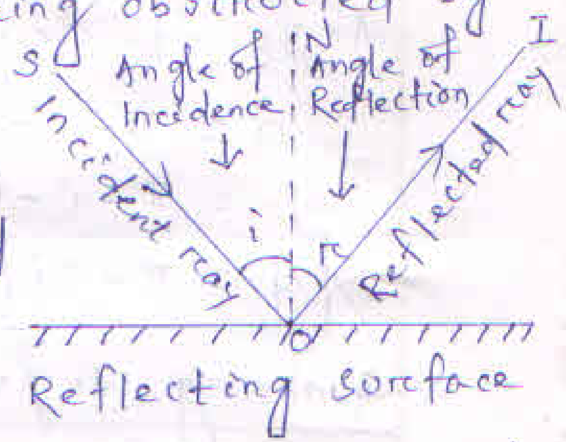
Optics

Reflection:-

It is the property of light by virtue of which light is sent back to the same medium from which it is coming after being obstructed by the surface.

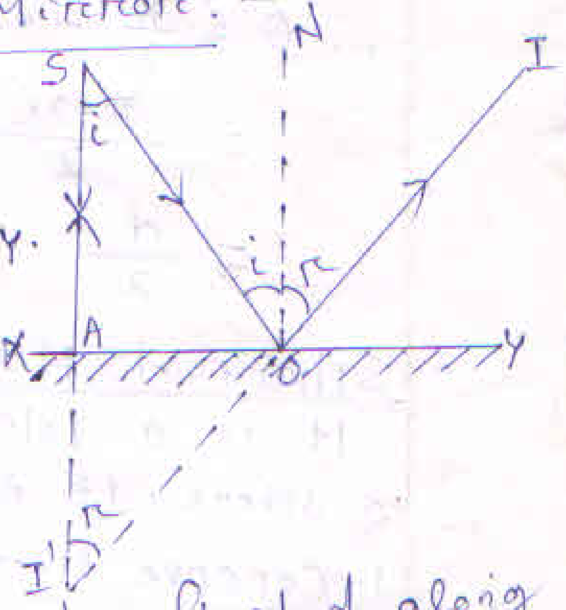


Laws of Reflection:-

i. The incident ray, the reflected ray and the normal to the reflecting surface, all lie in one plane.

ii. The angle of incidence is equal to the angle of reflection i.e. $\angle i = \angle r$

Image formed by a plane Mirror:-



i. Consider a point source 'S' situated at a distance AS from the reflecting surface XY.

ii. A ray of light 'SA' incident normally on 'XY' and is reflected back along AS.

iii. Another ray SO incident on XY making an angle 'i' and reflected along OI making an angle 'r', such that $\angle i = \angle r$.

iv. From the diagram, cosider the Δ AOS and AOI'.

$\therefore \angle SAO = \angle I'AO = 90°$

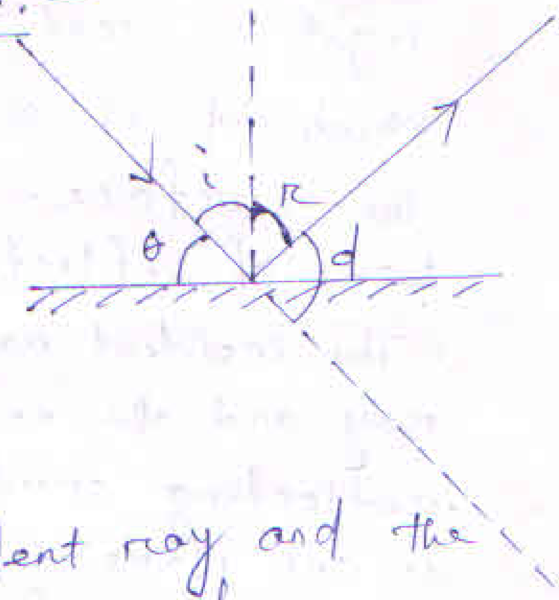
AO = Common side

$\angle ASO = \angle AI'O$ $\quad (\because \angle i = \angle r)$

$\therefore AS = AI'$

Conclusion :- The image formed at the same distance behind the mirror. It is virtual of same size and laterally inverted.

Deviation by the reflection :-



Angle of deviation

$$d = \pi - i - r$$
$$= \pi - i - i \quad (\because i = r)$$
$$\Rightarrow \boxed{d = \pi - 2i}$$

Glancing Angle :-

The angle between the incident ray and the mirror is known as glancing angle.

Let θ = Glancing Angle.

$$\therefore \theta = \frac{\pi}{2} - i$$
$$= \frac{\pi - 2i}{2}$$
$$= \frac{d}{2}$$

Spherical Mirror :-

It is a polished surface which forms the part of a sphere. It is of two types.

1. Concave Mirror :- It is a spherical mirror which when looked from the reflecting side is depressed at the centre and bulging at the edges.

2. Convex Mirror :- It is a spherical mirror which when looked from the reflecting side bulges at the centre and is depressed at the edges.

Uses of Spherical Mirror:—

1. Concave:—

i. It is used by the doctor to see the ear, nose and throats.

ii. It is used for shaving, because it gives erect and magnified image.

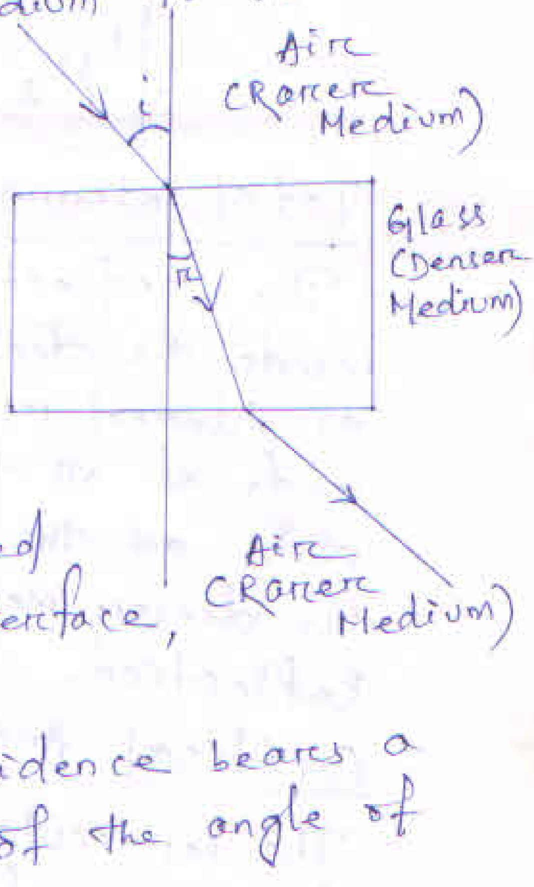
2. Convex:—

i. It is used in motor vehicle to see the distance objects behind the vehicle.

ii. It is also used as a street light reflector.

Refraction:—

It is the property of light by virtue of which it bends towards the normal or away from it, when it travels from one medium to the other.



Rarer → Denser → The beam bends towards the normal.

Denser → Rarer → The beam bends away from the normal.

Laws of Refraction:—

i. The incident ray, the refracted ray and the normal to the interface, all lie in one plane.

ii. The sine of the angle of incidence bears a constant ratio with the sine of the angle of refraction.

i.e. $\frac{\sin i}{\sin r} = \mu$.

This law is often called Snell's law.

Refractive Index (μ):—

The refractive index of a medium with respect to air is defined as the ratio of velocity of light in air to the velocity of light in medium.

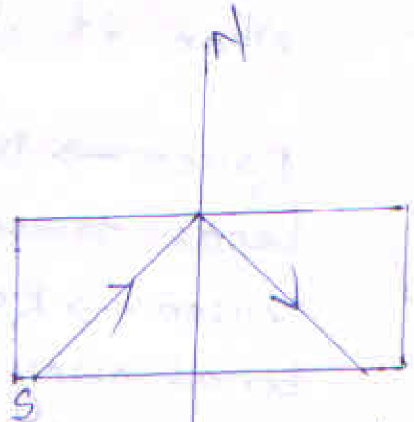
$$\therefore \boxed{\mu = \frac{v_a}{v_m}}$$

Or

Refractive index of second medium with respect to first is defined as the ratio between absolute refractive index of second medium to the absolute refractive index of first medium.

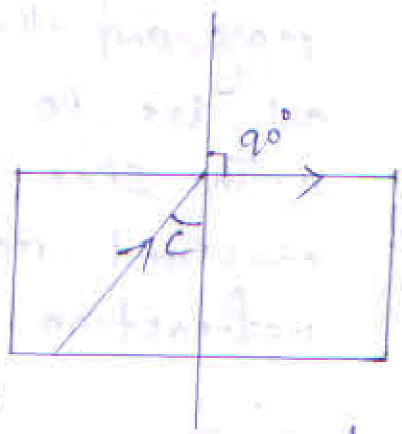
$$\therefore \boxed{{}^1\mu_2 = \frac{\mu_2}{\mu_1}}$$

Total Internal Reflection:—



The reflection that takes place inside the denser medium is known as internal reflection and the angle of all the incident rays at which all the refraction rays are observed inside the denser medium, is known as "Total Internal Reflection".

Critical Angle (C):—



The particular angle of incidence of a ray of ~~so~~light in denser medium for which the corresponding angle of refraction ~~is 90~~ in the rarer medium is 90°, is called critical angle.

Relation between μ and c :-

If μ be the refractive index of the denser medium with respect to the rarer medium,
In this case the refractive index of the rarer medium with respect to the denser medium is $\frac{1}{\mu}$.

$\therefore \frac{\sin i}{\sin r} = \frac{1}{\mu}$

$\Rightarrow \frac{\sin c}{\sin 90} = \frac{1}{\mu}$ $\quad (\because i = c \text{ and } r = 90°)$

$\Rightarrow \frac{\sin c}{1} = \frac{1}{\mu}$

$\Rightarrow \boxed{\mu = \frac{1}{\sin c}}$

Conditions for Total Internal Reflection :-

i. The ray must passes from a denser to a rarer medium.
ii. The angle of incidence must be greater than critical angle (c).

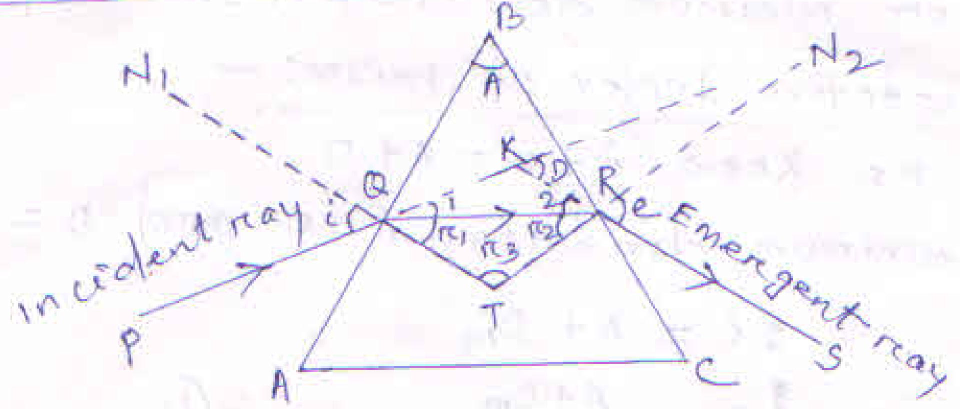
Examples of Total Internal Reflection :-

i. Formation of mirage due to total internal reflection.
ii. Sparkling of diamond.
iii. A coin floating in air.

Refraction through a prism: —

A prism is a transparent, wedge-shaped glass piece with three rectangulare faces.

Prove that $i+e = A+D$: —



i. Let's considere a prism ABC whose angle of prism is A.

ii. The ray of light incident on the face AB and get refracted along QR inside the prism and refraction emerges along RS.

iii. The angle of incidence $= i$

The angle of emergence $= e$

The angle of refraction $= r_1$ & r_2

The angle of deviation $= D$

From the figure; $i = 1 + r_1$

$e = 2 + r_2$

$\therefore i+e = 1+2+r_1+r_2$ —— (1)

From Δ QKR; $D = 1+2$

$\therefore i+e = D+r_1+r_2$ —— (2)

From Δ QRT; $r_1+r_2+r_3 = 180^\circ$ —— (3)

From quatdrilateral QBRT; $A+r_3 = 180^\circ$ —— (4)

From equation (3) and (4); $A = r_1+r_2$ —— (5)

$\therefore$ Equation (2) reduces to

$$\boxed{i+e = A+D}$$

Minimum Deviation (D_m) :—

i. The deviation produced by the incident ray is said to be minimum if the incident ray of light is parallel to the base of the prism.

ii. For minimum deviation $i = e$ and $r_1 = r_2$

Refractive Index of prism :—

We know $i + e = A + D$

For minimum deviation; $i = e$ and $D = D_m$

$$\therefore 2i = A + D_m$$

$$\Rightarrow i = \frac{A + D_m}{2} \quad \text{—— (1)}$$

Again we know; $r_1 + r_2 = A$

For minimum deviation; $r_1 = r_2 = r$

$$\therefore 2r = A$$

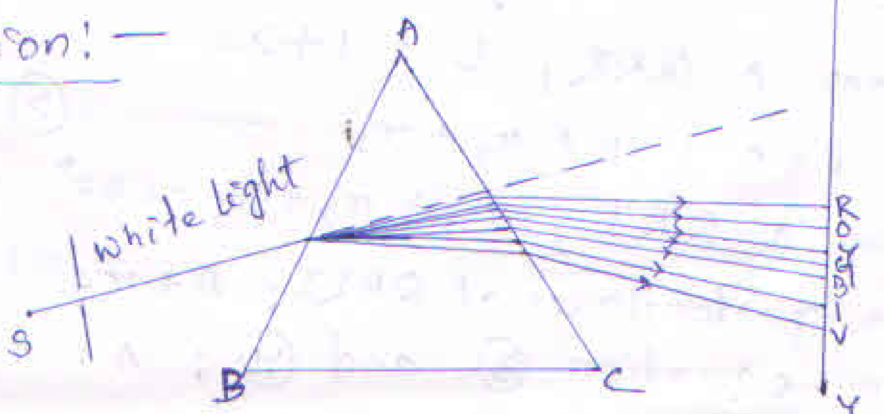
$$\Rightarrow r = \frac{A}{2} \quad \text{—— (2)}$$

We have refractive index, according to Snell's law,

$$\mu = \frac{\sin i}{\sin r}$$

$$\Rightarrow \boxed{\mu = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin \frac{A}{2}}}$$

Dispersion :—



Dispersion is the phenomenon of light by virtue of which a white light passing through a prism and splits up into it's constituent colours.

Electrostatics

Electrostatics:- It is the branch of physics which deals with the study of the properties of electric charge by means of friction.

Electric charge:-

The properties of attraction or repulsion by a substance is known as electric charge.

Unit:- MKS - Coulomb

CGS - stat-coulomb

There are two types of charge

+ve	-ve
i. Glass Rod	i. Silk cloth
ii. Woolen coat	ii. Plastic, Rubber
iii. Fur	iii. Ebonite

Example of +ve:-

When a glass rod is rubbed with silk, it aquires the quality of charge by which it attracts.

Example of -ve:-

When a ebonite rod is rubbed with fur, it aquires the quality of charge by which it attracts.

Here a glass rod is +vely charged and ebonite rod is -vely charged.

Note :-

1. Bound charge :- The charge induced at the nearer end is unable to leave its position, is known as bound charge.

2. Free charge :- The +ve charge at the farther end is known as free charge.

Coulomb's Law :-

i. Like charges repul each other while unlike charges attract each other.

ii. The electrostatic force of attraction or repulsion between two charge bodies is directly proportional to the product of their charges and varies inverously as the square of the distance between them.

$$\therefore F \propto q_1 q_2 \quad \text{—} (1)$$

$$F \propto \frac{1}{r^2} \quad \text{—} (2)$$

Combining these two equations, we have

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

$$\Rightarrow F = \beta \frac{q_1 q_2}{r^2} \quad \text{—} (3)$$

(where β = Constant of proportionality) and its value depends upon the nature of the medium and it also depends upon the system of unit used)

Value of β :-

1. In CGS or Electrostatic Unit (ESU) :-

In CGS $\beta = \frac{1}{K}$ (where K = Dielectric constant)

and $K = 1$ for free space.

$\therefore F = \frac{q_1 q_2}{r^2}$ —— (4)

2. In MKS :-

$\beta = \frac{1}{4\pi\epsilon}$ (where ϵ = Permitivity in medium

$= \frac{1}{4\pi\epsilon_0\epsilon_r}$ and $\epsilon = \epsilon_0 \epsilon_r \Rightarrow \epsilon_r = \frac{\epsilon}{\epsilon_0}$

For Air, ϵ_0 = Permitivity in free space

~~for~~ $\epsilon_r = 1$ ~~then~~ ϵ_r = Relative permitivity)

$\therefore \beta = \frac{1}{4\pi\epsilon_0}$

$\therefore F = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r^2}$ —— (5) (where $\frac{1}{4\pi\epsilon_0} = 9\times10^9 \, Nm^2C^{-2}$)

Point charge :-

The point where the total charge of the substance seems to be concentrated.

Unit Charge :-

i. In CGS or ESU :-

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

If $q_1 = q_2 = q = 1$ unit and $r = 1$ cm

then $F = \frac{1 \text{ unit}}{1 \text{ cm}^2} = 1$ dyne

Statcoulomb:— One statcoulomb is that amount of charge which when placed in air at a distance of 1 cm from a similar charge repels it with a force of 1 dyne.

ii. In MKS:—

$$F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$$

If $q_1 = q_2 = q = 1$ unit and $r = 1m$.

then $F = 9\times10^9 \frac{1 \text{unit}}{1 m^2}$

$\Rightarrow F = 9\times10^9$ ~~dyne~~ Newton

Coulomb:— One coulomb is that amount of charge which when placed in air at a distance of 1m. from a similar charge repels it with a force of 9×10^9 Newton.

Relation between Coulomb and stat-coulomb:—

1 coulomb $= 3\times10^9$ statcoulomb

Proof:— In MKS:— $F = \frac{1}{4\pi\epsilon_0}\frac{q_1 q_2}{r^2}$

$= 9\times10^9$ Newton

In CGS:—

Let $q_1 = q_2 = x$ statcoulomb

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

$\Rightarrow 9\times10^9 N = \frac{x\times x}{(100)^2}$ Dyne

$\Rightarrow 9\times10^9 N = \frac{x^2}{10^4}\times10^{-5} N$

$\Rightarrow 9\times10^9 N = \frac{x^2}{10^9} N$

$\Rightarrow x^2 = 9 \times 10^{18}$

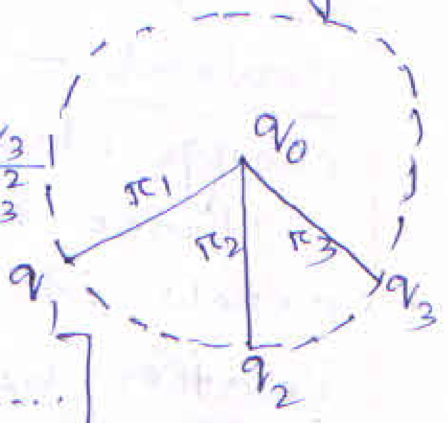
$\Rightarrow x = 3 \times 10^{9}$ statcoulomb

$\therefore$ 1 coulomb $= 3 \times 10^{9}$ statcoulomb

Superposition of coulomb's force:—

The force on a certain charge due to a large no. of other charges can be obtained by the application of principle of superposition.

Defination:— It states that all the charges when placed near each other, the net force on one charge due to all other charges is equal to the vector sum of forces produced by them.



$$F = F_1 + F_2 + F_3 + \cdots$$

$$= \frac{1}{4\pi\epsilon_0}\frac{q_0 q_1}{r_1^2} + \frac{1}{4\pi\epsilon_0}\frac{q_0 q_2}{r_2^2} + \frac{1}{4\pi\epsilon_0}\frac{q_0 q_3}{r_3^2} + \cdots$$

$$= \frac{1}{4\pi\epsilon_0}\left[\frac{q_0 q_1}{r_1^2} + \frac{q_0 q_2}{r_2^2} + \frac{q_0 q_3}{r_3^2} + \cdots\right]$$

$$= \sum_{i=1}^{n} \frac{1}{4\pi\epsilon_0}\frac{q_0 q_i}{r_i^2} \quad (\text{where } i = 1, 2, \cdots)$$

Dielectric constant:—

Dielectric constant of a medium is defined as the ratio of the force between two charges in air to the force between same two charges in the medium.

$$\therefore \text{Dielectric constant} = \frac{\text{Force between two charge in air}}{\text{Force between two charge in medium}}$$

Electric Field ($\vec{E}$) :-

The region around which a change body can be influenced or realized due to another change body is known as electric field.

$$\text{Electric field} = \frac{\text{Force}}{\text{Test charge}}$$

$$\Rightarrow E = \frac{F}{q_0}$$

We know $F = \frac{1}{4\pi\epsilon_0}\frac{qq_0}{r^2}$

$$\therefore E = \frac{1}{4\pi\epsilon_0}\frac{qq_0}{r^2} \Big/ q_0$$

$$\Rightarrow \boxed{E = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}}$$

Dimension :- $E = \frac{F}{q_0} = \frac{[M^1L^1T^{-2}]}{[A^1T^1]} = [M^1L^1T^{-3}A^{-1}]$

Electric field due to no. of changes :-

i. Let's consider a system having 'n' number of changes

ii. To measure the net electric field at a point, the principle of superposition should be followed.

iii. Let the changes are $q_1, q_2, q_3, \cdots q_n$

iv. $\therefore$ Total field due to number of changes is equal to the sum of the field due to separate changes.

$$\therefore E = E_1 + E_2 + \cdots + E_n$$

$$= \frac{1}{4\pi\epsilon_0}\frac{q_1}{r_1^2} + \frac{1}{4\pi\epsilon_0}\frac{q_2}{r^2} + \cdots$$

$$= \frac{1}{4\pi\epsilon_0}\left[\frac{q_1}{r_1^2} + \frac{q_2}{r_2^2} + \cdots\right]$$

$$= \sum_{i=1}^{n}\frac{1}{4\pi\epsilon_0}\frac{q_i}{r_i^2}$$

Electric Potential(V):-

Electric potential at any point in an electric field is defined as the amount of workdone in moving a unit positive charge from infinity to that point against the electric field.

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

Unit:- In SI, $1\ \text{Volt} = 1J/1C$

In CGS, $1\ \text{statvolt} = 1\ \text{erg}/1\ \text{statcoulomb}$

Relation between volt and statvolt:-

$$1\ \text{Volt} = \frac{1}{300}\ \text{statvolt}$$

$$1\ \text{volt} = \frac{1\ \text{Joule}}{1\ \text{coulomb}} = \frac{10^7\ \text{erg}}{3\times10^9\ \text{statcoulomb}}$$

$$= \frac{1}{3\times10^2}\ \text{erg}/\text{statcoulomb}$$

$$= \frac{1}{300}\ \text{statvolt}$$

Dimension:- $V = \frac{W}{q} = \frac{W}{it} = \frac{[M^1L^2T^{-2}]}{[A^1T^1]}$

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

Potential Difference:-

The amount of workdone by bringing a unit positive charge from one point to other inside the electric field is known as potential difference.

$$\therefore V_B - V_A = \frac{W_{AB}}{q_0}$$

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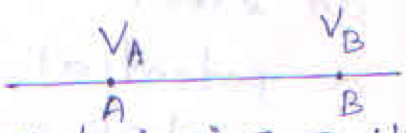
$$= \frac{1}{3 \times 10^2} \text{ erg}/\text{statcoulomb}$$

$$= \frac{1}{300} \text{ statvolt}$$

Dimension:- $V = \frac{W}{q} = \frac{W}{it} = \frac{[M^1 L^2 T^{-2}]}{[A^1 T^1]}$

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

Potential Difference:-



The amount of workdone by bringing a unit positive charge from one point to other inside the electric field is known as potential difference.

$$\therefore V_B - V_A = \frac{W_{AB}}{q_0}$$

Relation between Electric field and Potential :-

i. We know that the workdone on the unit positive charge inside the electric field,

$$dw = -F \cdot dr$$

$$\Rightarrow dw = -E q_0 dr \quad \text{--- (1)}$$

ii. Electrostatic potential at a point due to a point charge inside the electric field,

$$dv = \frac{dw}{q_0}$$

$$\Rightarrow dv = \frac{-E q_0 dr}{q_0}$$

$$\Rightarrow dv = -E \cdot dr$$

$$\Rightarrow \boxed{E = \frac{-dv}{dr}}$$

$-\frac{dv}{dr}$ is known as potential gradient.

Electron Volt (eV) :-

It is defined as the energy acquired by an electron when it is made to move through a potential difference of 1 volt.

$$1eV = 1e \times 1V$$

$$= 1.6 \times 10^{-19} C \times 1V$$

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

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

Equipotential Surface :-

i. An equipotential surface is defined as the locus of all the points in the medium at which the potential due to a charge distribution is the same.

ii. An equipotential surface may be curved or plane.

iii. Workdone in moving any charge from one point to the other on an equipotential surface is zero.

Current Electricity

Electric Current(i):-

i. The electric current is defined as the rate of flow of charge.

ii. If 'q' be the amount of charge that flows through a conductor in 't' second then

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

Unit:- In SI - $1 \text{ ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}$

In CGS -(i) ESU - $1 \text{ statampere} = \frac{1 \text{ statcoulomb}}{1 \text{ second}}$

(ii) EMU - $1 \text{ abampere} = \frac{1 \text{ abcoulomb}}{1 \text{ second}}$

Ampere:- The current flowing through a conductor is said to be 1 ampere if a charge of 1 coulomb flows across any of its cross-section in one second.

Relation between Ampere & Statampere:-

$$1 \text{ ampere} = \frac{1 \text{ coulomb}}{1 \text{ second}}$$

$$= \frac{3 \times 10^9 \text{ statcoulomb}}{1 \text{ second}}$$

$$= 3 \times 10^9 \text{ statampere}.$$

Conductors:-

Conductors are those substances through which electric charge can pass easily.

Exa:- Silver, Iron, Copper, Gold, Aluminium etc.

Insulators:-

Insulators are those substances through which electric charge can not pass easily.

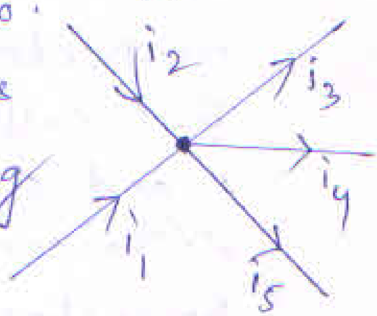
Exa:- Glass, Wood, pure water etc.

Kirchhoff's Law:—

1st law (Kirchhoff's Current Law - KCL):—

i. The algebraic sum of currents meeting at any junction in a circuit is zero.

ii. Taking the current flowing towards the junction as +ve and those flowing away from the junction as -ve;



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

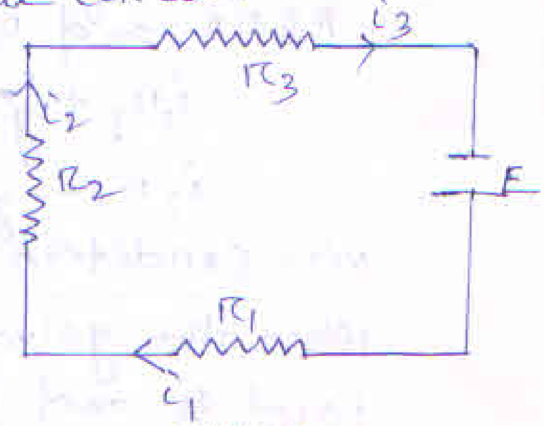
$$\Rightarrow \sum i = 0$$

2nd law (Kirchhoff's Voltage Law - KVL):—

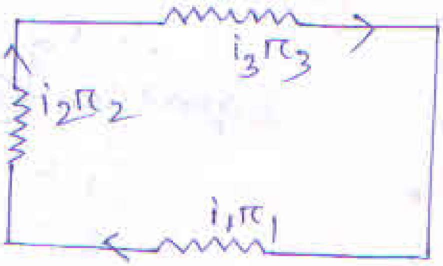
In a closed electrical circuit, the algebraic sum of the product of current and resistances of various branches of the circuit is equal to the total e.m.f. applied to the circuit.

$$\therefore i_1 r_1 + i_2 r_2 + i_3 r_3 = E$$

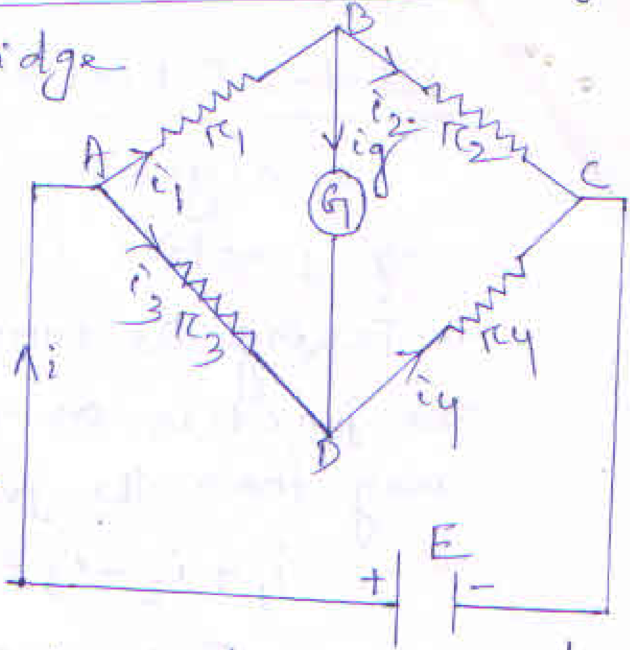
$$\Rightarrow \sum i r = E$$



$$i_1 r_1 + i_2 r_2 + i_3 r_3 = 0$$



Application of Kirchhoff's law to Wheatstone Bridge:-



i. Consider a wheatstone bridge of various branches of resistances r_1, r_2, r_3 & r_4 respectively.

ii. A cell is connected between A and C.

iii. The current through various branches are i_1, i_2, i_3 and i_4 respectively.

iv. The current through the galvanometer is i_g and resistance is G.

v. Applying Kirchhoff's 1st law to the junction B and D, we have;

$$i_1 - i_2 - i_g = 0 \quad \text{---} (1) \quad (\text{At} - B)$$

$$i_3 - i_4 + i_g = 0 \quad \text{---} (2) \quad (\text{At} - D)$$

vi. Applying Kirchhoff's 2nd law the closed circuit ABDA and BCDB we have;

$$i_1 r_1 + i_g G - i_3 r_3 = 0 \quad \text{---} (3) \quad (\text{At} - ABDA)$$

$$i_2 r_2 - i_g G - i_4 r_4 = 0 \quad \text{---} (4) \quad (\text{At} - BCDB)$$

vii. Condition for balance:-

When the galvanometer shows zero deflection, the point B and D are the same potential.

$\therefore i_g = 0$

$\therefore$ Equation (1), (2), (3) and (4) reduces to

$$i_1 = i_2 \quad \text{---} (5)$$

$$i_3 = i_4 \quad \text{---} (6)$$

$$i_1 r_1 = i_3 r_3 \quad \text{---} (7)$$

$$i_2 r_2 = i_4 r_4 \quad \text{---} (8)$$

Dividing (7) by (8), we have $\frac{i_1 r_1}{i_2 r_2} = \frac{i_3 r_3}{i_4 r_4} \Rightarrow \boxed{\frac{r_1}{r_2} = \frac{r_3}{r_4}}$

This is the condition for the wheatstone bridge circuit to be at balance, when the galvanometer deflection is zero.

Capacity:—

i. The capacity of a conductor implies the quantity of charge stored in it.

ii. The charge given to a conductor is directly proportional to its potential difference.

iii. If 'q' be the charge given to the conductor with a potential difference of V-volt then

$$q \propto V$$

$$\Rightarrow q = CV$$ (Where C = proportionality constant or known as capacity of the conductor)

$$\Rightarrow \boxed{C = \frac{q}{V}}$$

iv. If $V = 1$, then $C = q$

∴ The capacity of a conductor is defined as the charge required to raise it through a unit potential.

Unit:— SI – 1 Farad (F) $= \frac{1 \text{ coulomb}}{1 \text{ volt}}$

CGS – i. ESU – 1 statfarad $= \frac{1 \text{ statcoulomb}}{1 \text{ statvolt}}$

ii. EMU – 1 abfarad $= \frac{1 \text{ abcoulomb}}{1 \text{ abvolt}}$

Farad (F):— A conductor has a capacity of 1 farad if a charge of 1 coulomb raise its potential by 1 volt.

Dimension:— $C = \frac{q}{V} = \frac{q}{W/q} = \frac{q^2}{W} = \frac{(It)^2}{FS}$

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

Capacity of an isolated Spherical Conductor:-

i. Consider a spherical conductor of radius 'r' completely isolated from other charge bodies and a charge 'q' be given to it.

ii. Let 'V' be the potential at a point due to the point charge 'q' on the surface of the conductor.

iii. Then the capacity of the spherical conductor is,

$$C = \frac{q}{V} \quad \text{——} (1)$$

iv. We have the potential at a point on the surface of the conductor due to the point charge q is,

$$V = \frac{1}{4\pi\epsilon_0}\frac{q}{r}$$

$$\therefore C = \frac{q}{V}$$

$$\Rightarrow C = \frac{q}{\frac{1}{4\pi\epsilon_0}\frac{q}{r}}$$

$$\Rightarrow C = 4\pi\epsilon_0 r$$

$$\Rightarrow \boxed{C = \frac{r}{9\times10^9}} \qquad \left(\because \frac{1}{4\pi\epsilon_0} = 9\times10^9\right)$$

$\therefore$ The capacity of a spherical conductor varies directly with it's radius.

Magnetism

Magnetism - The properties of attraction by means of a magnet is known as magnetism.

Bar Magnet:- It is a chape of rectangular or cylindrical bar. A magnet has two poles. One end is north pole and other end is south pole.

Pole strength:- The no. of charges which is concentrated at the end of the magnet is known as magnetic pole strength. and it is denoted by 'm'.

Nature of force between two poles:-

Like poles repel each other while unlike poles attract each other.

Coulomb's law in Magnetism:-

The force of attraction or repulsion between two magnetic poles varies directly as the product of their pole strength and inversely as the square of the distance between them.

If m_1, m_2 are the strength of the two poles and r be the distance between them, then according to the law; $F \propto m_1 m_2$

$$F \propto \frac{1}{r^2}$$

Combining these two equations;

$$F \propto \frac{m_1 m_2}{r^2}$$

$$\Rightarrow F = K\frac{m_1 m_2}{r^2}$$ (where K = constant of proportionality)

In S.I, $K = \frac{\mu_0}{4\pi}$, $\therefore F = \frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2}$ (Where μ_0 = Absolute Magnetic permeability of free space)

In CGS, $K = 1$, $\therefore F = \frac{m_1 m_2}{r^2}$

Magnetic field (B):—

Magnetic field is defined as the space surrounded by a magnet upto which its magnetic influence can be ~~relatreata~~ realised.

Magnetic field intensity (H):—

The magnetic field intensity at any point inside the magnetic field is defined as the force experienced by a unit north pole placed at that point.

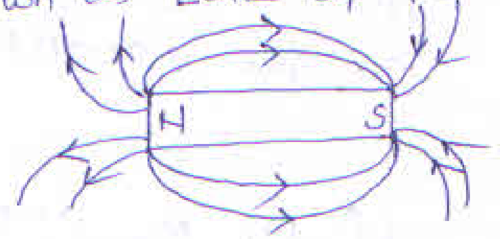
$$H = \frac{F}{m}$$

$$= \frac{\frac{\mu_0}{4\pi}\frac{m_1 m_2}{r^2}}{m}$$

$$= \frac{\mu_0}{4\pi}\frac{m}{r^2}$$

~~Mag~~ Magnetic Lines of force:—

The path followed by a unit north pole inside the magnetic field is known as Line of force.



properties:—

i. The lines of forces start from the north pole and end on the south pole.

ii. These curves are continuous and closed.

iii. The tangent drawn at any point on the lines of force indicates the direction of magnetic field intensity at that point.

iv. No two lines of force cross or intersect each other.

v. More concentration of lines of force represents strongfer magnetic field.

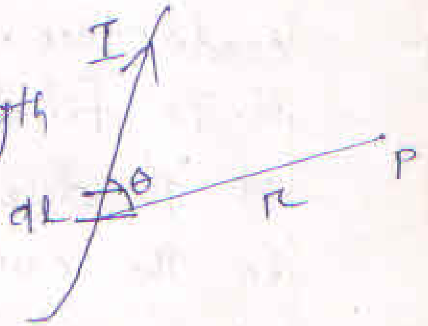
vi. It exerts lateral pressure by which the path is parabolic.

Magnetic Effect of Current

When an electric current is passed through a conductor, magnetic field is developed around it according to Oersted.

Biot-Savart's Rule:-

Biot-Savart's rule states that the magnetic field at any point around the conductor carrying current is



i. directly proportional to the length of the conductor.

$$\therefore dB \propto dl \quad \text{--- (1)}$$

ii. directly proportional to the strength of the current passing through the conductor.

$$\therefore dB \propto I \quad \text{--- (2)}$$

iii. directly proportional to the sine of angle between the element and the line joining the element to the point where the field is to be calculated.

$$\therefore dB \propto \sin\theta \quad \text{--- (3)}$$

iv. inversely proportional to the square of the distance from the element to the point.

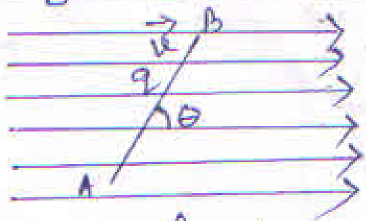
$$\therefore dB \propto \frac{1}{r^2} \quad \text{--- (4)}$$

Combining these 4 equations we have;

$$dB \propto \frac{I\,dl\sin\theta}{r^2}$$

$$\Rightarrow \boxed{dB = \frac{\mu_0}{4\pi}\frac{I\,dl\sin\theta}{r^2}}$$

Force on a moving charge in a magnetic field :-



i. Consider a charge 'q' moving through an uniform magnetic field 'B' with a velocity 'v' in such a way that the direction of motion of charge makes an angle 'θ' with the direction of the field.

ii. The force experienced by the charge particle

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

$$\Rightarrow F = qvB \sin\theta$$

Case 1 :- When $\theta = 90°$, $F = qvB$

Maximum force is experienced by a charged particle while moving at right angle to the magnetic field.

Case 2 :- when $\theta = 0°$, $F = 0$

No force is experienced by a charged particle while moving parallel or along the direction of magnetic field.

Unit of B :-

1. SI unit :- $B = \frac{F}{qv} = \frac{1\,\text{Newton}}{1\,\text{coulomb} \times 1\,\text{ms}^{-1}} = 1\,\text{Testla}$

2. CGS Unit :- $B = \frac{F}{qv} = \frac{1\,\text{Dyne}}{1\,\text{emu of charge} \times 1\,\text{cmsec}^{-1}}$

$= 1\,\text{Gauss}$

Conversion of Testla into Gauss :-

$$1\,\text{Testla} = \frac{1\,\text{N}}{1\,\text{C} \times 1\,\text{msec}^{-1}}$$

$$= \frac{10^5\,\text{Dyne}}{\frac{1}{10} \times 100\,\text{emu} \times \text{cmsec}^{-1}}$$

$$= 10^4\,\text{Gauss}$$

Dimension of B:—

$$B = \frac{F}{qv} = \frac{[M^1L^1T^{-2}]}{[A^1T^1][L^1T^{-1}]} = [M^1L^0T^{-2}A^{-1}]$$

Force on a charged particle moving in uniform magnetic field and electric field (Lorentz force):—

i. Whenever a charged particle passes through a region having electric field and magnetic field, the particle will feel two forces acting on it.

ii. Force due to electric field ($\vec{F}_{elec}$) = $q\vec{E}$

iii. Force due to magnetic field ($\vec{F}_{mag}$) = $q(\vec{v} \times \vec{B})$

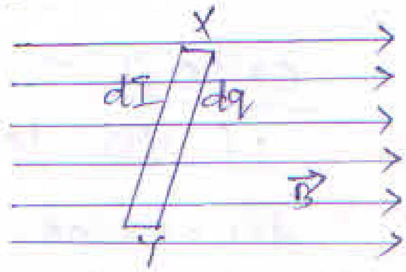
iv. The vector sum of these two forces is called Lorentz force and is given by

$$\vec{F} = \vec{F}_{elect} + \vec{F}_{mag}$$

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

Force on a conductor ~~current~~ carrying current when placed ~~conductor~~ in a uniform magnetic field:—

i. A conductor has free electrons in it. When a potential difference is maintained across the two ends of the conductor, the electrons drifts from lower potential to higher potential with a small velocity and constitute a current.



ii. When this current moves inside the magnetic field, it will experience a force.

iii. Let's consider a conductor 'XY' placed inside the magnetic field 'B'.

iv. Let 'dq' be the small amount of charge that moves with a velocity 'v'.

v. The force 'dF' that experience by the charge 'dq' is; $dF = dq\,(v \times B)$ —— (1)

vi. If the charge travels a small distance 'dl' in time 'dt' then $v = \frac{dl}{dt}$

$$\therefore dF = dq\left(\frac{dl}{dt} \times B\right)$$

$$\Rightarrow dF = \frac{dq}{dt}(dl \times B)$$

$$\Rightarrow dF = I\,(dl \times B)$$

The net force acting on the conductor;

$$\int dF = \int I\,(dl \times B)$$

$$\Rightarrow F = \int I\,dl\,B\sin\theta$$

$$\Rightarrow F = IB\sin\theta \int dl$$

$$\Rightarrow F = IlB\sin\theta$$

$$\Rightarrow \boxed{F = I\,(l \times B)}$$

Case 1:—

If the conductor is placed right angle to the field then $\theta = 90^\circ$

$\therefore F = IlB$ (Maximum)

Case 2:—

If the length of the conductor is along the direction of the lines of force then $\theta = 0^\circ$

$\therefore F = 0$ (Minimum)

Electro-Magnetic Induction

Electro-Magnetic Induction:-

The phenomenon of production of electricity due to magnetism, is called electro-magnetic induction.

Faraday's Laws of Electro-Magnetic Induction:-

1st Law:- If the magnetic flux linked with the circuit changes, an e.m.f. is induced in it.

2nd Law:- The induced e.m.f. in a circuit will continue so long as the magnetic flux linked with the circuit changes continuously.

3rd Law:- The induced e.m.f. is directly proportional to the rate of change of magnetic flux linked with it.

$$\therefore E \propto -\frac{d\phi_B}{dt}$$

Negative sign indicates the direction of e.m.f. (E) and B are opposite to each other.

Lenz's Law:-

Lenz's law deals with the direction of e.m.f. induced in the circuit due to the change in magnetic flux.

Defination:-

Lenz's law states that the direction of induced emf is such that it tends to oppose the very cause which produces it.

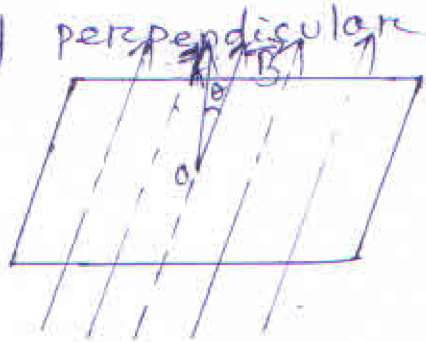
It means that the direction of induced e.m.f. is always opposite to the direction of magnetic field.

due to magnetism, is called electro-magnetic induction.

Magnetic Flux (ϕ_B):-

i. Magnetic flux measures the number of lines of force of magnetic field crossing a certain area.

ii. Magnetic ~~field~~ flux linked with a surface is defined as the product of area and the component of magnetic field perpendicular to area.



$$\therefore \phi_B = \vec{B} \cdot \vec{A}$$

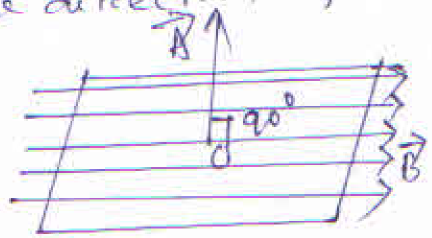
$$\Rightarrow \boxed{\phi_B = BA\cos\theta}$$

(where B = Magnetic flux density
A = Area of the coil placed in the magnetic field

Case 1:- If $\theta = 0°$, $\cos\theta = 1$

$$\therefore (\phi_B)_{Max} = BA \times 1 = BA$$

Magnetic field linked with a surface is maximum when area is held perpendicular to the direction of magnetic field.



Case 2:- If $\theta = 90°$, then $\cos 90° = 0$

$$\therefore \phi_B = BA \times 0 = 0$$

No magnetic flux is linked with the surface when the field is parallel to the surface.

Unit:- SI unit - weber
CGS unit - Maxwell

Relation between Weber and Maxwell:—

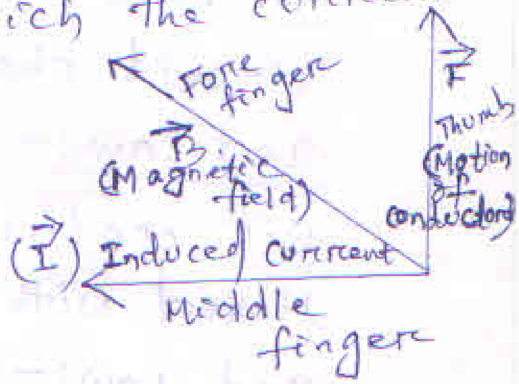
$$1 \text{ Weber} = 1 \text{ Tesla} \times 1 m^2$$
$$= 10^4 \text{ Gauss} \times (100 cm)^2$$
$$= 10^8 \text{ Gauss} \times cm^2$$
$$= 10^8 \text{ Maxwell}$$

Fleming's Right Hand Rule:—

i. Stretch the thumb, force finger and middle finger of the right hand mutual perpendicular to each other.

ii. If the force finger points towards the magnetic field, thumb points towards the direction of motion of conductor then the middle finger points in the direction in which the current is induced in the circuit.

iii. The right hand rule is applicable for generators.



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