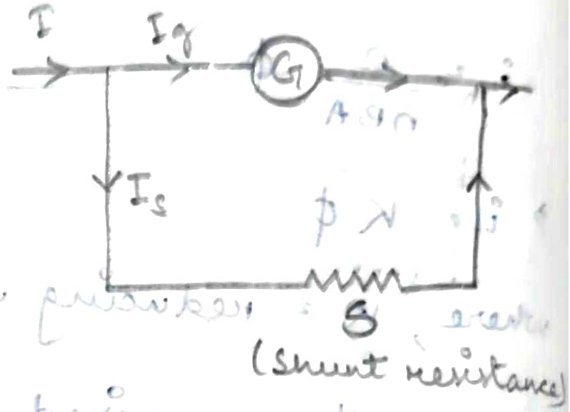
→ To convert galvanometre to voltmetre, add ~~short~~ shunt resitance in series.

→ It will be a high resistance.

*. Conversion of Galvanometre to ammeter G_T (low resistance req.)

→ $I = I_g + I_s$

→ $V_G = V_s$ (Potential is constant)



⟹ $I_g \times G = I_s \times S$ [∵ V = IR]

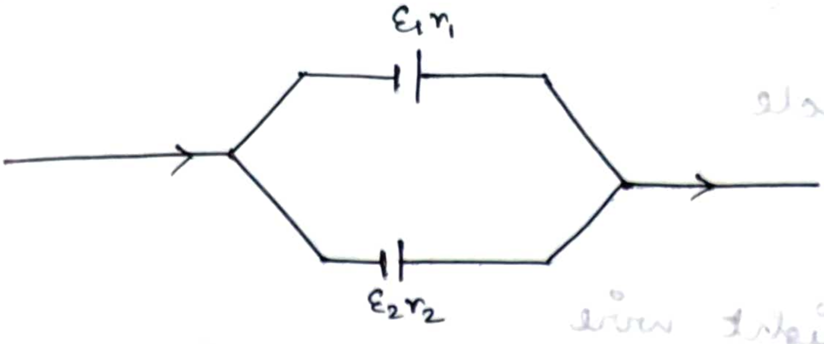
⟹ $S = \frac{I_g \times G}{I_s}$

⟹ $S = \frac{I_g \times G}{I_s} = \frac{I_g G}{I - I_g}$

⟹ $\boxed{S = \frac{I_g G}{I - I_g}}$

Imp-

1Q:-



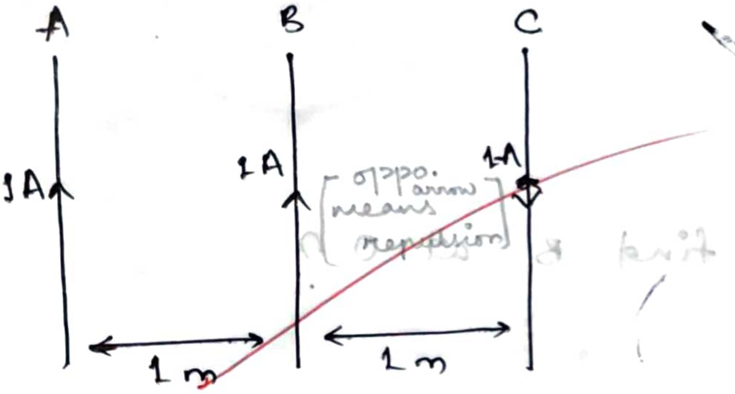
If two cells of Emf ε_1 & ε_2, internal resistance r_1 & r_2 are connected as shown in fig.

i) find equivalent emf.

ii) find equivalent resistance.

iii) find potential?

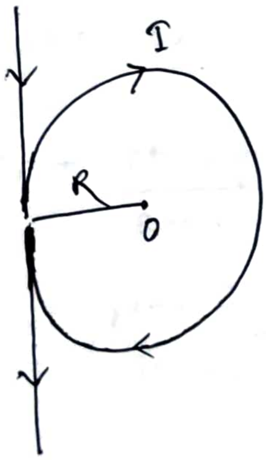
2.



find the direction of force on wire C.

Ans: towards right.

3.



find B at O?

Ans. B due to circle

$= \frac{\mu_0 i}{2r}$

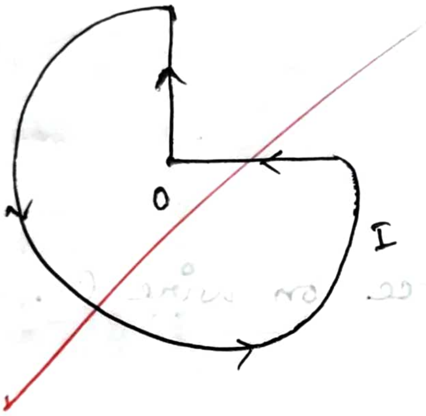
B due to straight wire

$= \frac{\mu_0 I}{2\pi r}$

$B_{total} = \frac{\mu_0 I}{2r} + \frac{\mu_0 I}{2\pi r}$

$= \frac{\mu_0 I}{2\pi r}\left(1 + \frac{1}{\pi}\right)$

Q.



find B at O ?

$2\pi - \frac{\pi}{2}$

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

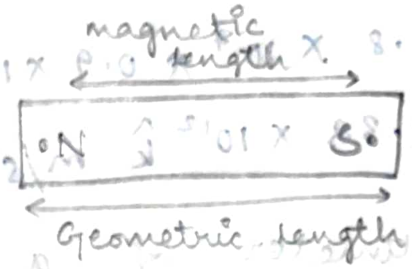
Ans. $B = \frac{\theta}{2\pi} \times \frac{\mu_0 I}{2r}$

$= \frac{3\cancel{\pi}}{2\times 2\cancel{\pi}} \frac{\mu_0 I}{2r}$

$= \frac{3\mu_0 I}{8r}$

5. Magnetism & Matter

*. Bar magnet :-



→ There are two poles
i) north pole
ii) South pole

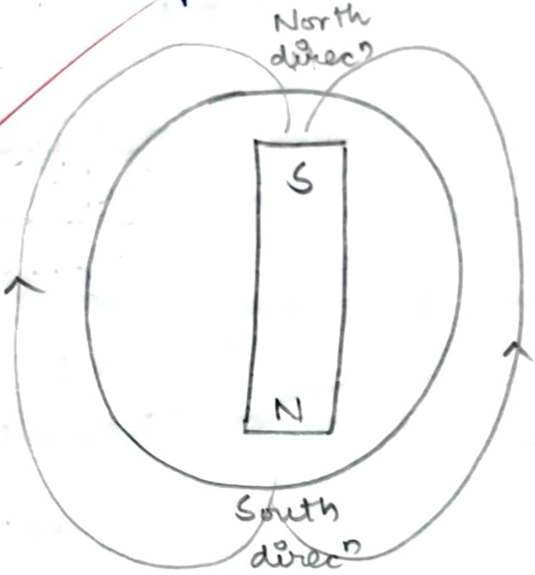
→ Distance betn two poles i.e. magnetic length.

→ Actual distance is geometric length.

→ $\boxed{M.L = \frac{5}{6} \times G.L}$

→ opposite pole → attract.

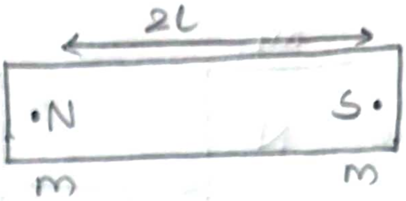
→ same pole → repel.



Earth magnetic field.

→ When magnet freely suspended then it aligns in N-S direction.

*. Magnetic dipole :-



m → magnetic pole strength

2l → distance between poles.

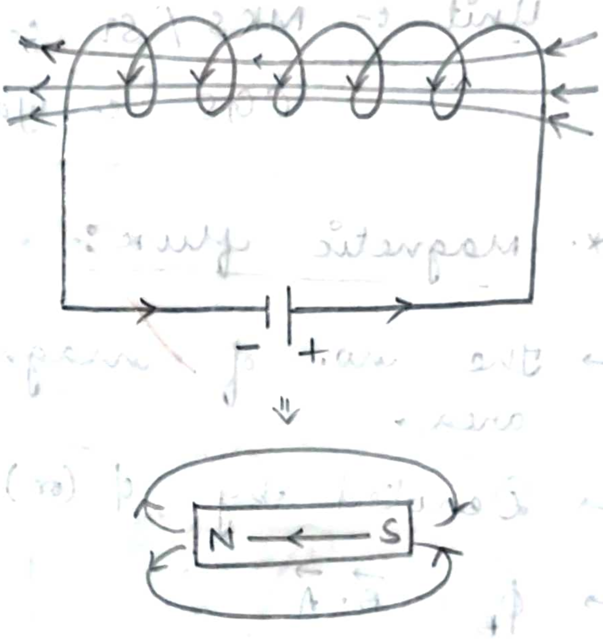
$\vec{M} = m \times \vec{2l} = i\vec{A}$

⊛ Unit → $A m^2$

*. Solenoid as bar magnet :-

→ When current start flowing in a solenoid, it's magnetic lines ~~from~~ form close loop same as bar magnet.

→ From the above fig.
it is conclude that current carrying solenoid act as bar magnet.



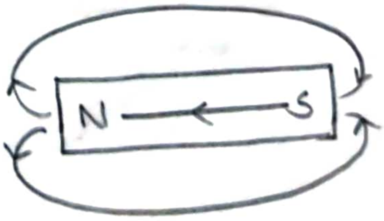
*. Magnetic field lines :-

→ Magnetic field lines starts from N pole to end on S pole outside.

→ Inside magnet, the direction will be S pole to N pole.

→ Magnetic ~~f~~ lines never cross each other as at crossing there will be two direction which is not possible.

→ Magnetic field lines form close curve.



18/08/23

19/08/2023

*. Magnetic field strength :-

$$B = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{r^2}$$

i.e. the force between two poles and also the strength of magnetic field.

Unit :- MKS / SI :- Tesla

CGS :- Gauss.

*. Magnetic flux :-

→ The no. of magnetic field lines crossing on area.

→ Denoted by ϕ (or) ϕ_B.

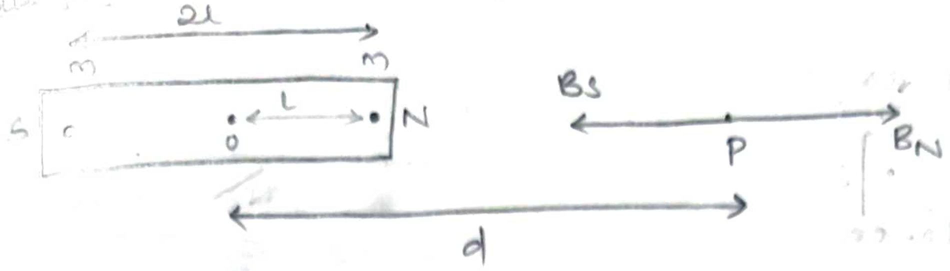
→ $\phi_B = \vec{B} \cdot \vec{A}$

Unit :- SI :- Weber
CGS :- Maxwell.

22/08/2023

*. Magnetic field due to Bar magnet :-

1) Axial points:



Magnetic field at P due to N pole

$$B_N = \frac{\mu_0}{4\pi} \frac{m}{(d-l)^2}$$

$$B_S = \frac{\mu_0}{4\pi} \cdot \frac{m}{(d+l)^2}$$

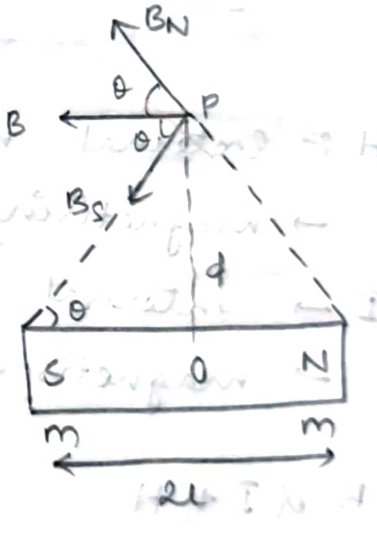
$$\boxed{B = B_N - B_S = \frac{\mu_0}{4\pi} \frac{2\vec{M}}{d^3}}$$

2. Equatorial point :-

$$|B_N| = |B_S| = \frac{\mu_0}{4\pi} \frac{m}{\sqrt{l^2+d^2}}$$

$$B_{net} = 2B \cos\theta \cdot$$

$$= \frac{\mu_0}{4\pi} \frac{\vec{M}}{d^3}$$



NOTE :-
$B_{axial} = 2 \times B_{equatorial}$

*. Torque on a magnet in magnetic field :-

Force is given as

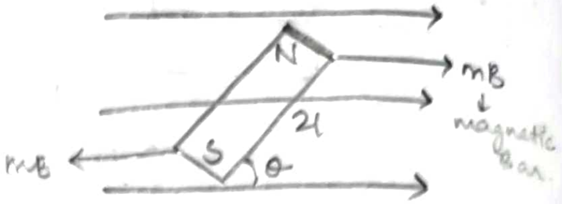
$F_B = mB$.

$\tau = F \times \perp^r$ distance

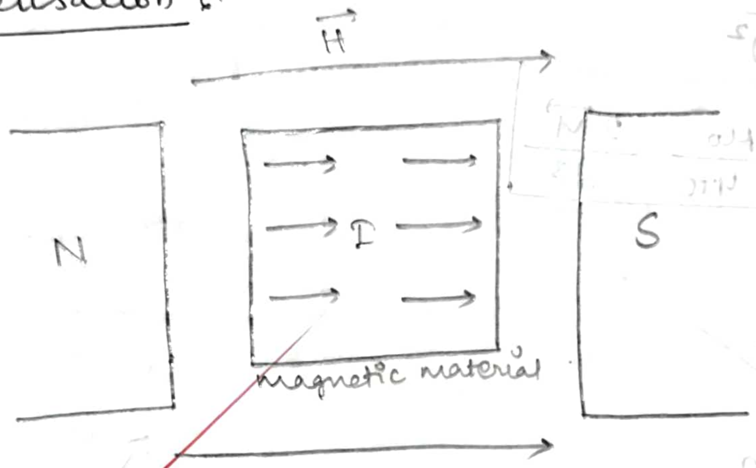
$= mB \times 2l \sin\theta$

$\Rightarrow MB \sin\theta$

$$\boxed{\vec{\tau} = \vec{M} \times \vec{B}}$$



*. Magnetisation :-



H :- External magnetic field.
→ magnetising field.

I → Internal magnetic field
→ magnetised field.

$B \propto I + H$

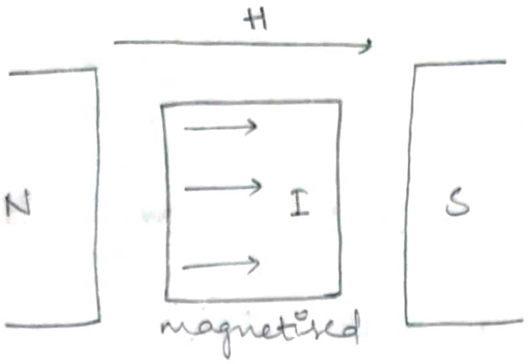
$\Rightarrow B = \mu_0 (H + I)$

$= \mu_0 = 4\pi \times 10^{-7}$ i.e
permiability is free space.

$\Rightarrow H + I = \frac{B}{\mu_0}$

$$\Rightarrow \boxed{H = \frac{B}{\mu_0} - I}$$

*. Relation between I & H :-



$I \propto H$

$\Rightarrow I = \chi H$

χ ↓ magnetic susceptibility.

We know

$B = \mu_0 (H + I)$

$\Rightarrow B = \mu_0 (H + \chi H)$

$\Rightarrow B = \mu_0 H (1 + \chi)$

Case $B_0 = \mu_0 H$

when there is no medium (or) material then $I = 0$.

*. Relative perniability :-

→ $\mu_r = \dfrac{\mu}{\mu_0} = \dfrac{\text{perniability in medium}}{\text{perniability in free space}}$.

*. Relation betn μ_r and χ :-

$$\boxed{\mu_r = 1 + \chi}$$

(Formulas)

→ $B = \mu_0 (H + I)$

→ $B = \mu_0 H (1 + \chi)$

→ $B_0 = \mu_0 H$

→ $\mu_r = \frac{\mu}{\mu_0}$

→ $\mu_r = 1 + \chi$

*. Diamagnetic material :-

→ Material that repel by magnetic field.

→ Ex :- N_2, NaCl, copper etc.

→ $\vec{M} = 0$ (magnetic dipole moment)

→ χ value is −ve i.e $-1 \leq \chi < 0$.

→ $\mu_r < 1$

→ magnetic lines less dense around it.

→

*. Para-magnetic material :-

→ Materials that slowly attract towards magnetic field.

→ Ex :- O_2, Aluminium, Calcium, sodium etc.

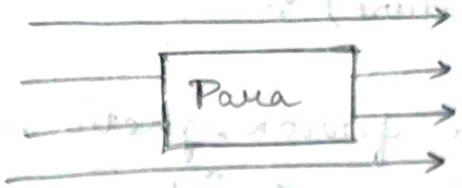
→ The magnetic dipole moment $\vec{M} \neq 0$.

→ χ value is positive and small.

→ $\mu_r > 1$

→ magnetic lines are more dense.

→



imp
*. **Ferromagnetic material** :-

→ The materials that strongly attract towards magnetic field.

→ Ex:- Iron, cobalt, nickel etc.

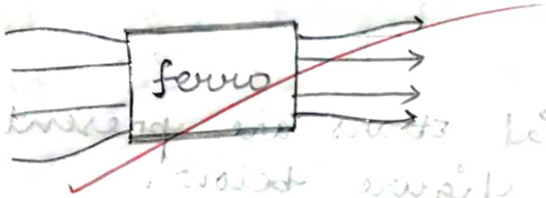
→ The magnetic dipole moment $\vec{M} \neq 0$ & high.

→ χ value is positive and large.

→ $\mu_r >>> 1$ (Large)

→ Magnetic lines highly dense.

→



*. **Dependency of magnetisation on temperature** :-

Magnetisation is inversely proportional to temperature.

$$I \propto \frac{B_0}{T}$$

$$\Rightarrow I = C\frac{B_0}{T}$$

$$(I = \chi H, \quad B_0 = \mu_0 H)$$

$$\Rightarrow \chi \cancel{H} = C\frac{\mu_0 \cancel{H}}{T}$$

$$\Rightarrow \chi = \frac{C\mu_0}{T}$$

$$\Rightarrow \chi = \frac{C}{T} \qquad \left[\begin{array}{l}\mu_0 \text{ is constant} \\ \text{\& neglected}\end{array}\right]$$

C = Curie's constant.

*. Curie Law (Curie Temperature) :-

The temperature, where a ferromagnetic material become a paramagnetic material.

$$\boxed{\underset{\text{curie const.}}{C} = \chi T}$$

24/08/23

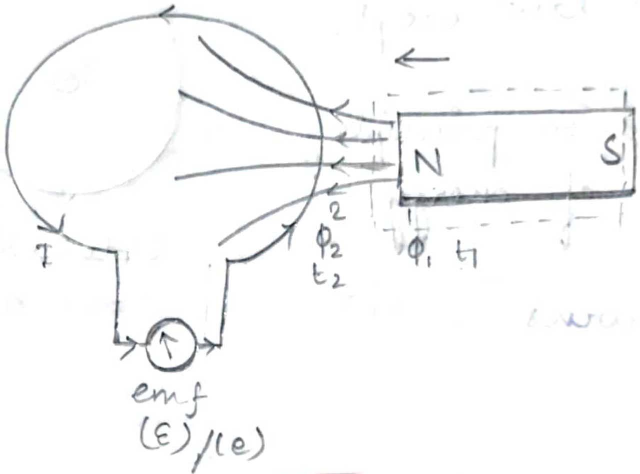
28/08/2023

6. Electromagnetic Induction

*. Faraday's 1st Law :-

→ As long as there is a change in magnetic field / flux then an emf induces in the circuit.

*. Faraday's 2nd Law :-



→ The rate of change of magnetic flux is directly proportional to induced emf.

$$e \propto \frac{\phi_2 - \phi_1}{t_2 - t_1}$$

$$\Rightarrow e = K \frac{\phi_2 - \phi_1}{t_2 - t_1}$$

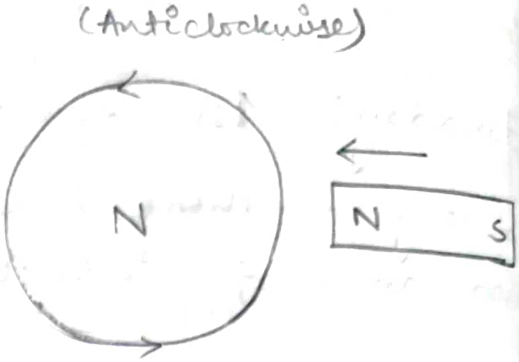
for neglection
$K = 1$.

$$\Rightarrow \boxed{e = \frac{d\phi}{dt}}$$

$$\left[\therefore \frac{dx}{dt} = \frac{x_2 - x_1}{t_2 - t_1}\right]$$

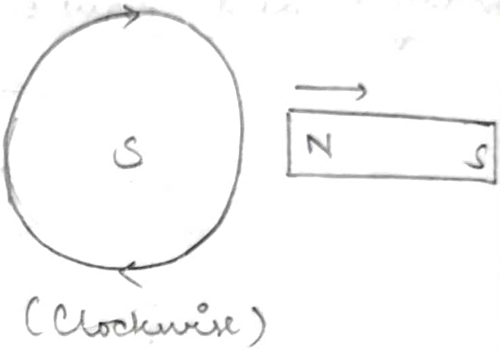
*. Lenz's Law :-

→ The direction of induced current is such that it oppose the change in ~~a~~ magnetic flux.



→ $e = -\frac{d\phi}{dt}$

-ve means lenz's law concept.



→ Lenz's Law works on principle of conservation of energy.

→ For N no. of turns

$$e = -N\frac{d\phi}{dt}$$

→ If resistance of coil is R then

$$I = \frac{|e|}{R} = \frac{N\frac{d\phi}{dt}}{R}$$

28/08/23

Q:- A coil having 500 loops of square size of side 10 cm is placed normal to magnetic field, which increases at the rate 1 T/S. What is the emf induced?

Ans N = 500

$\text{Area} = (10 \times 10^{-2})^2 = 0.01 \, m^2$

$$\frac{dB}{dt} = \cancel{e} = \frac{d\phi}{dt} = \frac{dBA}{dt} = A\frac{dB}{dt} = 0.01 \times 1 = 0.01 \text{ volt}.$$

$(\phi = BA)$

for 500 turns

$e = 0.01 \times 500 = 5$ volt.

imp Q. Magnetic flux is given as $\phi = 5t^2 + 2t$ weber. Find emf at $t = 2$ sec ?

Ans. $e = \frac{d\phi}{dt}$

$\frac{d(5t^2 + 2t)}{dt} = 10t + 2$

at $t = 2$ sec

$|e| = 10 \times 2 + 2 = 22$ volt.

Q. If a 20 cm side square loop of 100 turns produces 10 volt then find at what rate the magnetic field change ?

Ans. Area $= (20\ cm)^2 = (20 \times 10^{-2})^2 = 400 \times 10^{-4} = 0.04\ m^2$

$N = 100$

$|e| = 10$

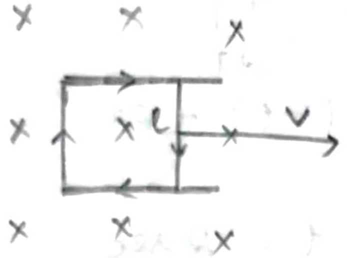
$|e| = NA\frac{dB}{dt} \Rightarrow \frac{dB}{dt} = \frac{|e|}{NA} = \frac{10}{100 \times 0.04} = \frac{10}{4} = 2.5$ T/sec.

2/09/2023

*. Motional emf :-

When coil of side l is moving with velocity v then

emf = $\boxed{e = BVl}$



→ If area increase, then current flow clockwise.

→ If area decrease, then current ~~flow~~ will be anticlockwise

$$I = \frac{e}{R} = \frac{Blv}{R}$$

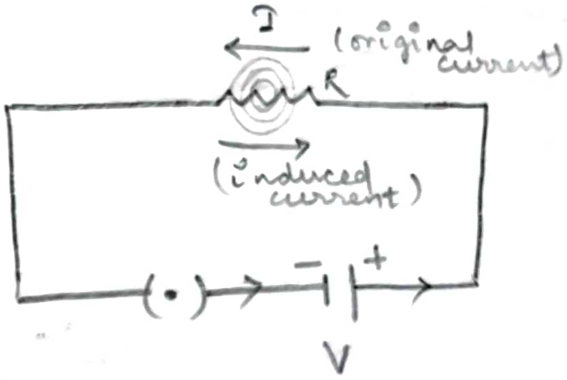
$$\rightarrow e = \frac{1}{2} B l^2 \omega$$

$$i = \frac{e}{R} = \frac{\frac{1}{2} B l^2 \omega}{R}$$

(Coil rotating)

*. Self Inductance :-

→ The property of coil to induce a current in opposite direction to oppose any change in the coil.



$$\phi \propto I$$

$$\Rightarrow \phi = LI$$ [∴ that L is coefficient of self inductance]

$$\boxed{L = \frac{\phi}{I}}$$

→ If N no. of coils then

$N\phi = LI$

$\Rightarrow L = \frac{N\phi}{I}$

→ Unit :- Henry (H)

→ Dimension :- $[M^1 L^2 T^{-2} A^{-2}]$

$e = \frac{-LdI}{dt}$

Q. what emf will induced in a 10 H inductor is which current changes 10A to 7A in 9×10^{-2}s.

Ans:- $L = 10H$

$dI = I_2 - I_1 = 7 - 10 = -3$

$dt = 9\times10^{-2}$

$e = \frac{LdI}{dt} = \cancel{-}\frac{10 \times \cancel{-}3}{9\times10^{-2}} = \frac{30}{9} \times 10^2 = 3.33 \times 10^2 = 333V.$

NOTE

$e = \frac{-d\phi}{dt}$ $[\because \phi = LI]$

$= \frac{-LdI}{dt}$

1 *. Self inductance of a solenoid :-

Magnetic field due to solenoid is $\frac{\mu_0 N I}{l}$

for N no. of turns,

$$B = \frac{\mu_0 N^2 I}{l}$$

$$\phi = B.A$$

$$= \frac{\mu_0 N^2 I}{l} \times A$$

But $\phi = LI$

i.e. $\frac{\mu_0 N^2 \cancel{I}}{l} A = L\cancel{I}$

$$\Rightarrow \boxed{L = \frac{\mu_0 N^2 A}{l}}$$

Q:- What is the self inductance of solenoid of length 40 cm, area 20 cm^2 and total turns 800?

Ans Given:-

$A = 20\,cm^2 = 20 \times (10^{-2})^2 = 20 \times 10^{-4} m^2.$

$l = 40$ cm $= 0.4$ m

$N = 800$

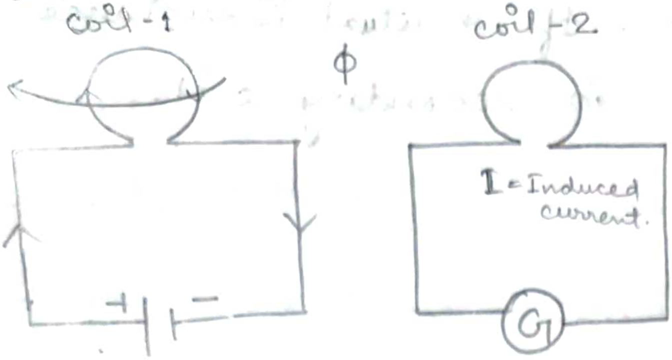
$\mu_0 = 4\pi \times 10^{-7}$

$$\Rightarrow L = \frac{4\pi \times 10^{-7} \times 800^2 \times 20 \times 10^{-4}}{0.4}$$

$$= 4.02 \times 10^{-3} H.$$

8/09/2023

*. Mutual Inductance :-



→ The property of a coil by virtue of which it oppose change in current due to another coil.

$$\phi \propto I$$

$\Rightarrow \phi = MI$ $\quad M = \frac{\phi}{I}$ = coefficient of mutual inductance.

Unit :- Henry (or) H

→ emf induced

$$e = \frac{-d\phi}{dt}$$

$$\Rightarrow e = -M\frac{dI}{dt}$$

If we have to find current.

$$I = \frac{V}{R} = \frac{e}{R} = \frac{-M\frac{dI}{dt}}{R}$$

Q:- A current of 10A is primary reduces to zero at a rate of 10^{-3} sec. If mutual inductance is 3H. What is the emf in secondary coil.

Ans $dI = 0 - 10 = -10$

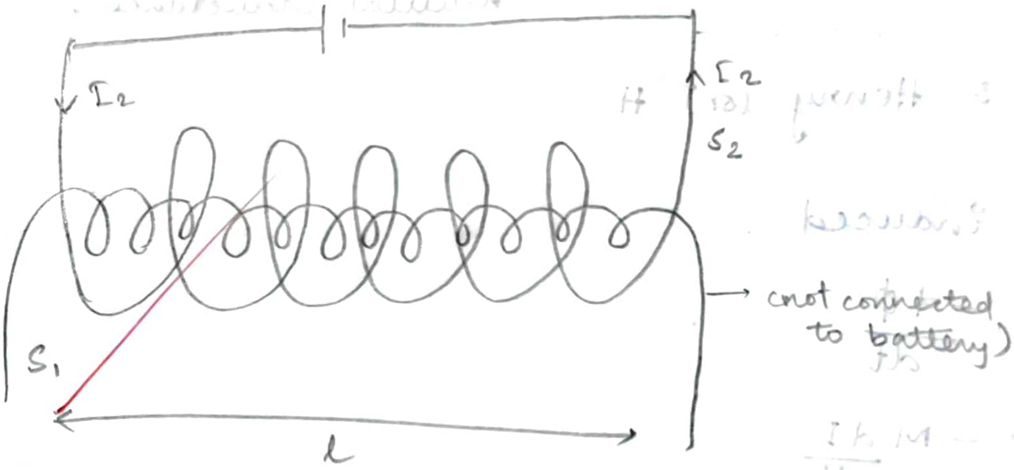
$dt = 10^{-3}$

$M = 3$

$e = -M \frac{dI}{dt}$

$= \cancel{-}3 \times \frac{\cancel{-}10}{10^{-3}} = 30 \times 10^{3}\,V$.

*. Mutual Inductance of Solenoid :-



Due to current in coil S_2 there is a magnetic field in S_2.

That magnetic field change flux in S_1 i.e., ϕ, which cause mutual inductance M_{12}

i.e. $\phi_1 = M_{12} \times I_2$.

$\Rightarrow B_2 = \mu_0 N_2 I_2$

$\Rightarrow \phi_1 = n_1 B_2 A_1$

$= n_1 \mu_0 N_2 I_2 A_1$

$$= N_1 \times l \times \mu_0 N_2 I_2 A_1$$

$$= N_1 \times l \times \mu_0 N_2 I_2 \times \pi r_1^2$$

$$\phi_1 = \underbrace{\mu_0 N_1 N_2 \pi r_1^2 l}_{M_{12}} I_2$$

$$M_{12} = \mu_0 N_1 N_2 \pi r_1^2 l$$

→ like that when we consider coil 2 i.e

$$M_{21} = \mu_0 N_1 N_2 \pi r_2^2 l$$

⇒ $r_1 = r_2$ ((coil of same size to be taken)

So,

$$A_1 = \pi r_1^2 = A_2 = A \text{ (say)}$$

$$M_{21} = \mu_0 N_1 N_2 A l = M_{12}$$

⇒ i.e $M_{12} = M_{21} = M = \mu_0 N_1 N_2 A L$

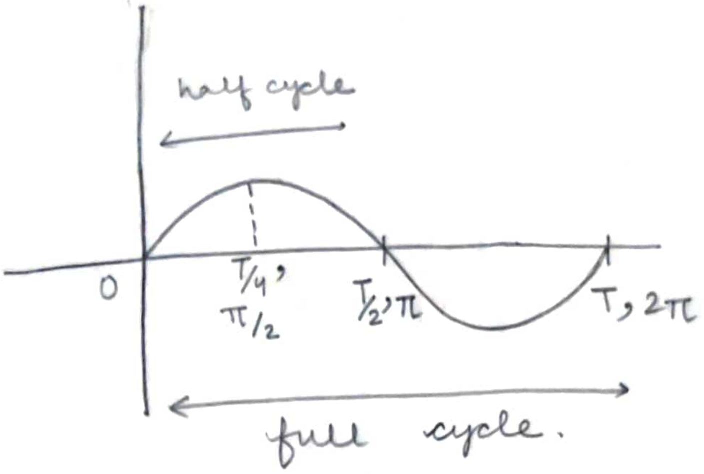
$$\Rightarrow M = \mu_0 \frac{n_1}{l} \frac{n_2}{\cancel{l}} \times A \times \cancel{l}$$

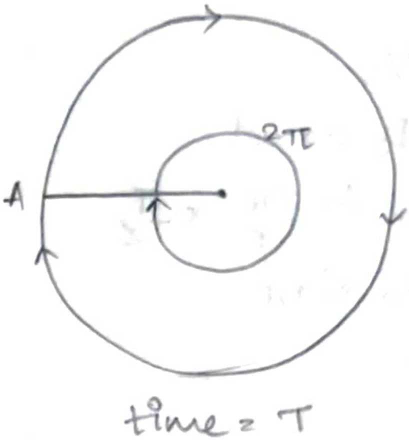
$$\Rightarrow \boxed{M = \frac{\mu_0 n_1 n_2 A}{l}}$$

12/07/2023

7. Alternating Current

*. Graph :-





$T = 2\pi$

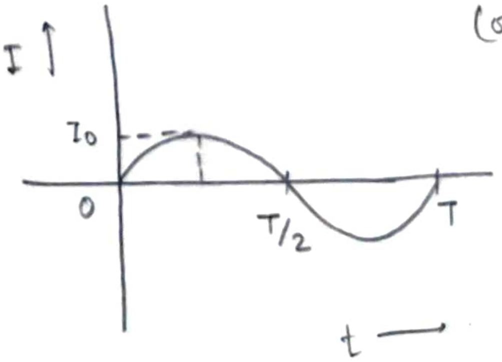
$\omega = \frac{2\pi}{T} = 2\pi f$ (or) $2\pi \nu$ $\quad [\because \frac{1}{T} = f]$

→ $\int_0^{T/2}$ → half cycle

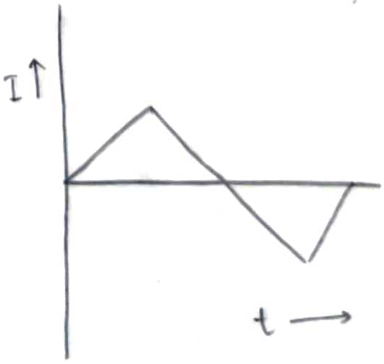
→ $\int_0^{T}$ → full cycle.

*. AC :-

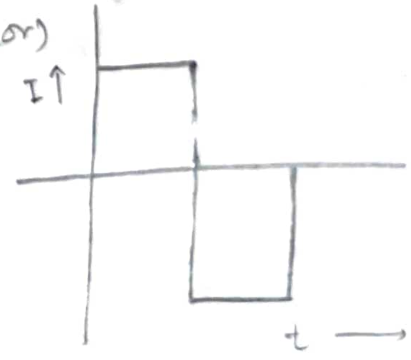
→ If direction of a current changes periodically in a fixed interval then it is called alternating current.



(or)



(or)



→ I_0 :- Peak (or) maximum current.

→ $I = I_0 \sin \underset{\substack{\uparrow \\ \text{angular} \\ \text{frequency}}}{\omega} t$ (or) $I = I_0 \cos \omega t$.

→ at $T/2$

$I = I_0 \sin \omega t$

$\Rightarrow I = I_0 \sin \frac{2\pi}{\cancel{T}} \times \frac{\cancel{T}}{\cancel{2}}$

$= I_0 \sin \pi$ [∵ $\sin \pi = \sin 180° = 0$]

$= 0$

→ at $T/4$, find $I = ?$

$\Rightarrow$ at $T/4$

$I = I_0 \sin \omega t$

$\Rightarrow I = I_0 \sin \frac{2\pi}{\cancel{T}} \times \frac{\cancel{T}}{\cancel{4}_2}$

$\Rightarrow = I_0 \sin \frac{\pi}{2} \frac{\cancel{2}}{\cancel{2}}$ [∵ $\sin \frac{\pi}{2} = \sin \frac{180}{2} = \sin 90° = 1$]

$= I_0$.

→ Alternating voltage :

$V = V_0 \sin \omega t$ (or) $V = V_0 \cos \omega t$.

where V_0 :- peak voltage

ω :- angular frequency

t :- time.

*. Average (or) Mean value of current :-

Average (or) mean current is given as ~~Iavg (or) I_M~~

$$I_{avg} \text{ (or) } I_M = \frac{\int I\,dt}{\int dt}$$

1. For half cycle :-

$$I_M = \frac{\int_0^{T/2} I\,dt}{\int_0^{T/2} dt} \qquad [\because I = I_0 \sin \omega t]$$

$$= \frac{\int_0^{T/2} I_0 \sin \omega t\,dt}{\int_0^{T/2} dt}$$

$$= \frac{I_0 \left[-\frac{\cos \omega t}{\omega}\right]_0^{T/2}}{[T]_0^{T/2}}$$

$$= \frac{I_0 \left[\frac{-\cos \omega T/2}{\omega} + \frac{\cos 0}{\omega}\right]}{T/2}$$

$$= \frac{\frac{I_0}{\omega}\left(-\cos \omega T/2 + \cos 0\right)}{T/2}$$

$$= \frac{\frac{I_0}{\omega}\left(-\cos \cancel{\omega}\pi + \cos 0\right)}{T/2} \qquad \left[\because \omega = \frac{2\pi}{\cancel{T}} \times \frac{\cancel{T}}{2} = \pi\right]$$

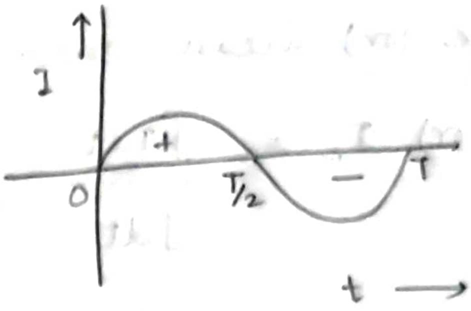
$$= \frac{\frac{I_0}{\omega}\left(-(-1)+1\right)}{T/2} = \frac{\frac{I_0}{\omega} \times 2}{T/2}$$

$$= \frac{I_0 \times 2 \times 2}{T \times \omega} = \frac{I_0 \times \cancel{2} \times 2}{\cancel{T} \times \frac{\cancel{2}\pi}{\cancel{T}}} = \boxed{\frac{2 I_0}{\pi}}$$

2. Full cycle :-

For full cycle the average value of sin ωt is zero.

i.e I_m (or) $I_{avg} = 0$.



*. Average (or) mean value of V (or) E :-

1. For half cycle :-

$$V_M = \frac{2V_0}{\pi} \text{ (or) } E_M = \frac{2E_0}{\pi}$$

2. for full cycle :-

$$V_M \text{ (or) } E_M = 0$$

*. Root mean square value of current :-

$$I_{rms} = \sqrt{\frac{I_1^2 + I_2^2 + \dots + I_n^2}{n}}$$

→ Rms value of current (I) is the steady current that generate heat in electrical appliances.

$$H = \int_0^T I^2 R dT$$

$$= R\int_0^T I_0^2 \sin^2\omega t \, dt$$

$$= R\int_0^T I_0^2 \left(\frac{1-\cos 2\omega t}{2}\right) dt.$$

$$\left[\because \sin^2\theta = \frac{1-\cos 2\theta}{2}\right]$$

$$= \frac{I_0^2 R}{2} \int_0^T dt - \int_0^T \cos 2\omega t$$

$$= \frac{I_0^2 R}{2} \left([T]_0^T - \left[\frac{\sin 2\omega t}{2\omega} \right]_0^T \right)$$

$$= \frac{I_0^2 R}{2} \left(T - \frac{\sin 2\omega T}{2\omega} + \frac{\sin 0}{2\omega} \right)$$

$$= \frac{I_0^2 R}{2} \left(T - \frac{\sin 2 \times \frac{2\pi}{\cancel{T}} \times \cancel{T}}{2\omega} \right)$$

$$= \frac{I_0^2 R}{2} \left(T - \frac{\sin 4\pi}{2 \times \frac{2\pi}{T}} \right)$$

$$= \frac{I_0^2 R}{2} (T - 0)$$

$$= \frac{I_0^2 RT}{2}$$

$$\Rightarrow H = I_{rms}^2 R\cancel{T} = \frac{I_0^2 R\cancel{T}}{2}$$

$$= I_{rms}^2 = \frac{I_0^2}{2}$$

$$\Rightarrow \boxed{I_{rms} = \frac{I_0}{\sqrt{2}}}$$

*. Rms value of Voltage :-

$$V_{rms} = \frac{V_0}{\sqrt{2}}$$

$$(\text{or})\ E_{rms} = \frac{E_0}{\sqrt{2}}$$

Q: What will be the instantaneous voltage for a.c. 220 V and 50 Hz.

Ans Given:-

✓ $V_{rms} = 220$

$V_0 = \sqrt{2} \times V_{rms} = 1.414 \times 220$
$= 311$ Volt.

$f = 50$ Hz

$\omega = 2\pi f = 100\pi$ $\quad [\because f = \frac{1}{T} ; \frac{2\pi}{T} = 2\pi f]$.

$V = V_0 \sin \omega t$
$= 311 \sin 100\pi t$.

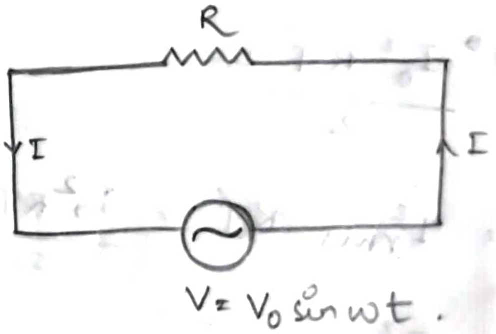
*. Imp Circuit containing only resistor:-

$V = IR$

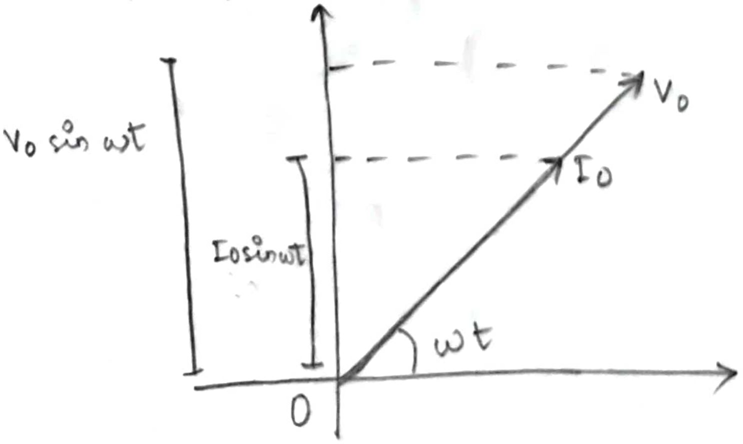
$\Rightarrow I = \frac{V}{R} = \frac{V_0 \sin \omega t}{R}$

$= \frac{V_0}{R} \sin \omega t$

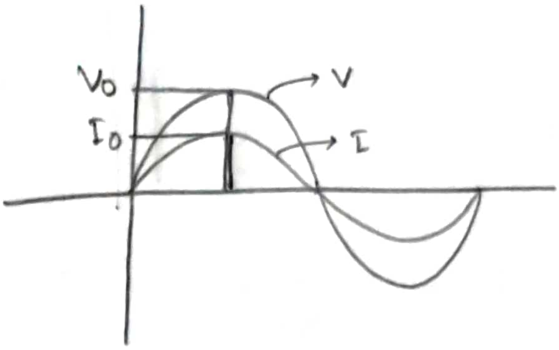
$$\boxed{I \Rightarrow I_0 \sin \omega t}$$



⊛ Phasor diagram:-

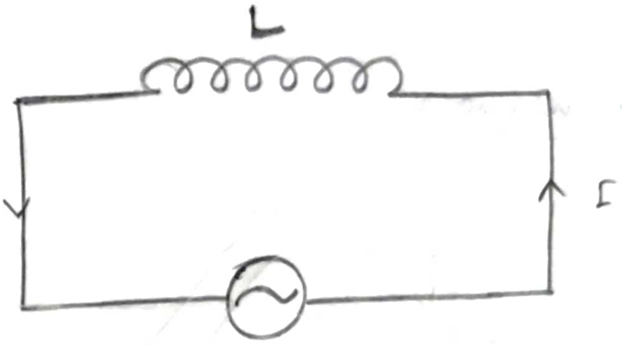


→ wave :-



Imp

*. Circuit containing Inductor :-



$E = E_0 \sin \omega t$

$$E = -\frac{d\phi}{dt}$$

$$\Rightarrow E = -L\frac{dI}{dt}$$

$$\Rightarrow dI = -\frac{E}{L}\,dt$$

Integrating

$$I = -\int \frac{E_0}{L} \sin \omega t\, dt$$

$$\Rightarrow I = -\frac{E_0}{L}\left(-\frac{\cos \omega t}{\omega}\right)$$

$$= -\frac{E_0}{\omega L}(-\cos \omega t)$$

$[\because \cos\theta = \sin(90-\theta)]$

$$\Rightarrow I = \frac{-E_0}{\omega L} - \left(\sin\left(\pi/_2 - \omega t\right)\right)$$

$$\Rightarrow I = \frac{-E_0}{\omega L} \sin\left(\omega t - \frac{\pi}{2}\right)$$

Due to self inductance concept

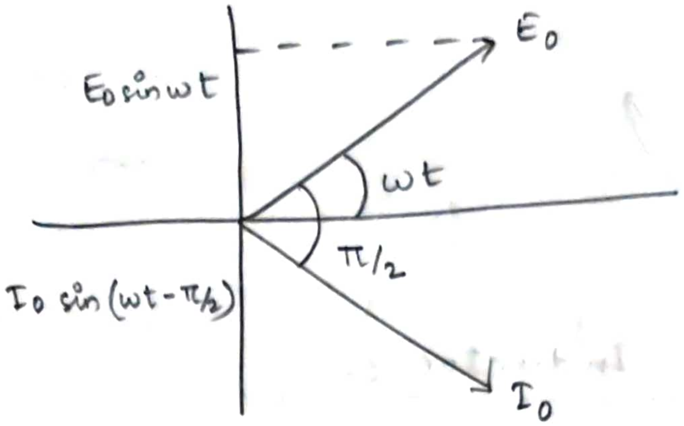
$$I = \frac{E_0}{\omega L} \sin(\omega t - \pi/_2)$$

$$= \frac{E_0}{X_L} \sin(\omega t - \pi/_2)$$

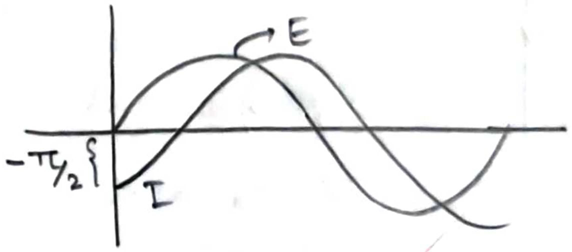
where $\boxed{X_L = \omega L}$

↳ Inductive reactance (or) Resistance of inductor.

→ Phasor diagram :-



→ Wave :



→ Current lags behind emf by phase of $\pi/2$

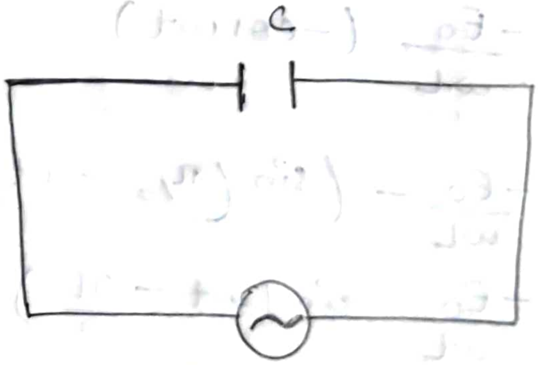
*. Circuit containing capacitor :-

We know

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

$$\Rightarrow q = CV$$

$$= C V_0 \sin \omega t$$



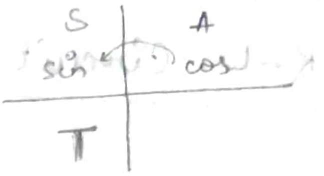
$V = V_0 \sin \omega t$

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

$$= \frac{d}{dt} \underbrace{C V_0 \sin \omega t}$$

$$\Rightarrow I = CV_0 \times \cos \omega t \times \omega$$

$$= CV_0 \omega \cos \omega t$$



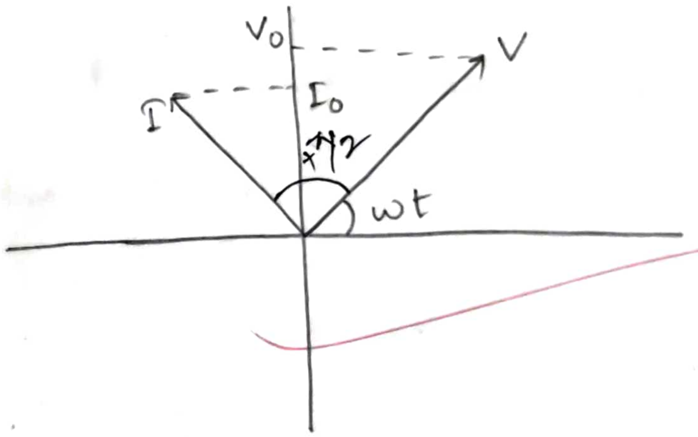
$$= \frac{V_0}{1/\omega C} \sin(\omega t + \pi/2)$$

$$= \frac{V_0}{X_c} \sin(\omega t + \pi/2)$$

where $X_c = \frac{1}{\omega C}$ = capaciti~~ance~~ve reactance (or) resistance of capacitor.

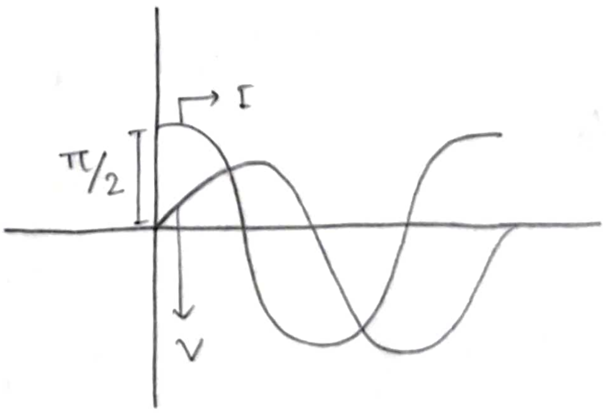
$\Rightarrow I = I_0 \sin(\omega t + \pi/2)$

→ Phasor diagram :-

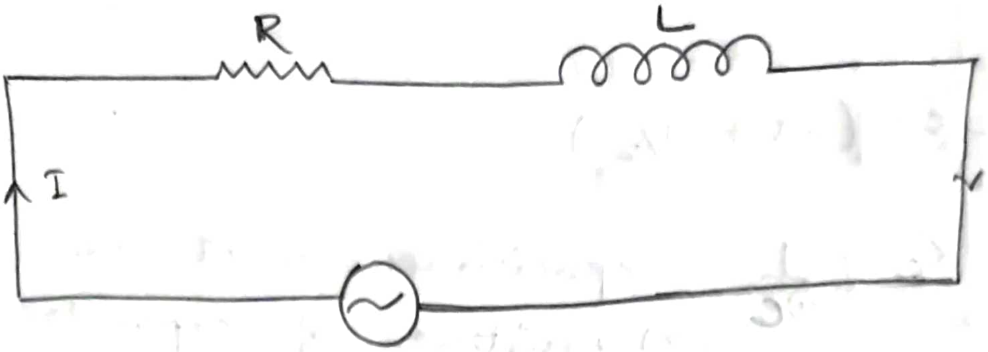


In capacitor circuit current leads voltage/emf by phase of $\pi/2$

→ Wave :-



*. R-L Circuit :-



$V = V_0 \sin \omega t$

$V_R = V_{0R} \sin \omega t$

$V_L = V_{0L} \sin(\omega t + \pi/2)$

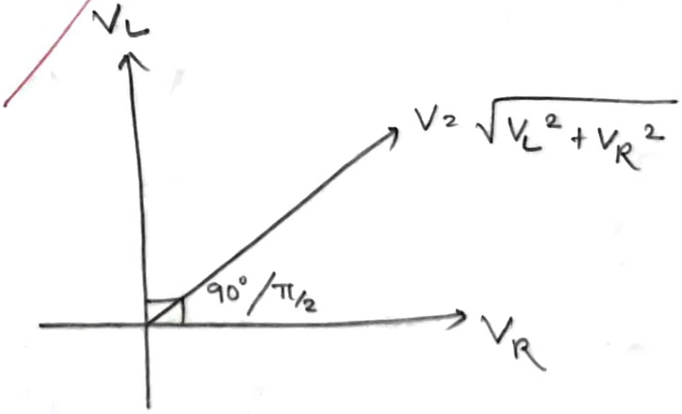
$V = IR$ (ohm's law)

$\Rightarrow V_0 = I_0 R$

$V_{0L} = I_0 X_L$ (Inductor)

$V_{0R} = I_0 R$ (Resistor).

→ **Phasor diagram :-**



$\Rightarrow V_0 = \sqrt{V_{0L}^2 + V_{0R}^2}$

$= \sqrt{(I_0 X_L)^2 + (I_0 R)^2}$

$= I_0 \sqrt{R^2 + X_L^2}$

$= I_0 Z$

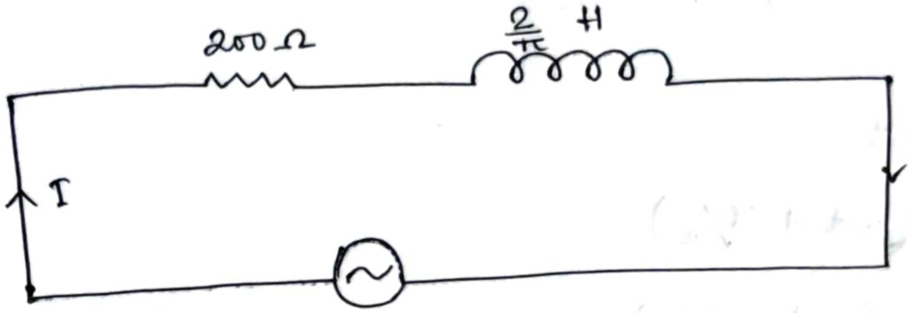
where

$Z = \sqrt{R^2 + X_L^2}$

$=$ impendance

(or) combine resistance of resistor & inductor.

Q:-



$V = 200 \sin 100\pi t.$

$V_0 \sin \omega t$

find impendance, I_{rms} and I_0 ?

Ans Given :-

$R = 200\,\Omega$

$L = \frac{2}{\pi}$ H

$V_0 = 200$

$\omega = 100\pi$

$X_L = \omega L$

$= 100\cancel{\pi} \times \frac{2}{\cancel{\pi}}$

$= 200$

$Z = \sqrt{R^2 + X_L^2}$

$= \sqrt{200^2 + 200^2}$

$= 200\sqrt{2}$

$\therefore \sqrt{a^2 + a^2}$

$= \sqrt{2a^2}$

$= \sqrt{2}$

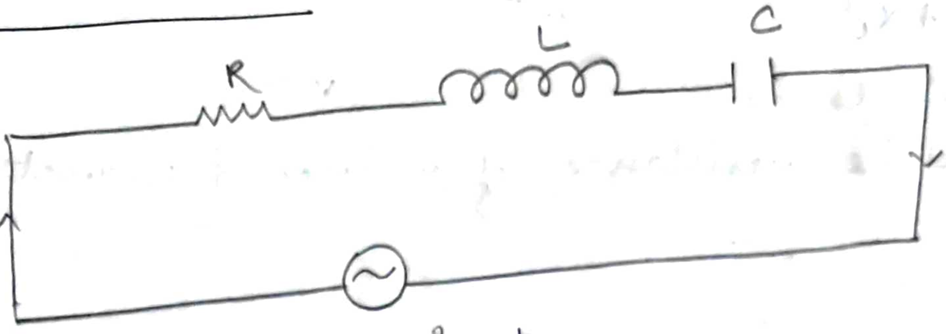
$I_0 = \frac{V_0}{Z} = \frac{\cancel{200}}{\cancel{200}\sqrt{2}} = \frac{1}{\sqrt{2}}$

$I_{rms} = \frac{I_0}{\sqrt{2}} = \frac{\frac{1}{\sqrt{2}}}{\sqrt{2}} = \frac{1}{2} = 0.5A$

22/09/2023

Imp

*. R-L-C Circuit :-

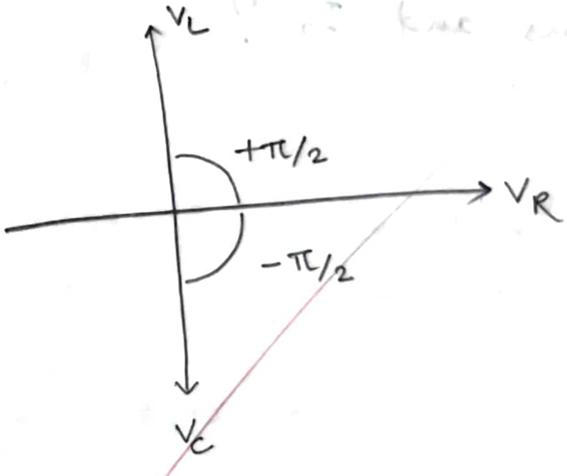


$V = V_0 \sin \omega t$

$V_R = V_{0R} \sin \omega t$

$V_L = V_{0L} \sin(\omega t + \pi/2)$

$V_C = V_{0C} \sin(\omega t - \pi/2)$



→ $V_{LC} = V_L - V_C$

→ $V_R = V_R$.

→ $V_0 = \sqrt{V_{0R}^2 + V_{0LC}^2}$

$= \sqrt{V_{0R}^2 + (V_{0L} - V_{0C})^2}$

$= \sqrt{(I_0 R)^2 + (I_0 X_L - I_0 X_C)^2}$

$= I_0 \sqrt{R^2 + (X_L - X_C)^2}$

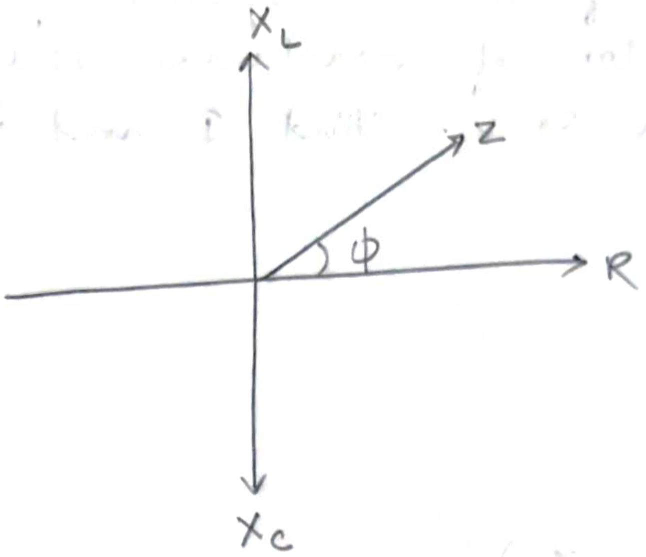
$= I_0 Z$

where $Z = \sqrt{R^2 + (X_L - X_C)^2}$

= impendance / combine resistance of R, L, C .

→ **Phasor** :-

$$\tan\phi = \frac{X_L - X_C}{R}$$



Imp

→ **Resonance** :-

At resonance

$$X_L = X_C$$

$$\Rightarrow \omega L = \frac{1}{\omega C}$$

$$\Rightarrow \omega^2 = \frac{1}{LC}$$

$$\Rightarrow \omega = \frac{1}{\sqrt{LC}}$$

$$\Rightarrow 2\pi f = \frac{1}{\sqrt{LC}}$$

$$\Rightarrow \boxed{f = \frac{1}{2\pi\sqrt{LC}}}$$

→ i.e. the frequency at which X_L and X_C will have same values and their resultant will zero.

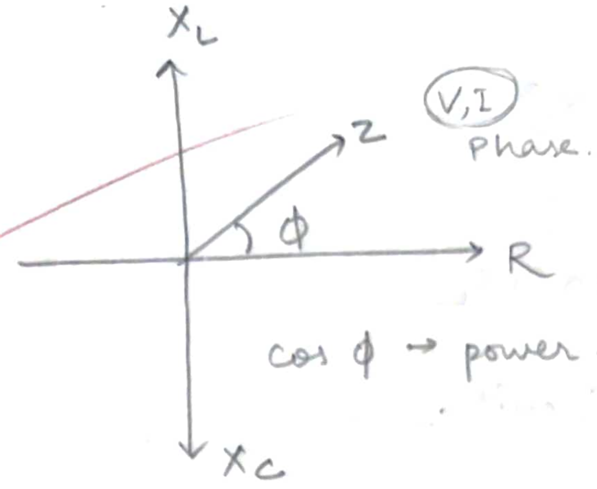
$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

If $X_L = X_C$

then $Z = R$.

*. Power of a RLC circuit :-

[$\therefore P = VI$]



$\cos\phi = \frac{R}{Z}$ → impendance

→ for capacitive circuit

$Z = X_C$

$\cos\phi = \frac{R}{X_C}$

⇒ $\phi = \frac{\pi}{2}$

$\cos\phi = \cos\pi/2 = 0$

i.e. power factor is zero.

→ Inductive circuit.

$\phi = \pi/2$ $\cos\phi = 0$.

→ For resistive circuit

$\phi = 0$

$\cos\phi = \cos 0 = 1$

(maximum).

→ For R-L circuit

$$Z = \sqrt{R^2 + X_L^2}$$

$$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2+X_L^2}}$$

→ For RLC circuit :-

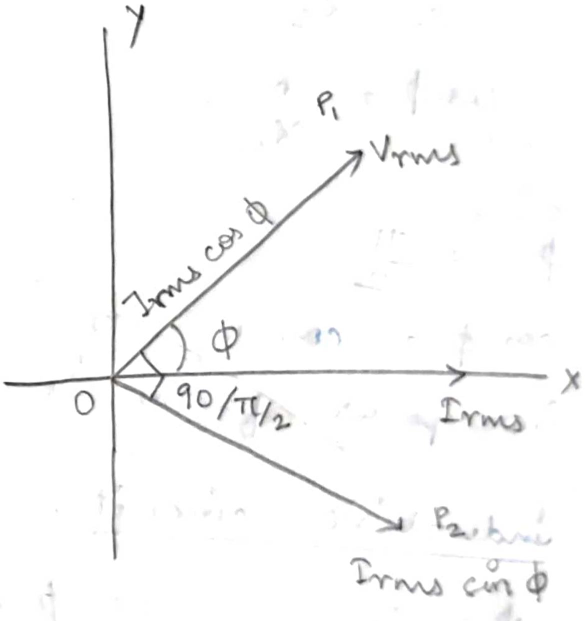
$$\cos\phi = \frac{R}{\sqrt{R^2+(X_L-X_C)^2}}$$

✱. Wattless Current :-

$P = I_{rms} V_{rms} \cos\phi$
(General formula).

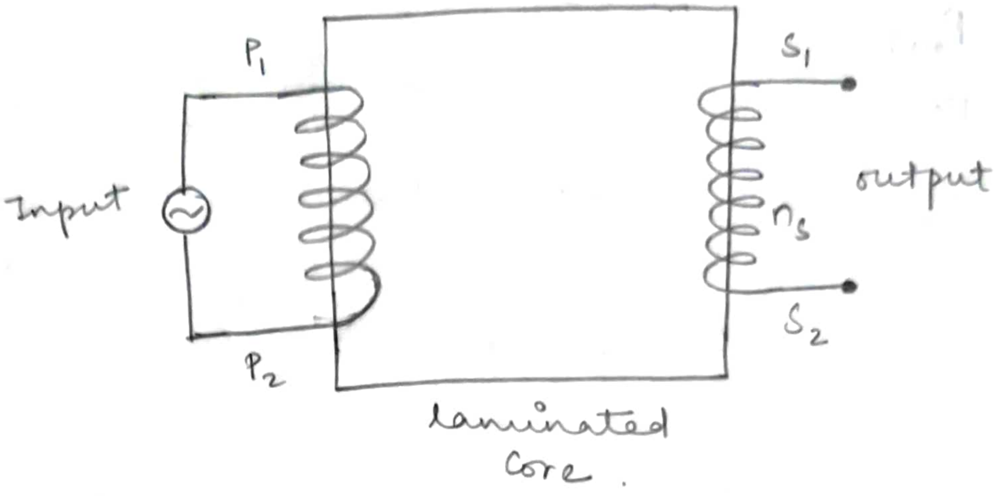
$P_1 = (I_{rms} \cos\phi) V_{rms} \cos 0$
$= I_{rms} V_{rms} \cos\phi$

$P_2 = (I_{rms} \sin\phi) V_{rms} \cos \pi/2$
$= 0$.



As power is zero that is why Irms sin ϕ is called wattless current.

* Transformer :-



→ Transformer works on mutual induction principle.

→ Faraday says induce emf per turn is same for ~~both~~ both coil .

$$\frac{E_p}{n_p} = \frac{E_s}{n_s}$$

n_p ↓ Primary .

n_s → secondary

→ no. of turn .

$$\Rightarrow \boxed{E_s = \frac{n_s}{n_p} E_p}$$

(For voltage) —— ①

→ If no energy loss then ,

$$E_s I_s = E_p I_p$$

$$\Rightarrow \boxed{I_s = I_p \frac{E_p}{E_s}}$$

E_p → Emf of primary coils

I_p → current of primary coils .

We know

$$\frac{E_p}{n_p} = \frac{E_s}{n_s}$$

$$\Rightarrow \frac{E_p}{E_s} = \frac{n_p}{n_s}$$

→ efficiency :-

$$\underset{(\text{eta})}{\eta} = \frac{P_{out}}{P_{in}}$$

23/09/23

Q1- A power transmission line feeds input at 2200V to a stepdown transformer of primary turns 3000. Find the number of turns in secondary to get the power output at 220 V.

Ans- $$\frac{E_p}{n_p} = \frac{E_s}{n_s}$$

$$\Rightarrow n_s = \frac{E_s \times n_p}{E_p} = \frac{\cancel{220} \times 300\cancel{0}}{\underset{1\cancel{0}}{\cancel{2200}}} = 300 \text{ turns.}$$

*. Energy loss in a transformer :-

→ Copper loss :-

Energy loss in form of heat due to Joules Law of heating effect.

→ Iron Loss :

When current pass through a iron core it get magnetised and demagnetised periodically which cause loss in energy. It is also called Hysteresis loss.

→ **Magnestriction :-**

Energy loss in form of sound.

*. **Uses of transformer :-**

- → Used in electrical appliances. (TV, refrigerator etc).
- → Induction furnace.
- → long transmission of current.

Q:- Capacitor of unknown capacitance, a resistance of 100 Ω, inductor of $\frac{4}{\pi^2}$ H are connected in series to a AC source of 200 V and 50 Hz. Calculate the value of capacitance and current that is not in phase with voltage.

Ans Given :-

$R = 100\ \Omega$

$L = \frac{4}{\pi^2}\ H$

$f = 50\ Hz$.

$V = 200\ V$

$X_L = X_C$

$\Rightarrow \omega L = \frac{1}{\omega C}$ $[\because \omega = 2\pi f]$

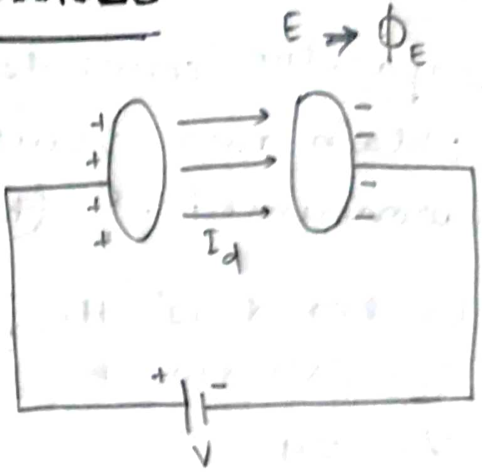
$\Rightarrow C = \frac{1}{\omega^2 L} = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4\pi^2 50^2 \frac{4}{\pi^2}} = \frac{1}{16 \times 2500} = 25\ \mu F$.

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

$= \frac{V}{R}$

$= \frac{200}{100} = 2\ A$.

8. ELECTROMAGNETIC WAVES



*. Displacement Current :-

→ We know the general current is conventional current I_c.

→ Inside a capacitor there is no physical medium but current flow depending on $\vec{E}$.

→ That current is called displacement current (I_d)

$$I_d = \frac{\varepsilon_0 \, d\phi_E}{dt}$$

→ Accelerated charge magnetic field.

→ Electric field also generate magnetic field.

→ L-C ossillator is used to generate Em-wave.

*. Maxwell's Equation:-

I. $\oint E.ds = q/\varepsilon_0$ → gauss law.

II. $\int B.ds = 0$ → Gauss law in magnetism.

III. $\int E.dl = -\frac{d}{dt}\int B.ds$ → Faraday Law.

IV. $\int B.dl = \mu_0 I$ → Ampere - maxwell eqn.

$= \mu_0 I_c + \mu_0 I_d$

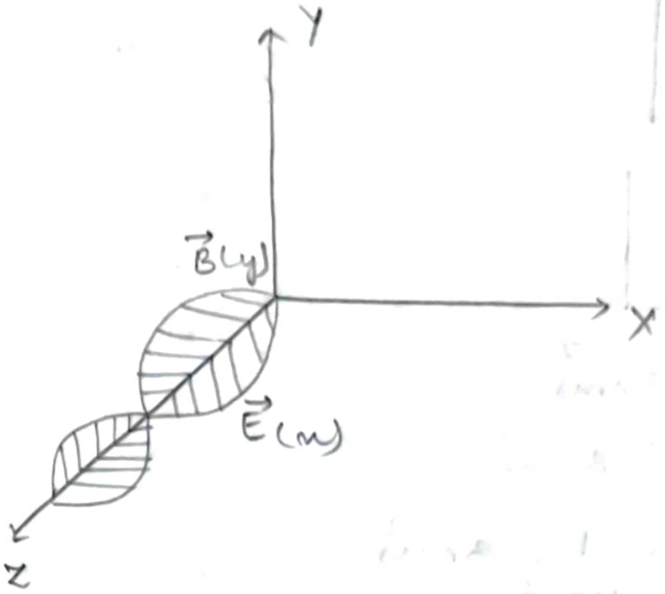
$I = I_c + I_d = \mu_0 I_c + \mu_0 I_d$

$= \mu_0 I_c + \mu_0 \varepsilon_0 \frac{d\phi_E}{dt}$

V. $F = q(E' + \vec{V} \times \vec{B})$
↓
Lorentz force.

*. Electromagnetic Wave :-

→ The wave originated from $\vec{E}$ and $\vec{B}$ produced by accelerated charge.



→ Electric field $\vec{E}$ is x and magnetic field $\vec{B}$ is Y the wave will be in Z i.e $(\vec{E} \times \vec{B})$

→ Velocity equal to $c(3 \times 10^8)$

$$c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$$

*. Characteristics :-

i. There is no phase between $\vec{E}$ and $\vec{B}$.

ii. Em waves are transverse in nature.

↳ (E(x), B(y), wave ( ) – angle = 90° → They are ⊥r to each other)

iii. In any other medium velocity will be changed.

iv) Em wave energy is equally divided by $\vec{E}$ and $\vec{B}$.

$$U_E = \frac{1}{2} \varepsilon_0 E^2$$

$$U_B = \frac{1}{2} \frac{B^2}{\mu_0}$$

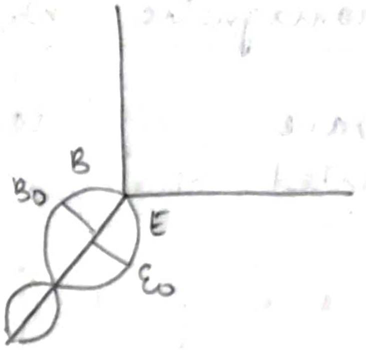
Now replace E & B with Erms and Brms.

$$\Rightarrow U_E = \frac{1}{2} \varepsilon_0 E_{rms}^2.$$

$$\Rightarrow U_B = \frac{1}{2} \frac{B_{rms}^2}{\mu_0}.$$

$$E_{rms} = \frac{E_0}{\sqrt{2}}$$

$$B_{rms} = \frac{B_0}{\sqrt{2}}$$



1) $$\boxed{\frac{E_0}{B_0} = c}$$

2) $$\boxed{\frac{E_{rms}}{B_{rms}} = C}$$

Now, $U_E = \frac{1}{2} \varepsilon_0 E_{rms}^2$

$= \frac{1}{2} \varepsilon_0 c^2 B_{rms}^2$

$= \frac{1}{2} \cancel{\varepsilon_0} \times \frac{1}{\mu_0 \cancel{\varepsilon_0}} B_{rms}^2$

$= \frac{1}{2} \frac{B_{rms}^2}{\mu_0}$

$= U_B$.

*. General Eqn of Em wave :

→ $E = E_0 \sin (Kx - \omega t)$

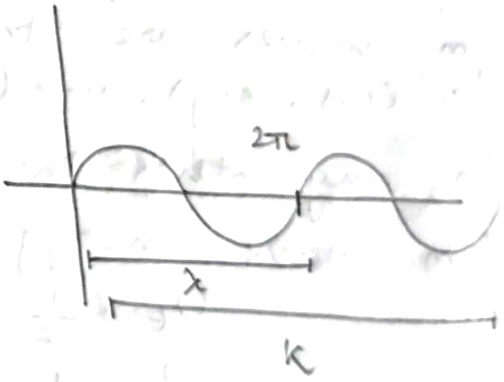
$B = B_0 \sin (Kx - \omega t)$

where, E_0 → Peak value

B_0 → Peak value

K = wave number

$$\boxed{K = \frac{2\pi}{\lambda}}$$



x = displacement

ω = angular frequency

$= \frac{2\pi}{T}$ (or) $2\pi f$ (or) $2\pi \nu$

→ If the general formula is (−) the wave will travel in (+) direction and vice versa.

→ $$\boxed{C = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = \frac{E_0}{B_0} = \frac{\omega}{K}}$$

Q: An electromagnetic wave is travelling in vaccum at a speed of 3×10^8 m/s. Find its velocity in a medium having relative electric and magnetic permiabilities 2 and 1 respectively?

Ans: Given, $C = 3 \times 10^6$ m/s.

$E_r = 2$

$\mu_r = 1$

Velocity of Em wave is

$$V = \frac{c}{\sqrt{\mu_r E_r}} = \frac{3 \times 10^8}{\sqrt{2 \times 1}} = \frac{3}{\sqrt{2}} \times 10^8 \text{ m/s}.$$

* Electromagnetic Waves :-

1. Radiowaves :-

Frequency $= 5 \times 10^5$ Hz to 3×10^9 Hz.

● Uses :-

→ Amplitude modulated (AM) band.

→ Short wave AM band.

→ Television waves

→ Frequency modulated (FM) radio band.

→ Commercial FM radio.

→ Ultra high frequency (UHF) band.

2. **Microwaves :-**

Frequency = 3×10^9 Hz to 3×10^{11} Hz

④ **Uses :-**

→ Microwaves are used in Radar system for air craft avigation.

→ A radar using microwave can help in detecting the speed of tennis ball, cricket ball, automobile while in motion.

→ Microwave ovens are used for cooking purpose.

→ Microwave are used for observing the movements of trains on rails while sitting in microwave operated control rooms.

3. **Infrared waves :-**

Frequency = 3×10^{11} Hz to 4×10^{14} Hz.

④ **Uses :-**

→ In physical therapy i.e. to treat muscular strain.

→ To provide electrical energy to satellite by using solar cells.

→ For taking photographs during the conditions of fog, smoke etc.

→ In solar water heaters and cookers.

→ In eye surgery

4. **Visible light :-**

Frequency = $4 \cdot \times 10^{14}$ Hz $\times$ 8×10^{14} Hz

④ **Uses :-**

→ to see the beautiful world around us as it excites our sense of vision.

→ In photography to take the picture of objects.

→ In astronomy to track the movement of heavenly bodies

→ In optical microscopy which involves to study of minute objects.

5. Ultraviolet rays :-

Frequency = 8×10^{14} Hz to 3×10^{17} Hz.

⊛ Uses :-

→ To destroy the bacteria and for stabilizing the surgical instruments.

→ in Lasik eye surgery.

→ To kill germs in water purifier.

6. X- rays :-

Frequency = 3×10^{17} Hz to 3×10^{20} Hz.

⊛ Uses :-

→ In surgery is for detection of fractures, foreign bodies like bullets, diseased organs and stones in the human body.

→ In Engineering (i) for detecting faults, cracks, flaws and holes in final metal products (ii) for the testing of weldings, castings and moulds.

→ In Radio therapy, to cure untracable skin diseases and malignant growths.

→ In detective departments (i) for detection of explosives, opium, gold and silver in the body of smugglers.

→ In Industry (i) for the detection of pearls in oysters and defects in rubber tyres, gold and tennis balls etc. (ii) for testing the uniformity of ~~insa~~ insulating material.

→ In Scientific Research (i) for the investigation of structure of crystals, arrangement of atoms and molecules in the complex substances.

7. **γ- rays :**

Frequency = 3×10^{18} Hz to 5×10^{23} Hz.

* **Uses :-**

→ In the treatment of cancer and tumours.

→ to preserve the food stuffs for a long time as the soft γ- rays can kill microorganisms easily.

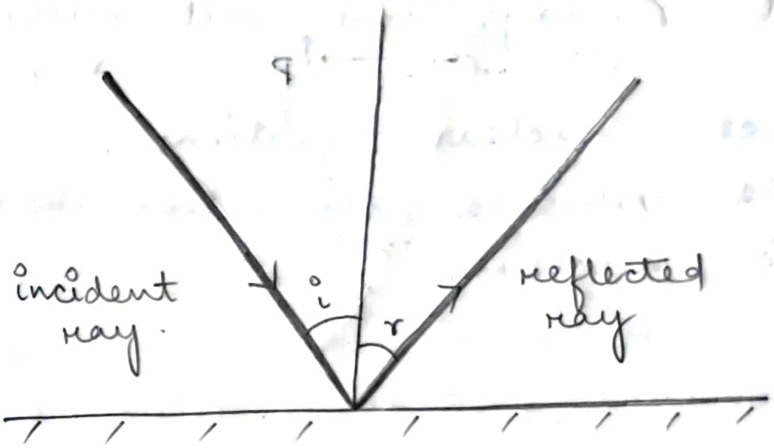
→ To produce nuclear reactions.

→ to provide valuable information about the structure of atomic nucleus.

9. OPTICS

* **Reflection** :-

→ Bounce back of light when incident on a shining face.



$\angle i$ = incident ray
$\angle r$ = reflected ray.

*. **Laws of reflection** :-

i) angle of incident is equal to angle of reflection.

$$\angle i = \angle r$$

ii) Incident ray, reflected ray and normal lie on same plane.

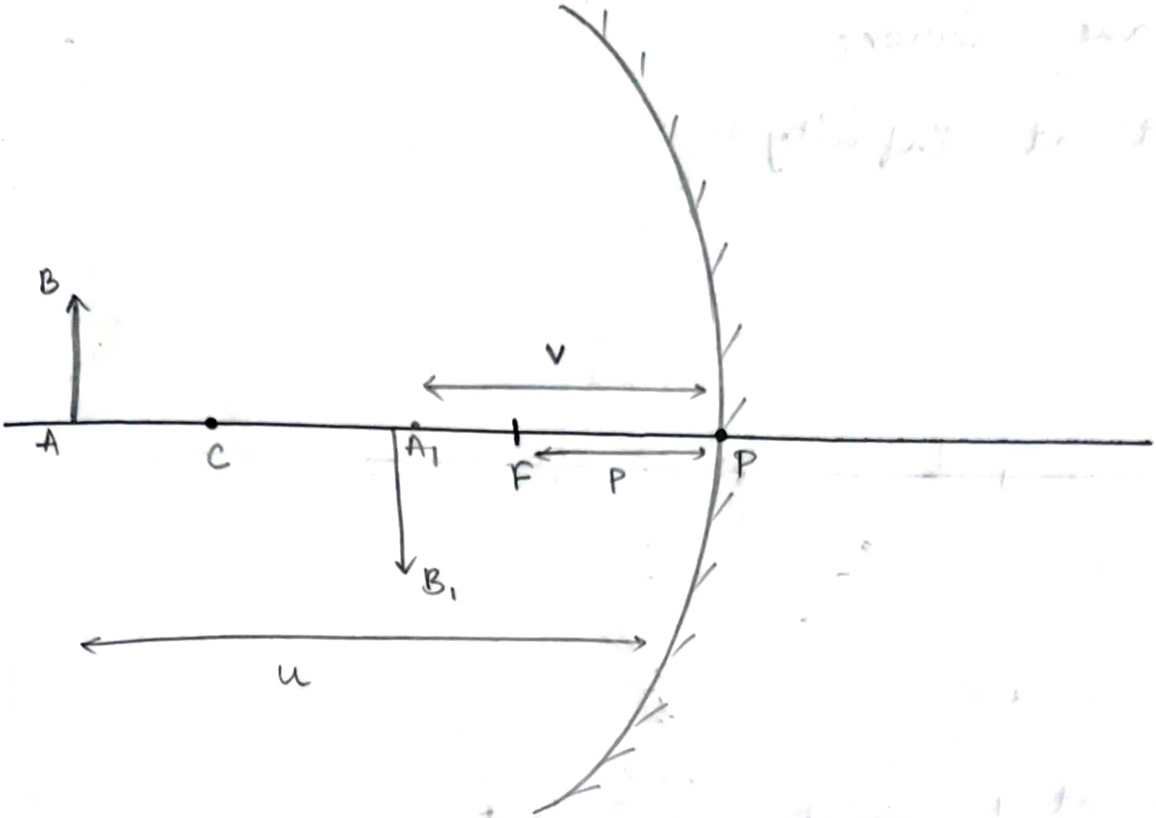
→ If angle θ in between two mirrors,
then image $= \frac{360}{\theta}$ if even

$= \frac{360}{\theta} - 1$ if odd.

*. **Spherical mirror** :-

1. Concave mirror

2. Convex mirror.



AP = u (object distance)

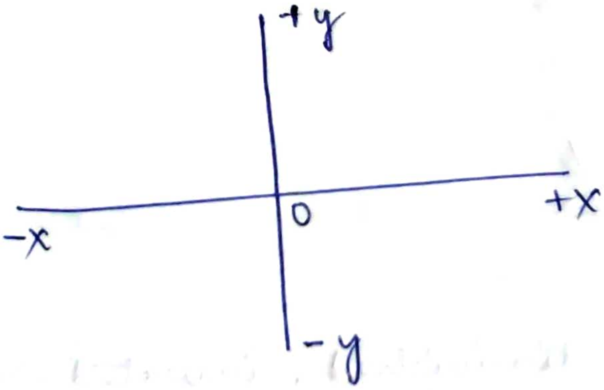
A'P = v (image distance)

CP = R (Radius of curvature)

FP = f (focal length)

AB = h = object height

A'B' = h' = image height.



u = -ve

v = -ve

f = -ve

h = +ve

h' = -ve

} sign convention.

*. Concave mirror :-

1. Object at infinity :-

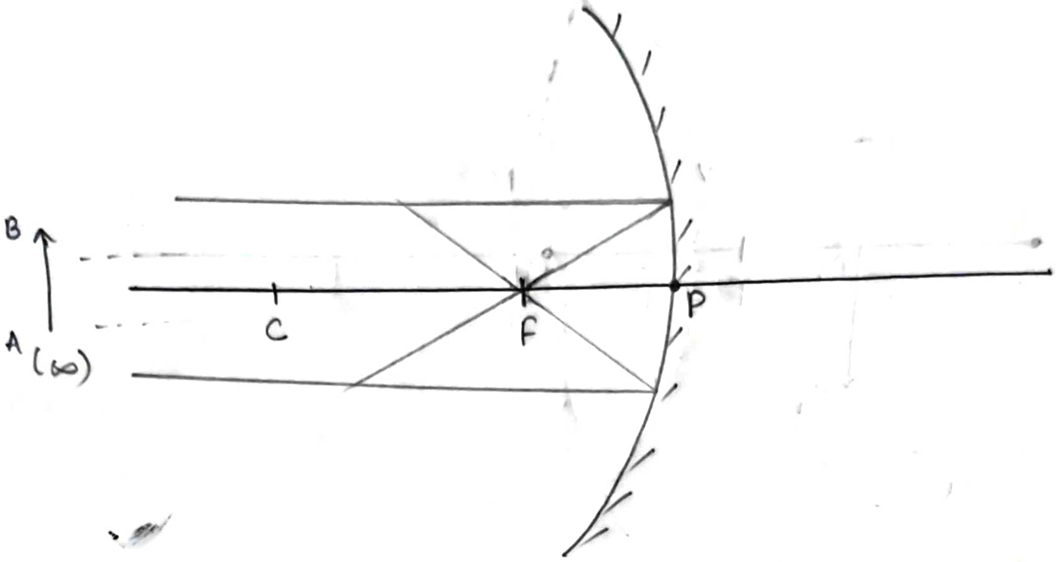


image at F, point size, real.

2. Object near C :-

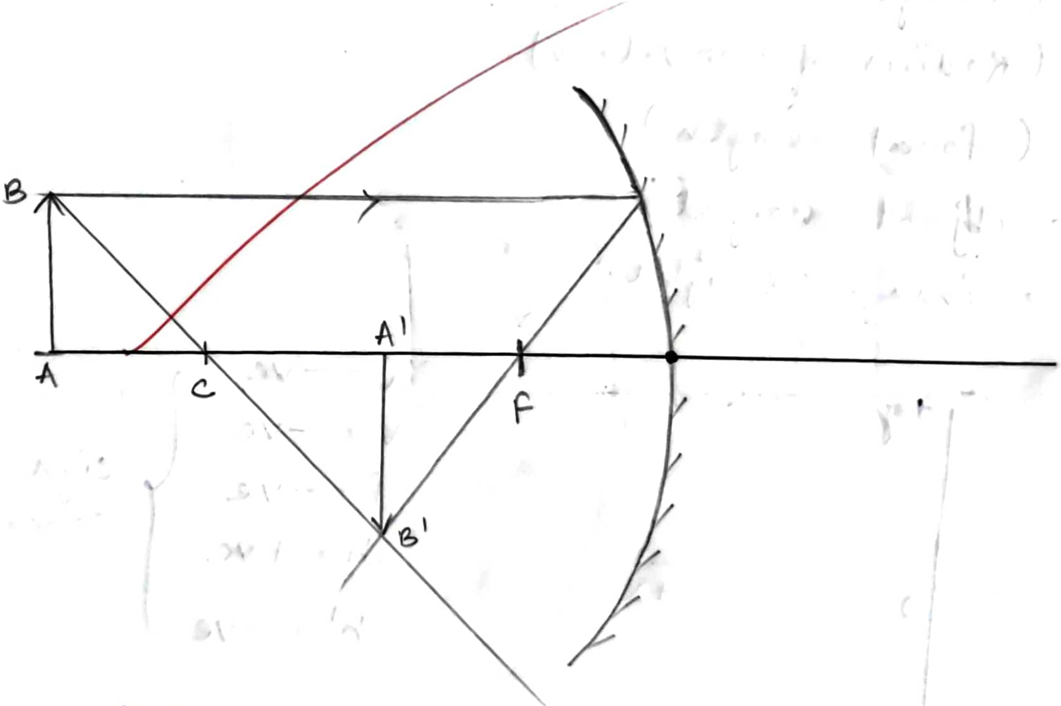


image between C and F diminished, inverted, real.

3. Object on C :-

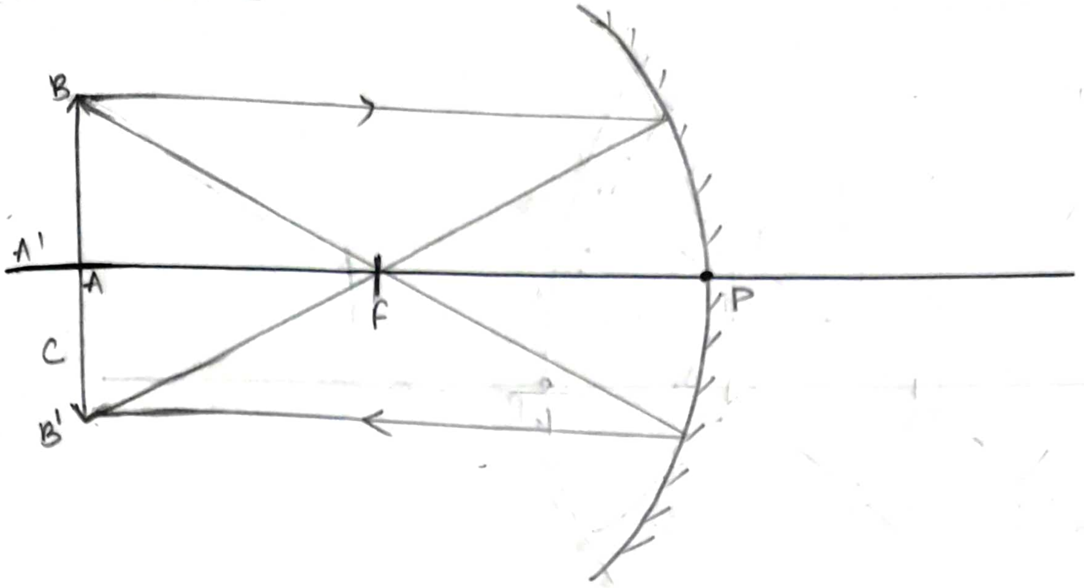


image at C, same size, inverted, real.

4. Object between C & F

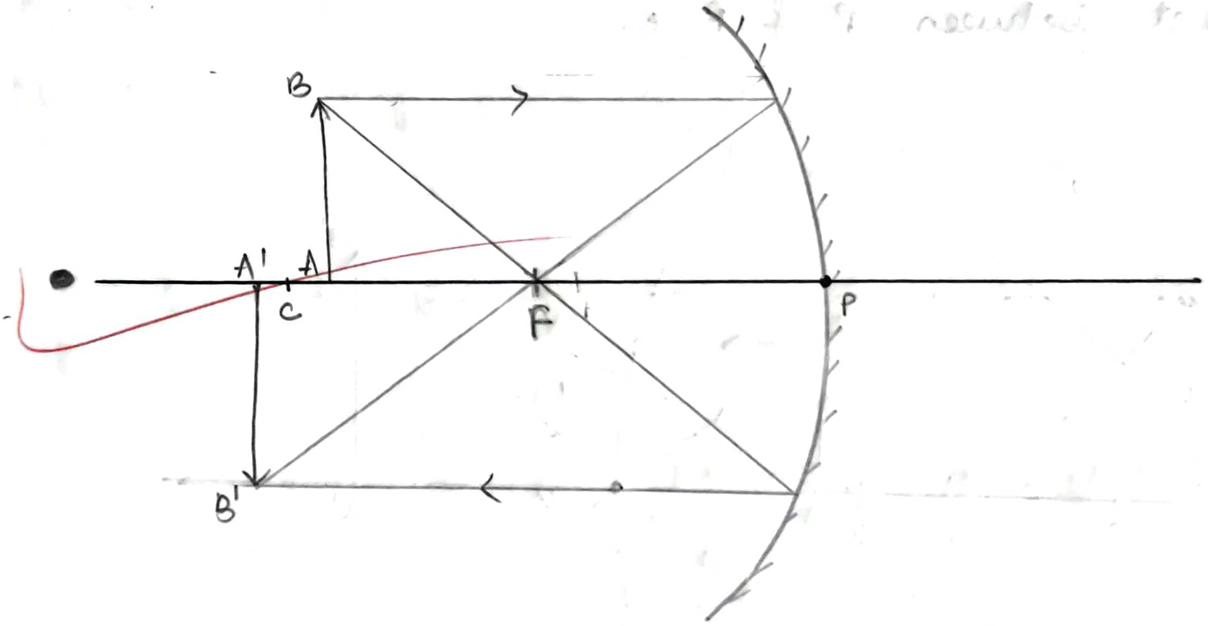


image beyond C, inverted, real, magnified.

5. Object at F :-

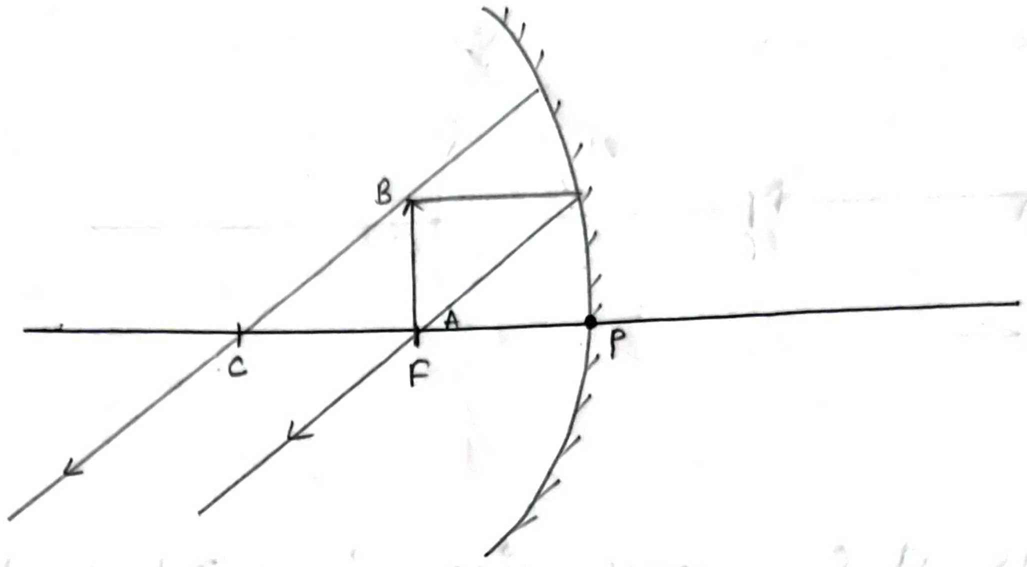


image at infinite, magnified inverted, real.

6. Object between P & F :-

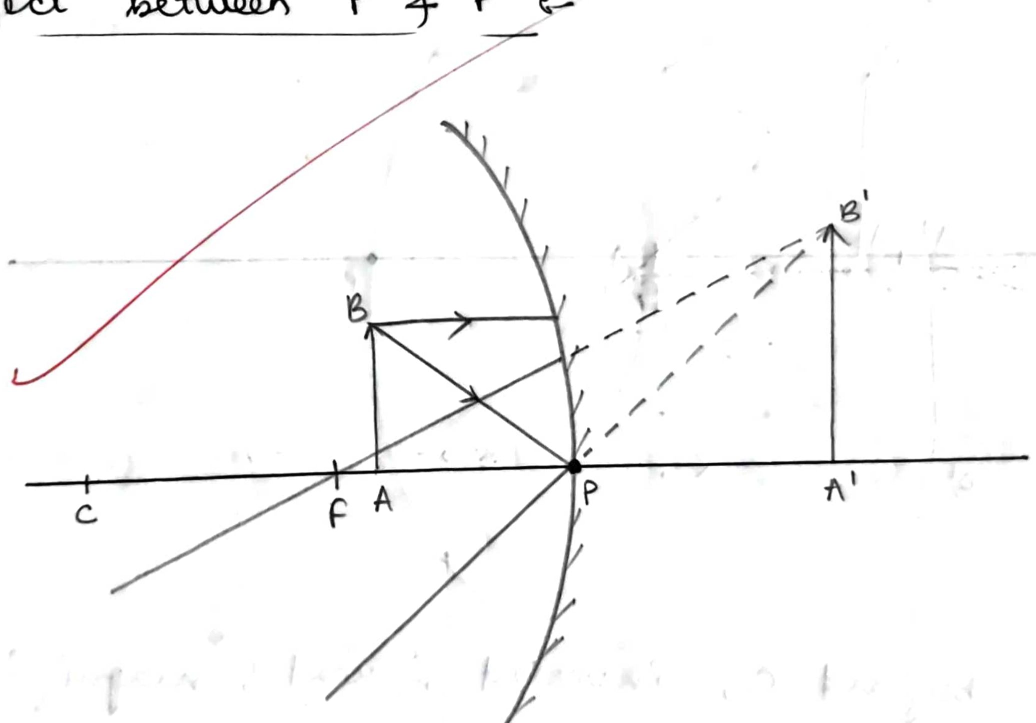


image virtual, erect.

*. **Convex mirror :-**

1. **Object at ∞ :-**

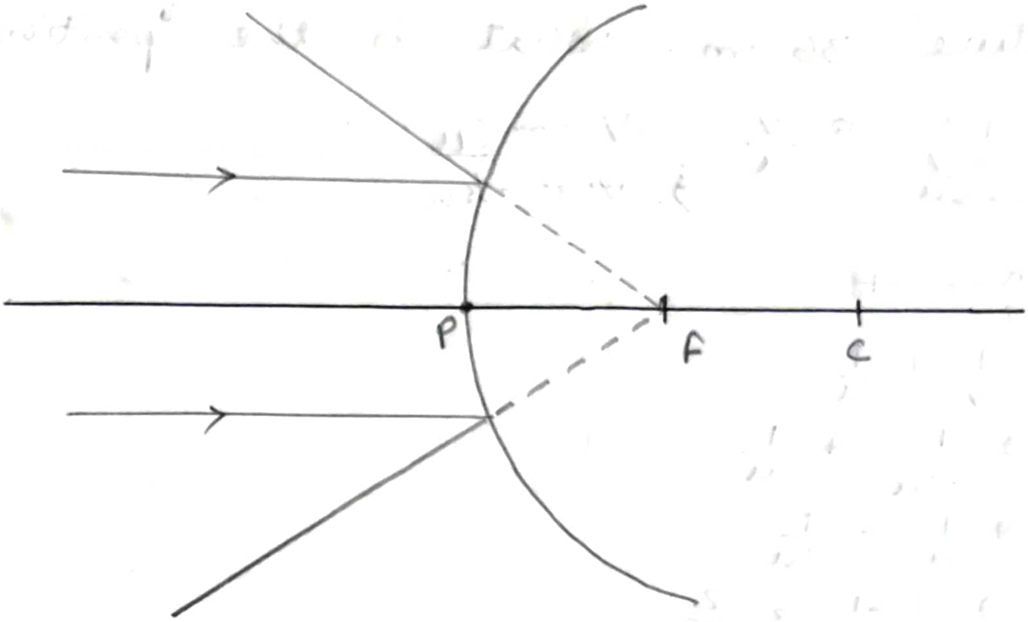


image at F, virtual, erect diminished.

2. **Object at any point :-**

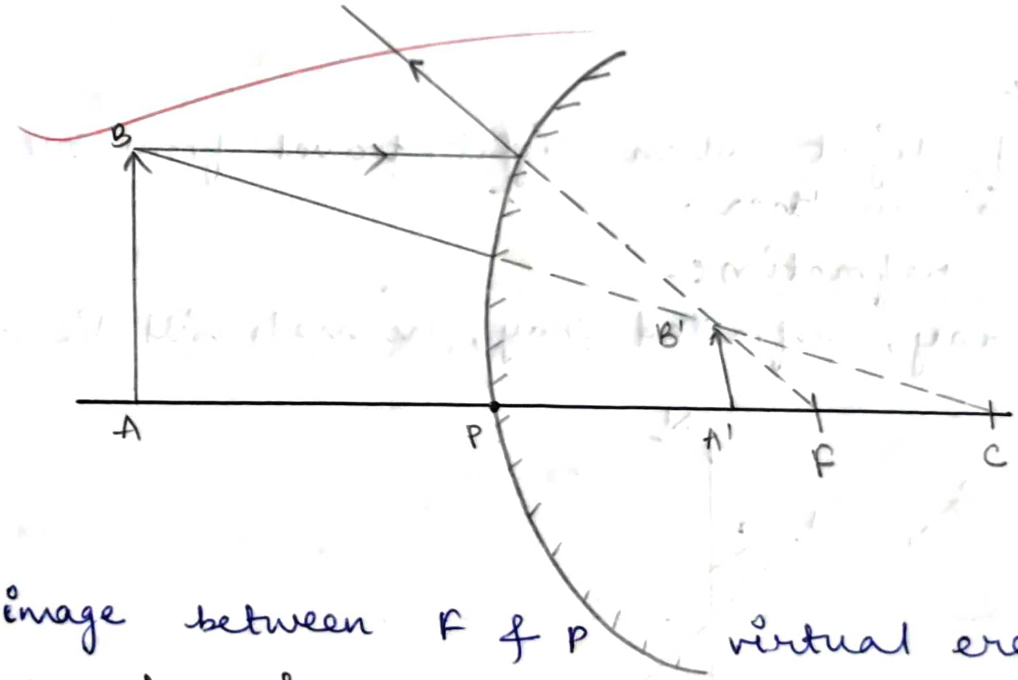


image between F & P virtual erect, diminished.

*. **Mirror formula:**

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

*. **Magnification :**

$$m = \frac{-v}{u} = \frac{h'}{h}$$

Q1. An erect image 3 times the size of object is obtained with a concave mirror of radius of curvature 36 cm. What is the position of object?

Ans. $M = +3$ ⇒ $-V = 3u$

⇒ $3 = -\frac{V}{u}$ ⇒ $V = -3u$

~~$R = 36$~~

~~$f = \frac{R}{2} = -18$~~

$$\frac{1}{f} = \frac{1}{V} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{-3u} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{u} - \frac{1}{3u}$$

$$\Rightarrow \frac{3-1}{3u} = \frac{2}{3u}$$

$$\Rightarrow f = \frac{3}{2}u$$

$$\Rightarrow -18 = \frac{3}{2}u$$

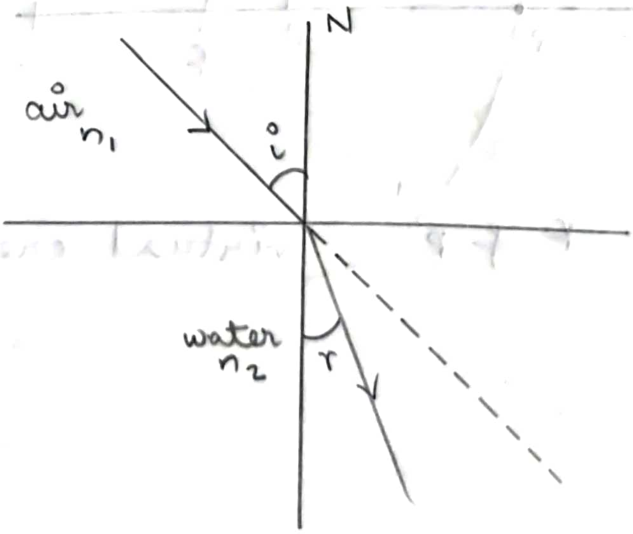
$$\Rightarrow -36 = 3u \Rightarrow u = -12\text{ cm.}$$

*. Refraction :-

→ Bending of light when light travel from one medium to another.

⊛ Law of refraction :-

→ Incident ray, refracted ray, normal will lie on same plane.



→ Snell's law

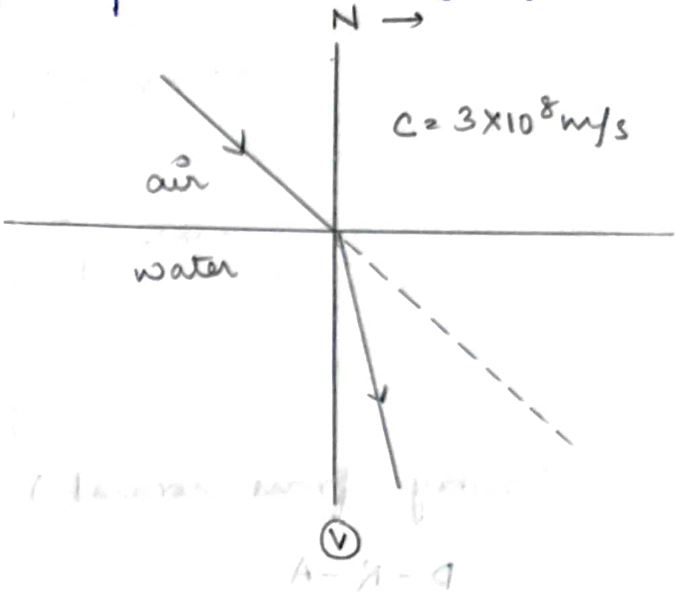
$n_1 \sin i = n_2 \sin r$

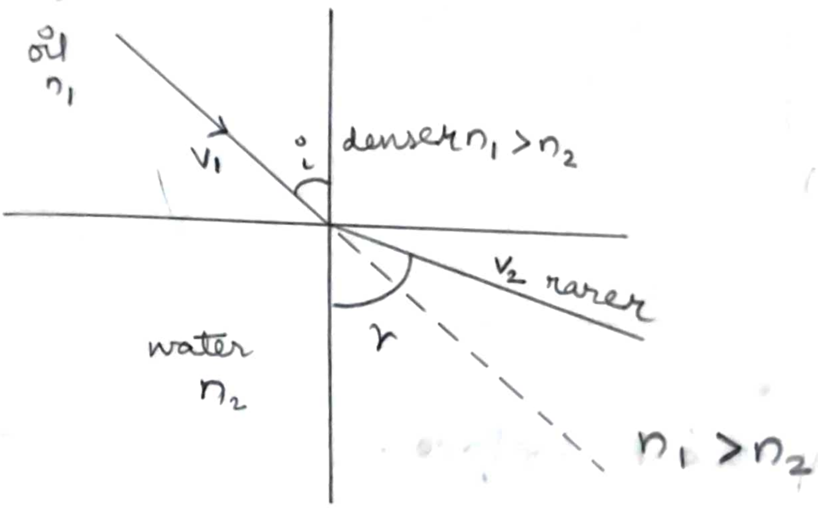
*. Refractive Index (n) (or) (μ) :-

→ Refractive index means the optical density of medium.

→ related to velocity.

$$\boxed{n \text{ (or) } \mu = \frac{c}{V}}$$





$$n_1 \text{ (or) } \mu_1 = \frac{c}{V_1}$$

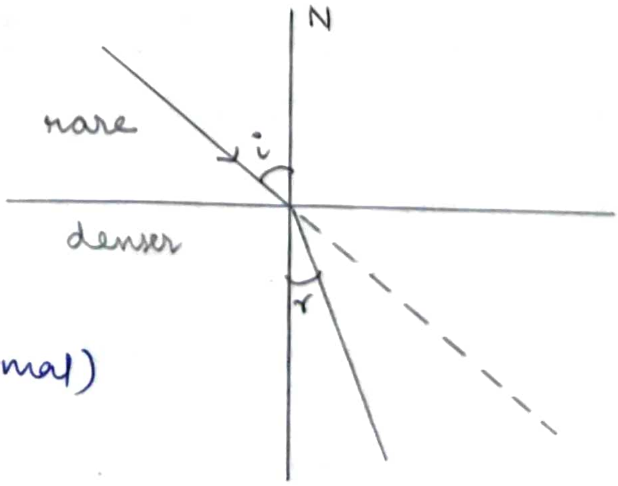
$$n_2 \text{ (or) } \mu_2 = \frac{c}{V_2}$$

$$\frac{n_1}{n_2} = \frac{\cancel{c}/V_1}{\cancel{c}/V_2} = \frac{V_2}{V_1}$$

$$\text{(or) } \boxed{{}_2n_1 = \frac{n_1}{n_2} = \frac{V_2}{V_1}}$$

⊛ Conditions of refraction :-

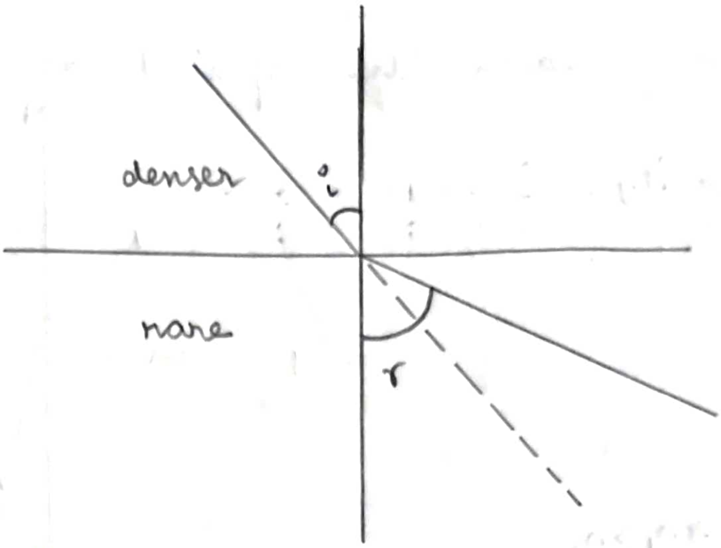
(1) Rare to Denser.



(Close to normal)

R – D – C

(2) Denser to Rare

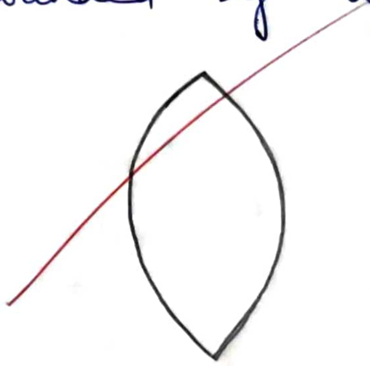


(away from normal)

D – R – A

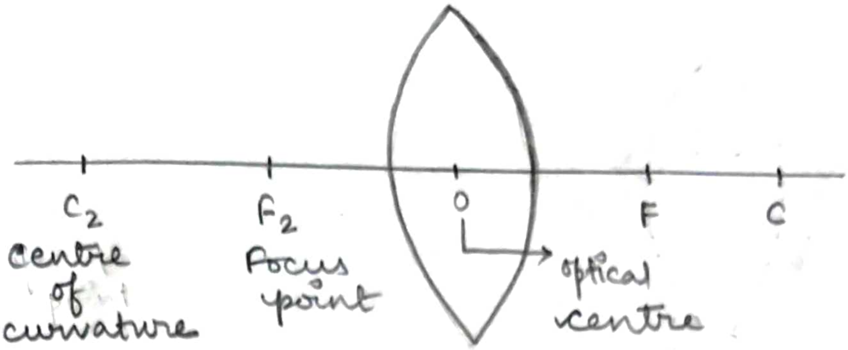
*. **Lens** :-

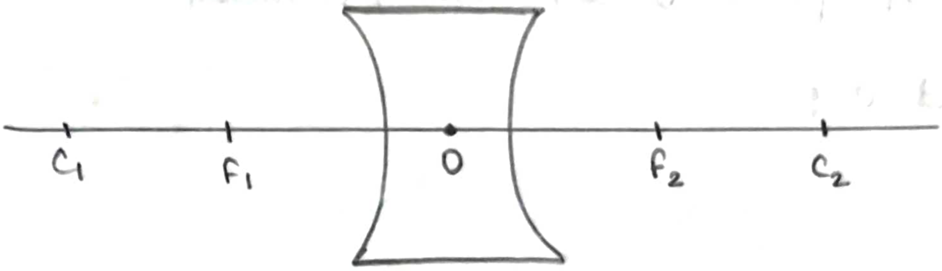
→ Bounded by two spherical surface.



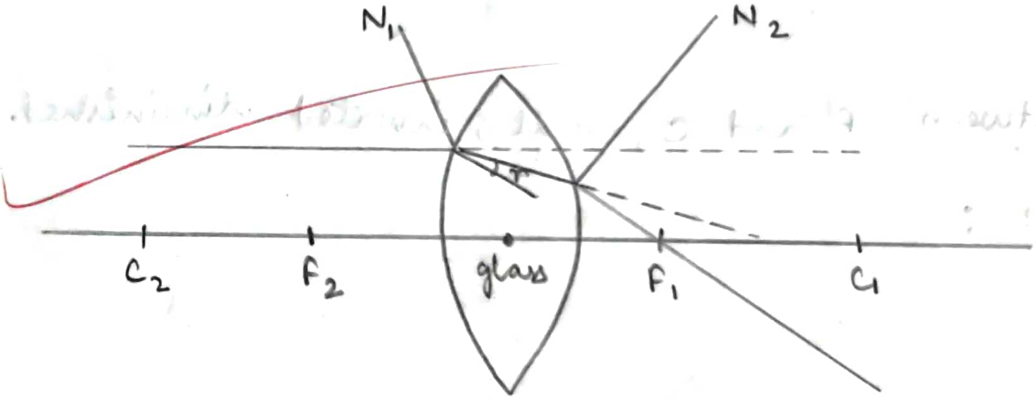
(Convex lens)

(Concave lens)

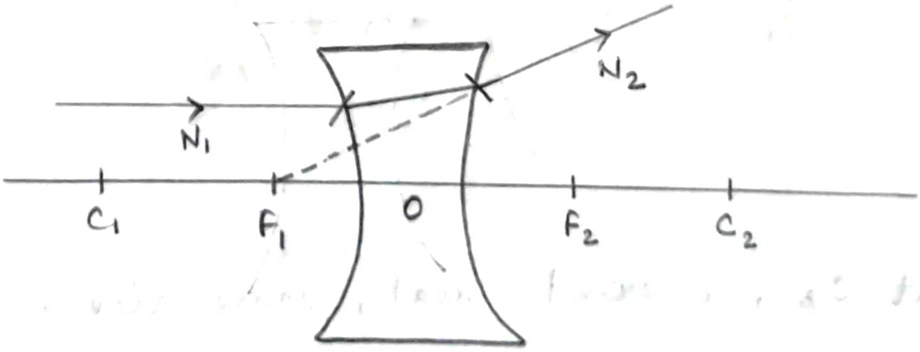




*. Refraction through lens :-



(converging)



(diverging)

*. Convex lens :

1. Object at ∞ :

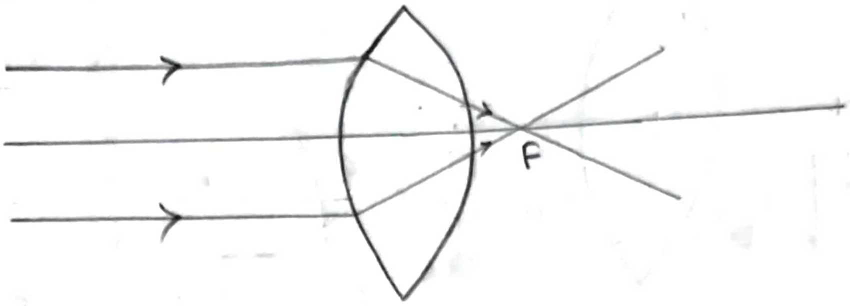


Image at F_1 point size, real, inverted.

2. Object beyond C :

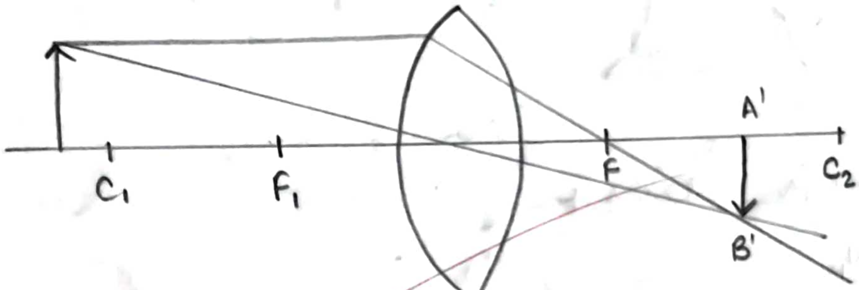


Image between F and C, real, inverted diminished.

3. Object at C :

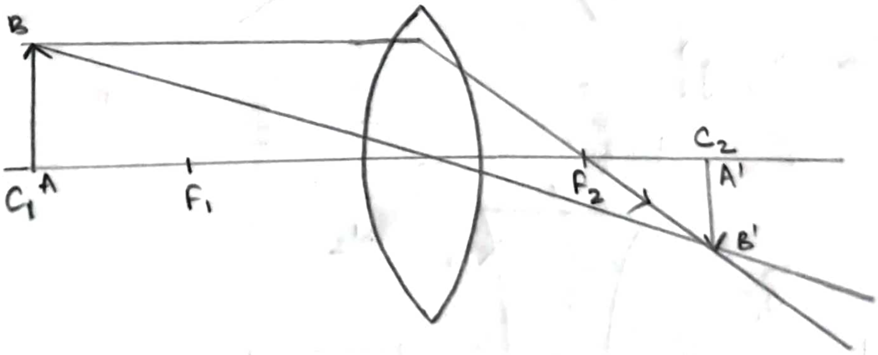


Image at C_2, inverted real, same size.

4. Object between C_1 and F_1 :

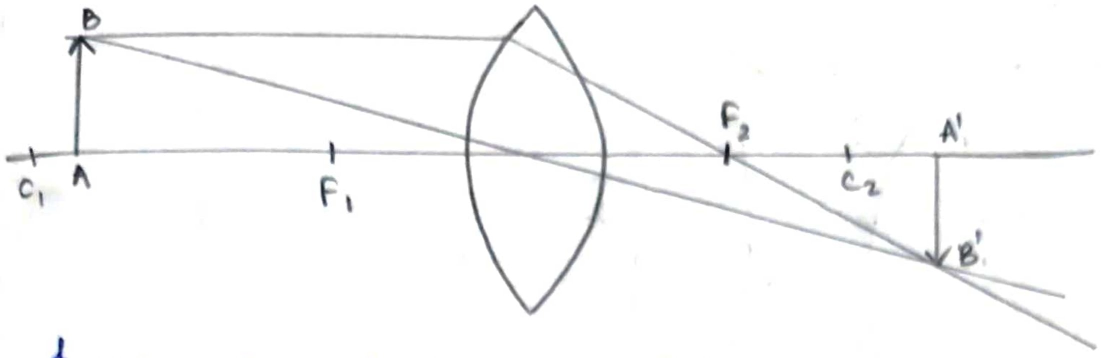


Image beyond C_2 magnified, real, inverted.

5. Object on F_1 :

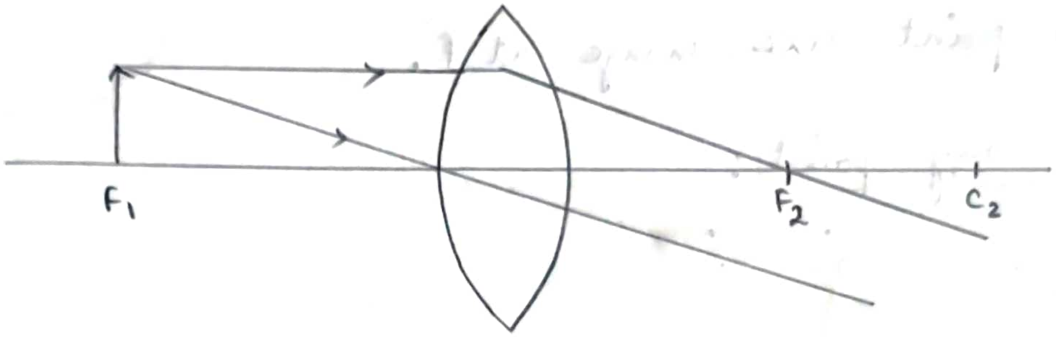


Image at ∞, ~~magnified~~, inverted, real.

6. Object between O and F_1 :

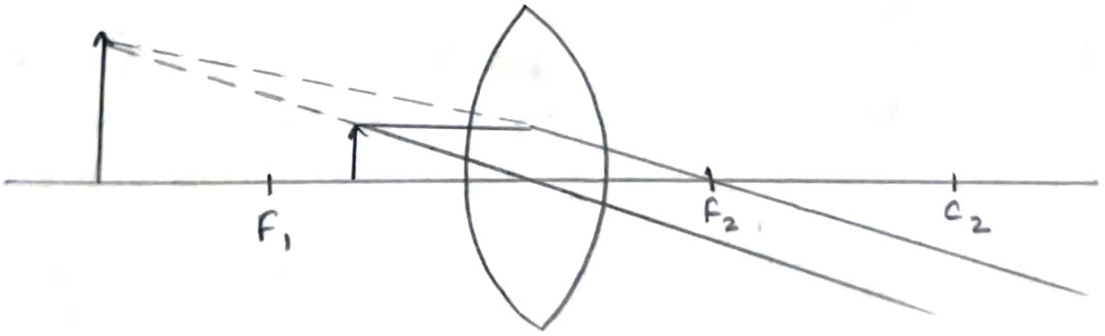
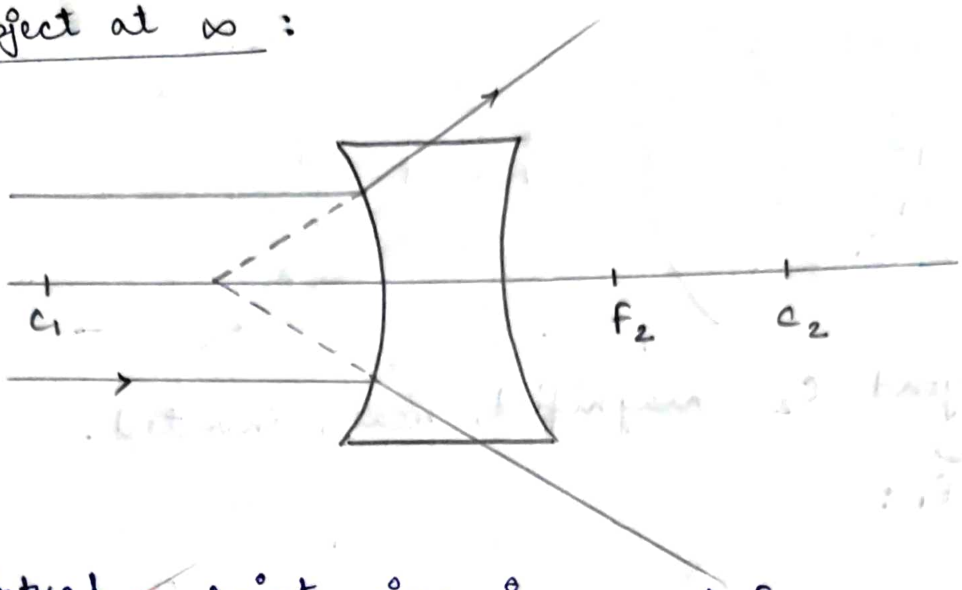


Image erect, virtual.

*. Concave lens:

1. Object at ∞ :



Virtual, point size, image at F.

2. Object at any point:

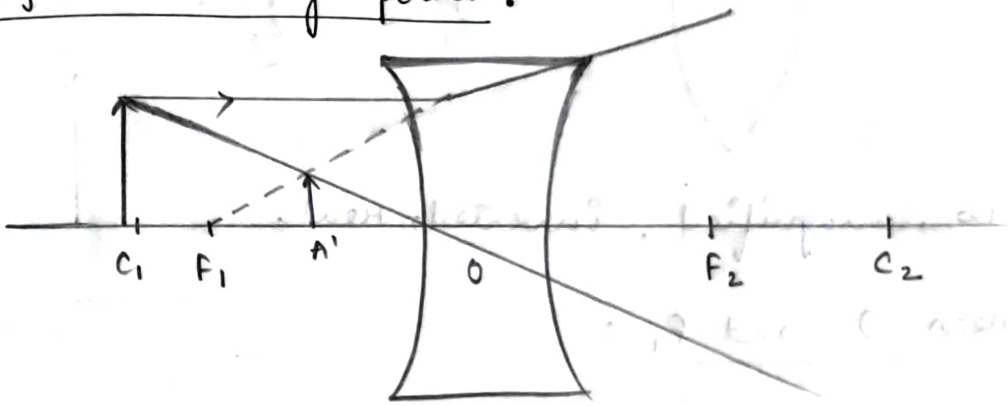
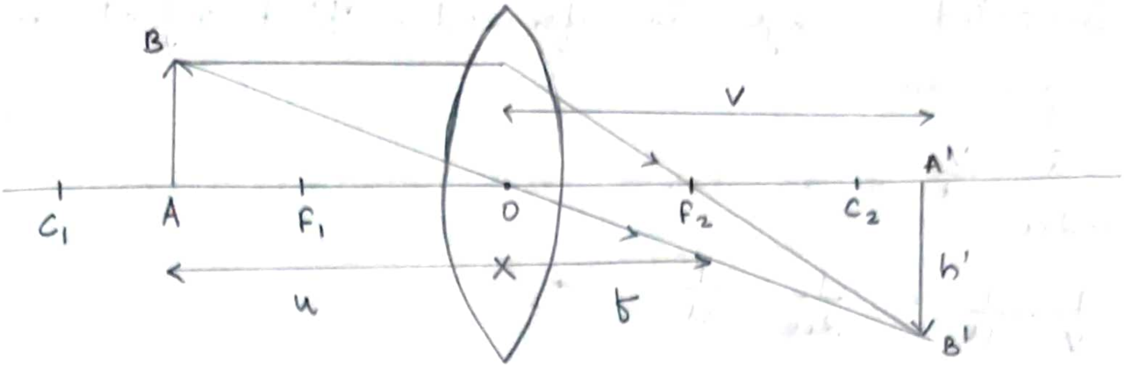


Image diminish, virtual, erect.

*. Sign convention of lens :-



u = -ve

v = +ve

f = +ve

h = +ve

h' = -ve

*. Lens formula and magnification :-

→ $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

$M = \frac{v}{u}$

Q. An object is placed at 20 cm in front of a convex lens of focal length 15 cm. Find image position and magnification.

Ans. u = - 20 cm

f = 15 cm

$\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{v} + \frac{1}{20} = \frac{1}{15}$

$= \frac{1}{v} = \frac{1}{15} - \frac{1}{20}$

$\Rightarrow \frac{1}{v} = \frac{4-3}{60} = \frac{1}{60}$

$\Rightarrow v = 60$ cm .

$m = \frac{v}{u} = \frac{60}{-20} = -3$

Q: An object is placed in front of a convex lens of focal length 20 cm such that a double size real, inverted image is formed. Find object and image position.

Ans, $m = -2 = \frac{v}{u}$

$\Rightarrow v = -2u$

$\Rightarrow \frac{1}{f} = \frac{1}{v} - \frac{1}{u} = \frac{-1}{2u} - \frac{1}{u}$

$\Rightarrow \frac{1}{20} = \frac{-1-2}{2u}$

$\Rightarrow \frac{1}{20} = \frac{-3}{2u}$

$\Rightarrow -60 = 2u$

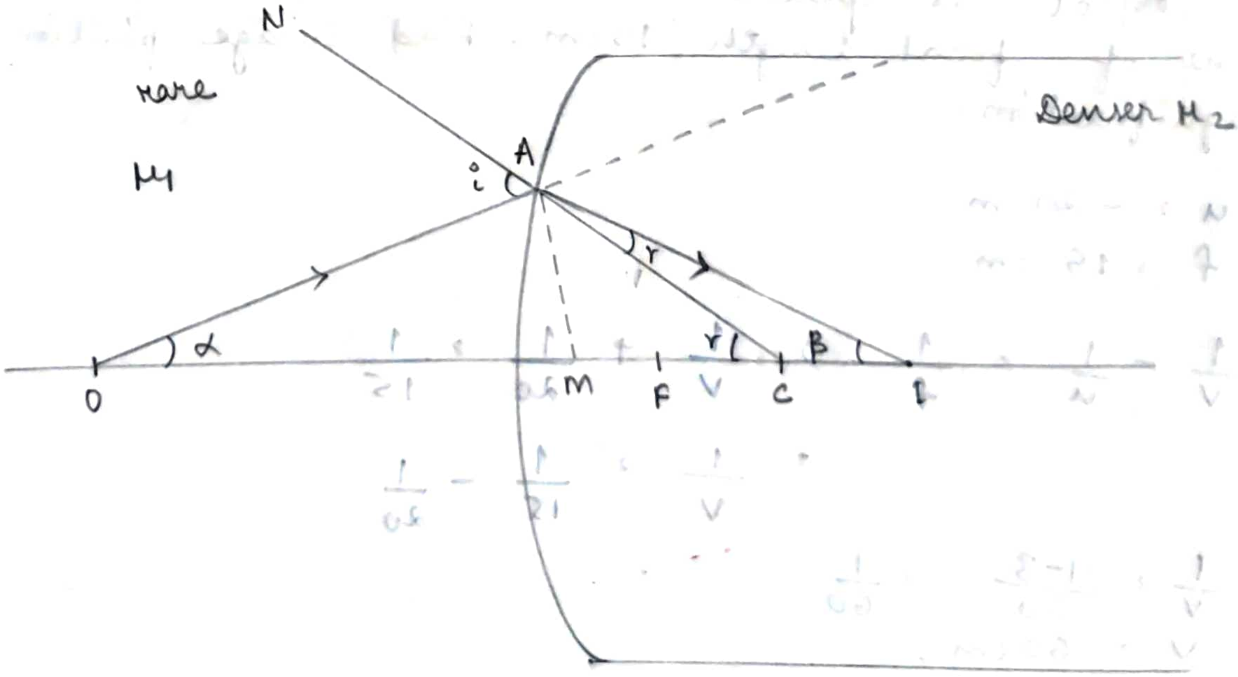
$\Rightarrow u = -30$

$v = -2 \times -30$

$= 60$ cm.

★. Refraction through convex spherical surface :-

Rare to denser medium.



OA be incident ray.

AI be refracted ray.

NC be the normal

AM $\perp^{r}$ OI

ΔAOM, ΔACM, ΔAIM are right angle Δ.

$\angle AOM = \alpha$, $\angle AIM = \beta$, $\angle ACM = \gamma$

In ΔACI

$\gamma = r + \beta$

$$\Rightarrow \boxed{r = \gamma - \beta}$$

In ΔAOC,

$$\boxed{i = \gamma + \alpha}$$

We know,

$$\mu_1 \sin i = \mu_2 \sin r.$$

For small angle,

$$\mu_1 i = \mu_2 r$$

$$\Rightarrow \mu_1(\gamma + \alpha) = \mu_2(\gamma - \beta)$$

We know, $\theta = \frac{l}{r} = \frac{p}{b}$

$$\Rightarrow \mu_1\left(\frac{AM}{OM} + \frac{AM}{MC}\right) = \mu_2\left(\frac{AM}{MC} - \frac{AM}{MI}\right)$$

For a small curve,

M replaced by P.

$$\text{So, } \mu_1\left(\frac{AP}{OP} + \frac{AP}{PC}\right) = \mu_2\left(\frac{AP}{PC} - \frac{AP}{PI}\right)$$

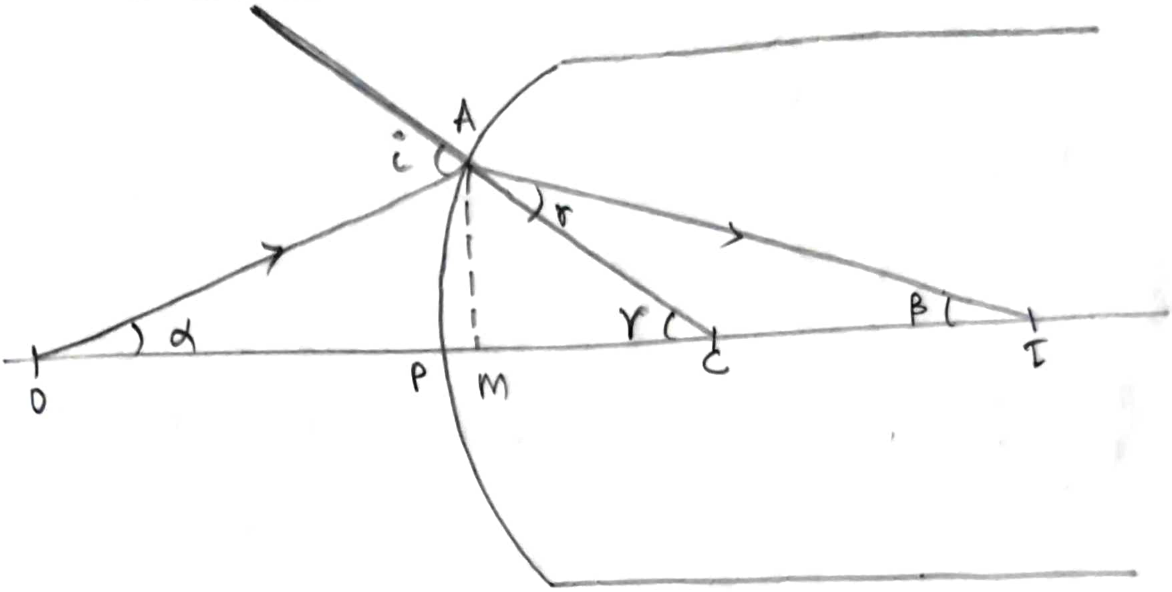
$$\Rightarrow \mu_1\left(\frac{1}{OP} + \frac{1}{PC}\right) = \mu_2\left(\frac{1}{PC} - \frac{1}{PI}\right)$$

$$\Rightarrow \mu_1\left(\frac{1}{-u} + \frac{1}{R}\right) = \mu_2\left(\frac{1}{R} - \frac{1}{V}\right)$$

$$\Rightarrow \frac{\mu_1}{-u} + \frac{\mu_1}{R} = \frac{\mu_2}{R} - \frac{\mu_2}{V}$$

$$\Rightarrow \boxed{\frac{\mu_2}{V} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}}$$

*. Denser to Rarer :



ΔAOC, $\gamma = i + \alpha$

$$\Rightarrow \boxed{i = \gamma - \alpha}$$

ΔACI,

$$\boxed{\gamma = \beta + \gamma}$$

We know,

$$\mu_2 \sin i = \mu_1 \sin r$$

For small angle

$$\mu_2 i = \mu_1 r$$

$$\Rightarrow \mu_2 (\underline{\quad - \alpha}) = \mu_1 (\underline{\quad + \beta})$$

For small angle

$$\theta = \frac{l}{r} = \frac{P}{b}$$

$$\Rightarrow \mu_2\left(\frac{AM}{MC} - \frac{AM}{MO}\right) = \mu_1\left(\frac{AM}{MC} + \frac{AM}{MI}\right)$$

$$\Rightarrow \frac{\mu_2}{MC} - \frac{\mu_2}{MO} = \frac{\mu_1}{MC} + \frac{\mu_1}{MI}$$

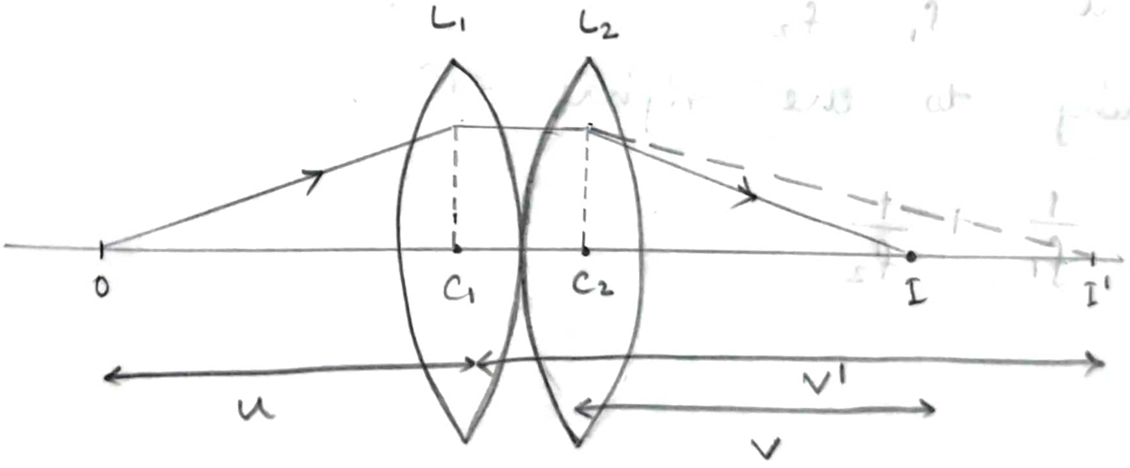
Replace M with P

$$\Rightarrow \frac{\mu_2}{PC} - \frac{\mu_2}{PO} = \frac{\mu_1}{PC} + \frac{\mu_1}{PI}$$

$$\Rightarrow \frac{\mu_2}{R} + \frac{\mu_2}{u} = \frac{\mu_1}{R} + \frac{\mu_1}{v}$$

$$\Rightarrow \boxed{\frac{\mu_2}{u} - \frac{\mu_1}{v} = \frac{\mu_1 + \mu_2}{R}}$$

*. Combination of Lens :-



L_1 & L_2 are two lens

O be the object I, I' are images.

$C_1O = u$

$C_2I' = v'$

$C_2I = v$

For lens L_1

$$\frac{1}{v'} - \frac{1}{u} = \frac{1}{f_1} \quad \text{——} ①$$

For lens L_2

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f_2}$$

For L_2, u will be I' i.e.

$u = v'$

$$\Rightarrow \frac{1}{v} - \frac{1}{v'} = \frac{1}{f_2} \quad \text{——} ②$$

Adding ① & ②

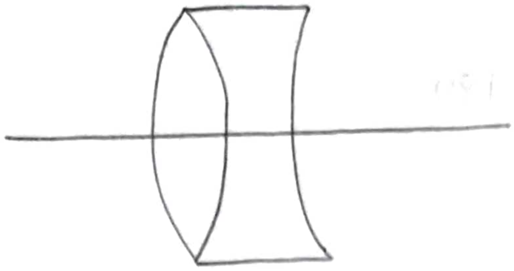
$$\frac{1}{v'} - \frac{1}{u} + \frac{1}{v} - \frac{1}{v'} = \frac{1}{f_2} + \frac{1}{f_1}$$

$$\Rightarrow \frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}$$

Comparing to the original eqn

$$\frac{1}{f_{eq}} = \frac{1}{f_1} + \frac{1}{f_2}$$

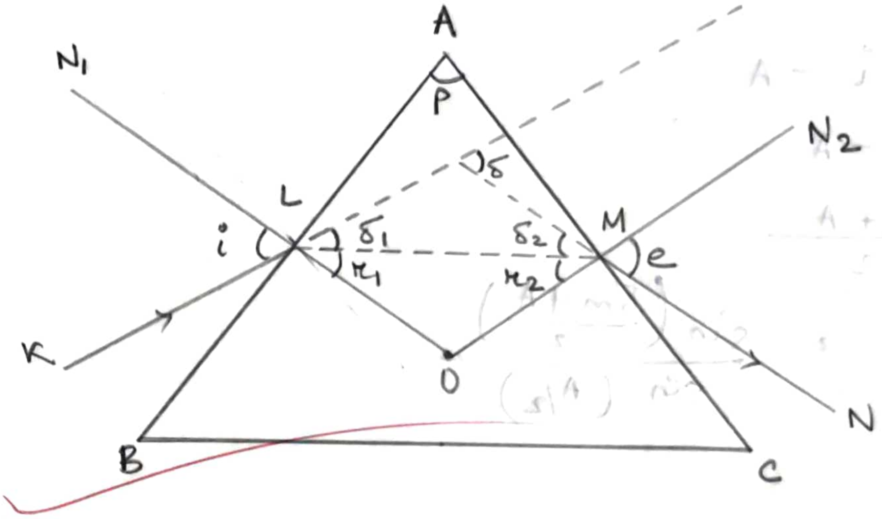
Case:



$f_1 = +ve$ $f_2 = -ve$

$$\frac{1}{f_{eq}} = \frac{1}{f_1} - \frac{1}{f_2}$$

*. **Prism:**



ABC is a prism of angle 60.
N₁ and N₂ are two normals.
$\angle i$ = incident angle.
$\angle e$ is emergent angle.
r_1, r_2 = refracted angle.
$\delta_1, \delta_2, \delta$ = are deviations
From fig,

$i = \delta_1 + ~~\delta~~ r_1$

$\Rightarrow \delta_1 = i - r_1$

Similarly, $\delta_2 = e - r_2$

adding,

$$\delta = \delta_1 + \delta_2 = i - r_1 + e - r_2$$
$$= (i+e) - (r_1 + r_2)$$

ΔALM,

$$A + (90° - r_1) + (90° - r_2) = 180°$$

$$\Rightarrow \boxed{A = r_1 + r_2}$$

$$\delta = (i + e) - A \quad \text{———} ①$$

In minimum deviation,

$$r_1 = r_2 \;,\; i = e$$

$$\Rightarrow A = r + r = 2r$$

$$\Rightarrow r = \frac{A}{2}$$

$$\Rightarrow \delta = i + i - A$$

$$= 2i - A$$

$$\Rightarrow i = \frac{\delta m + A}{2}$$

$$\mu = \frac{\sin i}{\sin r} = \frac{\sin\left(\frac{\delta m + A}{2}\right)}{\sin\left(A/2\right)}$$

NOTE :-

Q. A ray of light falling at an angle 50° refracted through a prism and suffer minimum deviation angle of prism is 60°. Find refractive index and minimum deviation.

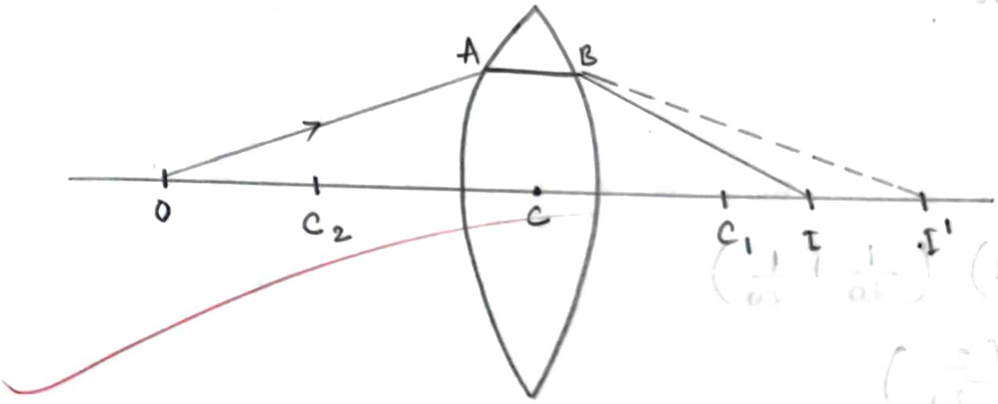
Ans. $i = 50$ $\quad r = A/2 = 30°$

$A = 60$ $\quad i = e = 50°$

$\Rightarrow \delta m = 2i - A = 2 \times 50 - 30 = 70$.

$\Rightarrow \mu = \frac{\sin i}{\sin r} = \frac{\sin 50}{\sin 30} = \frac{0.76}{0.5} = 1.5$.

*. Len's maker formula :-



At surface A, the light travels from medium air (μ_1) to lens (μ_2) i.e. $\frac{\mu_2}{v'} - \frac{\mu_1}{\mu} = \frac{\mu_2 - \mu_1}{R_1}$ —— ①

At surface B, light travels from lens to air. Consider I' as virtual object.

$$\frac{\mu_1}{v} - \frac{\mu_2}{u} = \frac{\mu_1 - \mu_2}{R_2}$$

$$\Rightarrow \frac{\mu_1}{v} - \frac{\mu_2}{v'} = \frac{\mu_2 - \mu_1}{-R_2} \quad \text{——} ②$$

Adding ① & ②,

$$\Rightarrow \frac{\mu_1}{v} - \frac{\mu_1}{u} = (\mu_2 - \mu_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\Rightarrow \mu_1\left(\frac{1}{v}-\frac{1}{u}\right) = (\mu_2-\mu_1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\Rightarrow \frac{1}{f} = \left(\frac{\mu_2}{\mu_1}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

We know, $\mu_1 = 1$ (air)

$\mu_2 = \mu$

$$\Rightarrow \boxed{\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)}$$

Q. A lens is made of glass of refractive index 1.3. If rad is measured to be 20 cm and 20 cm each then. Find th focal length?

Ans. $\mu = 1.3$

$R_1 = 20$ cm

$R_2 = -20$ cm.

$$\Rightarrow \frac{1}{f} = (1.3-1)\left(\frac{1}{20}+\frac{1}{20}\right)$$

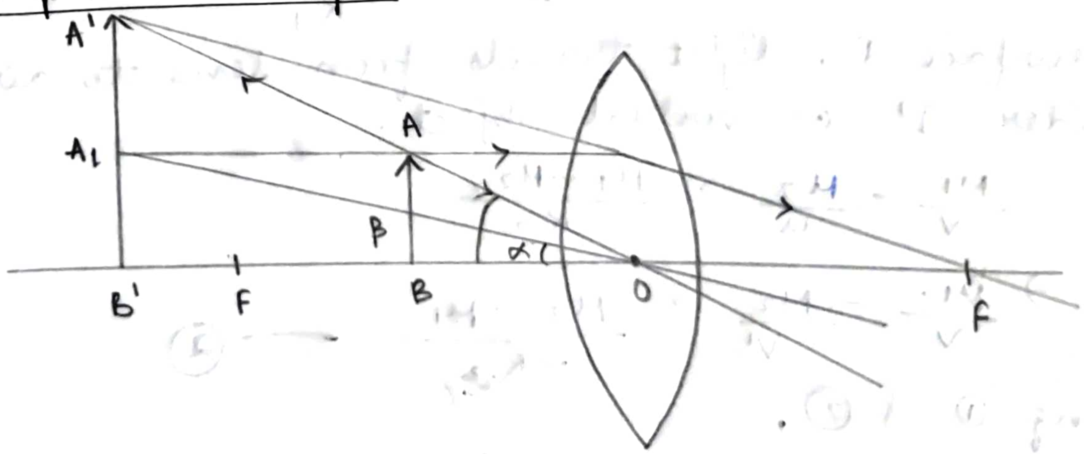
$$= (0.3)\left(\frac{2}{20}\right)$$

$$= (0.3)\left(\frac{1}{10}\right)$$

$$= 0.03$$

$$\Rightarrow f = \frac{100}{3} = 33.34 \text{ cm}.$$

*. Simple Microscope:



AB is the object.

A'B' is the image

$\alpha \rightarrow$ angle by object

$\beta \rightarrow$ angle by image.

$M = \frac{\beta}{\alpha}$ (angular magnification)

$$\tan\beta \text{ (or) } \beta = \frac{A'B'}{B'O}$$

$$\tan\alpha \text{ (or) } \alpha = \frac{A_1B'}{B'O}$$

We know,

$$A_1B' = AB$$

$$\Rightarrow \alpha = \frac{AB}{B'O}$$

$$\Rightarrow M = \frac{\frac{A'B'}{\cancel{B'O}}}{\frac{AB}{\cancel{B'O}}} = \frac{A'B'}{AB} = \frac{h'}{h} = \frac{v}{u}$$

Lens Formula :-

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

Multiplying v

$$\Rightarrow \frac{v}{v} - \frac{v}{u} = \frac{v}{f}$$

$$\Rightarrow 1 - M = \frac{v}{f}$$

$$\Rightarrow m = 1 - \frac{v}{f}$$

Now image will be formed at d i.e. 25 cm of normal vision.

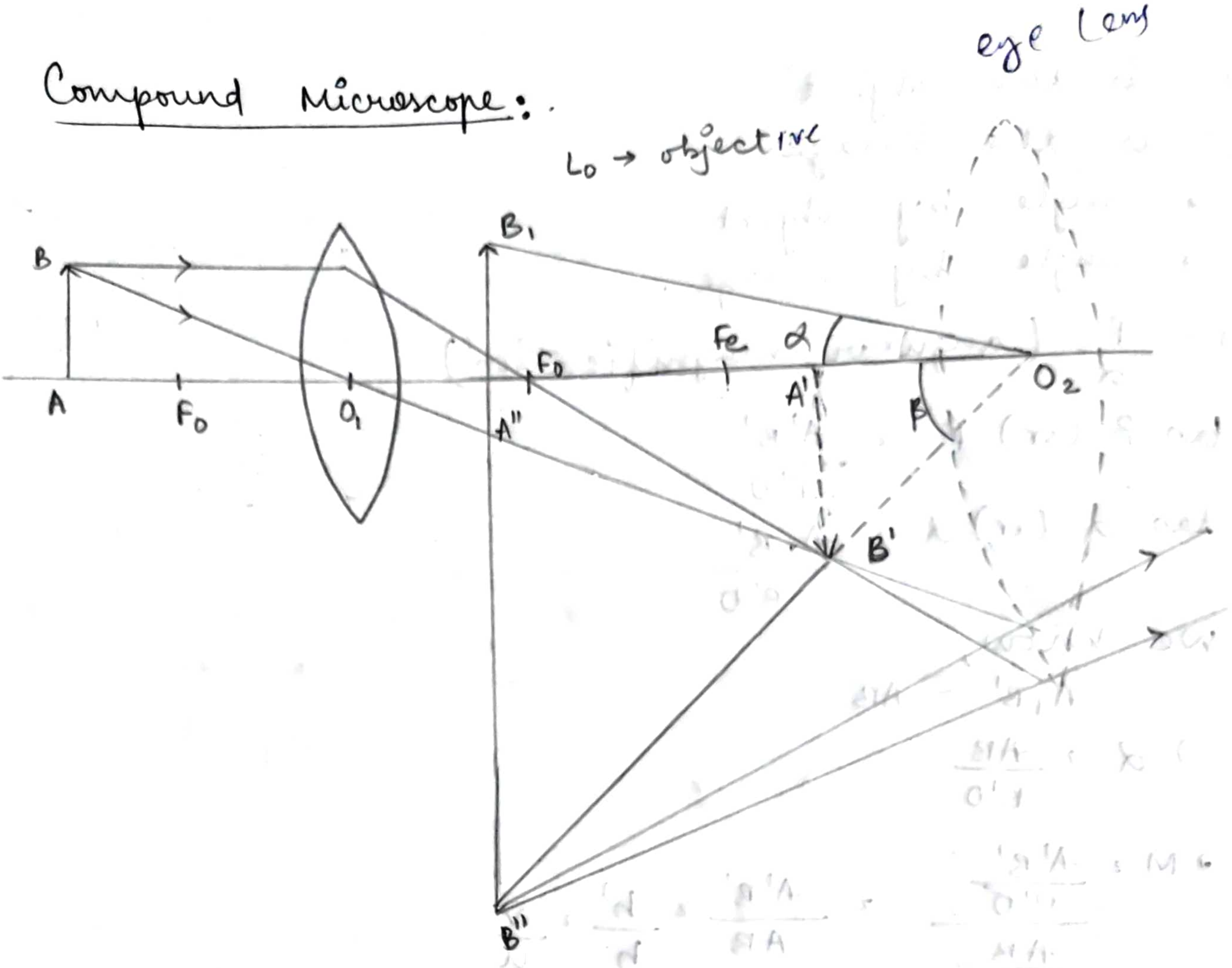
$$v = -d$$

$$\Rightarrow \boxed{m = 1 + \frac{d}{f}}$$

If image to be formed at infinity.

$$\Rightarrow \boxed{m = \frac{d}{f}}$$

*. Compound Microscope :



We know magnification,

$$M = \frac{\beta}{\alpha}$$

$$= \frac{A''B'' / \cancel{A''O_2}}{A''B_1 / \cancel{A''O_2}}$$

$$= \frac{A''B''}{A''B_1}$$

Replace → $A''B_1$ with AB.

$$M = \frac{A''B''}{AB}$$

$$= \underbrace{\frac{A''B''}{A'B'}}_{Me} \times \underbrace{\frac{A'B'}{AB}}_{mo}$$

$$= Me \times mo$$

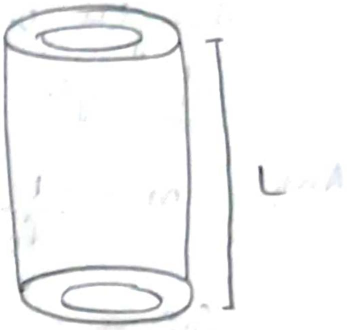
We know,

$$me = 1 + \frac{d}{fe}$$

$$Mo = \frac{v}{u} = \frac{fe}{-fo}$$

$$M = \frac{-f_e}{f_o} \times \left(1 + \frac{d}{f_e}\right)$$

'L' be the length of tube/ microscope.
i.e. $L = f_o + f_e$



$$\boxed{M = \frac{-L}{f_o}\left(1 + \frac{d}{f_e}\right)}$$ ✓

When image at infinite

$$\boxed{M = \frac{-L}{f_o} \times \frac{d}{f_e}}$$ ✓

Q:- Calculate the maximum magnifying power of a simple microscope of focal length 5 cm. when image is formed at distance of distinct vision ?

Ans $M = 1 + \frac{d}{f}$

$d = 25$
$f = 5$ ✓

$= 1 + \frac{25}{5}$

$= \frac{30}{5}$

$= 6$

Q. If we need a magnification of 375 from a microsco of tube length 15 cm and objective lens of focal length 0.5 cm. What should be the focal length of eye lens?

Ans:- $M = \frac{-L}{f_o}\left(1 + \frac{d}{f_e}\right)$

Given,

$M = -375$

$L = 15$ cm

$f_o = 0.5$ cm

$d = 25$

$\Rightarrow \cancel{-}375 = \cancel{-}\frac{15}{0.5}\left(1 + \frac{25}{f_e}\right)$

$\Rightarrow \frac{375 \times 0.5}{1.5} = 1 + \frac{25}{f_e}$

$\Rightarrow 12.5 = \frac{f_e + 25}{f_e}$

$\Rightarrow 12.5 f_e = f_e + 25$

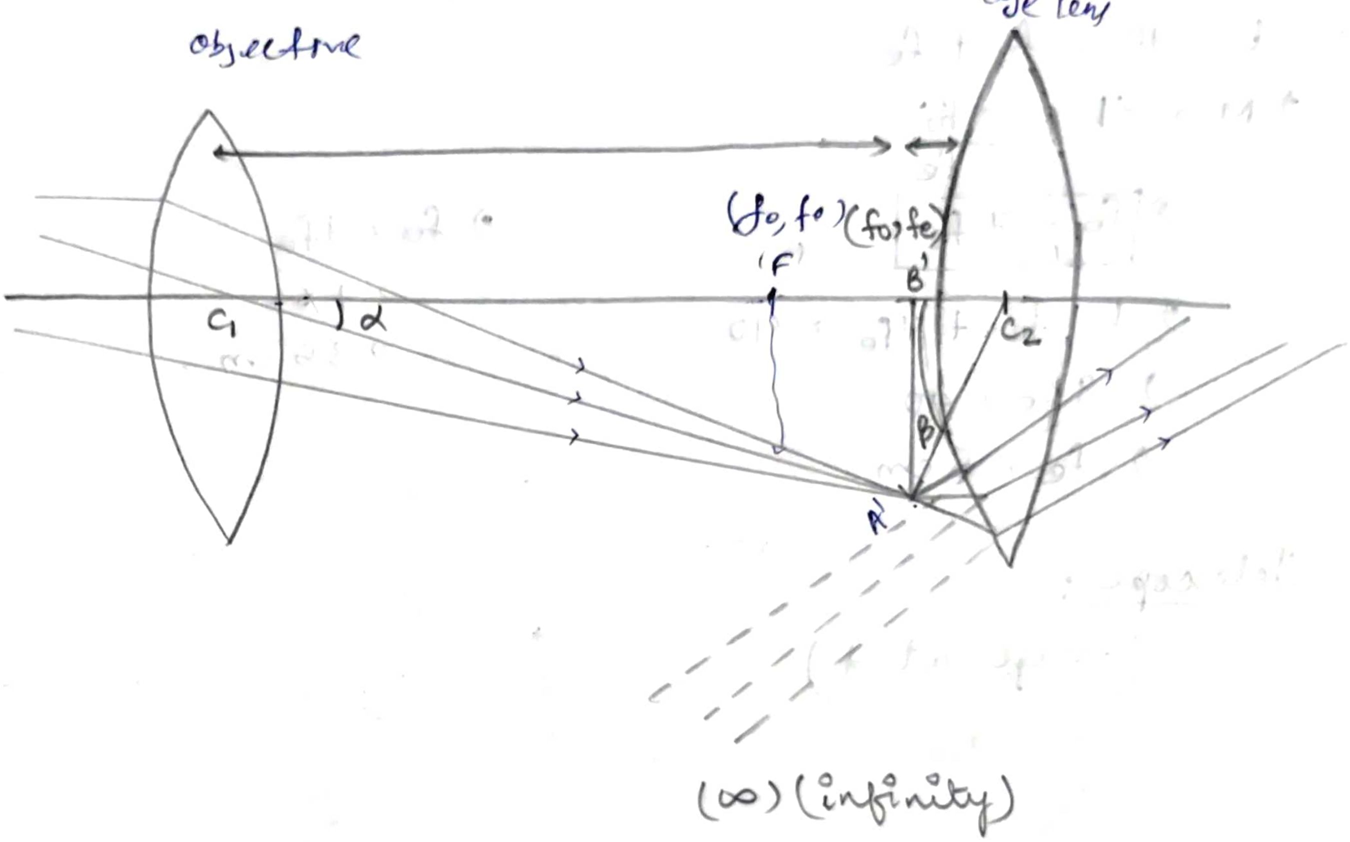
$\Rightarrow 12.5 f_e - f_e = 25$

$\Rightarrow 11.5 f_e = 25$

$\Rightarrow f_e = \frac{25}{11.5} = 2.2.$

* · Telescope :

(image at infinite)



AB → object at infinity.

A'B' → image at f of both objective & eye lens.

$$M = \frac{\beta}{\alpha} = \frac{\cancel{A'B'}/B'C_2}{\cancel{A'B'}/B'C_1} = \frac{B'C_1}{B'C_2} = \frac{f_o}{-f_e}$$

$$\boxed{M = \frac{f_o}{-f_e}}$$

Q. A telescope of magnifying power 7 consist of two lens 40 cm apart in normal adjustment. Calculate the focal length of lens ?

Ans $L = 40 = f_o + f_e$

$\Rightarrow M = -7 = \frac{-f_o}{f_e}$

$\Rightarrow \boxed{f_o = 7 f_e}$

$\Rightarrow L = f_e + 7f_e = 40$

$\Rightarrow 8 f_e = 40$

$\Rightarrow f_e = 5$ cm.

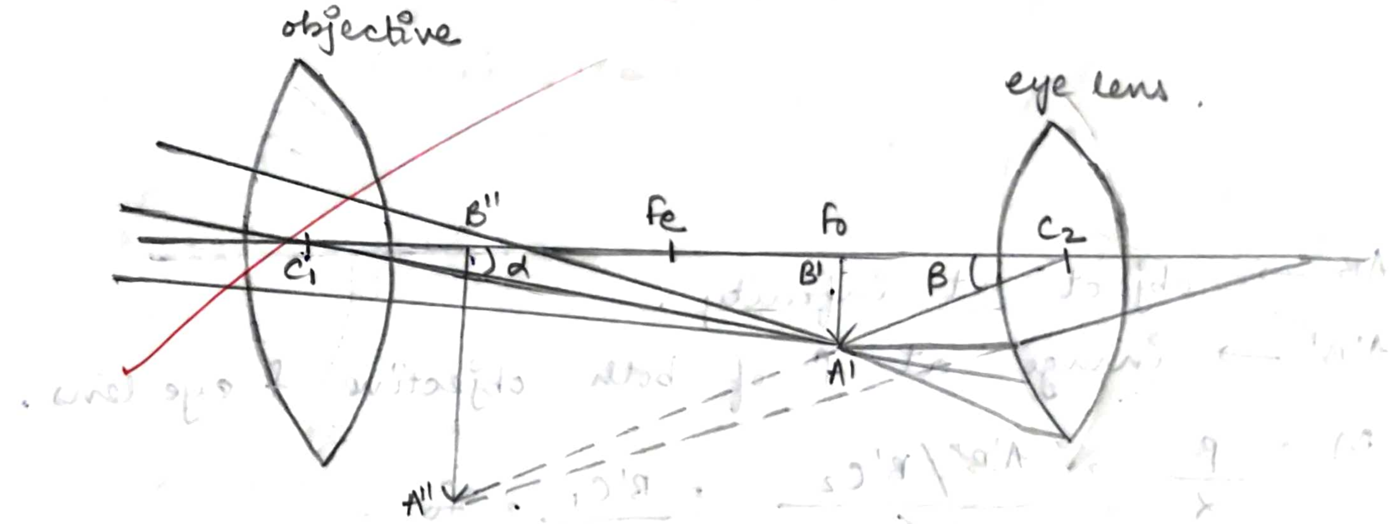
$\Rightarrow f_o = 7 f_e$

$= 7 \times 5$

$\Rightarrow 35$ cm.

*. Telescope :

(image at d)



AB → object at infinity.

A'B' → Image ~~at~~ of objective at fo

A''B'' → final image near objective lens.

$C_1B' = v$

$C_2B' = -u_e$

$C_2B'' = -d$

$$\Rightarrow M = \frac{\beta}{\alpha} = \frac{A'B' / B'C_2}{A'B' / C_1B'}$$

$$\Rightarrow M = \frac{C_1B'}{C_2B'} = \frac{f_o}{-u_e}$$

We know,

$$\frac{1}{V} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{-d} - \frac{1}{-u_e} = \frac{1}{f_e}$$

$$\Rightarrow \frac{1}{u_e} - \frac{1}{d} = \frac{1}{f_e}$$

$$\Rightarrow \frac{1}{u_e} = \frac{1}{d} + \frac{1}{f_e}$$

$$\Rightarrow M = -f_o \left(\frac{1}{d} + \frac{1}{f_e}\right)$$

$$\Rightarrow \boxed{M = -\frac{f_o}{f_e}\left(1 + \frac{f_e}{d}\right)}$$

Q: In telescope, focal length of eye lens is 5 cm & focal length of objective is 75 cm. If final image is to form at distance of distinct vision then what will be the magnifying power?

Ans $f_e = 5$ cm, $d = 25$

$f_o = 75$ cm

$$M = -\frac{f_o}{f_e}\left(1 + \frac{f_e}{d}\right)$$

$$= \frac{-75}{5}\left(1 + \frac{5}{25}\right)$$

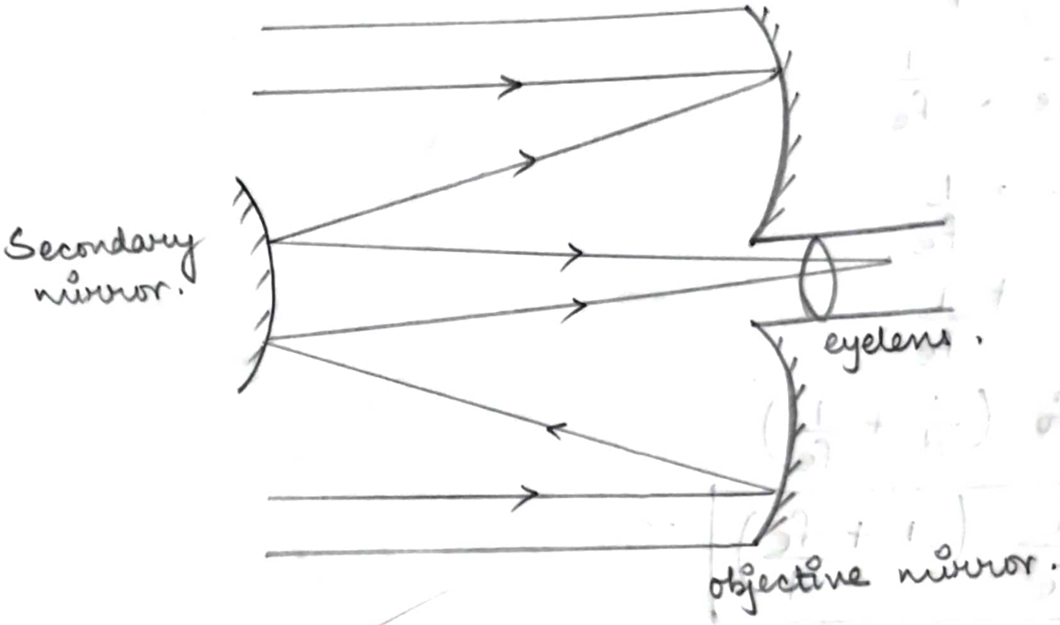
$$\Rightarrow -15\left(\frac{30}{25}\right)$$

$$\Rightarrow -\cancel{15}^{3}\left(\frac{6}{\cancel{5}}\right)$$

$$= -18.$$

*. Reflecting Telescope (cassegranian Telescope) :-

- → It consists 3 things.
- → Two objective mirror (concave)
- → One secondary mirror (convex)
- → One lens i.e. eye lens.
- → It is also called cassegranian Telescope.



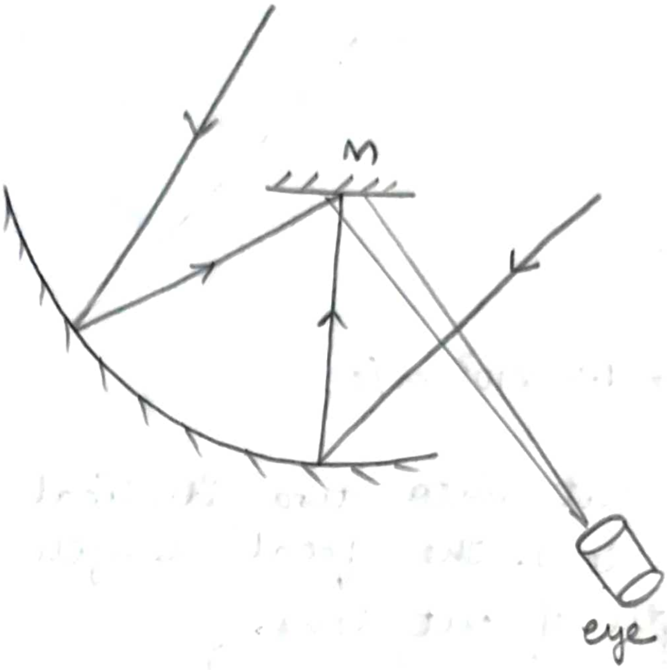
Advantages:

- → To avoid chromatic of spherical aberation.
- → Image will be brighter and clear.
- → It has higher resolving power.

$$M = \frac{f_o}{f_e} = \frac{R/2}{f_e}.$$

*. Newtonian reflecting Telescope :-

→ It consists of two mirrors i.e. concave mirror and mirror aligned at 45° to each other.



Advantages :-

→ To avoid chromatic of spherical aberation.
→ Image will be brighter and clear.
→ It has higher resolving power.
→ Mirror are to be grinding and polishing on one side
→ It also weight less.

Q:- The angle of deviation of an equilateral prism is half of angle of prism. Find refractive index of prism when it suffer minimum deviation.

Ans. $A = 60$

$\sin = \frac{60}{2} = 30^\circ$

$$\mu = \frac{\sin \frac{A + \sin}{2}}{\sin A/2}$$

$$\mu = \frac{\sin 30 \; \frac{60 + 30^\circ}{2}}{\sin 30 \; 60/2}$$

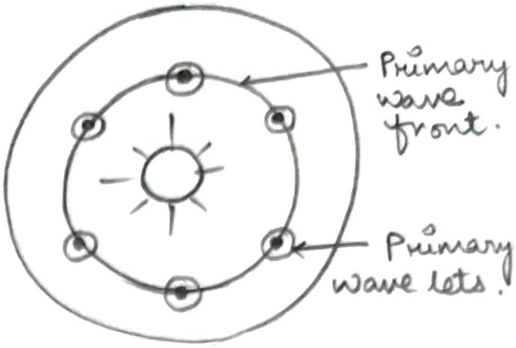
$$= \frac{\sin 45}{\sin 30} = \frac{1/\sqrt{2}}{1/2} = \frac{2}{\sqrt{2}} = \sqrt{2} = 1.44.$$

9/11/2023

10. WAVE OPTICS

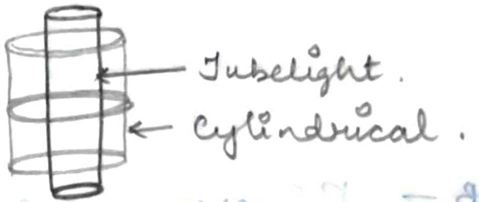
*. Wave front :-

→ The locus of points vibrating in same phase from wave front.

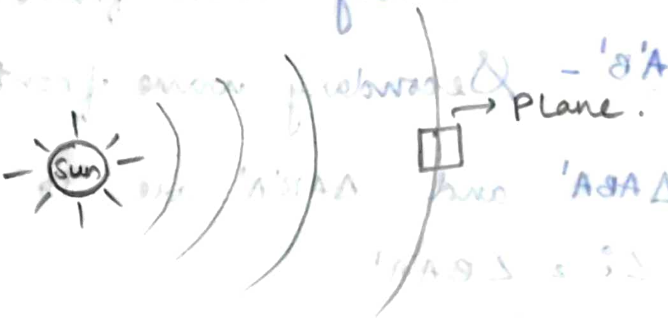


1. Spherical :
   → Point source
   Eg :- bulb, candle etc.

2. Cylindrical :
   → line source
   Eg :- Tubelight.



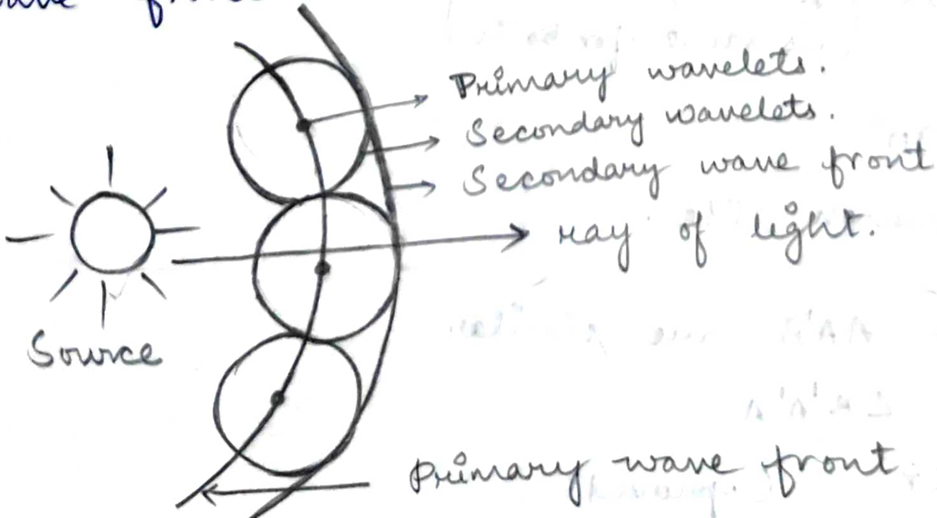
3. Plane wave front
   → Point source at large distance.
   Eg :- Sun.



*. Huygen's Principle :-

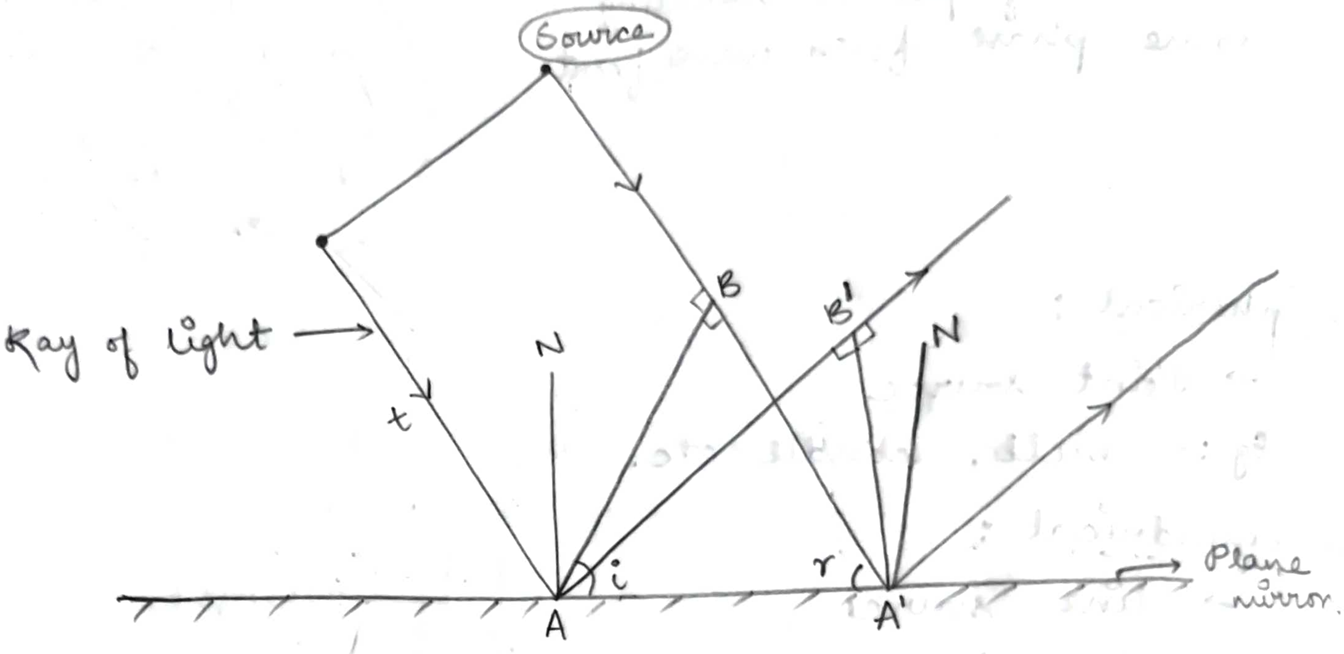
→ Each particle on primary wave front act like a new source which travel in direction of light.

→ The tangent of primary wavelet gives you secondary wave front.



→ Ray of light is always perpendicular to wave.

*. Reflection on basis of wave theory :-



AB – Primary wave front.

A'B' – Secondary wave front.

ΔABA' and ΔAB'A' are to be proved similar.

∠i = ∠BAA'

∠r = ∠B'A'A.

~~reflection law is i = r~~

~~∠BAA' = ∠B'A'A.~~

AB' = A'B as (velocity × time is same for both)

∠B = ∠B' = 90°

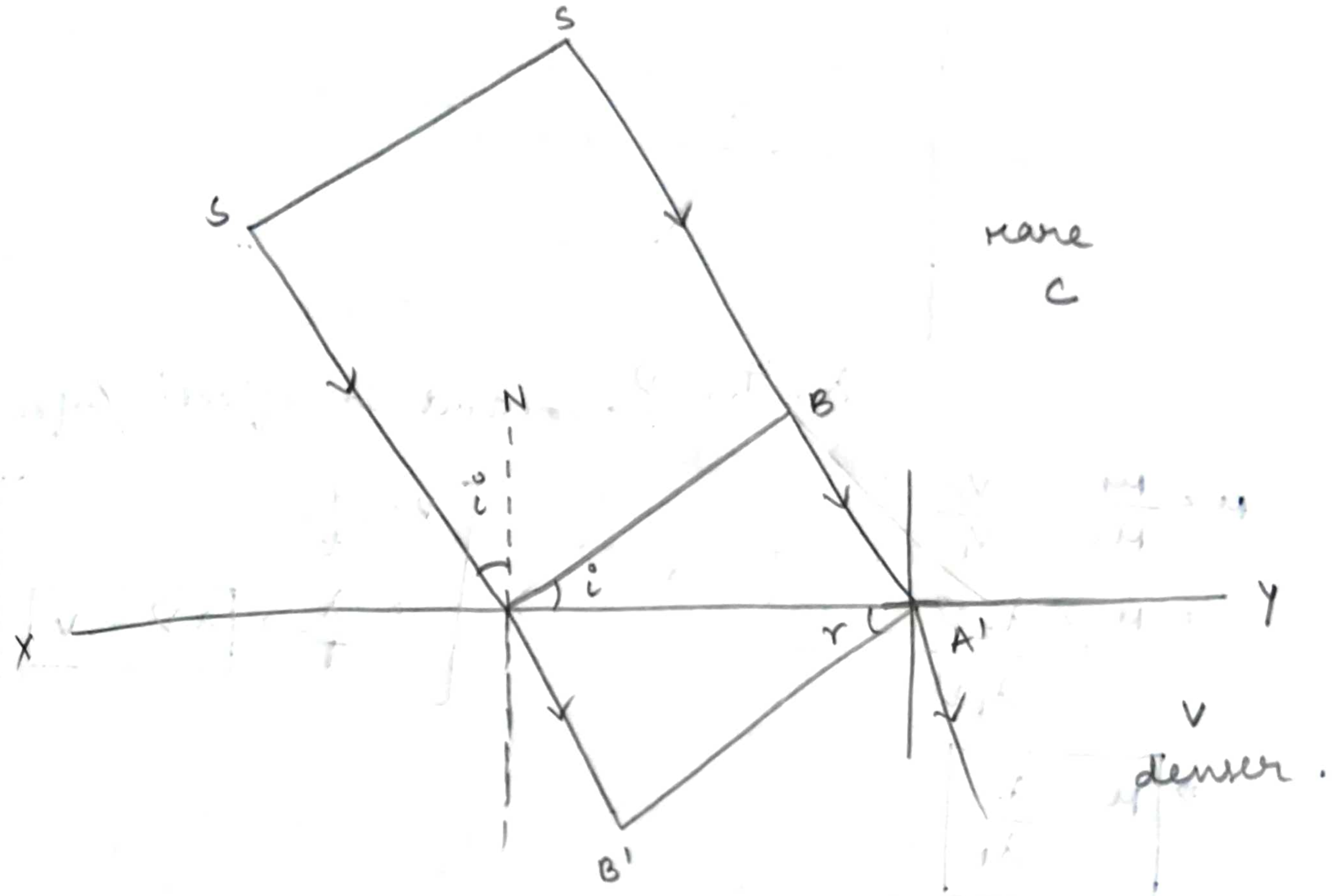
AA' is common side.

ΔAA'B' and AA'B are similar

i.e. ∠BAA' = ∠B'A'A

⇒ ∠i = ∠r (proved)

*. Refraction using wave theory :-



AB → primary wavefront.

A'B' → secondary wavefront.

AB' = v × t

BA' = c × t.

In $\Delta ABA'$ and $AB'A'$

$\angle ABA' = \angle AB'A' = 90°$

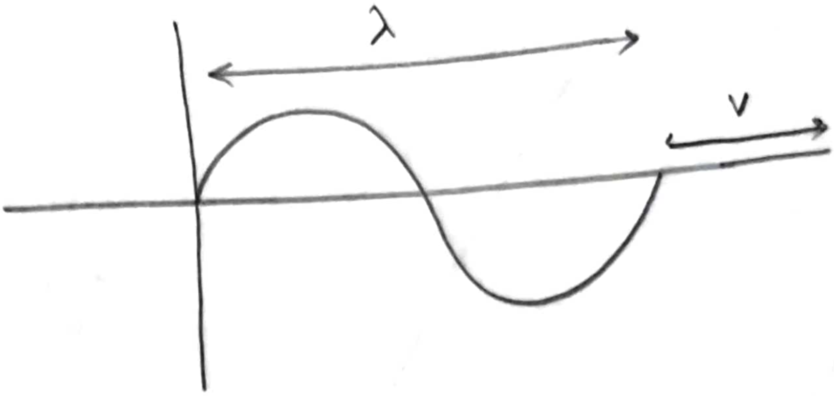
These two are right angle triangle.

Snell's law

$$\mu = \frac{\sin i}{\sin r} = \frac{A'B / AA'}{AB' / AA'} = \frac{A'B}{AB'}$$

$$\Rightarrow \mu = \frac{ct}{vt} = \frac{c}{v}$$ (proved)

*. Wavelength & frequency :-



λ, T, ν ↳ constant in reflection/refractio

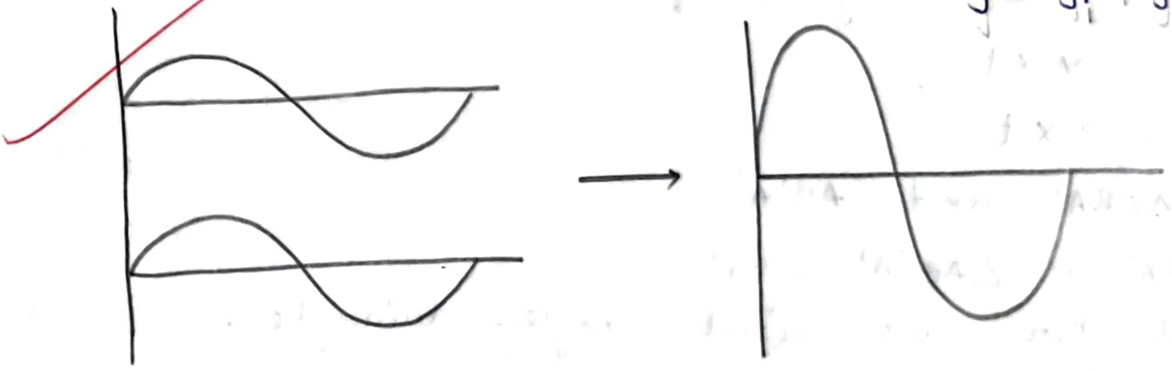
$$\mu = \frac{\mu_1}{\mu_2} = \frac{V_2}{V_1}$$

$$= \mu = \frac{\lambda_2 \nu}{\lambda_1 \nu}$$

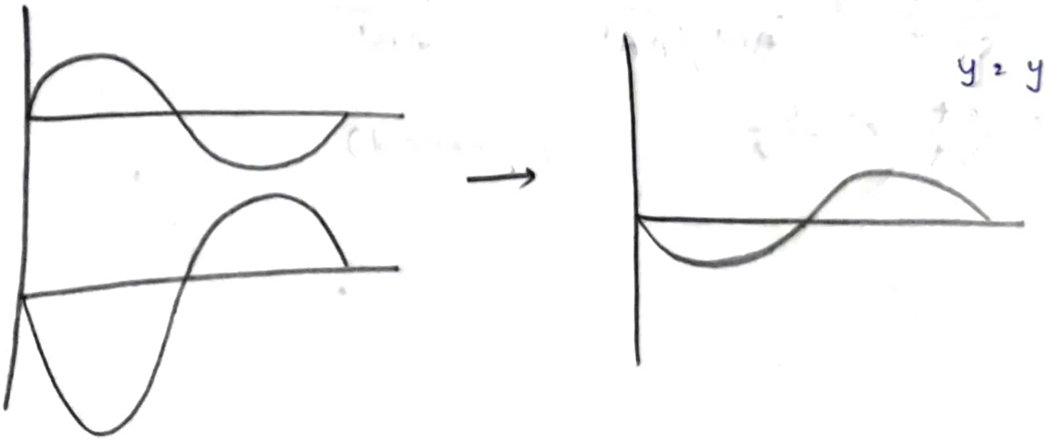
$$\Rightarrow \boxed{\mu = \frac{\lambda_2}{\lambda_1}}$$

$$\left[v = \frac{d}{t} = \frac{\lambda}{T} = \boxed{\lambda \nu = v} \right]$$

*. Superposition Principle :-



$y = y_1 + y_2$

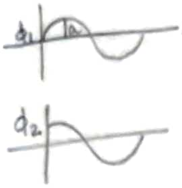


$y = y_1 - y_2$

→ When two light wave superimpose on each other then their result will be the vector sum of individual.

⊛ Coherent and incoherent addition :-

Let us consider two waves



$E_1 = a_1 \cos(\omega_1 t + \phi_1)$

$E_2 = a_2 \cos(\omega_2 t + \phi_2)$

$\underset{\text{wave}}{E_2}$ ↓ wave, a_2 ↓ amplitude, ϕ_2 ↓ phase.

$\Delta\phi = \phi_2 - \phi_1$

$I \propto E$

$\Rightarrow I = \overset{\to \text{const.}}{K} \underset{\text{wave}}{E}$

↓ Intensity

$$\left.\begin{aligned} I_1 &= KE_1^2 = K a_1 \cos(\omega_1 t + \phi_1) \\ I_2 &= KE_2^2 = K a_2 \cos(\omega_2 t + \phi_2) \end{aligned}\right\} \text{Intensity formula.}$$

→ **Coherent addition**

$$I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos(\phi_1 - \phi_2)$$

If $\phi_1 = \phi$ and $\phi_2 = 0$.

then $\boxed{I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos\phi}$

→ **Incoherent addition**

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

($\cos\phi$ average value is 0)

Q:- Two light of intensity I and 2I cross each other at phase 60°. Find their resultant intensity if

a) they are coherent

b) they are incoherent.

Ans. a) Given :-

$I_1 = I$

$I_2 = 2I$

$\phi = 60°$.

$I = I_1 + I_2 + 2\sqrt{I_1 I_2} \cos\phi$

$I = I_{\cancel{8}} + 2I + 2\sqrt{I \times 2I} \cos 60$

$= 3I + \cancel{2}\sqrt{2I^2} \times \cancel{\cos} \frac{1}{\cancel{2}}$

$= (3 + \sqrt{2}) I$

$= 4.414\ I.$

b) $I_1 = I_1 + I_2$

$= I + 2I = 3I.$

*. Interference of light :-

Consider two waves

$y_1 = a \sin\omega t$

$y_2 = b \sin(\omega t + \phi)$

When two waves interfere each other then the Resultant amplitude is given as

$R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$

$I \propto R^2$

$\Rightarrow \boxed{\underset{\text{intensity}}{I} = KR^2}$

$\Rightarrow I = K(a^2 + b^2 + 2ab\cos\phi)$

1. Constructive interference

$I \rightarrow \cos\phi$

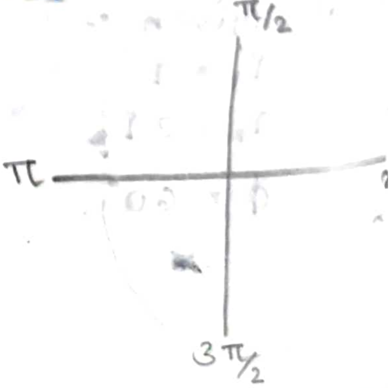
$R \rightarrow \cos\phi$

To make I, R max^m we have to take

$\cos\phi = +1.$

when $\phi = 0, 2\pi, 4\pi \ldots$

$\boxed{\phi = 2n\pi}$



2. **Destructive interference :-**

$\cos\phi = -1$

$\phi = \pi, 3\pi, 5\pi$

$\phi = (2n-1)\pi$

$\phi = 2n\pi \longrightarrow$ constructive

$\phi = (2n-1)\pi \Rightarrow$ destructive

$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$A_R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$

Case I

For maximum intensity

$\cos\phi = 1 = 2n\pi$

$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}$

$= (\sqrt{I_1})^2 + (\sqrt{I_2})^2 + 2\sqrt{I_1}\sqrt{I_2}$

$= \boxed{(\sqrt{I_1} + \sqrt{I_2})^2}$

$A_R = a + b.$

Case - II

For minimum intensity

$\cos\phi = -1 = (2n-1)\pi$

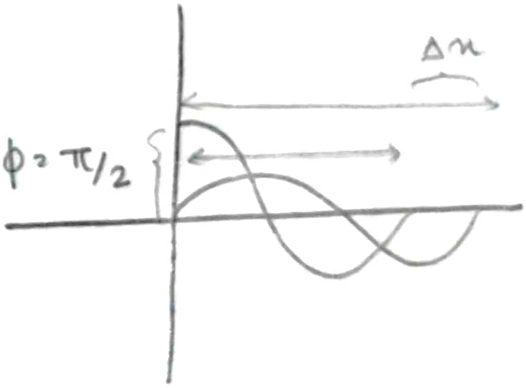
$I_R = (\sqrt{I_1} - \sqrt{I_2})^2$

$A_R = a - b$

*. **Relation between phase & path difference :-**

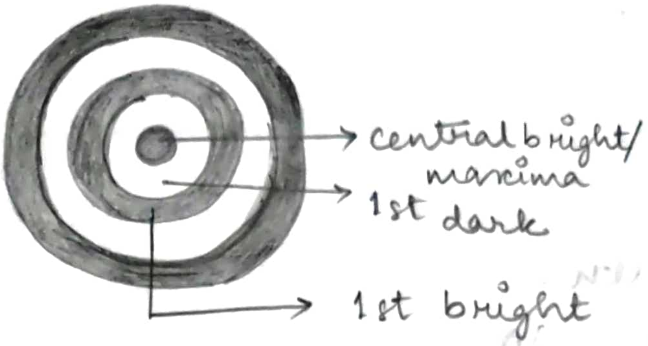
$$\boxed{\phi = \frac{2\pi}{\lambda} \times \Delta x}$$

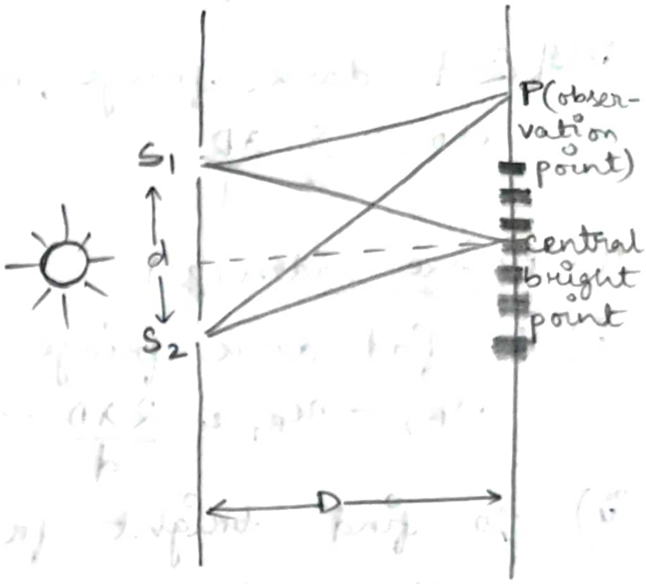
$$\boxed{\text{Phase difference} = \frac{2\pi}{\lambda} \times \text{path difference}}$$



*. YDSE (Young's double slit experiment):-

Fringe pattern:-





$S_1, S_2 \rightarrow$ Slits

d = distance between slits

D = distance between slit and screen

x = Position of fringe.

ϕ = angular separation / width.

1. Angular separation of fringes.

$$\boxed{\sin\theta = \frac{\lambda}{d}}$$

2. If bright fringes is observed at P.

$$\boxed{x_B = \frac{n\lambda D}{d}}$$

If central bright

then $n = 0$

$x_B = 0$

If 1st bright $n = 1$.

$$x_{B_1} = \frac{\lambda D}{d}$$

3. If dark fringe is observed

$$\boxed{x_D = (2n+1)\frac{\lambda D}{2d}}$$

i) If 1st dark fringe, n = 1

$$x_{D_1} = \frac{3}{2} \frac{\lambda D}{d}$$

ii) If 2nd dark fringe, n = 2.

$$x_{D_2} = \frac{5}{2} \frac{\lambda D}{d}.$$

4. Fringe width (β)

i) to find dark fringe width.

$$x_{B_2} - x_{B_1} = \frac{2\lambda D}{d} - \frac{\lambda D}{d} = \frac{\lambda D}{d}$$

ii) to find bright fringe width

$$x_{D_2} - x_{D_1} = \frac{5}{2} \frac{\lambda D}{d} - \frac{3\lambda D}{2d}$$

$$= \frac{\lambda D}{d}$$

→ β i.e for fringe width is $\frac{\lambda D}{d}$ same for bright & dark.

★. Diffraction of light :-

→ In diffraction single slit is used.

→ Path difference is $\lambda/2$

1. Dark Fringe / minima :-

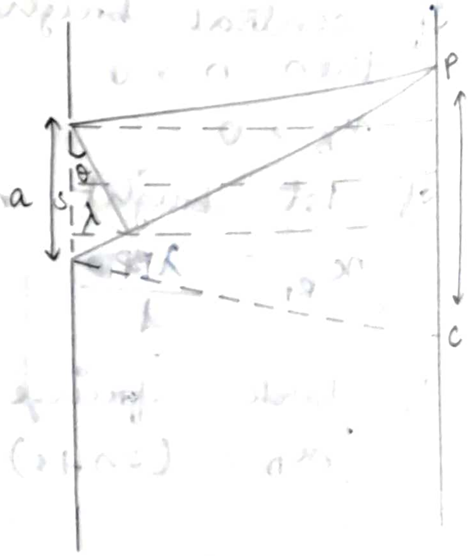
→ angular width,

$$\sin\theta = \frac{\lambda}{2}$$

→ $\theta = \frac{\lambda}{a}$

For nth,

$$\theta_{nth} = \frac{n\lambda}{a}$$



→ $y_{nth} = \frac{n\lambda D}{a}$

2. **Bright Fringe / maxima :-**

$$\theta_{n^{th}} = (2n+1)\frac{\lambda}{2a}$$

$$y_{n^{th}} = (2n+1)\frac{\lambda D}{2a}$$

3. **Fringe width :-**

$$\beta = \frac{\lambda D}{a}$$

Q:- In YDSE, distance between two slits is 1mm and a screen is kept at 1m apart from slit. If wave length is used 500nm find fringe spacing?

Ans:- $d = 1mm = 10^{-3} m$

$D = 1 m$

$\lambda = 500\ nm = 500 \times 10^{-9} m.$

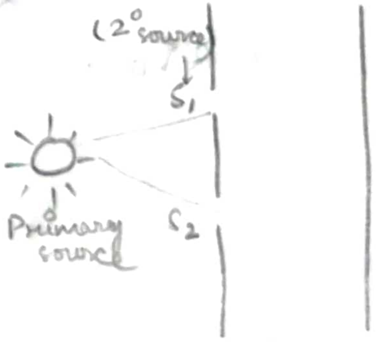
$$\beta = \frac{\lambda D}{d} = \frac{500 \times 10^{\overset{-6}{\cancel{-9}}} \times 1}{10^{\cancel{-3}}} = \cancel{500}5 \times 10^{-4} m$$

Q:- In YDSE, the intensity of light at a point is K when the path difference is λ. So find the intensity when path difference is $\frac{\lambda}{2}, \frac{\lambda}{4}$?

Ans:- $I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

$I_1 = I_2 = I_0$

→ because the S_1 & S_2 sources in YDSE are originated from one source.



$$I_R = I_0 + I_0 + 2\sqrt{I_0 I_0}\cos\phi$$

$$= 2I_0 + 2I_0\cos\phi$$

$$\Rightarrow I_R = 2I_0(1+\cos\phi) \qquad [\therefore \qquad]$$

$$= 2I_0 \times 2\cos^2\phi/2$$

$$\boxed{I_R = 4I_0\cos^2\phi/2}$$

→ λ

$$\phi = \frac{2\pi}{\lambda} \times \Delta x$$

$$\Rightarrow \phi = \frac{2\pi}{\cancel{\lambda}} \times \cancel{\lambda} = 2\pi$$

$$\Rightarrow I_R = 4I_0 \cos^2 \cancel{2}\pi$$

$$\boxed{I_R = 4I_0 = K}$$

→ $\lambda/2$

$$\phi = \frac{\cancel{2}\pi}{\cancel{\lambda}} \times \frac{\cancel{\lambda}}{\cancel{2}} = \pi$$

$$I_R = 4I_0 \cos^2 \pi/2$$

$$= 0 .$$

→ $\frac{\lambda}{4}$

$$\phi = \frac{\cancel{2}\pi}{\cancel{\lambda}} \times \frac{\cancel{\lambda}}{\cancel{4}_2} = \frac{\pi}{2}$$

$$I_R = 4I_0 \cos^2 \frac{\lambda}{4} \quad [\therefore \cos\frac{\lambda}{4} = \cos 45°)$$

$$= 4I_0 \times \left(\frac{1}{\sqrt{2}}\right)^2$$

$$= \overset{2}{\cancel{4}} I_0 \times \frac{1}{\cancel{2}}$$

$$= 2I_0 .$$

17/11/2023 **11. Dual Nature Of Radiation & Matter**

*. Electron Emission :-

→ When light of high (more is the frequency more will be the energy) frequency and low wavelength falls on a metal object, the free electrons escape out

→ The electron emission depends on a property of metal is known as work function (ϕ_0).

→ Work function means the minimum energy that cause the electron emission.

→ Unit is J (or) eV
↓
electron volt.

$1 eV = 1.6 \times 10^{-19} C \times V$

$= \underline{1.6 \times 10^{-19} J}$

→ ϕ_0 highest for platinum :- 5.65 eV

ϕ_0 minimum for Caesium :- 2.14 eV.

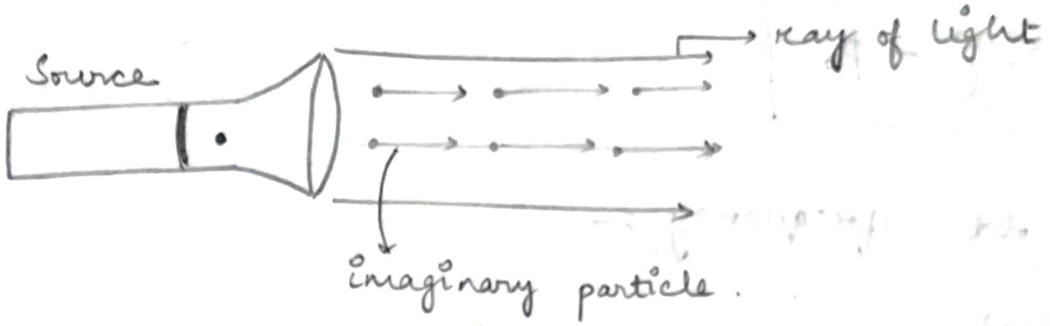
→ There are 3 methods of electron emission.

i) Thermonic emission
  → By application of heat.

ii) Field emission
  → By application of electric field.

iii) Photoelectric emission.
  → By application of light.

*. Photoelectric effect :- Particle nature of light :-



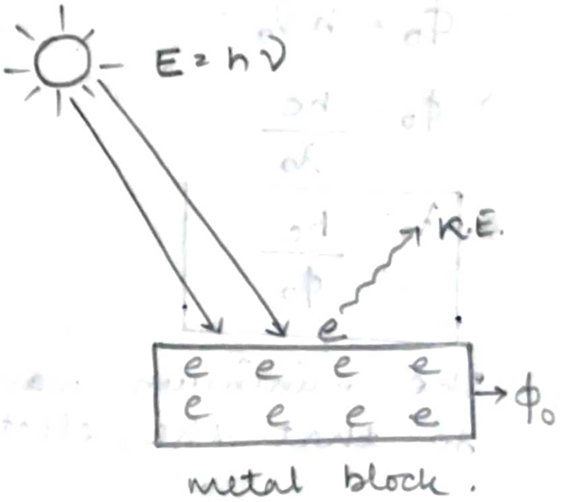
↓

Photon

- Energy
  - $E = h\nu$
  - ↓ Plank's const.
- Mass ↳ [Zero Rest mass (M_0)]
  - ↓ gravity.

→ $E > \phi_0$

$$\boxed{\underset{\text{Kinetic energy}}{K.E.} = \underset{\text{Total energy}}{E} - \phi_0}$$



→ Photons are neutral in charge.

→ Energy, $E = h\nu$
↓ Plank's const.
6.63×10^{-34} J/s.

We know, $\nu = \dfrac{c}{\lambda}$

$$\boxed{E = \frac{hc}{\lambda} = \frac{1240\ eV}{\lambda}}$$

→ momentum $P = \dfrac{h}{\lambda}$.

→ The collision between photon & electron is perfectly elastic.

1. $P_i = P_f$

2. $E_i = E_f$

→ $KE = E - \phi_0$

$$\Rightarrow \boxed{\frac{1}{2}mv^2 = \frac{hc}{\lambda} - \phi_0}$$

*. Threshold frequency :-

$\phi_0 = h\nu_0$

$$\Rightarrow \boxed{\nu_0 = \frac{\phi_0}{h}}$$

→ The minimum frequency of light that must be supplied to escape electrons.

*. Threshold wavelength :-

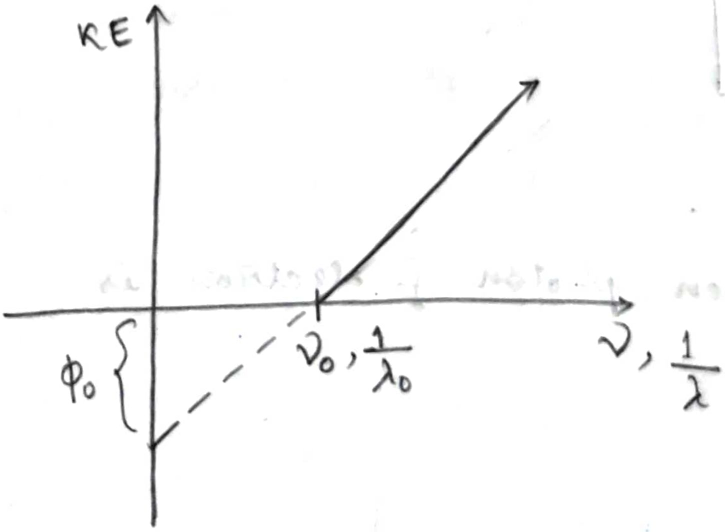
$\phi_0 = h\nu_0$

$$\Rightarrow \phi_0 = \frac{hc}{\lambda_0}$$

$$\Rightarrow \boxed{\lambda_0 = \frac{hc}{\phi_0}}$$

The minimum wavelength of light that must be given so that the electrons escape out.

*. $KE \sim \nu, \frac{1}{\lambda}$:-



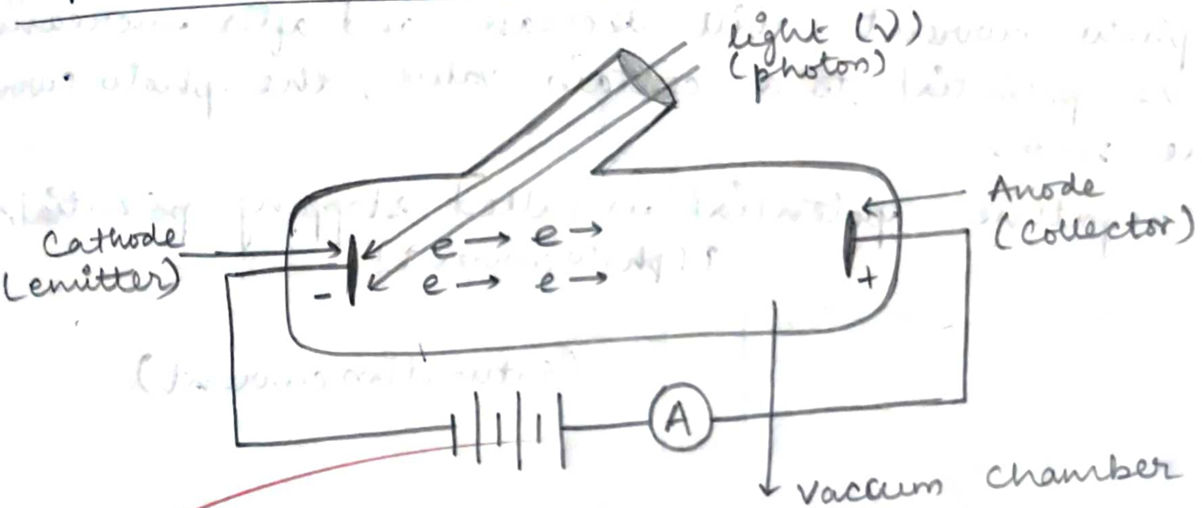
Q:- ϕ_0 of a substance is 4 eV. The longest wave length of light that can cause e^- emission ?

Ans:- $\phi_0 = \frac{hc}{\lambda_0} = \frac{1240 \, eV}{\lambda_0}$

$\Rightarrow 4 \, \cancel{eV} = \frac{1240 \, \cancel{eV}}{\lambda_0}$

$\Rightarrow \lambda_0 = \frac{1240}{4} = 310$ nm.

*. Experimental study of photoelectric effect :-



- → When light photon strike cathode it emit e⁻s.
- → This e⁻s are called as photoelectrons.
- → Anode is positive potential which collect the photoelectrons constitute a current called as photocurrent.
- → If we increase the ~~energy~~ intensity of light then no. of electrons will increase.
- → If collectors accepting rate is not increased then extra electrons gathered which form a e^- cloud called as space charge.
- → If we increase the potential of collector then it will attract the gathered electrons.
- → If we increase the collector potential but e^- emission is fixed then the maximum current after which it will be a fixed value.

→ That maximum / fix value of current is called saturation current.

→ If we increase the intensity of light then no. of electrons will increase and current will increase

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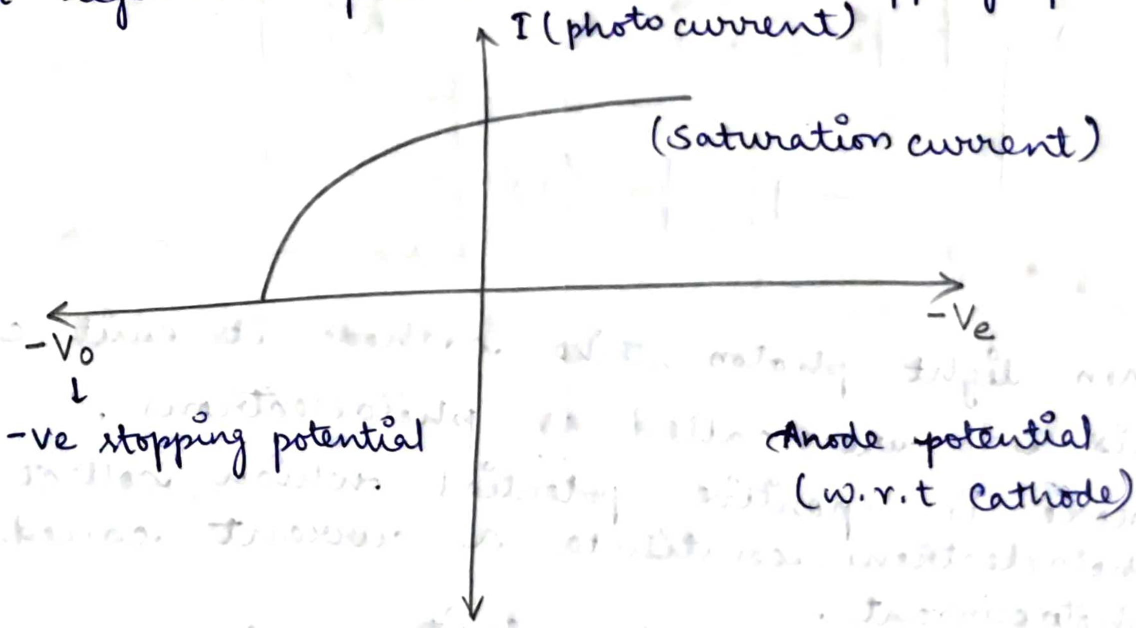
→ Now if we apply -ve potential at anode w.r.t cathode, photo-electrons will be repelled.

→ The photo current will decrease and after increasing the -ve potential to a certain value, the photo current became zero.

→ That negative potential is called stopping potential.



→ While moving from C to A e^- expense it is maximum K.E into work as it move against electrostatic force.

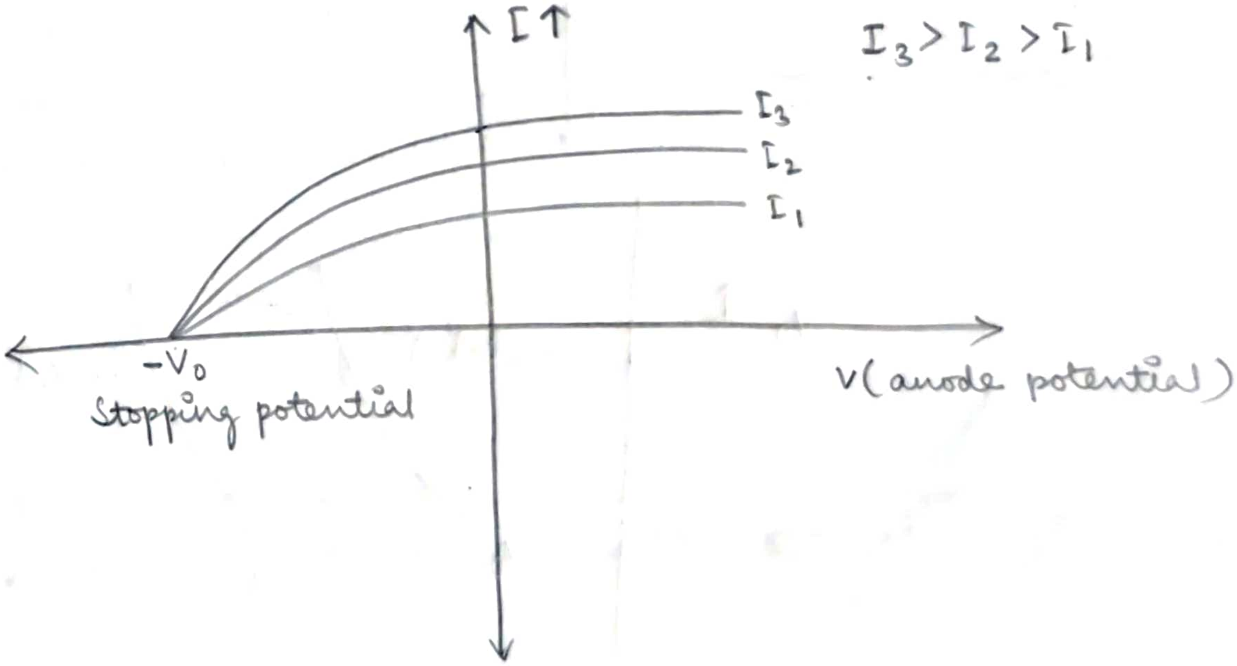
$\Rightarrow$ KEmax = workdone.

$\Rightarrow$ KEmax = eV_0

$$\Rightarrow \boxed{V_0 = \frac{KE_{max}}{e}}$$

*. Effect of intensity of light photocurrent :-

- → Keeping the frequency of the radiation and potential fixed.
- → The intensity of incident radiation increased, it is observed that the photocurrent increases.
- → That is with increase in intensity, the no. of photoelectrons emitted from emitor increases.
- → The photocurrent is directly proportional to the no. of photo electrons emitted per second.
- → That the no. of photoelectrons emitted for second is directly proportional to the intensity of incident radiation.
- → But the energy of photoelectrons remains same i.e. KE max remains same.
- → So, the stopping potential is independent of intensity of radiation of light.
- → That V_0 is same for all intensity of radiation of light.
- → That V_0 is same for all intensity of radiation.
- → Graph :-

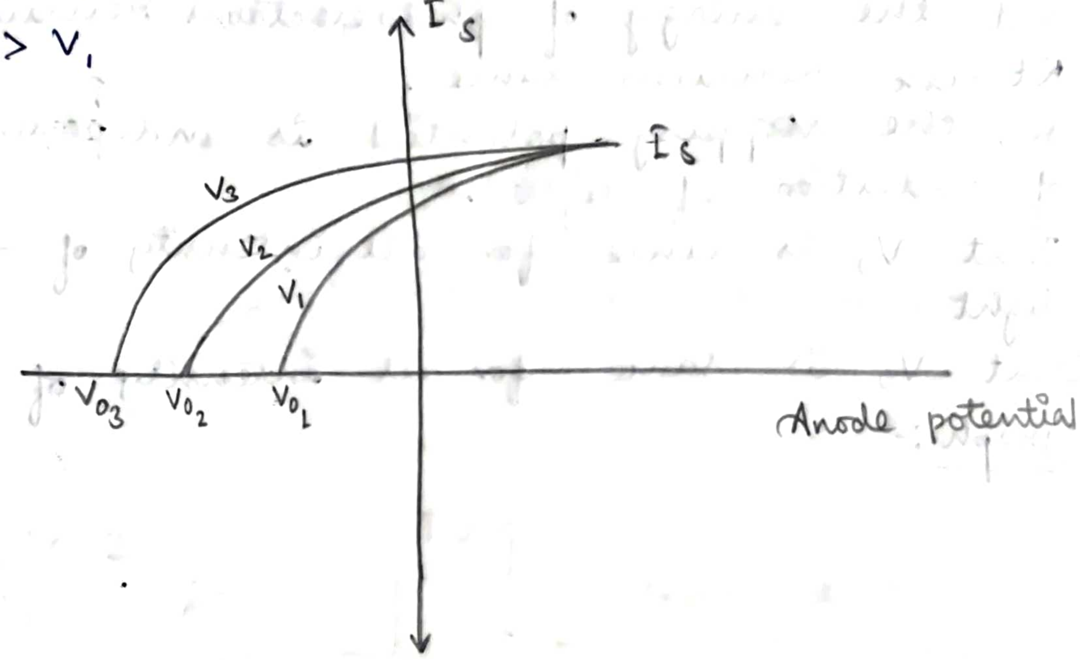


* Effect of frequency of radiation on stopping potential :

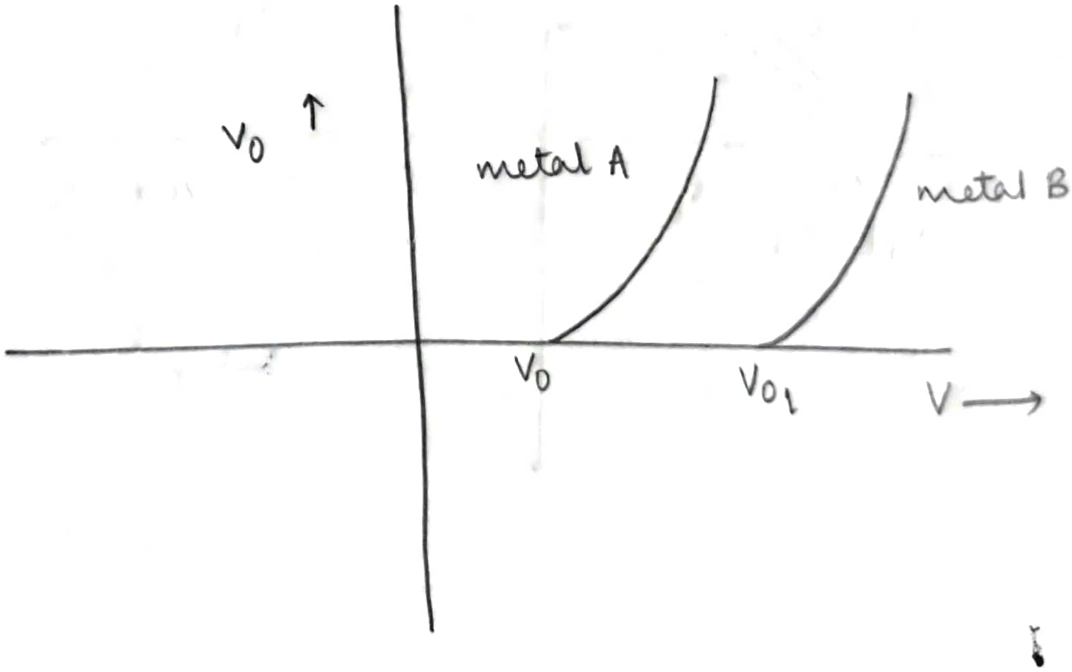
- → Now, vary frequency of light radiation keeping intensity fix.
- → It is observed that the saturation current is same independent of frequency of light radiation.
- → But the stopping potential increases with increases in frequency.
- → Because due to high frequency radiation the energy of photoelectrons increases and more -ve potential requires to stop them.

→ $V_{03} > V_{02} > V_{01}$

& $V_3 > V_2 > V_1$



→



→ Graph between V_0 and ν for different metals.

i) Stopping potential (V_0) varies linearly with frequency of radiation for a given metal.

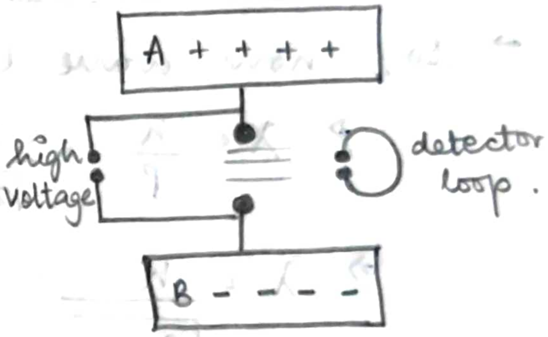
ii) There is a certain minimum cut off frequency no. of ~~a~~or which the stopping potential is zero.

✱. Hertz Observation :-

→ Due to high voltage, there is a sparking.

→ On application of UV Ray, the intensity of sparking enhanced.

→ From that it is concluded that there is a photoelectric effect on application of light.



✱. Hallwach & Lenard's observation :-

→ When UV ray applied on a charged zinc plate, it was observed that it became neutral.

→ Because $e^{-}s$ escape due to photoelectric effect.

→ A neutral zinc plate became charged when applied with UV ray.

→ A +vely charged plate can be enhanced by application of radiation.

✱. Debroglie Hypothesis :-

(wave nature of particle)

→ $\boxed{\lambda = \frac{h}{p}}$

→ moving matter display wave like property i.e. ~~rea~~ relation between λ (wave length) and p (momentum).

→ $\boxed{\lambda = \frac{h}{mv}}$

→ We know,

$$\Rightarrow E_K = \frac{1}{2}mv^2$$

$$= \frac{1}{2}\frac{m^2v^2}{m}$$

$$\Rightarrow \boxed{E_K = \frac{p^2}{2M}}$$

$$\Rightarrow \boxed{P = \sqrt{2mE_K}}$$

→ So, now wave length

$$\Rightarrow \lambda = \frac{h}{P} = \frac{h}{\sqrt{2ME_K}}$$

$$\Rightarrow \lambda = \frac{h}{\sqrt{2mev}} = \frac{h}{\sqrt{2me}\sqrt{V}}$$

↓ constant 1.227 × 10^{-9}

↳ voltage

$$\Rightarrow \lambda = \frac{1.227 \times 10^{-9}}{\sqrt{V}} m$$

$$\Rightarrow \boxed{\lambda = \frac{1.227}{\sqrt{V}} nm}$$

Q:- If e^- emission is subjected by 150 V of potential then find the wave length of radiation.

$$\lambda = \frac{1.227}{\sqrt{V}} nm.$$

Ans:- $V = 150$

$$\lambda = \frac{1.227}{\sqrt{150}} nm$$

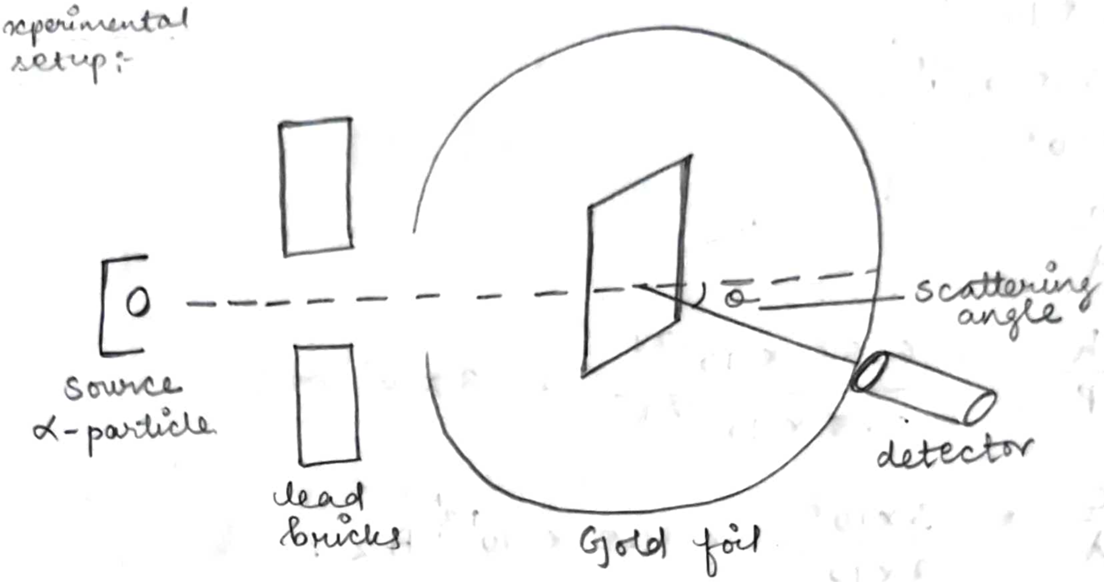
$$= \frac{1.227}{12.27} nm.$$

$$= 0.1 nm.$$

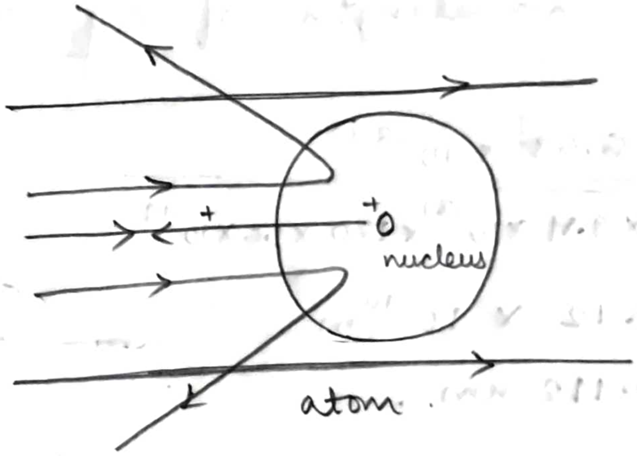
12. ATOMS

*. Alpha particle scattering experiment :-

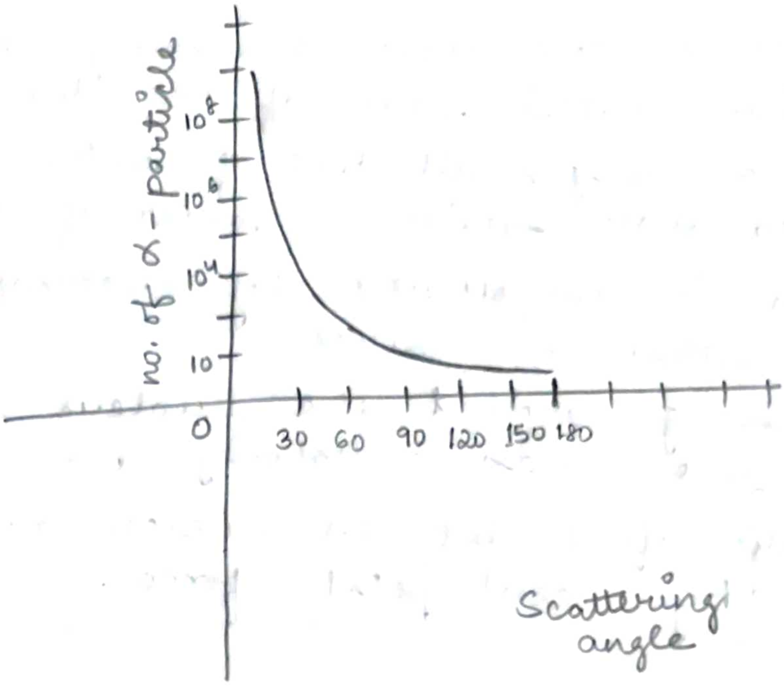
Experimental setup :-



Observation :-



- → Alpha particles are positively charged particles.
- → Most of the α- particle are observed to be pass through without any deflection.
- → Atom has maximum blank space.
- → About 0.14 % of total particles scattered.
- → 1 out of 8000 particles probably seems to be repelled back.

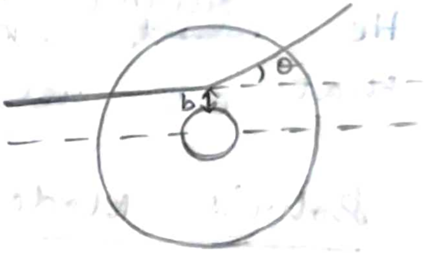


→ No. of α - particles scattered per unit area of θ is

$$N \propto \frac{1}{\sin^4\left(\frac{\theta}{2}\right)}$$

→ Impact parametre means the distance between the centre line to the scattered line of α particle.

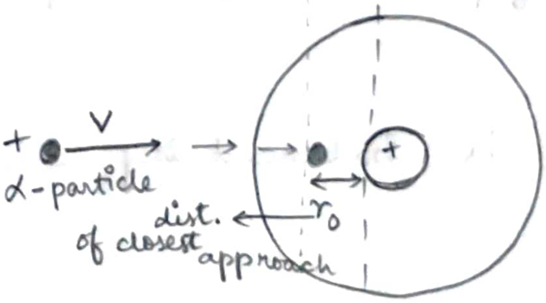
$$b = \frac{1}{4\pi\varepsilon_0} \frac{Ze^2 \cot \theta/2}{K.E}$$



→ α - particle when bombarded then it approach nucleus of gold foil.

→ It does notmean that it completely collide with nucleus but from a certain distance it repelled back.

→ That distance of approach is called distance of closest approach.



$$r_0 = \frac{1}{4\pi\varepsilon_0} \frac{2Ze^2}{KE}$$

*. Rutherford's model of atom :-

- → At the centre of atom there is a +vely charged nucleus which contain whole of the atom mass.
- → Nucleus is a very small size of order of 10^{-15} m as compared to atom which is order of 10^{-10} m.
- → The nucleus is surrounded by electrons and the atom is neutral in nature.
- → Electrons moving around the nucleus in a fixed orbit just like earth revolving around Sun.
- → The electrostatic force between nucleus and electron is balanced by centripetal force.

⊛ Drawbacks :-

- → While revolving around nucleus, the e⁻s continuously radiate energy in form of electromagnetic (EM) waves which will make the path spiral such that the e⁻ falls on nucleus.
- → He ~~coudt~~ couldn't explain the nature of EM wave spectrum that e⁻s release while revolving.

*. Bohr's Model :-

Postulates :-

- → Each atom has a stable state due to fix energy which is called stationary state.
- → The frequency of wave radiation depends on the energies of orbits.

  i.e. the energy of photon = difference of energy of orbits

$$\Rightarrow h\nu = |E_f - E_i|$$

- → The electrostatic force is balanced by centripetal force

$$\frac{mv^2}{r} = \frac{KZe^2}{r^2}$$

→ The angular momentum is integral multiple of $\frac{h}{2\pi}$

$$\boxed{\underset{\text{angular momentum}}{\underset{\downarrow}{L}} = \frac{nh}{2\pi}} \quad n = 1, 2, 3$$

⊛ Radius of orbit :-

→ In an atom, the electrons revolve in different orbits of different radius which is given by

$$\boxed{r_n = \frac{\overset{\text{no. of orbits}}{\overset{\uparrow}{n^2}}\, h^2\, \epsilon_0}{\pi\, \underset{\text{mass}}{\underset{\downarrow}{m}}\, \underset{\text{At. no.}}{\underset{\downarrow}{Z}}\, e^2}} \xrightarrow{} \text{Electron charge}$$

→ $\boxed{r_n \propto n^2}$

as rest of the thing are constant.

→ Bohr's radius :-

- Bohr considered H-atom (or) H like atom where $n = 1$, $Z = 1$.

$$r_1 = \frac{1^2 h^2 \epsilon_0}{\pi m 1 e^2}$$

$$= 0.53 \times 10^{-10}$$

$$= 0.53\ A^\circ.$$

If we want to calculate 2nd orbit

$r_2 = 4 \times 0.53\ A^\circ.$ $[\because n = 2]$

*. Velocity of electrons in orbit :-

$$\boxed{V = \frac{Ze^2}{2h\varepsilon_0 n}}$$

$\Rightarrow V \propto \frac{1}{n}$

→ The speed of electrons decreases as we move higher orbit.

*. Energy :-

$$K.E = \frac{1}{2}mv^2 = \frac{Ze^2}{8\pi\varepsilon_0 r}$$

$$P.E = -\frac{Ze^2}{4\pi\varepsilon_0 r}$$

Potential Energy

$$\text{Total Energy (T.E)} = K.E + PE$$

$$= \frac{Ze^2}{8\pi\varepsilon_0 r} - \frac{Ze^2}{4\pi\varepsilon_0 r} = -\frac{Ze^2}{8\pi\varepsilon_0 r}$$

We know

$$r = \frac{n^2h^2\varepsilon_0}{\pi m Ze^2}$$

$$TE \text{ (or) } E = \frac{-Ze^2}{8\cancel{\pi}\varepsilon_0} \times \frac{\cancel{\pi} m Ze^2}{n^2h^2\varepsilon_0}$$

$$= -\frac{mZ^2e^4}{8\varepsilon_0^2h^2} \times \frac{1}{n^2}$$

For H atom, $Z = 1$.

$$E = \frac{-me^4}{8\varepsilon_0^2 h^2} \times \frac{1}{n^2}$$

$$= -13.6 \times \frac{1}{n^2} \text{ ev.}$$

For 1st orbit, $n = 1$.

$E = -13.6$ ev.

For 2nd orbit, $n = 2$

$$E = \frac{-13.6}{4} \text{ ev} = -3.4 \text{ ev.}$$

For 3rd orbit, $n = 3$.

$$E = \frac{-13.6}{9} \text{ ev} = -1.51 \text{ ev,}$$

For 4th orbit, $n = 4$.

$$E = \frac{-13.6}{16} \text{ ev} = -0.85 \text{ ev.}$$

For 5th orbit, $n = 5$.

$$E = \frac{-13.6}{25} \text{ ev} = -0.54 \text{ ev.}$$

$E_1 = -13.6$ ev

Energy

$= -13.6 \times 1.6 \times 10^{-19}$ J.

$= 21.76 \times 10^{-19}$ J.

*. Spectral lines :-

→ When e⁻s jumps from higher orbit to lower orbit they radiate energy in different spectral series.

→ The 1st orbit i.e. $n = 1$ is ground state
$E_1 = -13.6$ ev

→ Consider higher orbit as n_2 & lower orbit as n_1.

→ So, Radiant Energy $= E_2 - E_1$.

$$\Rightarrow h\nu = E_2 - E_1$$

$$\Rightarrow h\nu = \frac{-mZ^2e^4}{8\varepsilon_0^2h^2n_2^2} + \frac{mZ^2e^4}{8\varepsilon_0^2h^2n_1^2}$$

$$= \frac{mZ^2e^4}{8\varepsilon_0^2h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow \frac{hc}{\lambda} = \frac{mZ^2e^4}{8\varepsilon_0^2h^2}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow \frac{1}{\lambda} = \frac{mZ^2e^4}{8\varepsilon_0^2ch^3}\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\Rightarrow \frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$\therefore R =$ Rydberg constant.

$$= \frac{me^4}{8\varepsilon_0^2ch^3} = 1.097 \times 10^{-7} m^{-1}$$

For H atom, $Z = 1$.

$$\Rightarrow \frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

→ on basis of different values of n_1 and n_2 the radiation spectrum categorised into different series.

1. When $n_1 = 1$, $n_2 = 2, 3, 4, 5 \ldots\ldots$
   (Layman Series → ultraviolet region).

$$\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{n_2^2}\right)$$

2. When $n_1 = 2$, $n_2 = 3, 4, 5 \ldots\ldots$
   (Balmer Series, → visible region)

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n_2^2}\right)$$

3. When $n_1 = 3$, $n_2 = 4, 5, 6 \ldots\ldots$
   (Pachan Series → infrared series)

$$\frac{1}{\lambda} = R\left(\frac{1}{3^2} - \frac{1}{n_2^2}\right)$$

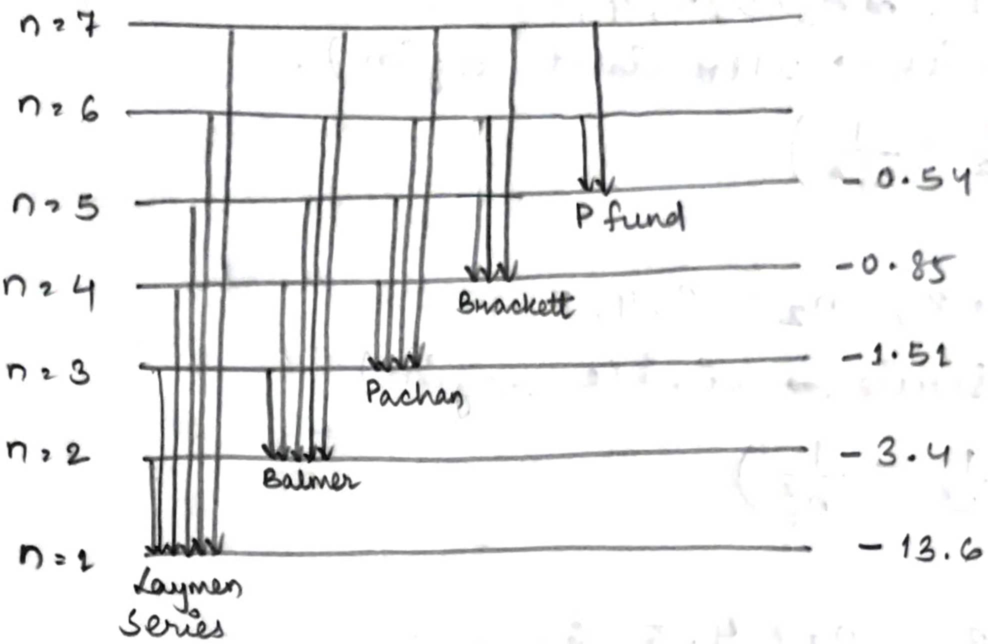
4. When $n_1 = 4$, $n_2 = 5, 6, 7 \ldots\ldots$
   (Brackett series → infrared series)

$$\frac{1}{\lambda} = R\left(\frac{1}{4^2} - \frac{1}{n_2^2}\right)$$

5. When $n_1 = 5$, $n_2 = 6, 7, 8 \ldots\ldots$
   (P fund series → infrared)

$$\frac{1}{\lambda} = R\left(\frac{1}{5^2} - \frac{1}{n_2^2}\right)$$

*. Energy level diagram :-



NOTE :-

→ $\frac{1}{\lambda_{max}}$, when e^-s jumps from nearest orbit.

→ $\frac{1}{\lambda_{min}}$, when e^-s jumps from ∞ orbit.

Q:- Find longest and shortest wavelength of Brackett series.

Ans:- $\frac{1}{\lambda_{max}} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$

$n_1 = 4$, $n_2 = 5$

$\Rightarrow \frac{1}{\lambda_{max}} = R\left(\frac{1}{4^2} - \frac{1}{5^2}\right)$

$\Rightarrow \frac{1}{\lambda_{max}} = 1.097 \times 10^7 \left(\frac{1}{16} - \frac{1}{25}\right)$

$= 0.0246 \times 10^7$

$\Rightarrow \lambda_{max} = 40.650 \times 10^{-7} = 40650$ A°.

$$\frac{1}{\lambda_{min}} = R\left(\frac{1}{4^2} - \frac{1}{\infty}\right)$$

$$= 1.097 \times 10^7 \times \frac{1}{16}$$

$$\lambda_{min} = 14.58 \times 10^{-7} = 1458\ A^\circ$$

13. NUCLEI

*. Introduction :-

→ Nucleus is the centre of atom consisting of proton + neutron.

→ Radius of nucleus is about 10^{-15} m.

→ Nucleus → Proton ($m_p = 1.67 \times 10^{-27}$ kg)
  → Neutron ($m_n = 1.67 \times 10^{-27}$ kg)

*. Atomic mass / Atomic number :-

→ Z

→ i.e. ~~sum of~~ mass of p(~~or~~) e⁻.

*. Mass number :-

→ A

→ i.e. mass of p + n.

*. Format to write element :-

$${}_{Z}X^{A}$$

Imp

* Size of nucleus :-

→ Volume of nucleus depends on A.

$$\frac{4}{3}\pi R^3 \propto A.$$

$$\Rightarrow R^3 \propto A$$

$$\Rightarrow R \propto A^{1/3}$$

$$\Rightarrow R = \underbrace{R_0}_{} A^{1/3}$$

↳ range of nuclear size.

$= 1.2 \times 10^{-15}$ m.

Imp

→ density

$$\rho = \frac{m}{\text{Volume}}$$

$$= \frac{\text{mass of } p+n \leftarrow m\,A \rightarrow \text{mass no.}}{\frac{4}{3}\pi R^3}$$

$$= \frac{m\,A}{\frac{4}{3}\pi R_0^3 A}$$

$$= \frac{m}{\frac{4}{3}\pi R_0^3}$$

→ $\rho = 23 \times 10^{17}$ kg/m^3

* Mass - Energy Relation :-

$$E = mc^2$$

where m = mass

c = speed of light

= 3×10^8 m/s

* Mass defect :-

→ The difference between actual mass and observed mass.

$$\Delta m = M_{actual} - M_{observed}$$

$$= (m_p + m_n) - M$$

$$= (Z \times m_p + (A-Z)m_n) - m.$$

Q:- Calculate the mass defect of $_2He^4$ if observed mass is $4.001506u$ $\left(\begin{array}{l} M_p = 0.007267 \ u \text{ and} \\ M_n = 1.008665 u \end{array} \right)$

Ans $\Delta m = ((Zm_p + (A-Z) M_n) - M_{observed}$

$A = 4$

$Z = 2$

$\Delta m = (2 \times 0.007267 + 1.008665) - 4.001506$

$= 0.030592u.$

*. Binding Energy:-

→ The amount of energy required to separate the nucleons and place them to infinite.

→ $B.E = \Delta m \times c^2$

$= [((Zm_p + (A-Z) m_n) - M_{obs}) \times c^2$

*. Binding Energy per unit nucleons:-

$BE_{nucleon} = \frac{BE}{A}$

Graph:-

→ From A value 2-20 the graph rise ~~stop~~ sharply.
(He, Li, C, N, O)

→ A value 30 - 120 (S, Fe, I) the graph maximise.

→ Maximum BE/N → Fe^{56} → 8.8 meV/N.

→ Then graph decreases to U^{238} which has been BE/N is 7.6 meV/N.

Q:: Two nuclei of mass no. 125 and 64 have radius R_1 and R_2. Find Ratio R_1 & R_2?

Ans:- $R_1 = R_0 A^{\frac{1}{3}}$

$= R_0 125^{\frac{1}{3}}$

$= R_0 5$

$R_2 = R_0 64^{\frac{1}{3}}$

$= R_0 4$

$$\frac{R_1}{R_2} = \frac{R_0 5}{R_0 4} = 5:4.$$

*. Nuclear Energy :-

→ The energy released during the transformation of nuclei with less B.E to nuclei of more B.E.

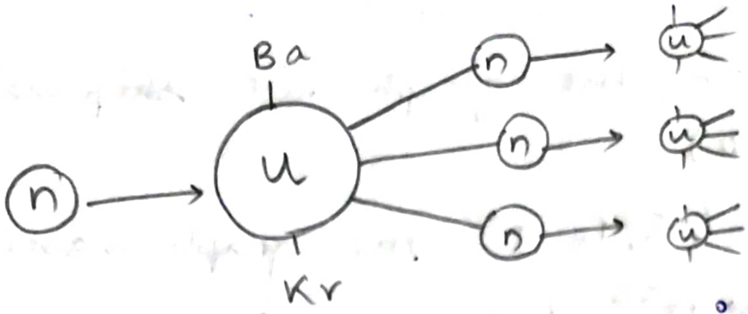
→ (i) Nuclear fission

→ (ii) Nuclear fusion.

(I) Nuclear Fission :-

→ The phenomenon of splitting heavier nuclei into two or more lighter nuclei by ~~bombing~~ bombading of proton, neutron, α - particle, etc.

→ Ex :- $${}^{236}_{92}U + {}^{1}_{0}n \longrightarrow {}^{141}_{56}Ba + {}^{92}_{36}Kr + 3\,{}_{0}n^{1} + \underset{\text{energy / Q-value}}{\underset{\downarrow}{Q}}$$

→ 

→ After the reaction, there is a huge amount of energy released called as Q-value.

→ It's value is 200 Mev.

→ It also has release 3 neutrons which continue the reaction further is called as chain reaction.

→ But this reaction is uncontrolled as 3 neutrons continues to give 9 neutrons and so on.

→ Which cause a huge amount of energy release and this concept is used in atom bomb.

→ Ex :- Hirosima incident :- 50kg of U^{236} is used which cause 10^{15} J of energy.

→ To control the chain reaction cadmium rod is used, as it absorb 2

→ The reaction will continue 1. to 1.

→ This controlled reaction is used in nuclear reacter.

***. Nuclear Fusion :-**

→ To form heavier nuclei and energy by combining two or more lighter nuclei.

→ Ex :- $_1H^1 + _1H^1 \longrightarrow _1H^2 + e^+ + \nu + 0.42$ Mev.
(proton) (proton) (neutro) (positron) (nutrino).

→ ~~So~~ In fusion, two nuclei must be lighter because there will be less electrostatic force.

- To make fusion, the required kinetic energy is 400 Kev which is possible by a temp. of 3×10^9 K.
- It only happens in sun.
- It is a exothermic process which means energy released during fusion.
- It is used in Hydrogen bomb.

*. Fusion in Sun :-

- $_1H^1 + {}_1H^1 \longrightarrow {}_1H^2 + e^+ + \nu + 0.42$ Mev.
- $_1H^2 + {}_1H^1 \longrightarrow {}_2He^3 + \nu + 5.49$ mev.
- $e^+ + e^- \longrightarrow \nu + \nu + 1.02$ Mev.
- $_2He^3 + {}_2He^3 \xrightarrow{\text{anhiliation}} {}_2He^4 + {}_1H^1 + {}_1H^1 + 12.86$ ev.

14. SEMICONDUCTOR

*. Energy Band :-

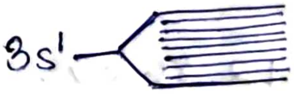
→ In a single atom, there are several energy levels available.

→ When more than same type of atoms combines form overlapped energy level.

→ The overlapped energy level ~~so~~ now form two type of Energy band.

i) Conduction band
ii) Valence band.

→ Na → $1s^2\ 2s^2\ 2p^6\ 3s^1$



(for one atom).

→ combines more than one atom.

→ Na →

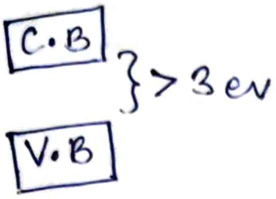
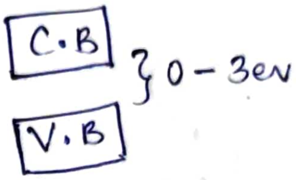
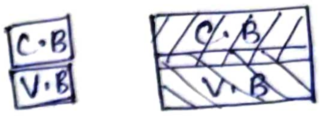
→ The gap is called Energy gap / band gap.

→ The band which is partially / completely filled with valence electrons is called valence band.

→ The energy band above valence band which maybe filled / empty is called conduction band.

→ The energy gap is called band gap and Energ is given by $E = h\nu = \frac{hc}{\lambda}$

→ Unit :- ev

* Insulator	Semi conductor	Conductor
→ The energy gap is so large that e^-s never conduct from V.B to C.B	→ The energy gap lies between conductor and insulator so that an application of energy e^- conduct to C.B.	→ The energy gap is zero (or) the C.B and V.B overlapped
→ $E_g > 3ev$	→ $0 < E_g < 3ev$	
→ 	→ 	→ 
		$E_g = 0$. overlapped.

* Semi-conductor :-

→ $0 < E_g < ev$

→ e^-s conduct on application of energy.

→ Semiconductor is of two types :-

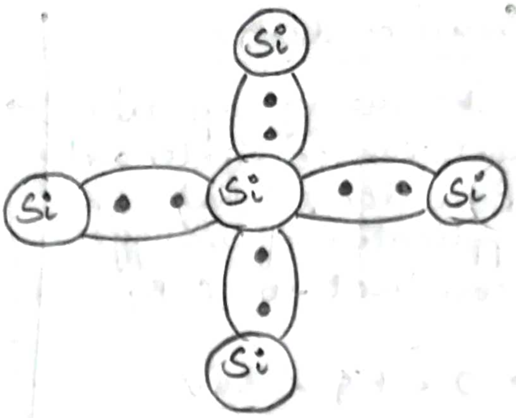
(1) Intrinsic semiconductor.
(2) Extrinsic semiconductor .

(1) Intrinsic semiconductor :-

→ The purest form of semiconductor without any doping or impurity.

→ Ex. :- pure Si (4 valence e^-)
pure Ge (4 valence e^-)

→



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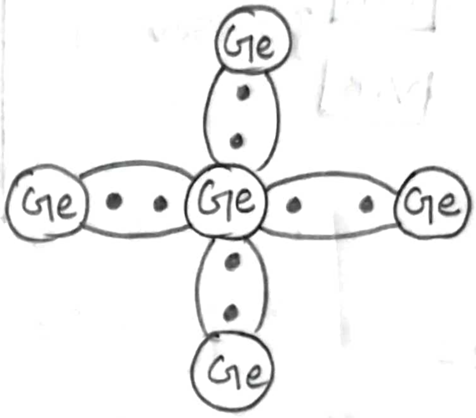

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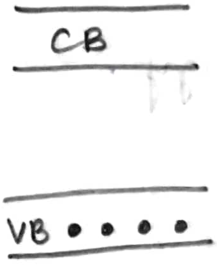
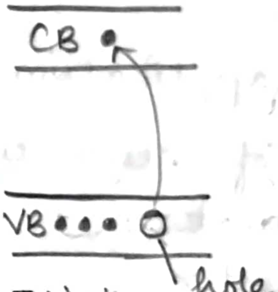


T = 'O'K



T > 'O'K

- → At 'O'K , semiconductor behaves like insulator when temp. increases , e^- from V.B jumps to C.B making a hole at V.B .

- → The no. of e^- is equal to no. of hole
  i.e. $n_e = n_h = n_i$
  ↳ Intrinsic semiconductor concentration

- → Holes are positive in nature.

- → when electric current applied, the e^-s as well as hole's moves in opposite direction.

→ They both constitute current.

$$\boxed{I = I_n + I_e}$$

→ The intrinsic concentration is given as

$n_i \propto e^{-E_g/KT}$ K = Boltzman constant.

*. Extrinsic Semiconductor :-

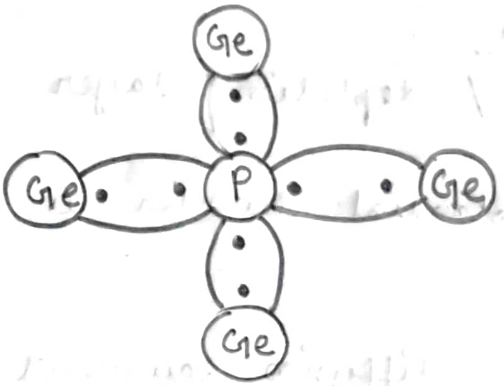
→ It is the impure form of semiconductor.

→ An impurity i.e. either pentavalention, trivalent is added.

→ The process is known as dopping.

① n-type semiconductor :-

→ Pentavalent impurity like P, As, Sb is added to get n-type semiconductor.

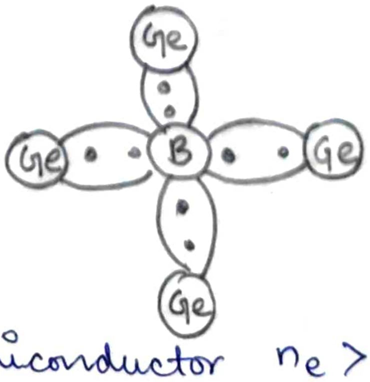


→ In n-type semiconductor $n_e > n_h$ i.e. major charge-carrier is electron minor charge carrier is hole.

② P-type semiconductor :-

→ Trivalent impurity like (B, Al) are used to make p-type semiconductor.

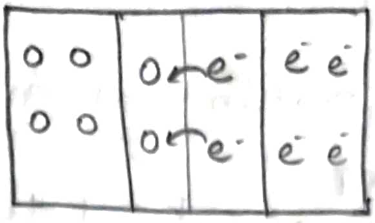
→



→ In p-type semiconductor $n_e > n_h$ i.e. major charge carrier is hole and minor charge carrier e^-.

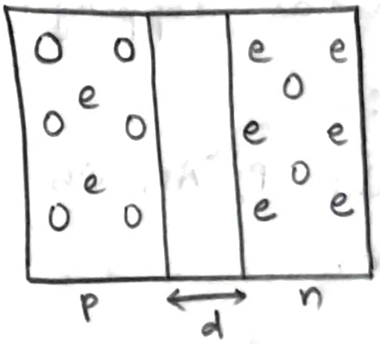
*. P-N Junction :-

→



→ When P and N type semiconductor are junctioned together, then some e⁻s from n side diffused to hole of p- side.

→ After that, near junction a depletion layer/potential barrier creator.



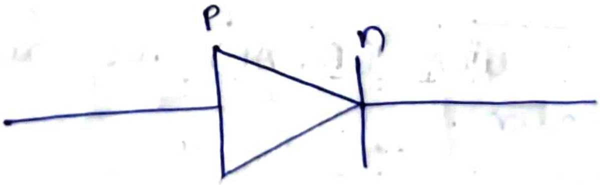
→ The potential barrier / depletion layer oppose further diffusion.

→ The potential of potential barrier is gives as

$V = Ed$

→ In steady state the diffusion current is balanced with drift current.

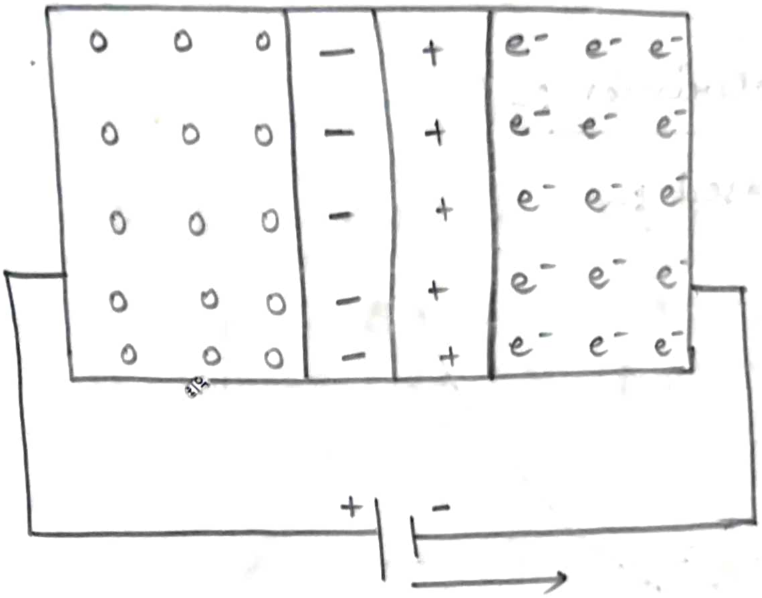
→ Symbol :-



*. Forward Biasing :-

→ Junction diode is said to be forward biased when positive terminal of entrance battery connected to p- side and negative to n - side.

→



→ In this connection, the p- side is connected to dhe terminal i.e. the hole conc. increases in p side and same also happens in n side.

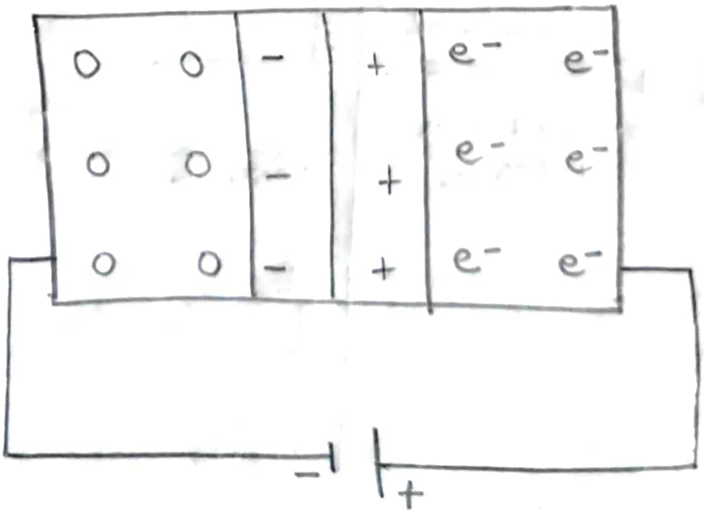
→ That is why the depletion layer decreases.

→ The effective potential barrier decreases.

*. Reverse Biased :-

→ When +ve terminal of battery is connected to n- side and vice- versa then the connection is called reverse biased.

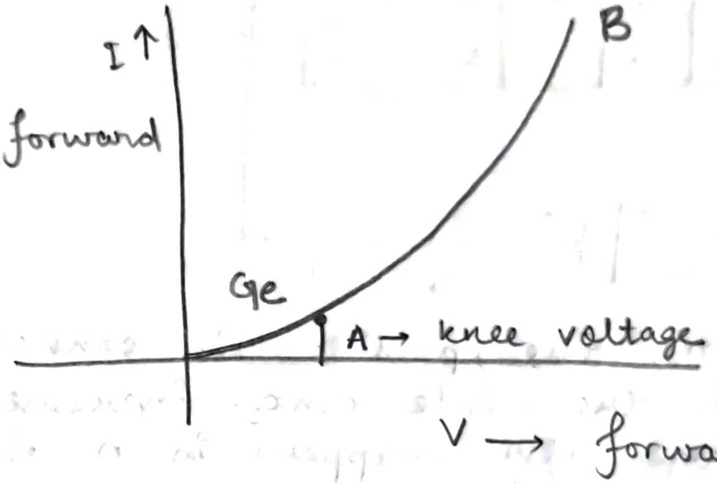
→



- → The effective potential barrier increases.
- → The depletion layer. increases.
- → In reverse bias, the current flow is actually due to minority charge carrier and also small so the current is called reverse current.

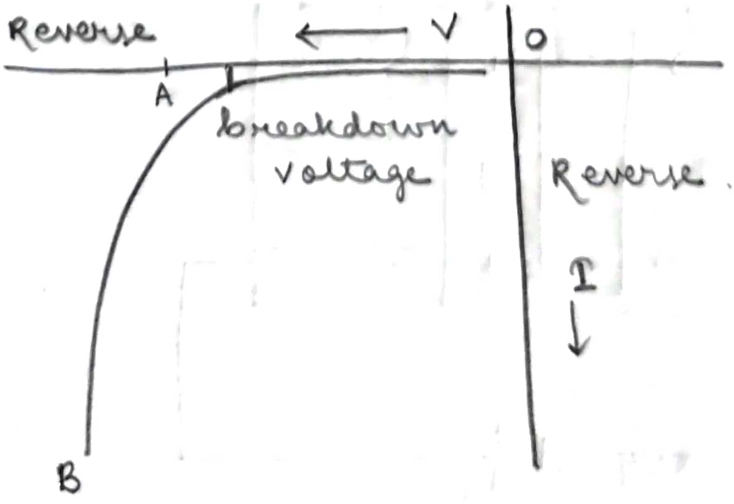
*. I- V characteristics :-

(a) Forward biased :-



- → In forward biased when voltage is applied the current first increases slowly because of potentia barrier.
- → After a certain voltage through the diode increases rapidly which 5 known as knee voltage or Threshol voltage.

(b) Reverse biased :-



→ In reverse bias minority charge carriers constitute a small amount of current.

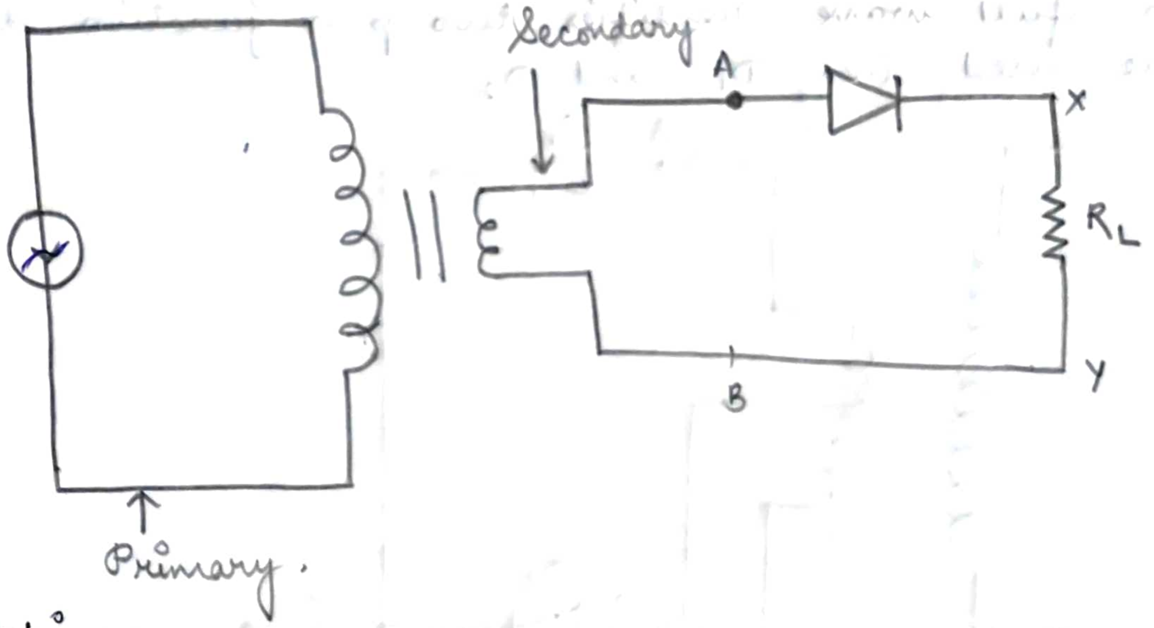
→ After a certain voltage the reverse current is independent of reverse voltage which is known as breakdown voltage.

→ In general when diode is forward bias it allow current when it is reverse biased it work as a off circuit.

*. Diode as half - wave rectifier :-

→ In half wave rectifier the AC voltage to be rectified is connected to primary coil of a step down transfer and secondary coil is connected to the diode.

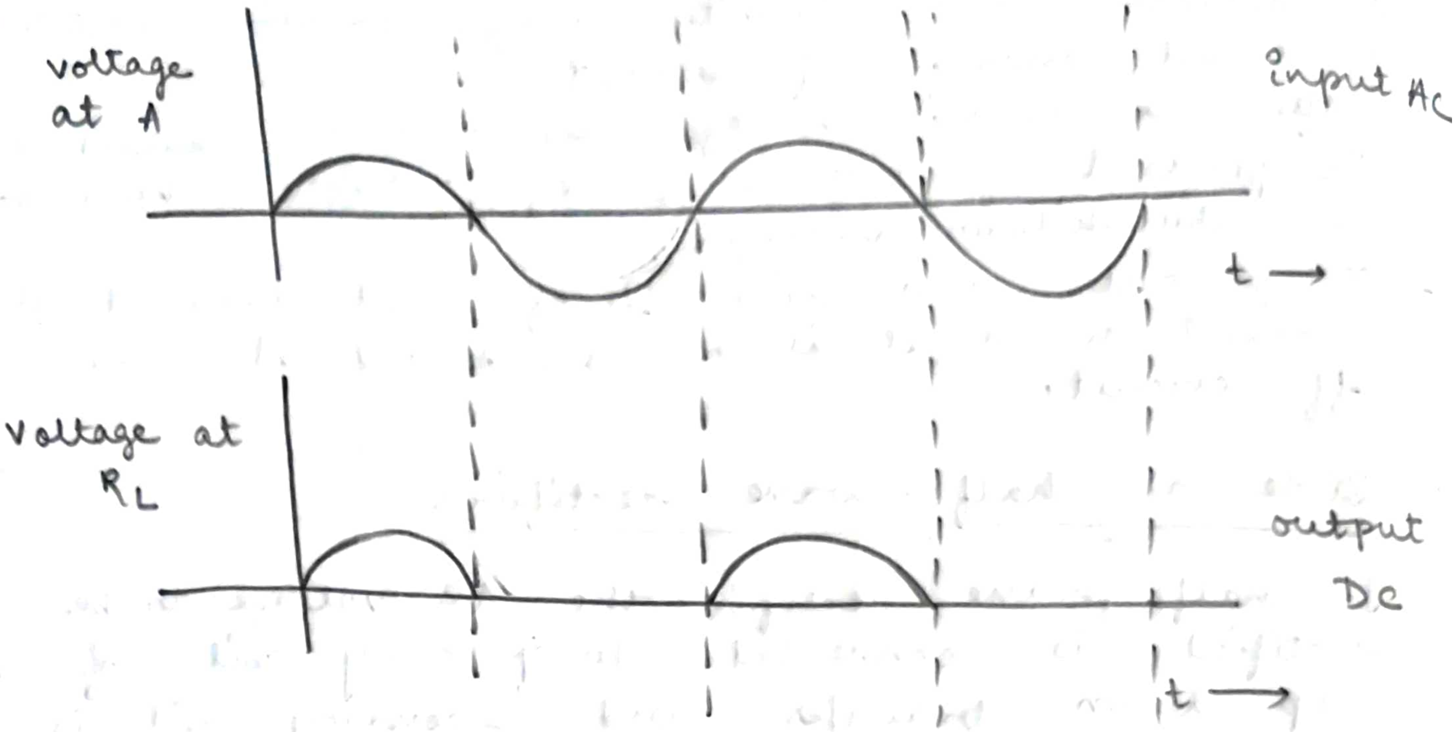
→ Across load resistance R_L the output is obtained.



Working :-

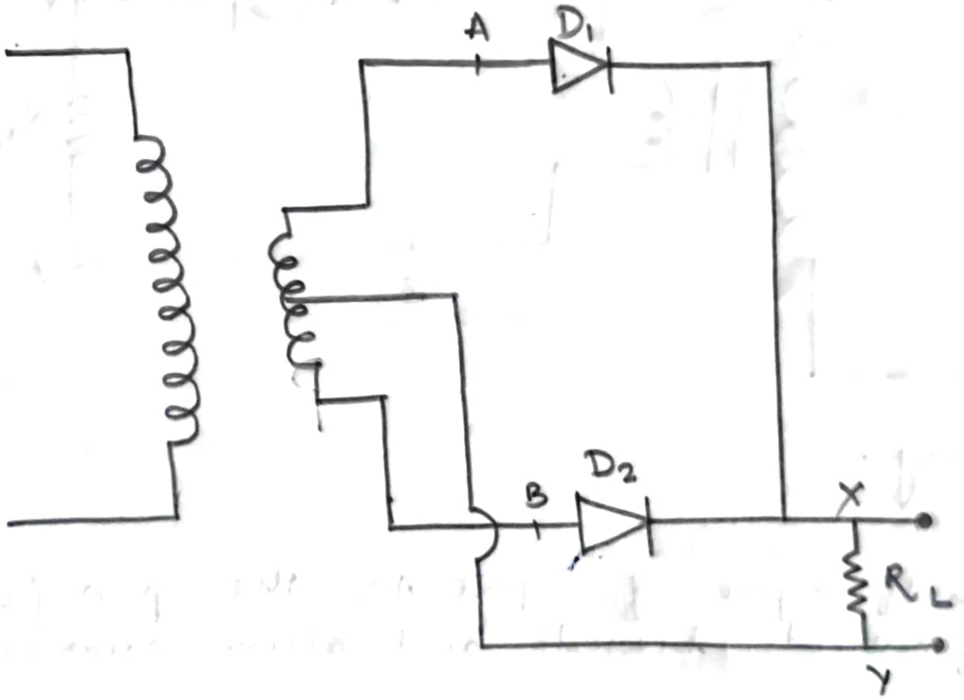
→ During +ve half cycle of input AC the p-n junction diode is forward biased and allow current to flow.

→ During negative half cycle of input AC the p-n junction reverse biased and no output is obtained.



***. Diode as full wave rectifier :-**

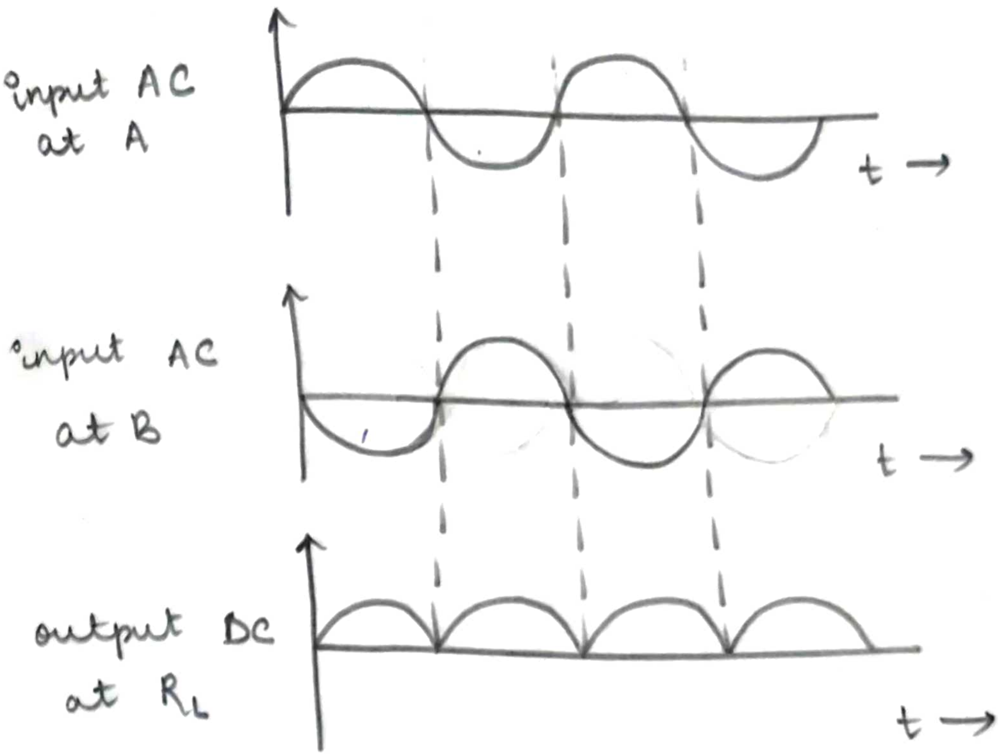
→ In full wave rectifier two p-n junction diode are used i.e. D_1 and D_2



→ In this setup the positive half cycle of AC input is rectified by D_1

→ And the negative half cycle of AC input is rectified by D_2.

→


input AC at A
t →
input AC at B
t →
output DC at R_L
t →