Hand Notes On

Engg. Physics by

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Unit-1 Babita Paolli (Chect. in physics)

Unit and Dimension

Science is a knowledge gained systematically and is supported by experimental verification.

physics:- It is a branch of science, which deals with the study properties of matter and energy.

Matter:- which have mass & occupying space is called matter.

Matter are three types:-
(I) Solid
(II) Liquid
(III) Gas

* Solid have fixed volume and fixed shape
* Liquid have fixed volume & unfixed shape.
* Gas have no fixed volume and no fixed shape.

physical Quantity:-
A quantitative description of any physical phenomena always involves certain measurable quantities in terms of which the laws of physics are invariably expressed. They are the building blocks of physics.

Fundamental Quantity:-
A set of independently chosen quantities.

Ex:- Mass, Length, time, unit of substance, Temperature etc.

Derived Quantity:-
The physical quantity which is derived from fundamental quantity, Ex - Force, voltage, velocity, workdone etc.

Unit:- In order to measure physical quantity, we need a standard for measurement & express physical quantity relative to each other, that standard is called "unit".

Two types:- (I) Fundamental
(II) Derived

Definition:-

Fundamental units:- A set of units which are arbitrarily defined & from which other units are derived.

Ex:- Metre, kilogram, sec etc.

There are 7 fundametal units.

Derived Units:-

These are units of measurement derived from the seven base fundamental units.

There are expressed in terms of fundamental units.

Ex:- Newton, Tesla, Joule, etc.

Definition of dimensions:-

The dimensions of a derived physical quantity may be defined as the powers to which its fundametal base units must be raised to represent it completely.

Dimensional formula:- A dimensional formula is an expression which shows how (with what powers) & which of the fundamental quantity enter into the given physical quantity.

Ex:- The brackets [ ] used and capital letters are used to specify the fundamental quantity without any comma, as given below

$$\text{Area} = [M^0 L^2 T^0]$$

$$\text{Momentum} = [M^1 L^1 T^{-1}]$$

* The dimension of momentum :- 1, 1 & -1

Seven Fundamental P.Q	Units
(i) Mass	kg
(ii) Length	m
(iii) Time	sec
(iv) Temperature	Kelvin (K)
(v) Current	Ampere
(vi) Luminous Intensity	Candela (cd)
(vii) Amount of substance	Mole

System of units:-

1. C.G.S → Centimetre - Gram - Second (French/Gaussian system)
2. F.P.S → Foot - Pound - Second (British system)
3. M.K.S → Metre - Kilogram - Second (Giorgi system)
4. SI → Systeme International (Seven fundamental units mentioned above)

Properties of unit:-

1) Easily avaible
2) Invariable
3) Non perishable
4) It should be accurate
5) Convient in size

Symbol

Joule - J
Watt - W
Coulomb = C
Frequency = Hz
Resistance = Ω ohm
Tesla = t
Weber = wb
Simon = S
Radian = Rad

Steps to write dimensional formula

1) Write down the formula of the physical quantity.
2) Simplify the formula int length mass & time
3) Replace them with [L] for length, [M] for mass & [T] for time.
4) Collect all the terms & write the final dimensional formula.

Example:-

Area = $l \times b = [L] \times [L] = [L^2] = [M^0 L^2 T^0]$

Volume = $l \times b \times h = [L] \times [L] \times [L] = [L^3] = [M^0 L^3 T^0]$

velocity = $\frac{\text{Displacement}}{\text{time}} = \frac{l}{t} = \frac{[L]}{[T]} = [M^0 L^1 T^{-1}]$

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Accelaration = $\frac{velocity}{time} = \frac{l}{t} \times \frac{1}{t} = \frac{l}{t^2} = [M^0 L^1 T^{-2}]$

Force = ma = $[M] \times [M^0 L^1 T^{-2}] = [M^1 L^1 T^{-2}]$

Momentum $p = mv = [M] \times [M^0 L^1 T^{-1}] = [M^1 L^1 T^{-1}]$

kinetic energy = $\frac{1}{2} m v^2$

$= [M] \times [M^0 L^1 T^{-1}]^2 = [M^1 L^2 T^{-2}]$

potential energy = mgh

$= [M] \times [M^0 L^1 T^{-2}] \times [L]$

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

Principle of Homogeneity:- It states that dimensional formula of every terms on the two sides of a correct relatⁿ is same.

$[M^a L^b T^c] = [M^1 L^2 T^{-2}]$.

$\Rightarrow a = 1, \; b = 2, \; c = -2$

How to check correctness of a given relation :-

Ex-1 $F = \frac{mv^2}{r}$

L.H.S = $F = [M^1 L^1 T^{-2}]$

R.H.S = $\frac{mv^2}{r} = \frac{[M] [L^2 T^{-2}]}{[L]} = [M^1 L^1 T^{-2}]$

Ex-2 $v^2 - u^2 = 2as$

LHS $v^2 - u^2 = [L^1 T^{-1}]^2 - [L^1 T^{-1}]^2$

$= [L^2 T^{-2}] - [L^2 T^{-2}]$

RHS $2as = [L^1 T^{-2}] \times [L^1] = [L^2 T^{-2}]$

here LHS = RHS, so the both relations are correct.

—x—

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①

Unit - 2 Scalar and Vector

Scalar:- Scalar is a number which express quantity. It has only magnitude but not direction.

Ex:- Speed, mass, distance, volume, energy, ~~mas~~ temp, power, work, energy, time, electric current.

Vector: A vector is a quantity which has both magnitude direction. The magnitude of a vector is a scalar.

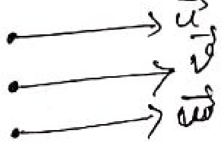
Ex:- Force, Displacement, velocity acceleration, electric field, momentum, weight, Impulse.

Types of vectors:-

① **Null vector (·):-**

-> Zero magnitude
-> Arbitrary direction
-> $\vec{A} \times \cdot = 0$
-> $\vec{A} \cdot \cdot = 0$
-> When added gives same vector $(\vec{A} + \cdot) = \vec{A}$

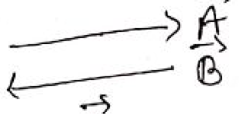
② **Equal vectors:-**



Magnitude is same in $\vec{u}, \vec{v}, \vec{w}$ & the direction is also same.

$\vec{u} = \vec{v} = \vec{w}$

③ **Negative vectors:-**

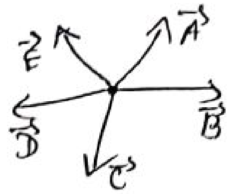


$\vec{A} = -\vec{B}$

Magnitude is same in $\vec{A}, \vec{B}$ & the direction is opposite.

④ Co-Enitial Vector

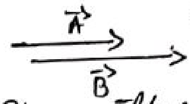
A number of vectors are said to be Co-Enitial when they have common initial point.



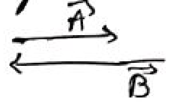
⑤ Co linear vector

Vectors having common line of action is called co-linear vector

(a) Parallel vector ($\theta = 0°$):- when the angle between the vector is $0°$ is called parallel vector.

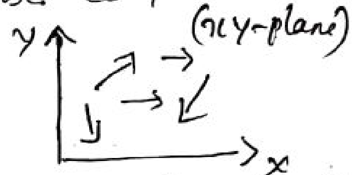


(b) Antiparallel vector ($\theta = 180°$):- when the angle between two vector is $180°$ is called antiparallel vector.



⑥ Co-planner Vector:-

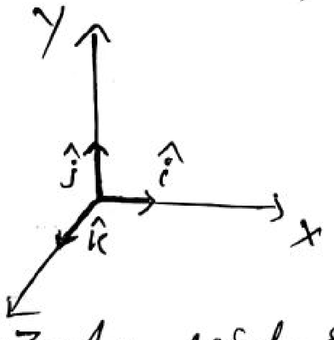
A number of vectors are said to be co-planner when they are lying in the same plane.



⑦ Unit Vector

Any vector whose magnitude is one unit is called as unit vector.

In three dimensional co-ordinate system, unit vectors along positive X, Y, & Z-axes are usually represented by $\hat{i}, \hat{j}, \hat{k}$ respectively. These unit vectors are mutually perpendicular to each other.

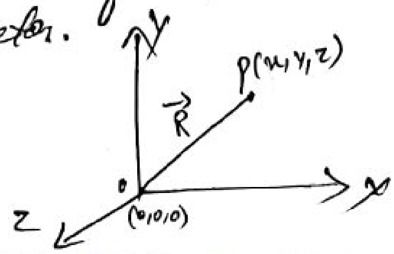


⑧ Position Vector

vectors that indicates the position of a point in a co-ordinate system is called position vector.

Position vector can be written as

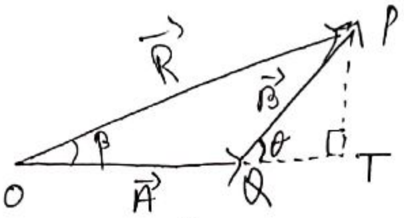
$$\vec{R} = x\hat{i} + y\hat{j} + z\hat{k}$$



Triangle law of vector addition :-

When two vectors are represented by two sides of a triangle taken in same order then the third side is represented by the resultant vector taken in opposite order.

$$\begin{bmatrix} \sin\theta = P/h \\ \cos\theta = b/h \\ \tan\theta = P/b \end{bmatrix}$$



θ : Smallest angle between $\vec{A}$ & $\vec{B}$

β : Angle made by $\vec{R}$ with $\vec{A}$.

In the right angle ΔPQT

$$\sin\theta = \frac{PT}{PQ} \Rightarrow PT = PQ\sin\theta \Rightarrow \boxed{PT = B\sin\theta}$$

$$\cos\theta = \frac{QT}{PQ} \Rightarrow QT = PQ\cos\theta \Rightarrow \boxed{QT = B\cos\theta}$$

In the right angle ΔOPT

$$\begin{bmatrix} OP = h \\ OT = b \\ PT = P \end{bmatrix}$$

$$OT = OQ + QT$$

$$OP^2 = (PT)^2 + (OT)^2$$

$$\Rightarrow R^2 = (PT)^2 + (OQ+QT)^2$$

$$= (B\sin\theta)^2 + (OQ)^2 + (QT)^2 + 2OQ\,QT$$

$$= B^2\sin^2\theta + A^2 + B^2\cos^2\theta + 2A\cdot B\cos\theta$$

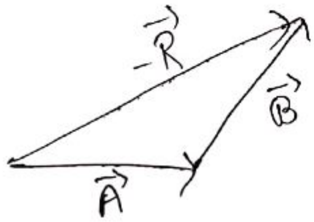
$$\Rightarrow R^2 = A^2 + B^2(\sin^2\theta + \cos^2\theta) + 2AB\cos\theta$$

$$\Rightarrow \boxed{R = \sqrt{A^2+B^2+2AB\cos\theta}} \quad \text{(proved)}$$

R: called the magnitude of the resultant vector.

$$\tan\beta = \frac{PT}{OT} = \frac{PT}{OQ+QT}$$

$$\beta = \tan^{-1}\left(\frac{B\sin\theta}{A+B\cos\theta}\right)$$



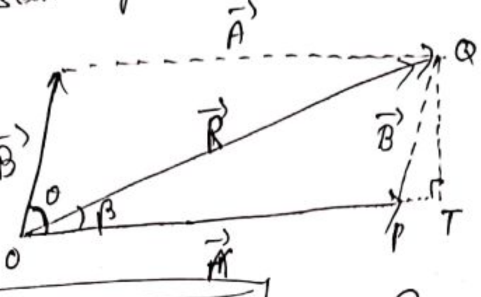
$$\vec{A} + \vec{B} = -\vec{R}$$

$$\vec{A} + \vec{B} + \vec{R} = 0$$

If 3 vectors of Δ are in clockwise then sum of these 3 vectors are equilibrium.

Parallelogram law of vector addition:

If two vectors are represented by two sides of a parallelogram acting at a same point, then the resultant of those vectors is represented by the diagonal passing through the same point.



θ: Smallest angle between $\vec{A}$ & $\vec{B}$.

β: Angle made by $\vec{R}$ with $\vec{A}$.

$$\boxed{R = \sqrt{A^2+B^2+2AB\cos\theta}} \qquad \beta = \tan^{-1}\frac{B\sin\theta}{A+B\cos\theta}$$

R: called the magnitude of the resultant vector.

Questions:

① Two forces 5N and 20N acting at an angle of 120° between them. Find the resultant force in magnitude and dirⁿ.

Ans: Given that,

$F_1 = 5N$

$F_2 = 20N$

$\theta = 120$

$R = \sqrt{(5)^2+(20)^2+2\cdot 5\cdot 20\cos\theta}$

$R = \sqrt{25+400+2\cdot 5\cdot 20\cos 120}$

$\therefore R = \sqrt{325}$ N

Special case:

① * $\theta = 0°$ $\cos 0 = 1$

$R = \sqrt{A^2+B^2+2AB\times 1} = \sqrt{(A+B)^2}$

$\Rightarrow R = A+B$ (Maximum), $\beta = \tan^{-1}(0) = 0°$

$\longrightarrow A$
$\longrightarrow B$
$\longrightarrow \vec{R}$

The resultant R is equal to the sum of A & B and acting in same dirⁿ of $\vec{A}$ & $\vec{B}$.

② * $\theta = 180$, $\cos 180° = -1$

$R = \sqrt{A^2+B^2+2AB(-1)} = \sqrt{(A-B)^2}$

$\Rightarrow R = A-B$ (Minimum), $\beta = \tan^{-1}(0) = 0°$

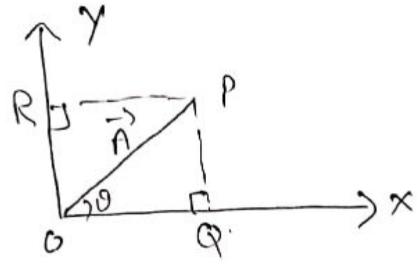
$\longrightarrow \vec{A}$
$\longleftarrow \vec{B}$
$\longrightarrow R$

The resultant R is equal to the difference of A & B & acting in the dirⁿ of $\vec{A}$.

③ $\theta = 90°$ $\cos 90 = 0$

$R = \sqrt{A^2+B^2}$

Resolution of vectors :-



$$\cos\theta = \frac{OQ}{OP} \Rightarrow OQ = A\cos\theta \quad -(1)$$

$\Downarrow$ x-component of $\vec{A} = A_x$

$$\sin\theta = \frac{PQ}{OP} \Rightarrow PQ = A\sin\theta \rightarrow \text{y-comp of } \vec{A} = A_y$$

$$\therefore \vec{A} = A_x \hat{i} + A_y \hat{j}$$

$$\boxed{\vec{A} = A\cos\theta\, \hat{i} + A\sin\theta\, \hat{j}}$$

* If the x-comp of a force of 65N is 25N, then find the y-comp of force?

Ans: $F = 65N$
$F_x = 25N$
$F_y = ?$

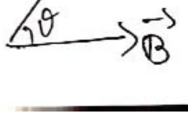
$F_x = F\cos\theta$
$25 = 65\cos\theta$
$\Rightarrow \cos\theta = \frac{25}{65} = 5/13$
$\Rightarrow \theta = \cos^{-1}(0.38) = 67.66$

$F_y = F\sin(67.66)$
$\Rightarrow F_y = 65 \times 0.92$
$\Rightarrow F_y = 60.12\,N$

Vector multiplication :-

(1) Dot Product $(\cdot)$ $\rightarrow$ Scalar multiplication
(2) Cross Product $(\times)$ $\rightarrow$ Vector multiplication

Dot Product :-
It is defined as the product of magnitude of two vectors and the cosine of angle between them



$$\vec{A} \cdot \vec{B} = AB\cos\theta \rightarrow \text{Scalar Quantity}$$

(i) Commutative law:

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

(ii) Distributive law

$$\vec{A}\cdot(\vec{B}+\vec{C}+\vec{D}+\ldots)$$

$$\Rightarrow \vec{A}\cdot\vec{B}+\vec{A}\cdot\vec{C}+\vec{A}\cdot\vec{D}+\ldots$$

Perpendicular vector: $(\theta = 90)$

$$\vec{A}\cdot\vec{B} = AB\cos\theta$$

$$\vec{A}\cdot\vec{B} = 0$$

Note

$$\begin{bmatrix} i\cdot j = 0 \\ j\cdot k = 0 \\ k\cdot j = 0 \end{bmatrix}$$

Collinear:

Parallel $(\theta = 0)$

(a) $\vec{A}\cdot\vec{B} = AB$

(b) $\vec{A}\cdot\vec{B} = -AB$ $(\theta = 180^\circ)$

Anti parallel

Note

$$\begin{bmatrix} i\cdot i = 1 \\ j\cdot j = 1 \\ k\cdot k = 1 \end{bmatrix}$$

(c) Equal vector $(\theta = 0)$

$$\vec{A}\cdot\vec{A} = A\cdot A\cos\theta = A^2$$

Dot product in terms of rectangle components:

$$\vec{A}\,(A_x, A_y, A_z) = A_x i + A_y j + A_z k$$

$$\vec{B}\,(B_x, B_y, B_z) = B_x i + B_y j + B_z k$$

$$\Rightarrow \boxed{\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z}$$

* Magnitude of $\vec{A}$ = $\boxed{|\vec{A}| = A = \sqrt{A_x^2 + A_y^2 + A_z^2}}$

Cross Product :

$\vec{A} \times \vec{B}$ = Vector quantity = $\vec{C}$

Defined by the product of the magnitude and sine of angle between and direction is along ⊥ to plane containing them.

$$\vec{A} \times \vec{B} = AB \sin\theta \, \hat{n}$$

$\hat{n}$ = direction of $(\vec{A} \times \vec{B})$

where $\hat{n}$ is ⊥ to the plane containing $\vec{A}$ and $\vec{B}$.

Properties :

(1) Not Commutative

$$\vec{A} \times \vec{B} \neq \vec{B} \times \vec{A}$$

(2) Distributive

$$\vec{A} \times (\vec{B} + \vec{C} + \vec{D} - - - -) = \vec{A} \times \vec{B} + \vec{A} \times \vec{C} + \vec{A} \times \vec{D}$$

(3) Perpendicular Vector :- $\vec{A} \times \vec{B} = AB \sin 90 = AB\hat{n}$

$$\begin{bmatrix} i \times j = k & j \times i = -\hat{k} \\ j \times k = i & k \times j = -i \\ k \times i = j & i \times k = j \end{bmatrix}$$

– Important data of cross product of two perpendicular vector

(4) Collinear : $\theta = 0^\circ$ (Parallel)
$180^\circ = \theta$ (Anti parallel)

$$\sin\theta = \sin 180^\circ = 0$$

$$\vec{A} \times \vec{B} = 0$$

(5) Equal vectors , $\theta = 0$, **Note** $\begin{bmatrix} i \times i = 0 \\ j \times j = 0 \\ k \times k = 0 \end{bmatrix}$

$$\vec{A} \times \vec{A} = 0$$

(6) Cross Product in Rectangular Components

$$\vec{A} \times \vec{B} = \begin{vmatrix} i & j & k \\ A_x & A_y & A_z \\ B_x & B_y & B_z \end{vmatrix}$$

Ex-1 If $\vec{A} = 2\hat{i} + 3\hat{j} + 7\hat{k}$ & $\vec{B} = 3\hat{i} + 4\hat{j} - \hat{k}$ Find $\vec{A}\cdot\vec{B}$ & $\vec{A}\times\vec{B}$

$$\vec{A}\cdot\vec{B} = 2\times3 + 3\times4 - 7 = 11$$

$$\vec{A}\times\vec{B} = \begin{vmatrix} i & j & k \\ 2 & 3 & 7 \\ 3 & 4 & -1 \end{vmatrix} = i(-3-28) - j(-2-21) + k(2\times4 - 3\times3)$$

$$= -31\hat{i} + 23\hat{j} - \hat{k}.$$

Ex-2

What will greatest and least resultant of two vector acting at a point.

Soln $\vec{A} \longrightarrow$ $\vec{B} \longrightarrow$

$\theta = 0^\circ$ $(A+B)$

$R =$ greatest

$\vec{A} \longleftarrow$ $\vec{B} \longrightarrow$

$\theta = 180^\circ$ $(A-B)$

$R = A-B$ least

Unit - III KINEMATICS Babita Pradhi (Lect. in physics) (1)

Rest & Motion :-

When an object changes it's position w.r.t it's Surrounding then it's said to be in motion.

When an object doesnot change it's position w.r.t it's Surrounding ~~then~~ it is said to be in rest.

→ Displacement :- It is a vector joining the initial point to the final point of an object position directed from initial to final → $\boxed{(x_f - x_i) = \Delta x}$

→ Velocity :- Rate of change of displacement.

$$\boxed{\vec{v} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i}}$$

Velocity — Instantaneous, Uniform, Non uniform

→ Uniform velocity :-
When an object travels equal displacement in equal interval of time, then it is said to be uniform velocity.

→ Non Uniform :-
When an object or body travels unequal displacement in equal interval of time then it is said to non-uniform velocity

→ Instantaneous Velocity :-
The velocity of an object or body at an particular instant or moment, then it is called Instantaneous velocity.

Accelaration :-

Rate of cehange of velocity is called accelaration.

It is a vector quantity.

$$\boxed{\vec{a} = \frac{\Delta v}{\Delta t} = \frac{dv}{dt} = \frac{\vec{v}_f - \vec{v}_i}{t_f - t_i}}$$

Unit:- m/s^2

Dimension : $[M^0 L^1 T^{-2}]$

* Re-tardation is denoted by $(-a) = \frac{-dv}{dt}$ or $-\frac{\Delta v}{dt}$ the Retardation is the value of accelaration shows that the velocity of a Body is decreasing.

Uniform Accelaration :-

when the velocity changes by equal amount in equal interval of time.

Non uniform Accelaration :- when velocity doesnot change by equal amount in equal interval of time.

Equation of motion in one Dimension (1D)

1. $\vec{v} = \vec{u} + \vec{a}t$
2. $\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2$
3. $v^2 - u^2 = 2as$
4. $S_{nth} = \vec{u} + \frac{\vec{a}}{2}(2n-1)$

$\vec{u}$ = initial velocity

$\vec{v}$ = Final velocity

$\vec{a}$ = Accelaration

$\vec{s}$ = Displacement

n = time after n second

Equation of motion under gravity :-

Replace $\vec{a}$ with $\vec{g}$, $\vec{g}$ = acc^n due to gravity

1. $\vec{v} = \vec{u} + \vec{g}t$
2. $\vec{s} = \vec{u}t + \frac{1}{2}\vec{g}t^2$
3. $v^2 - u^2 = 2gs$
4. $S_{nth} = \vec{u} + \frac{\vec{g}}{2}(2n-1)$

Force :-

It is defined the push or pull which produces or tends to produce, which destroys or tends to destroy the amount of motion or rest in a body is called force. It may increase & decrease of the force.

Numericals :-

Q.1 Calculate the time taken by the light emitted from the sun reach the surface on earth.

Ans :- Surface of earth $= 3 \times 10^8 m/s$ $\left[As\ t = \frac{\vec{D}}{v}\right]$

Sun - earth $= 1.5 \times 10^{11} m$

velocity $= \frac{\vec{D}}{t}$, $t = \frac{1.5 \times 10^{11}}{3 \times 10^8} = .5 \times 10^3 = 500 sec = 8.33 min$

Q.2. A railway train takes 8 hrs to covers a distance of 400km between two stations. What is the speed of the train assuming it to be uniform.

Ans :- $Speed = \frac{Distance}{Time} = \frac{400 km}{8 hr} = \frac{400 \times 1000 m}{8 \times 60 \times 60 sec}$

$= \frac{4 \times 10^5 m}{28800} = 13.889 m/sec$

Q.3. A body starts from rest & acquires a velocity of 12m/s in 5 sec. Calculate 'a' & distance travelled.

Ans :- $u = 0$, $v = 12 m/sec$, $t = 5 sec$

(1) $v = u + at$

$12 = 0 + 0.5a$

$\Rightarrow a = 12/5 = 2.4 m/s^2$

$\Rightarrow \boxed{a = 2.4 m/s^2}$

(2) $\vec{S} = \vec{u}t + \frac{1}{2}\vec{a}t^2$

$\Rightarrow S = 0 + \frac{1}{2} 2.4 (5)^2$

$\Rightarrow \boxed{S = 30 m}$

Circular Motion :-

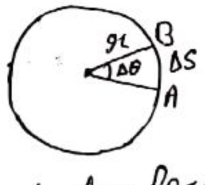
Circular motion is defined as motion of an object from a fixed point which is rotating in a circle.

or

The motion of an object is said to be circular motion when the distance of the object is fixed from a particular point.

Angular Displacement ($\Delta\theta$)

The angle turned by the radius vector during the circular motion.



$$\text{Angle} = \frac{\text{Length of arc}}{\text{radius}}$$

$$\Delta\theta = \frac{\Delta S}{r} \Rightarrow \boxed{\Delta S = \Delta\theta \cdot r} \Rightarrow \boxed{\vec{\Delta S} = \vec{\Delta\theta} \times \vec{r}} \rightarrow \text{Vector form}$$

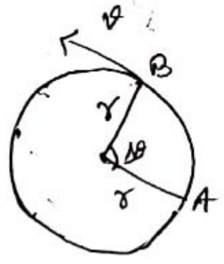
$\Rightarrow$ Linear displacement = Radius × Angular displacement

Angular Velocity (ω)

The rate of change of angular displacement is called Angular velocity.

$$\omega = \frac{\Delta\theta}{\Delta t} = \frac{\theta_2 - \theta_1}{t_2 - t_1}$$

Derivation



Suppose v is the linear velocity of the object travelling from A to B in time t.

$$v = \frac{\Delta S}{t} \Rightarrow \Delta S = vt \quad \text{—(1)}$$

As $\Delta S = r\Delta\theta$ —(2)

Now $v = \frac{\Delta s}{t} = \frac{r\Delta\theta}{t}$

$\Rightarrow \underline{v = r\omega}$ $\left(\text{As } \omega = \frac{\Delta\theta}{t}\right)$

Scalar form

$\Rightarrow$ Linear Velocity = radius × angular velocity

In Vector form

$$\boxed{\vec{v} = \vec{\omega} \times \vec{r}}$$

Angular Accelaration (α)

The rate of change of angular velocity.

$$\alpha = \frac{\Delta\omega}{\Delta t} = \frac{\omega_2 - \omega_1}{t_2 - t_1} = \frac{\frac{v_2}{r} - \frac{v_1}{r}}{t_2 - t_1} \qquad \left(\because \omega = \frac{v}{r}\right)$$

$$\Rightarrow \alpha = \frac{1}{r}\left(\frac{v_2 - v_1}{t_2 - t_1}\right)$$

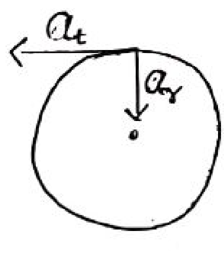
$$\Rightarrow \alpha = \frac{1}{r} a$$

$$\Rightarrow \boxed{a = r\alpha}$$

Linear Acceloration = radius × angular acceln

Vector form of a and α

Let us start with eqn.



$$\vec{v} = \vec{\omega} \times \vec{r}$$

$$\Rightarrow \frac{d\vec{v}}{dt} = \frac{d}{dt}(\vec{\omega} \times \vec{r})$$

$$\Rightarrow \vec{a} = \frac{d\vec{\omega}}{dt} \times \vec{r} + \vec{\omega} \times \frac{d\vec{r}}{dt}$$

$$\Rightarrow \vec{a} = \underbrace{\vec{\alpha} \times \vec{r}}_{\text{Tangential component}} + \underbrace{\vec{\omega} \times \vec{v}}_{\text{Radial Component}}$$

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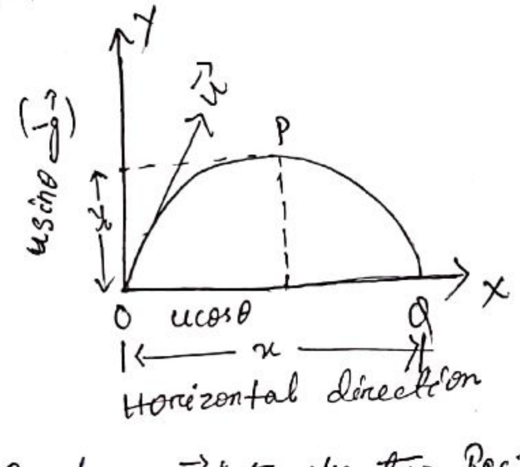
Projectile Motion

An Object which is no longer propelled by any fuel is called a projectile.

The projectile is under the influence of gravity or gravitational force.

Ex: Bullet fired from a Rifle or gun.
Ball thrown into space.
A small bag dropped from a airplane

The horizontal component of velocity not experience any accelaration.
But the vertical component is having accelaration.
Both are independent of each other.



u = initial velocity
projectile is making angle θ.

Resolving $\vec{u}$ into its two Rectangular Component.

$u\cos\theta$ = Horizontal Component (uniform, $a=0$)

$u\sin\theta$ = Vertical Component (Non-uniform, $a=-g$)

① Equation of Projectory :-

The distance travelled in horizontal direction

$$x = (u\cos\theta)\, t \Rightarrow t = \frac{x}{u\cos\theta}$$

Distance along vertical direction.

$$y = u\sin\theta \cdot t + \frac{1}{2}(-g)t^2 \quad \left[\because S = ut + \frac{1}{2}at^2\right]$$

$$\Rightarrow y = u\sin\theta \times \frac{x}{u\cos\theta} - \frac{1}{2} g \left(\frac{x}{u\cos\theta}\right)^2$$

$$\Rightarrow \boxed{y = x\tan\theta - \frac{1}{2} g \frac{x^2}{u^2\cos^2\theta}} \quad \text{—— (1)}$$

$\therefore$ It is an eqn of parabola, where axis of symmetry is parallel to y-axis.

② Maximum Height (y_0) :-

It is the maximum distance travelled by projectile in vertical direction.

Let us consider the motion of the projectile from O to P (vertical direction)

Initial velocity = $u\sin\theta$

Final velocity = 0

Accelaration = $-g$

y_0 = distance along vertical direction.

$$\therefore v^2 - u^2 = 2as$$

$$\Rightarrow 0 - u^2\sin^2\theta = 2(-g)y_0$$

$$\Rightarrow \boxed{y_0 = \frac{u^2\sin^2\theta}{2g}} \quad \text{—— (2)}$$

③ Time of Ascent (t):-

It is the time taken by the projectile to raise to the maximum height.

Initial velocity = $u\sin\theta$

Final velocity = 0

Accelⁿ = $-g$

$\therefore$ $v = u + at$

$\Rightarrow 0 = u\sin\theta + (-g)t$

$\Rightarrow \boxed{t = \frac{u\sin\theta}{g}}$ —— ③

④ Time of descent (t):-

It is the time taken by the projectile to come from maximum height to ground.

Initial velocity = 0

Final velocity = $u\sin\theta$

Accelⁿ = g

$\therefore$ $v = u + at$

$\Rightarrow u\sin\theta = 0 + gt$

$\Rightarrow t = \frac{u\sin\theta}{g}$

As the time taken by the projectile to go from O to P = The time taken by the saying while come down from 'P' to 'Q'

⑤ Total time of Flight (T)

The total time taken by the projectile to come down to the same level from where it is projected.

$$T = 2t = \frac{2u\sin\theta}{g}$$

⑥ Horizontal Range (x) :-

The maximum distance travelled by the projectile along horizontal direction.

$x = u\cos\theta \times$ Total time of Flight (T)

$= u\cos\theta\, T$

$= u\cos\theta \times \dfrac{2u\sin\theta}{g}$

$\Rightarrow \boxed{x = \dfrac{u^2\sin 2\theta}{g}}$ $[\because \sin 2\theta = 2\sin\theta \cdot \cos\theta]$

Condition for Maximum Horizontal Range

$x = \dfrac{u^2\sin 2\theta}{g}$, x is max for $\sin 2\theta$ = maximum

$\sin 2\theta = \sin 90 = 1$ — As 1 is the maximum value of $\sin(\;)$ any angle.

$\Rightarrow 2\theta = 90$

$\Rightarrow \boxed{\theta = 45^\circ}$ → Condition for Maximum Horizontal Range.

Babita Padhi (Lect. in physics)

Work & Friction :-

Work :-

Work is said to be done when a force displaces an object through certain distance, such that the force has an component along the displacement work is a vector quantity.

$$W = \vec{F} \cdot \vec{S} = FS\cos\theta = S(F\cos\theta)$$

The component of force along the direction of displacement.

$[W] = [M^1 L^2 T^{-2}]$ = Joule = $kg\, m^2 s^{-2}$

↓ dimension ↓ Unit

Friction :-

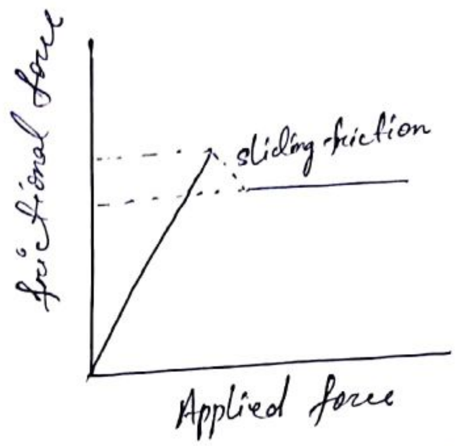
It is defined as the opposing force which comes into play between two objects when one is moving over the other.

Static friction :-

Static friction is the force of friction which comes into play, when there is no relative motion between them.

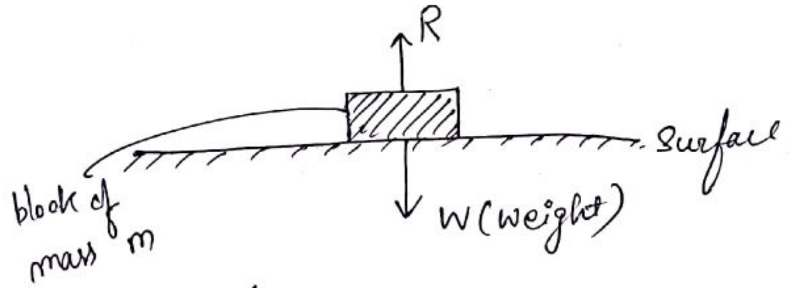
Limiting friction

The maximum value of force of friction (static friction), when there is no relative motion.

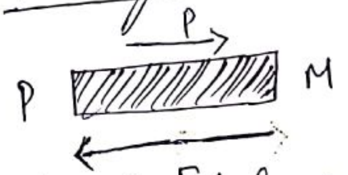


Dynamic friction :-

A force of friction which comes into play, when there is some relative motion between the two objects.



Law of limiting friction :-

① 

P & F are opposite to each other.

The direction of force of friction is always opposite to the dirn of motion.

② The force of limiting friction depends upon nature & state of surfaces in contact and acts tangentially to the interface between the two surfaces.

③ The magnitude of limiting friction F is directly proportional to the magnitude of normal reaction R between the two surfaces in contact. $F \propto R$.

④ The magnitude of the limiting friction between two surfaces is independent of the area & shape of the surfaces in contact so long as the normal reaction remains the same.

Coefficient of limiting friction (μ)

It is the ratio between the magnitude of limiting friction to the normal reaction.

Mathematically,

$$F \propto R$$

$$\Rightarrow F = \mu R$$

$$\Rightarrow \boxed{\mu = F/R}$$

Since F depends upon the nature & state of polish of the surface in contact, μ also depends upon these factors.

Methods of reducing friction

(i) By rubbing and polishing :- By rubbing, the irregularities of the surface are smoothened thus avoiding the chance of getting the irregularities interlocked. This reduces the friction between them.

(ii) By lubricants :- A lubricant is an oil or grease which when spread over the surfaces fills the irregularities and forms a thin layer between them, thus avoiding their interlockings. The sliding now takes place between upper surface & the layer of lubricant. This friction is much lesser than that between two surfaces.

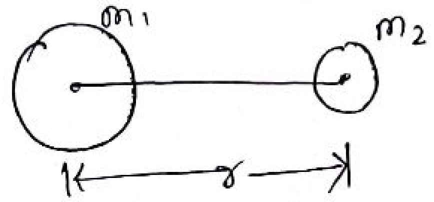
(iii) By converting sliding into rolling friction:-
If we slide a heavy object on the floor we require a big force. On the other hand, if we put it on wheels (a trolly) we can move it easily. This is due to the reason that rolling friction is much lesser than the sliding friction. Sliding friction can be converted into rolling friction by means of a system known as ball bearing system. A number of steel balls are inserted between the axle & wheel, which reduces the force of friction by considerable amount.

(iv) By streamlining:- As a body is driven through fluid, fluid friction depends upon the shape of body. It is minimum for a shape known as streamlined shape. This space is a pin-pointed one. That is why all high speed bodies, aeroplanes, rockets etc. have pin pointed shapes.

Gravitation :-

Newton's law of Gravitation:-

Every body in the universe attracts every other body with the force of attraction, which is directly proportional to the product of their masses & inversely proportional to the square of the distance between them.



The force of attraction bet^n any two bodies in the universe is known as the force of gravitation. This force is mutual & acts along the line joining the centers of two bodies.

Consider two bodies of m_1 & m_2 masses shown above.

Let r be the distance between their centres.

F be the magnitude of force $\vec{F}$ bet^n them.

1) $F \propto m_1 m_2$

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

Combining 1) & 2)

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

$$\Rightarrow \boxed{F = G \frac{m_1 m_2}{r^2}} \quad \text{—— (1)}$$

where, G = Universal gravitational constant.

$$\boxed{G = 6.67 \times 10^{-11}\ Nm^2kg^{-2}}$$

Definition of G : Let $m_1 = m_2 = 1$ unit $r = 1$ unit

from eqn ①, we get

$$F = G\frac{1 \times 1}{1^2} = G$$

$$\text{or } G = F$$

The gravitational constant may be defined as the magnitude of force of attraction between two bodies each of unit mass & separated by a unit distance from each other.

In C.G.S system, the gravitational constant is numerically equal to the force of attraction between two masses 1 gram each & placed at a distance of 1 cm from each other.

In SI, the gravitational constant is numerically equal to the force of attraction between two masses of 1 kg each & placed at a distance of 1 metre from each other.

Unit of G:- CGS :- dyne $cm^2 g^{-2}$

SI :- $N m^2 kg^{-2}$

Dimension :-

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

Gravity - Acceleration due to gravity :-

Force betⁿ earth & a body near it is called gravity.

The force with which a body is attracted towards earth is called weight.

Weight of body & the gravity are similar things.

The acceleration produced by gravity is called acceleration due to gravity and is denoted by 'g'.

$\therefore$ Gravity, $F = mg$ —— (2)

Since the body is placed on the surface of earth of mass M & radius R according to Newton's law of gravitation

$$F = G\frac{Mm}{R^2} \quad \text{—— (3)}$$

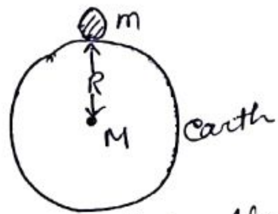


Fig (a) :- Attraction due to earth.

From eqⁿ (2) & (3)

$$mg = G\frac{Mm}{R^2}$$

or $$\boxed{g = \frac{GM}{R^2}} \quad \text{—— (4)}$$

Since 'g' depends upon mass of planet & radius of planet, it is not a universal constants.

Unit of 'g' are $cm\,s^{-2}$ or $m\,s^{-2}$ in CGS System & SI respectively

The variation of g with height :-

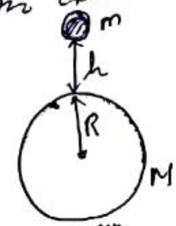
Consider a body of mass m placed on the surface of the earth. Let M & R denote the mass & radius respectively of the earth. Let g be the value of acceleration due to gravity on the free surface of earth.

Then, $g = \frac{GM}{R^2}$ —① (object on the surface)

Q(i)

where G is gravitational constant.

Suppose the body is taken to height 'h' above the surface of earth. Let the value of acceleration due to gravity at this height be g'.



Q(ii)

q^n ① will be modified to

$$g' = \frac{GM}{(R+h)^2} \quad \text{—② (object at certain height)}$$

Comparing q^n ① & ②

$$\frac{g'}{g} = \frac{\cancel{GM}}{(R+h)^2} \times \frac{R^2}{\cancel{GM}} = \frac{R^2}{[R(1+h/R)]^2}$$

$$\Rightarrow \frac{g'}{g} = \frac{\cancel{R^2}}{\cancel{R^2}(1+h/R)^2} = (1+h/R)^{-2}$$

Binomial expansion of $\left(1+\frac{h}{R}\right)^{-2}$ is (5)

$$\left(1+\frac{h}{R}\right)^{-2} = \left(1-\frac{2h}{R}+\frac{3h^2}{R^2}-\cdots\right)$$

As R is >>> h. Neglecting higher order terms

$$\frac{g'}{g} = 1-\frac{2h}{R}$$

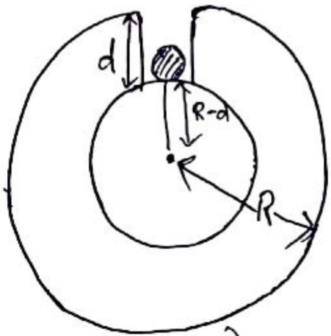
$$\Rightarrow \boxed{g' = g\left(1-\frac{2h}{R}\right)} \quad \text{——— (3)}$$

$$\Rightarrow g' = g - \frac{2h}{R}g \quad (\because g'<g)$$

$$\Rightarrow g-g' = \frac{2h}{R}g.$$

So if h increases g' must decrease because g is constant

The variation 'g' with depth:



Let us assume the earth to be a homogeneous sphere of radius R and mass M. Let ρ be the mean density of the material of earth. Consider a body lying on the surface of earth (b) where the value of accelaration due to gravity is g.

$$g = \frac{GM}{R^2} \quad \text{——— (4)}$$

Mass = volume × density

$$M = \frac{4}{3}\pi R^3 \times \rho$$

So,
$$g = \frac{G \times \frac{4}{3}\pi R^3 \rho}{R^2}$$

or
$$g = \frac{4}{3}\pi G R \rho \quad \text{--- (5)}$$

Let the body be taken to a depth d below the free surface of earth as shown fig (6)

Let g' be the value of accelaration due to gravity at the depth d. Now the force of gravity acting on the body is only due to the inner solid sphere of radius (R-d).

$$g' = \frac{GM'}{(R-d)^2}$$

Where M' is the mass of the inner solid sphere of radius (R-d).

$$g' = \frac{G}{(R-d)^2} \times M' = \frac{G}{(R-d)^2} \times \frac{4}{3}\pi (R-d)^3 \times \rho$$

$$g' = \frac{4}{3}\pi G (R-d) \rho \quad \text{--- (6)}$$

dividing eqn (6) by (5)

$$\frac{g'}{g'} = \frac{\frac{4}{3}\pi G (R-d)\rho}{\frac{4}{3}\pi G R \rho} = \frac{R-d}{R} = 1 - d/R$$

$$\boxed{g' = g\left(1 - \frac{d}{R}\right)} \quad \text{--- (7)}$$

This eqn depicts the variation of g with depth.

$$g' = g - \frac{d}{R}g$$

or $g - g' = \frac{d}{R}g$

Since g is constant at a given place on the earth and R is also a constant.

$$\therefore \quad g - g' \propto d$$

It is clear from above that if d increases, g' must decreases because g is constant. Thus the value of acceleration due to gravity decreases as the depth increase.

<u>Note</u> weight of a body at the center of earth:-

We know, that at a depth d below the free surface of earth.

$$g' = g(1 - d/R)$$

At the center of earth, $d = R$

$$g' = g(1 - R/R) = 0$$

If m is the mass of a body placed at the centre of earth then weight $mg' = 0$

Hence the weight of body at the centre of earth is equal to zero.

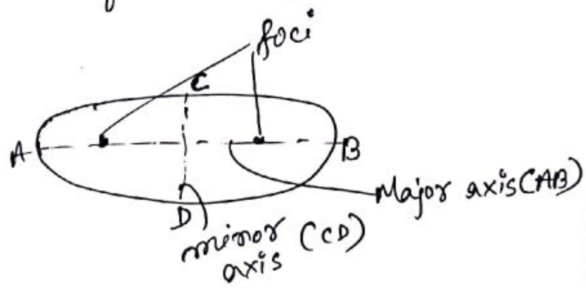
Difference between Mass & Weight

Mass	Weight
→ Amount of matter content in a body	→ Weight is caused by gravity
→ Mass is constant	→ Weight can vary
→ Mass is scalar quantity	→ Weight is a vector quantity.
→ Mass can never be zero.	→ Weight can be +ve, -ve or zero.
→ Unit: kg or g	→ Unit: kg wt or Newton. Dyne.

Kepler's law of planetary Motion:

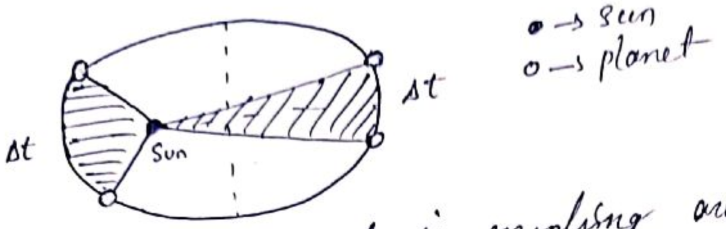
1st Law:-

planets moves around ~~the~~ sun in an elliptical orbit with sun situated at one of its foci.



(elliptical orbit)

2nd law (Law of Areal velocity)



When the planet is revolving around the sun in an elliptical orbit sweeps or covers equal area in equal interval of time by the line joining the sun with planet.

3rd Law (Law of time periods)

It states that the square of the time period of the planet revolving around the sun is directly proportional to the cube of the length of the semi major axis.

$$T^2 \propto R^3$$

If we have a planet (1) with time period T_1 & R_1 and planet (2) with time period T_2 & R_2 Then

By the law $T_1^2 \propto R_1^3$ —(1)

$T_2^2 \propto R_2^3$ —(2)

So $\boxed{\dfrac{T_1^2}{T_2^2} = \dfrac{R_1^3}{R_2^3}}$

Unit - 6

Babita Podhi (Cheet in physics)

Oscillations and Waves :-

Periodic Motion:

When an object passes through a similar condition in equal interval of time is called periodic motion.

Example :

Oscillation of pendulum, rotation of earth around sun, rotation of e^- around nucleus, vibration of string, vibration of tuning fork.

Non Periodic Motion :-

A motion which doesnot repeat itself after regular interval of time.

Examples:- Shaking the branch of a tree
Bouncing of a rubber ball under gravity.
Batsman running in a field.
Motion of the pestle in a mortar when operated manually.

Simple Harmonic Motion (SHM)

SHM is defined as the motion of an object where the restoring force is proportional to the displacement from the mean position and tries to opposed.

$$F \propto -y$$

$$\Rightarrow F = -ky$$

$$\Rightarrow ma = -ky$$

$$\Rightarrow m\frac{dv}{dt} = -ky$$

$$\Rightarrow m\frac{d}{dt}\left(\frac{dy}{dt}\right) = -ky$$

$$\Rightarrow m\frac{d^2y}{dt^2} = -ky \quad \text{--- (1)}$$

$$\therefore \quad a \propto -y$$

A particle is said to move in SHM if its accelaration is proportional to the displacement & is always directed towards the mean position.

The solution of eqn (1) is $y = r \sin(\omega t + \phi)$

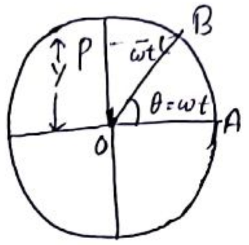
here r = amplitude of SHM

ω = angular velocity

ϕ = phase angle.

Parameters of S.H.M / Characteristics of SHM

(i) Displacement (y) – Amplitude (r)



(SHM as projection of uniform circular motion)

The motion of the projection of the object undergoing uniform circular motion on the diameter of the circle of reference.

Displacement is the distant of the projection of an object from the mean position.

In Δ OPB,

$\angle P = 90^\circ$

$\sin\omega t = \frac{OP}{OB} = \frac{y}{r}$

$\Rightarrow y = r\sin\omega t$

$\Rightarrow \boxed{y = \pm r}$ if $\sin\omega t = \pm 1$

Maximum displacement of an object from mean position on either side is called amplitude.

(ii) Velocity (v)

$v = \frac{dy}{dt} = \frac{d}{dt}(r\sin\omega t) = r\cos\omega t \times \omega = r\omega\cos\omega t$

$\Rightarrow \boxed{v = r\omega\cos\omega t}$

(In Δ OPB, $\cos\omega t = \frac{PB}{OB} = \frac{\sqrt{r^2-y^2}}{r}$

$v = \cancel{r}\omega \frac{\sqrt{r^2-y^2}}{\cancel{r}}$

$\boxed{v = \omega\sqrt{r^2-y^2}}$

At centre $y = 0$

$$\text{So } V = \omega\sqrt{r^2 - 0^2} = \omega r$$

So velocity is maximum at mean position.

At extreme $y = r$

$$V = \omega\sqrt{r^2 - r^2} = \omega \times 0$$

$$\Rightarrow \boxed{V = 0}$$

So velocity is minimum at extreme position.

(iii) Acceleration

$$a = \frac{dv}{dt} = \frac{d}{dt}(r\omega\cos\omega t) = r\omega\frac{d}{dt}\cos\omega t$$

$$\Rightarrow a = -r\omega^2 \sin\omega t$$

$$= -r\omega^2 \frac{y}{r}$$

$$\Rightarrow \boxed{a = -\omega^2 y}$$

At centre $y = 0 \quad \therefore a = 0$

At the extreme, $y = r$

$$a = -r\omega^2$$

A particle vibrating in SHM has zero acceleration while passing through mean position & has maximum acceleration while at extreme position.

Wave motion

(5)

Wave motion is the disturbance that travels through the medium & is due to repeated periodic motion of the particle of the medium, the motion being handed over from particle to particle.

Ex Radio waves, water waves, sound waves, etc.

Waves are of two types:

(i) Transverse wave
(ii) Longitudinal wave.

Transverse Wave	Longitudinal Wave
(1) The wave in which the particles are vibrating perpendicular to the direction of propagation of wave	(1) The wave in which the particle are vibrating in the direction of wave is called longitudinal wave.
(2) It produces temporary change in the shape of medium	(2) It produces temporary change in the size of medium.
(3) It produces shear modulus & inertia	(3) It produce compressibility & inertia.
(4) wave velocity $= \sqrt{T/m}$	(4) Wave velocity $= \sqrt{E/\rho}$
(5) Ex: Water wave, light wave vibration of a string.	(5) Ex:- Vibration of tuning fork, sound wave, vibration of a spring

(6) Crests & troughs are formed during its propagation

(6) Compression & rarefaction are produced during its propagation

(7) It travel through solids & shallow pool of liquid but not through gases.

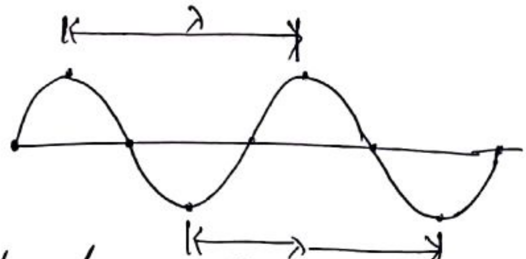
(7) It travels through solid, liquid & gas.

Wave parameters

(1) Wave length (λ) It is distance between two consecutive crests or two consecutive troughs.

Or It is the distance between two consecutive particles executing SHM in same phase.

Unit λ:- cm or nm or m



(2) Wave number ($\bar{n}$) :- It is defined as the reciprocal of the wavelength of wave. $\bar{n} = \frac{1}{\lambda}$

Unit $\bar{n}$:- cm^{-1} or m^{-1}

(3) Time period (T):- It is the time taken by the particle to complete one vibration/oscillation.

(4) Frequency (η):- Total number of vibration in one second is called frequency. $\boxed{\eta = \frac{1}{T}}$

frequency is also defined by the reciprocal of time period (T).

(5) Amplitude :- The maximum extend of oscillation or vibration is called amplitude.

(6) velocity of wave (v) :- According to the definition of wavelength, it is the distance (λ) travelled by the wave during the time (T), a particle completes one vibration.

$$v = \frac{\text{distance}}{\text{Time}} = \frac{\lambda}{T}$$

Since $\frac{1}{T} = n$

$$\therefore \boxed{v = n\lambda}$$

velocity of wave = freq^n × wave length

Ultrasonics :-

Sound of freq^n greater than the upper limit of audible range (20000 Cs^{-1}) is termed as ultrasonic.

* Human ear is responsive only to freq^n lying in between 20 & 20000 cycles per second

Properties of ultrasonics

(i) Ultrasonic waves are longitudinal in nature.

(ii) Propagation of ultrasonic through a medium results in the formation of compression & rarefaction.

(iii) These are waves of very high freqn having a range 2×10^4 to 10^9 hertz.

(iv) They travel with the speed of sound.

(v) Since the energy of sound waves is proportional to the square of their frequency, ultrasonics are highly energetic waves.

(vi) Due to their much smaller wavelength, ultrasonic do. donot spread that much as audible sound do.
So They can constitute narrow beams.

(vii) Passage of ultrasonics through a liquid results in a variation of density (greater at nodes & lesser at antinodes). Such a liquid can be used as diffraction grating to produce diffraction of light

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Applications of Ultrasonics:-

Ultrasonics being highly energetic waves have found a large number of application in industry & scientific research.

1- Echo Sounding.

2- Thickness Gauging

3- Flaw detection

4- Fuel gauging

5- Determination of elastic constants

6- Ultrasonic welding.

7- Ultrasonic cleaning

8- Producing stable emulsions

9- Coagulation

10- Study of microstructure

11- Drilling holes.

12- In metallurgical indust..

13- Chemical effects

14- Biological effects

15- Diagnostic use

16- Ultrasonic therapy

17- Measurement of velocity of sound in liquids.

Unit-7 HEAT AND THERMODYNAMICS P-7-1

(Babita Podhi
Lect. in physics)

Definition of heat & Temperature:-

Heat:- It is a form of energy which moved between two systems when one of them is hotter than the other.

or

→ Heat is defined as a spontaneous flow of energy from one object to another, caused by a difference in temperature between two objects.

Temperature:- The degree or intensity of heat present in a substance or object. It is generally measured in degree Celcius, kelvin, farehite scale.

** Unit of Heat – SI system – Joule (J)
CGS system – Calorie (cal)
M.K.S system – Kilo calorie (kcal)

Specific Heat (S):- Specific heat is the amount of heat required to rise the temperature of unit mass through 1°C.

Mathematically, $Q = mS\Delta T$

$$\boxed{S = \frac{Q}{m\Delta T}}$$

where, Q – Heat energy
m – Mass of substance
ΔT – change in Temperature
S – specific heat of substance.

Latent Heat (L):- Latent heat is defined as the change in state of the substance without any change in the temperature.

Ex:- Conversion of water from liquid to vapour at 100°C
Freezing of water from liquid state to ice at 0°C

Mathematically, $\boxed{\begin{array}{l} Q = mL \\ L = Q/m \end{array}}$ where Q:- Heat energy
m = Mass of Substance
L = Latent Heat of Substance

P-7-2

Dimension & unit of specific heat (s) & Latent heat (L)

* Specific heat $S = \frac{Q}{m\Delta T}$

Dimension of $S = \frac{[M^1L^2T^{-2}]}{[M^1][K^1]}$

Dimension of Q is equivalent to energy i.e $\doteq [M^1L^2T^{-2}]$
Temperature $[T] = [K]$
Mass $M = [M]$

So $[S] = [M^0L^2T^{-2}K^{-1}]$

Dimension is $(0, 2, -2, -1)$ respectively.

unit of $s \rightarrow$ kcal/kg°c

unit of $L \rightarrow$ J~~kcal~~/kg

* Latent Heat (L) $= \frac{Q}{m}$

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

Dim of $L = [M^0L^2T^{-2}]$

Some Simple Numerical :-

Q1 Calculate the amount of heat required to increase the temperature of 2 kg of ~~copper~~ water from 25°C – 65°C?

Soln :- Here the state of water is not changing So, we use the heat equation $Q = ms\Delta T$

$m = 2kg$
$S = 1$ kcal/kg°c

* specific heat of water = 1 kcal/kg°c

change in temperature $\Delta T = T_{final} - T_{initial}$

So $\Delta T = 65 - 25 = 40$

So $Q = ms\Delta T$

$= 2 \times 1 \times 40 = 80$ kcal

So The amount of heat required to increase the temperature is 80 kcal.

P-7-(3)

Q(2) Calculate the amount of heat required to melt a block of ice of 2kg at $0°C$.
Given Latent heat of ice = 80 cal/gram

Sol^n:- $Q = mL$ [As the state is changing from ice to water]

or $L = Q/m$, $m = 2kg$, $L = 80 cal/g$
$= 2000g$

$Q = 2 \times 10^3 \times 80 = 160{,}000 cal$ (Ans).

** Imp Previous year
Q(3) How much steam at $100°C$ will melt 3.2 kg of ice at $-10°C$? Given that specific heat of ice 0.5 kcal/kg°C Specific Latent heat of steam 540 kcal/kg, Latent heat of ice 80 kcal/kg.

Sol^n: As going from steam to water is not happen directly. Several intermediate step is involved.

Step-1: Ice at $-10°C$ to $0°C$ (No change of state)
↳(ice - ice)

$Q_1 = ms\Delta T$
$= 3.2 (0.5) \times 10 = 16 kcal$

Step-2:- Ice at $0°C$ to water at $0°C$ (State is changing ice - water)

$Q_2 = mL = 3.2 (80)$
$= 256 kcal$

Step-3:- Water at $0°C$ to water at $100°C$ → (No Change of State) (water - water)

$Q_3 = ms\Delta T$
$= 3.2 (1)(100) = 320 kcal$

Step-4:- Water at $100°C$ to Steam at $100°C$ → (change of state (water - steam))
$Q_4 = mL = (3.2)(540) = 1728 kcal$

So The Total amount of heat $Q_{Total} = Q_1 + Q_2 + Q_3 + Q_4$
$= 16 + 256 + 320 + 1728 = 2320 kcal$

P-7-4

N.B. We should note that the Question No-3 if a Substance is Not changing its state (solid, liquid, gas) remaining in the same state only temperature is changing the use the equation $\boxed{Q = ms\Delta T}$

If the substance is changing its state from one to another (solid- liquid, liquid - gas or liquid - solid

Thermal Expansion :-

In general, when an object is heated whether it be a solid liquid or gas, it expands.

We have observed certain phenomena →

(1) In laying down the rail track, a gap is left in between two pieces. As in Summer track of rail is metallic it expands if no gap is there it may bend causing life risk to the train & the passengers.

(2) Concrete floors are not laid in one piece, they are in small sections, with joints in between to adjust the expansion during summer as temperature is very high in Summer

(3) In tropical regions rocks expand during heat in day time & contract during night. This expansion & contraction process over a long time results in breaking of rocks forming sandy deserts.

Many more example can be given on this.

P-7-5

** From atomic view of thermal expansion

Every two atoms of matter exert a force upon each other.
The potential energy of a pair (two atoms) depends upon their inter atomic separation.

Consider a block of substance (say iron) in fig (a)
As there are infinite numbers of atoms present inside the iron block (fig (a)).

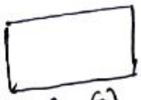


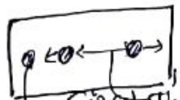
fig (a)

Let us consider only two atoms inside that block of iron. (Fig (b))

Fig (b) r_0 is the intermolecular separation between two atoms (when the temp is 0 kelvin)

Now we the iron block heated up the atoms starts vibrating about their mean position.

Look at the third fig (c)



when the separation increases

Fig (c) The separation increased. A neighbouring atom which is near the pair

Other atoms which are in near place of those atoms also need space to vibrate so the over all spacing increases for all atoms, so the block expands when heated up.

Co-efficients of thermal Expansion of Solids.

When a solid is heated, it expands in all dimensions, i.e. along its length breadth & thickness simultaneously.

Three types of coefficient in TE

Linear expansion (one dimension)

(Expansion in 2D) Superficial exp^n

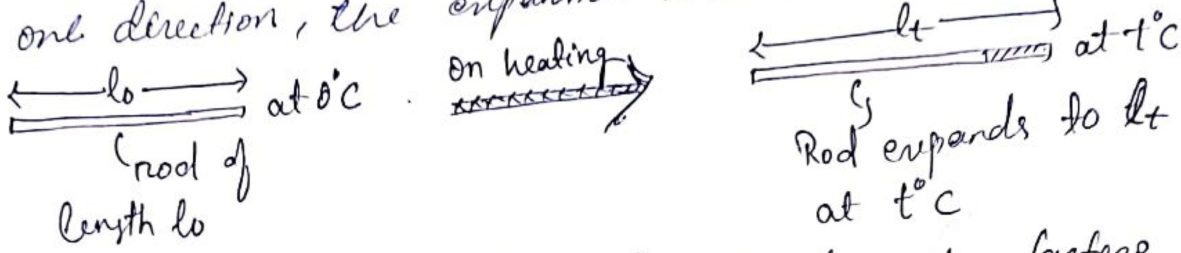
Expansion in 3D (Cubical expansion)

P-7-(6)

Pfor

(1) Expⁿ along one-dimension :- (Linear expansion)

When the expansion due to heating takes place only along one direction, the expansion is said to be 1D or linear.



So the change in length = $(l_t - l_0)$ → depends on two factors

$l_t - l_0 \propto l_0$

& $l_t - l_0 \propto t°C$

proportionality symbol

So $(l_t - l_0) \propto l_0 t$

$\Rightarrow (l_t - l_0) = \alpha\, l_0 t$

Alpha

$\Rightarrow \boxed{\alpha = \dfrac{l_t - l_0}{l_0 t}}$ —(A) $\xrightarrow{\text{After rearranging}}$ $\boxed{l_t = l_0(1+\alpha t)}$ —(1)

Coefficient of linear expansion

If $l_0 = 1$, $t = 1°C$ then $\alpha = l_t - l_0$

Imp
** Definition of α

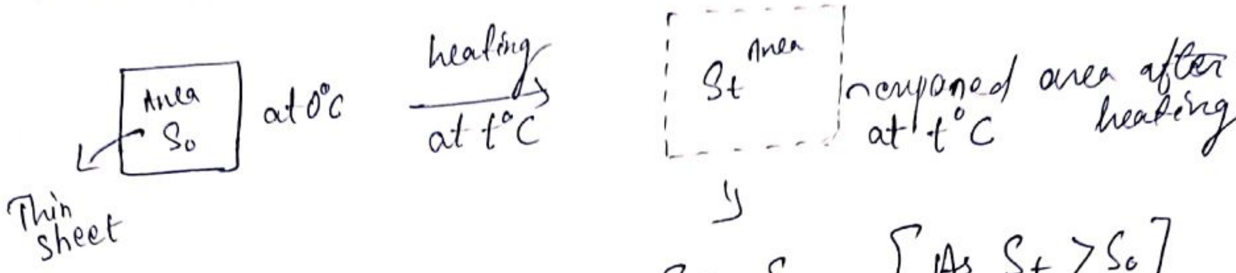
Coefficient of linear expⁿ of the rod is defined as the change in length per unit length at $0°C$ per degree centigrade rise in temperature.

(2) Expansion in two-Dimension :- (Superficial expansion)

When the expansion of a body is confined to a plane, it is said to be ~~two~~ two dimensional expansion or Superficial expansion.

P-7-(7)

Surface area is having some length & breadth, very less thickness can be called 2-D object.



Change in Surface area = $S_t - S_0$ [As $S_t > S_0$]

$S_t - S_0$ is increased surface area depends on two factors.

(1) $S_t - S_0 \propto S_0$

(2) $S_t - S_0 \propto t$

Finally $S_t - S_0 \propto S_0 t$ β called Beta

$\Rightarrow S_t - S_0 = \beta S_0 t$ —(B)→ $\boxed{S_t = S_0(1+\beta t)}$ —(2)

$\Rightarrow \boxed{\beta = \dfrac{S_t - S_0}{S_0 t}}$

Coefficient of superficial expansion.

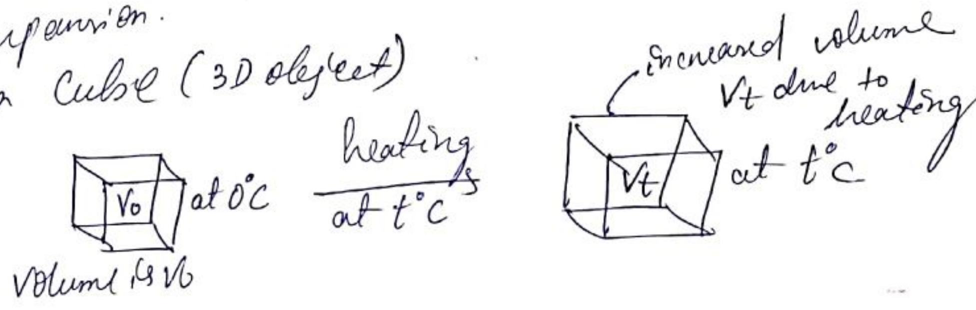
When $S_0 = 1$, $t = 1°C$, $\beta = S_t - S_0$

Imp
** Definition of β :- Coefficient of superficial expn is defined as the change in area of the surface per unit area at 0°C per degree centigrade rise of temperature..

(3) Expn in 3D - Cubical expansion

When thermal expansion of the body takes place in space,, it is said to be three dimensional expansion or cubical expansion.

Consider a Cube (3D object)



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P-7-8

change in volume $V_t - V_0$ depends on

$V_t - V_0 \propto V_0$

& $V_t - V_0 \propto t$

$\Rightarrow V_t - V_0 \propto V_0 t$

$\Rightarrow V_t - V_0 = \gamma V_0 t$

$\Rightarrow \boxed{\gamma = \frac{V_t - V_0}{V_0 t}}$ — (C) $\longrightarrow \boxed{V_t = V_0(1+\gamma t)}$ — (3)

Gamma → called the coefficient of cubical expansion.

Imp
** Definition of γ

Coefficient of cubical expansion is defined as the change in volume per unit volume at 0°C per degree celcius rise of temp.

** Imp
Relations between expansion coefficients (α, β, γ)

(i) Relation between α & β:

Consider a square sheet having each side 'l_0' at 0°C

Area S_0 at 0°C $\boxed{S_0 = l_0^2}$ — (4)

On heating the sheet to t°C, each side expands to 'l_t'

Area at sheet at t°C $S_t = l_t^2 = l_0^2(1+\alpha t)^2$ (from eq^n (1))

from eq^n (B) $\beta = \frac{S_t - S_0}{S_0 t} = \frac{l_0^2(1+\alpha t)^2 - l_0^2}{l_0^2 t}$

$\Rightarrow \beta = \frac{\cancel{l_0^2}[(1+\alpha t)^2 - 1]}{\cancel{l_0^2} t} = \frac{(1+\alpha t)^2 - 1}{t}$

$\Rightarrow \beta = \frac{\cancel{1} + \alpha^2 t^2 + 2\alpha t - \cancel{1}}{t} = \frac{2\alpha t + \alpha^2 t^2}{t}$

P - 7 - (9)

$$\beta = \frac{t(2\alpha + \alpha^2 t)}{t}$$

$\Rightarrow \beta = 2\alpha + \alpha^2 t$

Note: When a quantity is small its higher power is too small
ex:- 0.001 is small.
$(0.001)^2 = 0.00001$ too small can be neglected

Since α is very small, term $\alpha^2 t$ can be neglected being small

So $\boxed{\beta = 2\alpha}$ — (5) (derived)

(ii) Relation Between α & γ :-

Let V_0 & V_t be the volume of a cube at 0°C & t°C respectively. If l_0 & l_t are the sides of this cube at 0°C & t°C so, $\boxed{V_0 = l_0^3}$ & $\boxed{V_t = l_t^3 = l_0^3 (1+\alpha t)^3}$

So by eqn (c) $\gamma = \frac{V_t - V_0}{V_0 t}$

$$\Rightarrow \gamma = \frac{l_0^3 (1+\alpha t)^3 - l_0^3}{l_0^3 t} = \frac{\cancel{l_0^3}[(1+\alpha t)^3 - 1]}{\cancel{l_0^3} \cdot t}$$

$$\Rightarrow \gamma = \frac{(1+\alpha t)^3 - 1}{t} = \frac{\cancel{1} + \alpha^3 t^3 + 3\alpha t + 3\alpha^2 t^2 - \cancel{1}}{t}$$

$(\because (a+b)^3 = \cancel{1^3 + (\alpha t)^3 + 3}$
$\hookrightarrow a^3 + b^3 + 3a^2 b + 3ab^2$

So $(1+\alpha t)^3 = 1^3 + (\alpha t)^3 + 3\alpha t + 3\alpha^2 t^2)$

$$\Rightarrow \gamma = \frac{\cancel{t}[\alpha^3 t^2 + 3\alpha + 3\alpha^2 t]}{\cancel{t}}$$

As α is very small higher order terms α^3 & α^2 are too small, hence neglected.

So $\boxed{\gamma = 3\alpha}$ (derived) — (6)

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P-7-(10)

(iii) Relation between β & γ

from eqn (5) $\beta = 2\alpha$ or $\alpha = \beta/2$

from eqn (6) $\gamma = 3\alpha$ or $\alpha = \gamma/3$

so $\frac{\beta}{2} = \frac{\gamma}{3}$ or $\boxed{\gamma = \frac{3}{2}\beta}$ — (7)

Work and Heat Concept:-

Heat & work are two different ways of transfering energy from one system to another.

The distinction between heat & work is important in the field of thermodynamics.

Heat is the transfer of themal energy between systems, while work is the transfer of mechanical energy between two system

Both work & heat are path functions

Joules Mechanical Equivalent of Heat

Heat is contained in the body in the form of moleculer motion. Type of moleculer motion is different in Solids, liquids & gases. Thus heat can be said to be a form of mechanical energy. Work is also a form of mechanical energy.

So heat & work should be inter convertible

Ex:- The two hands become hot if we rub them.

P-7-11

Statement : Whenever heat is converted into work or work into heat, the quantity of energy disappearing in one form is equivalent to the quantity of energy appearing in the other.

If an amount of work W results in the production of an amount of 'H' of heat

$$W \propto H$$

$$\Rightarrow \boxed{W = JH} \Rightarrow J = \frac{W}{H}$$

When, $H = 1$ cal, $J = W$, $J = 4.18\ J\,cal^{-1}$

Joule's mechanical equivalent (J) is defined as amount of work done to raise unit amount of heat (H).

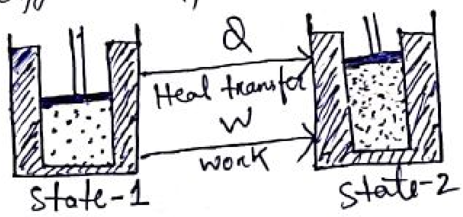
$\boxed{1\text{ cal of heat} = 4.18\text{ Joules}}$

<u>First Law of Thermodynamics</u> :-

Statement :- When a certain amount of heat Q is supplied to a system which does external work W is passing from State 1 to State 2, the amount of heat is equal to sum of the increase in the internal energy of the system & the external work done by the system.

In symbol, the law is expressed as $Q = (U_2 - U_1) + W$ —(1)

For a very small change in the state of system, it is expressed in differential form as $\delta Q = dU + \delta W$ —(2)



U = Internal energy

$\boxed{U_2 - U_1 = Q - W}$

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P- 7- (12)

Explanation on 1st LTD:-

(i) Based on the idea that energy is neither created nor destroyed i.e. the law obeys the law of conservation of energy.

(ii) Internal energy of a system = kinetic Energy + Potential energy

(iii) Internal energy of a system increases when heat flows into it & decreases when heat flows out of it.

(iv) Internal energy changes when work is done

(a) Compressing a gas increases internal energy.

(b) Expansion of a gas results in decrease of its internal energy.

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Reflection & Refraction:-

Reflection

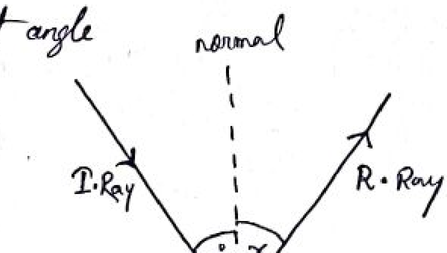
The phenomenon of light by virtue of which a ray of light moving from a medium to another medium is sent back to the same medium from the interface between the two media is called as reflection.

Incident Ray:- The ray of light falling on the surface of a mirror is called incident ray.

Point of Incidence - The point at which the incident ray falls on the mirror surface is called point of incidence.

Reflected Ray - The ray of light which is sent back by the mirror from the point of incident is called reflected ray.

Normal: A line ⊥r or at the right angle to the mirror surface at the point of incidence is called normal.



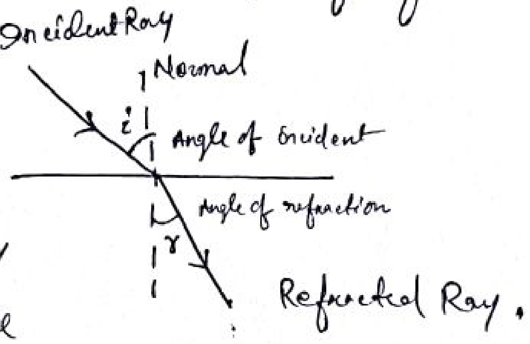
Angle of Incidence: The angle made by the incident ray with the normal is called angle of incidence.

Angle of reflection:- The angle made by the reflected ray with the normal at point of incidence is called angle of refraction.

Refraction

The phenomenon of light by virtue of which a ray of light moving from one medium to another medium undergoes a change in its velocity is called as refraction.

Angle of refraction: The angle made by the refracted ray with the normal at point of incidence is called angle of refraction.



Laws of Reflection & Refraction:-

Laws of Reflection:-

1) The incident ray, the reflected ray & the normal to the reflecting surface at the point of incidence, all lie in one plane & that plane is $\perp^r$ to the reflecting surface

2) The angle of incidence is equal to the angle of reflection.
   i.e. $i = r$

Laws of Refraction:-

1) The incident ray, the refracted ray & the normal to the interface at the point of incident all lie in one plane & that plane is $\perp^r$ to the interface separating the two media

2) The ratio of sine of the angle of incidence to the sine of the angle of refraction is a constant. This is also known as Snell's law of refraction $\frac{\sin i}{\sin r} = \text{constant}$

Refractive Index :-

Refractive index is the property of medium/material that measure the optical density of that medium & it describes how fast light travels through that medium.

By Snell's Law :-

$$\frac{\sin i}{\sin r} = const = {}^1\mu_2 \quad \text{—①}$$

Refractive index of the second medium with respect to first medium.

It is defined as the ratio of sine of the angle of incidence to sine of the angle of refraction.

If v_1 & v_2 are the velocities of light in 1st & 2nd medium respectively, then ${}^1\mu_2 = \frac{v_1}{v_2}$ —②

hence it can also be defined in an alternative form as, the ratio of the velocity of light in first medium to the velocity of light in second medium.

or ${}^1\mu_2 = \frac{\mu_2}{\mu_1}$ = Defined as the ratio of absolute refractive index of second medium to absolute refractive index of first medium.

Example-1 Refractive index of water w.r.t air is 4/3, while that of glass is 3/2, what will be Refractive index of glass w.r.t. water.

Solution: we know that,

$$^{1}\mu_2 = \frac{\mu_2}{\mu_1} = {}^{w}\mu_g = \frac{\mu_g}{\mu_w} = \frac{3}{2} \times 3/4$$

$$\Rightarrow {}^{w}\mu_g = 9/8$$

Critical Angle & Total Internal Reflection

Critical Angle :-

Critical angle is defined as the angle of incidence in optically denser medium for which angle of refraction in the optically rarer medium is 90°.

Total Internal Reflection

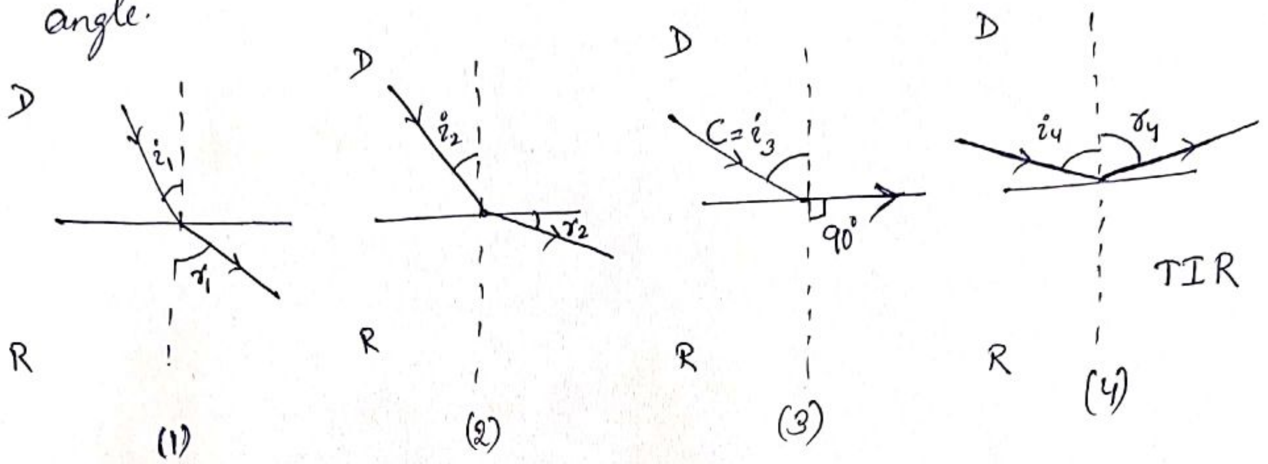
If the angle of incidence of the ray increased further i.e. greater than critical angle, it is reflected back into the same medium. This is called Total Internal Reflection.

Defn : Total internal reflection is the phenomenon by virtue of which a ray of light travelling from a optically denser medium to a rarer medium is sent back to the same medium when the ray is incident at an angle more than the critical angle for that medium.

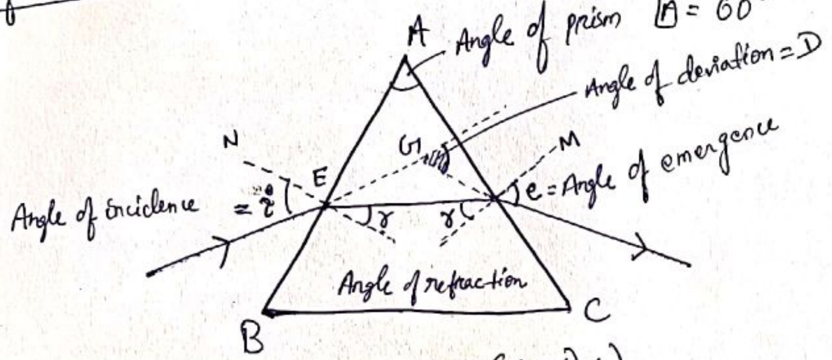
Conditions for total External reflection:-

→ Light ray must be travel denser to rarer medium.

→ Angle of incidence must be greater than critical angle.



Refraction through a prism:-

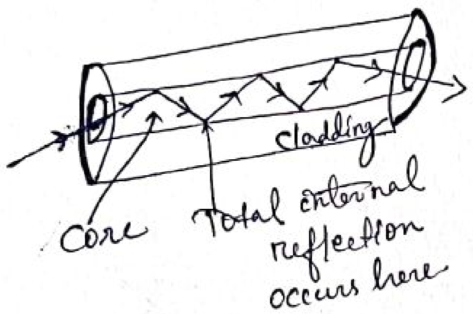


$$\mu = \frac{\sin\left(\frac{A + D_m}{2}\right)}{\sin A/2}$$

Fiber optics:-

Defination:- An optical fiber is a dielectric cylindrical wave guide consisting of two layers i.e. Core & a surrounding cladding. The refractive index of the material of the core is higher than that of the cladding. Both are made up of thin, flexible, high quality transparent fiber of glass or plastic, where light undergoes successive total internal reflections along the length of the fibre & finally comes out at the other end. P-8-6

The study of optical fiber is called fiber optics.



Properties of Optical fibers (O.F.)

-> It has a large bandwidth. The optical frequency of 2×10^{4} Hz can be used & hence the system has higher bandwidth, thus have greater information carrying capacity over longer distances.

-> O.F. are small in size & have light weights as compared to electrical cables. They are flexible & have very high tensile strength. Thus they can be twisted & bent easily.

-> O.F. provides high signal securities as it is confined to the inside of fibre & can not be tapped & tempered easily. Thus it satisfies the need for security which is required in banking & defence.

-> O.F. communication is free from electromagnetic interference.

-> O.F. material does not carry high voltage or current, hence they are safer than electrical cable.

Applications:

Some of the major applications areas of optical fibers are:-

-> Communications - For transmitting audio & video signals through long distances. Voice, data & video transmission are the most common uses of fiber optics & these include, tele communications local area networks (LANs), industrial control system.

-> Sensing:- Fiber optics can be used to deliver light from a remote source to a detector to obtain pressure, temperature or spectral information. The fiber also can be used directly as a transducer to measure a number of environmental effects, such as strain, pressure, electrical resistance etc.

-> Power delivery:- O.F. can deliver remarkably high levels of power for tasks such as laser cutting, welding, marking & drilling.

-> Illumination- A bundle of fibers gathered together with a light source at one end can illuminate areas that are difficult to reach, for example in medical field, inside the human body with an endoscope.

-> O.F. are used instead of metal wires because signals travel along them less loss.

-> O.F are used for transmitting & receiving electrical signals which are converted to light by suitable transducers.

For example these are used as a light pipe to facilitate visual examination of internal organs like Oesophagus, Stomach & intestines

-> Available decorative lamps having fine plastic fibers with their free ends forming a fountain like structure have the end of the fibers is fixed over an electric lamp. When lamp is switched on, the light travels from the bottom of each fiber & appears at the top of its free end as a dot of light. The fibers in such decorative lamps are optical fibers.

Babita Poddhi [Lecturer Physics]

Unit-9 Electrostatics & Magnetostatics

Electrostatics is the study of electrical effects of charges at rest.

Charge is the property associated with matter due to which it produces electrical & magnetic effects.

Unit of charge - CGS → Electrostatic unit → stat-coulomb
Electromagnetic unit → ab-coulomb

SI → Coulomb.

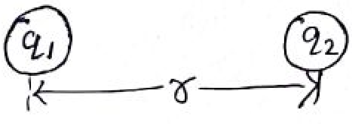
$$1 \text{ Coulomb} = \frac{1}{10} \text{ ab coulomb}$$
$$= 3\times10^{9} \text{ stat-Coulomb.}$$

Def^n of Electric field:-

The space surrounding an electric charge within which the electric effects can be felt is called electric field.

Coulomb's Laws in electrostatics:-

The force of attraction or repulsion between two point charge is directly proportional to the product of their charges and inversely proportional to the square of the distance between them.



q_1 = Magnitude of 1st charge
q_2 = Magnitude of 2nd charge
r = Distance between the charge.
F = force of attraction or repulsion between the charges

According to the statement of coulomb's law

$$F \propto q_1 q_2$$
$$\& \; F \propto \frac{1}{r^2}$$

P-9-(2)

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

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

K= Proportionality constant which depends upon the Surrounding medium & system of units chosen.

In SI system, $K = \frac{1}{4\pi\epsilon}$, ($\epsilon$ = Permittivity of medium between the charges.)

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

$\epsilon = \epsilon_0 \epsilon_r$

ϵ_0 = permittivity of free space or air.

ϵ_r = Relative permittivity of the medium.

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

When the medium between the two charges is air.

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

value of $\epsilon_0 = 8.854 \times 10^{-12} \frac{Coul^2}{N\ m^2}$ or $\frac{Farad}{metre}$

Thus $\frac{1}{4\pi\epsilon_0} = \frac{1}{4\pi \times 8.854 \times 10^{-12}} = 9 \times 10^9 \frac{Nm^2}{c^2}$]- unit of $\frac{1}{\epsilon_0}$

** Definition of absolute permittivity (ϵ_0):

For measuring relative permittivity, vacuum is to be chosen as the reference medium. It is alloted as absolute permittivity. In order words Absolute permittivity is the measure of the resistance that is encountered when forming an electric field in a vacuum.

** Definition of Relative permittivity (ϵ_r)

The ratio between the permittivity of the medium to the permittivity of the free space. $\boxed{\epsilon_r = \frac{\epsilon}{\epsilon_0}}$

P-9-(3)

** ϵ_r is called dielectric Constant
↳ defined as the ratio between the force between the two charges separated by some distance in air or vacuum to the force between the same two charges separated by the same distance in that medium.

Unit charge

In order to understand unit charge
Consider the Coulomb force for free space

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

Let us assume that $F = 9\times10^9 N$, $q_1 = q_2 = q$ (say)
$r = 1$ unit length
$= 1$ mt

So putting all values

$$9\times10^9 = \frac{1}{4\pi\epsilon_0}\frac{q^2}{1^2}$$, As the value of $9\times10^9 = \frac{1}{4\pi\epsilon_0}$

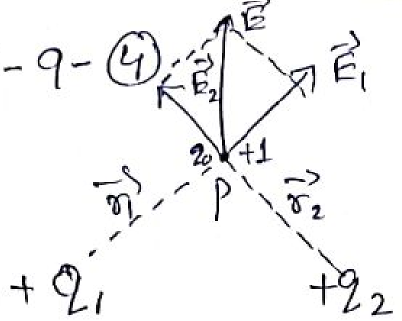
$\Rightarrow \cancel{9\times10^9} = \cancel{9\times10^9}\,\frac{q^2}{1}$

$\Rightarrow q^2 = 1 \Rightarrow \boxed{q = \pm 1}$ → magnitude of charge so as it is one so q is called unit charge on this condition

definition:-
Unit charge is a charge of that much strength which when placed at a distance of 1 mt from a similar charge repels it with a force of 9×10^9 Newton.

Electric field Intensity ($\vec{E}$):- Electric field intensity at any point within an electric field is the force experienced by a unit charge placed at that point.

P-9-4



At P we have a test charge (+1) generally test charge is denoted by q_0 having very small magnitude So we consider it as 1.

According to coulomb's law in electrostatics Force experienced by the test charge q_0 is

$$f_1 = \frac{q_1 q_0}{r_1^2} = \frac{q_1}{r_1^2} \text{ — (2) (As } q_0 = 1\text{)}, \quad \text{similarly } F_2 = \frac{q_2}{r_2^2} \text{ — (1)}$$

As $\vec{E}$ is the electric field at P.

So $\vec{E} = \frac{\vec{F}}{q_0}$; unit of $\vec{E}$ is $\frac{\text{Newton}}{\text{Coulomb}}$.

here $\vec{E}$ is the resultant vector of $\vec{E_1}$ & $\vec{E_2}$.

q_0 is the test charge placed at P.

$\vec{E}$ is a vector quantity. The direction of $\vec{E}$ is the direction in which a unit charge would move if it were free to do so.

<u>Electric</u> <u>Potential (V)</u>:-

Electric potential at a point within an electric field is the work done in moving a unit positive charge (test charge) from infinity to that point against the field.

V is Scalar quantity $V = \frac{W}{q} = \frac{\text{Joule}}{\text{Coulomb}}$

unit of V is = Volt (SI)

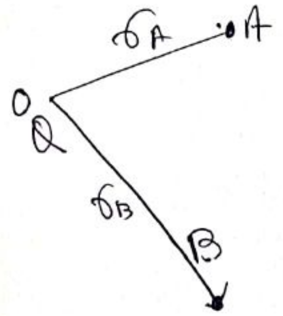
or Joule/coulomb.

P-9-5

Dimension of $V := \frac{W}{q} = \frac{\text{Force} \times \text{Displacement}}{\text{Current} \times \text{Time}}$

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

Potential difference :-



two points A & B at distance r_A & r_B from the source charge $+Q$ at 'O'.

potential at A = V_A

potential ~~at~~ B = V_B

Then the difference of potential is $V_A - V_B$ (As $V_A > V_B$)

The potential difference is the difference of electrical potential between two points.

→ Measured in volts(V) is also called voltage.

Capacitance :-

Definition :-

~~Capacitance~~ of a conductor is defined as the amount of charge given to raise its electric potential by unity.

Capacitance 'C' = Q/V , Q = charge supplied to the conductor

V = Rise in potential of conductor.

Unit of capacitance is farad (F).

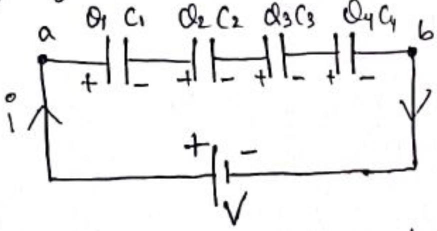
1 Farad = $\frac{1C}{1\,\text{Volt}}$ | Dimension of $C = [M^{-1}L^{-2}T^{4}A^{2}]$

P-9-6

Grouping of capacitors

1. Series Combination of capacitors
2. Parallel Combination of capacitors.

→ **Grouping of capacitors in Series:-**



C_1, C_2, C_3 are the capacitors connected in series.

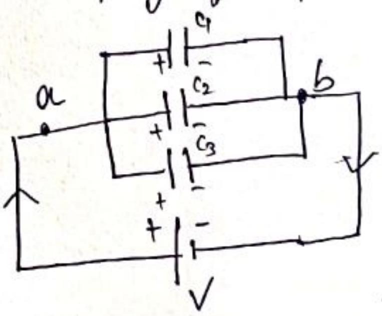
$$\frac{1}{C_{equivalent}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}$$ where Cequivalent is the equivalent capacitance of all three.

In general, if there are 'n' number of capacitors then,

$$\boxed{\frac{1}{C_{equi}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots + \frac{1}{C_n}}$$

So, the overall capacitance of the circuit decreases.
Cequivalent < than the individual capacitance (C_1, C_2, C_3 & so on)

→ **Grouping of capacitors in parallel:-**



$C_{equivalent} = C_1 + C_2 + C_3$

In general, if there are 'n' number of capacitors, then

$$\boxed{C_{equi} = C_1 + C_2 + C_3 + \cdots + C_n}$$

So the overall capacitance of the circuit increases.
Cequivalent > each capacitance of capacitors (C_1, C_2, C_3 & so on)

P-9-(7)

Some Simple numericals on grouping of capacitors :

Q1) Find the equivalent capacitance of the circuit consisting of two capacitors of 2 μF & 3 μF in series?

Solⁿ : For series grouping

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} \Rightarrow \frac{1}{C} = \frac{1}{2} + \frac{1}{3}$$

$$\Rightarrow \frac{1}{C} = \frac{3+2}{6} = 5/6$$

So $C_{equivalent} = 6/5 = 1.2\,\mu F$ (Ans)

Q2) Find the cummulative value of capacitance in a circuit having 3 capacitors of capacitance 7 μF, 3 μF & 10 μF in parallel.

Solⁿ : Here μF means microfarad.

For parallel grouping

$C_{equivalent} = C_1 + C_2 + C_3$

$\Rightarrow C_{equ} = 7 + 3 + 10 = 20\,\mu F$ (Ans)

Q3) If two capacitors are grouped in series having equal capacitance. Find the value of the two capacitance for their equivalent capacitance 8 μF.

Solⁿ : Given that two capacitances in series.

So $\frac{1}{C_{equi}} = \frac{1}{C_1} + \frac{1}{C_2}$ but $C_1 = C_2 =$ equal so $\Rightarrow C$ (let)

$C_{equi} = 8\,\mu F$

$$\Rightarrow \frac{1}{8} = \frac{1}{C} + \frac{1}{C} = \frac{2C}{C^2} \Rightarrow \frac{C}{2} = 8 \Rightarrow C = 16\,\mu F \text{ (Ans)}$$

So value of two are 16 μF.

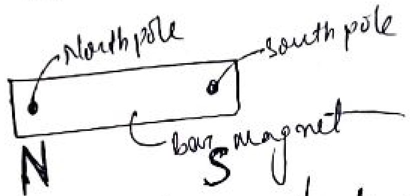
P - 9 - (8)

Magnetostatics :

→ Magnet :- A substance which attracts small pieces of iron & Steel is called a magnet.

→ The property of attracting or repelling is called magnetism.

→ Bar Magnet is the simplest form of magnet. It has two poles North pole & South pole.



→ m symbol used to denote pole strength.

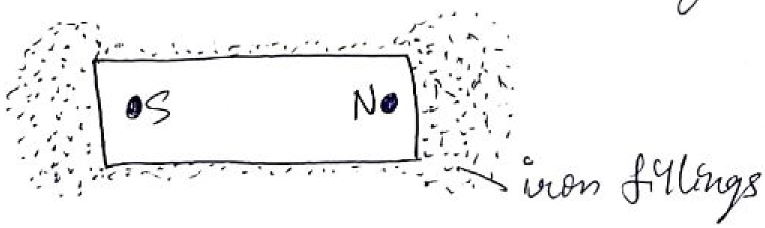
→ Unit of m is amper meter or weber.

Properties of Magnet :-

(1) Attracting Property of a magnet :- A magnet is capable of attracting small pieces of iron towards it. These pieces (iron fillings) are attracted towards both the poles north as well as South.

This attraction is greatest at the poles & decreases as move towards the centre of magnet.

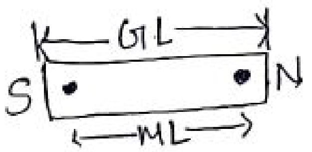
It will be observed that the iron fillings sticking to the magnet in largest in number near the poles fig (a) & are smaller in the portion of magnet in between



② <u>Two poles of a magnet</u>:- A magnet has two poles, one is north seeking pole or simply north pole (N) while the second is south seeking pole or the south pole (S). These poles are situated a little distance inside the faces of the magnet Fig(a). Face to Face length of the magnet is called geometric length while pole to pole length is called the magnetic length of the magnet.

Magnetic length is slightly less than geometric length. Magnetic length is always < geometric length

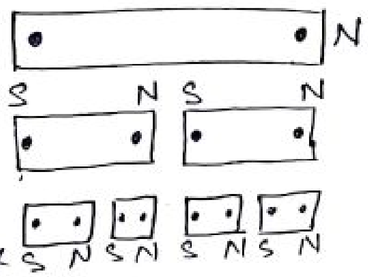
$$\boxed{\text{Magnetic length, } 2l = \frac{7}{8} \times \text{geometric length}}$$



GL = Geometric length
ML = Magnetic length.

③ <u>No existance of isolated magnetic poles</u>:-

The magnetic poles exist only in pairs of opposite nature. It is not possible to obtain an isolated magnetic pole. If we break a magnet into two parts we get two independent complete magnets each with a pair of opposite pole. On further subdivision into four pieces we get four magnets of opposite poles.



Breaking a magnet

This process continues till we reach the smallest particle (i.e. an atom), that also behaves like a magnet.

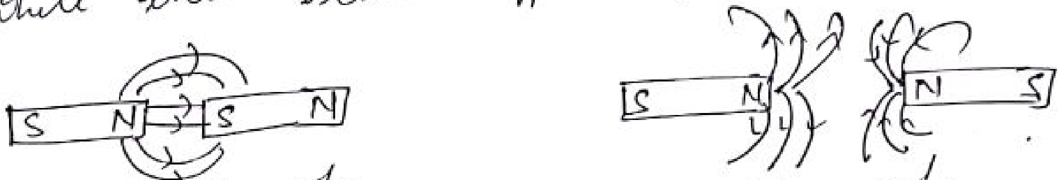
P- 9-(10)

This is the reason we say that it is not possible to obtain an isolated pole.

Sometimes we need an isolated pole for ~~theoritical~~ theoritical consideration. In that case we can assume the pole of a very long magnet to be an isolated one, since the second pole will be a large distance.

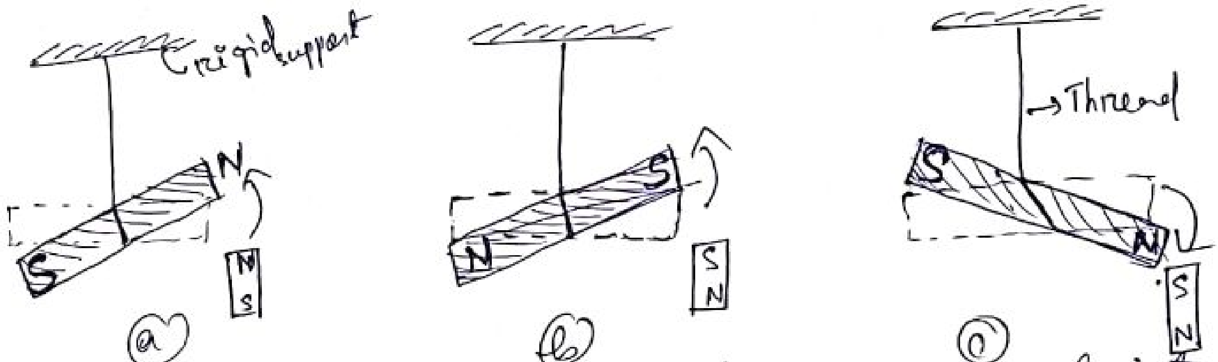
(4) Nature of the force between two poles:-

Magnetic poles exert forces upon each other. The nature of force between similar poles is repulsive while that between opposite pole is attractive.



Unlike pole attract eachother

like pole repel each other.



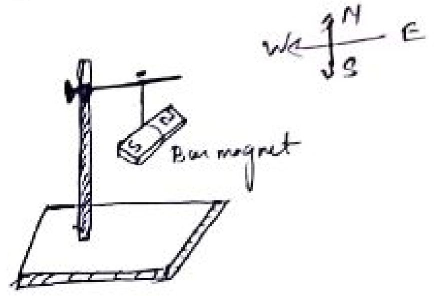
A freely suspended magnet seen to be deviated by an other magnet from it's original position which is given by dotted line.

P-9-(ii)

(5) Directionality Property :-

If you take an magnet and freely suspend it with a help of a string from a rigid support, then it always points in the north-south direction. Here north-South is geographical north-south of earth.

Every magnet irrespective of its shape, has a north pole & a south pole.



Definition of Magnetic field :-

The space surrounding a magnetic pole within which the magnetic effects of pole can be felt is called magnetic field. Unit of 'B' = Tesla (SI)
= Gauss (CGS)

$F_B = qVB$

$\rightarrow \boxed{B = \frac{F}{qV}}$

V is velocity of charge.

Magnetic field intensity ('H') :- Magnetic field intensity at any point within a magnetic field is the force experienced by a unit north pole placed at that point.

Unit:- $H = \frac{\text{Newton}}{\text{Weber}}$ formula 'H' $= \frac{\mu_0}{4\pi} \frac{m}{d^2}$

where m = pole strength
d is distance between two poles.

P- 9- 12

Coulomb's laws in Magnetism: This law states that the force of attraction or repulsion between two magnetic poles is directly proportional to the product of their pole strengths and inversely proportional to the square of distance between them.

m_1 = pole strength of 1st pole
m_2 = pole strength of 2nd pole
d = Distance between the poles

F = Force of attraction or repulsion between the poles.

According to the statement of coulomb's law

$F \propto m_1 m_2$

& $F \propto \frac{1}{d^2}$

So $F \propto \frac{m_1 m_2}{d^2} \Rightarrow F = K \frac{m_1 m_2}{d^2}$ — K: proportionality constant

So $K = \mu/4\pi$ (SI) → μ = called the permeability of the medium between poles.

$F = \frac{\mu}{4\pi} \frac{m_1 m_2}{d^2}$, $\mu = \mu_0 \mu_r$ — μ_0 = Permeability of free space, μ_r = Relative permeability of medium.

$\Rightarrow F = \frac{\mu_0 \mu_r}{4\pi} \frac{m_1 m_2}{d^2}$

When the medium is air $\mu_r = 1 \Rightarrow \mu = \mu_0 \Rightarrow F = \frac{\mu_0}{4\pi} \frac{m_1 m_2}{d^2}$

where $\mu_0 = 4\pi \times 10^{-7} \frac{\text{Henry}}{\text{metre}}$

Def^n

Unit pole:-

Unit pole is a pole of that much strength which when placed at a distance of 1m from a similar pole repels it with a force of $\frac{\mu_0}{4\pi}$ N or 10^{-7} N.

Mathematically, Assume $F = 10^{-7}$ N, $m_1 = m_2 = m$, $d = 1$ mt

Then, $F = \frac{\mu_0}{4\pi} \frac{m m}{d^2} \Rightarrow 10^{-7} = 10^{-7} \frac{m^2}{1}$

$\Rightarrow m^2 = 1 \Rightarrow \boxed{m = \pm 1}$

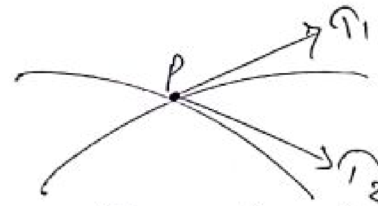
P - 9 - 13

Properties of magnetic lines of forces :

(i) Lines of force are directed away from a north pole and are directed towards a south pole. A line of force starts from a north pole and ends at a south pole if they are isolated poles.

(ii) Tangent, at any point, to the magnetic line of force gives the direction of magnetic intensity at the point.

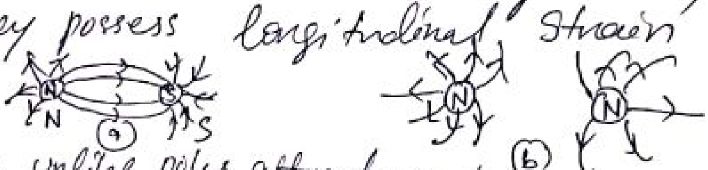
(iii) Two lines of force never cross each other. If the two lines were to cross, two tangents could be drawn to the line of force at the common point meaning thereby two directions of magnetic intensity, at that point, which is not possible.



Two direction of magnetic intensity at point

(iv) The number of lines of force per unit area is proportional to magnitude of strength of field (magnetic intensity) at that point. Thus more concentration of lines represents stronger magnetic field.

(v) The lines of force tend to contract longitudinally or lengthwise i.e. they possess longitudinal strain show below.



Due to this property two unlike poles attract each other

(vi) The lines of force tend to exert lateral (sideways) pressure i.e. they repel each other laterally. This explains the repulsion between two similar poles. fig (6) (given in page-(11))

(vii) 4π lines of force start from a unit magnetic pole.

Magnetic flux : Magnetic flux deals with study of number of lines of force of magnetic field crossing a certain area.

Let A = area of the coil placed in the magnetic field

θ = Angle between B & normal to area A

The area in vector notation can be represented by a vector directed along the normal to the area and having a length proportional to the magnitude of the area.

Magnetic flux through the area is given by,

$$\phi = \vec{B} \cdot \vec{A} = BA\cos\theta = A(B\cos\theta)$$

$B\cos\theta$ = component of B perpendicular to the area A.

Defn: Magnetic flux linked with a surface is defined as the product of area and the component of B perpendicular to the area ** Unit of "ϕ" = Weber (SI)

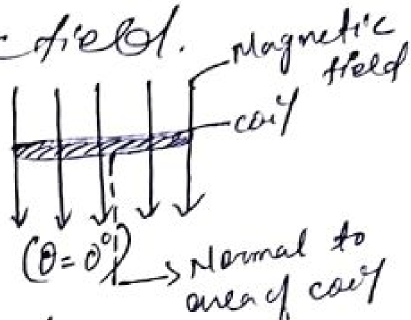
Maxwell (CGS)

[SI 1 weber = 10^8 Maxwell]

P-9-15.

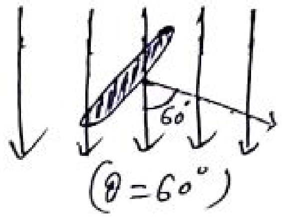
Imp. Unit of flux is Weber.

(i) When $\theta = 0°$ i.e. the coil is held perpendicular to the magnetic field and the normal to the coil is parallel to the magnetic field.
$\phi = BA$.

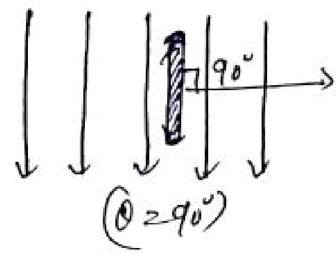


(ii) When $\theta = 60°$, i.e.
the normal to the coil is held at $60°$ to the magnetic field $\phi = BA\cos 60$

(N.B. The normal is always $\perp^r$ to the surface area)



(iii) When $\theta = 90°$, coil is held $\parallel$ to the magnetic field & the normal to the coil is held at $90°$ to the magnetic field,
$\phi = BA\cos 90° = 0$



Magnetic Flux density ($\vec{B}$):-

It is defined as the magnetic flux crossing unit area, when the area is held $\perp^r$ to the magnetic field. $B = \frac{\phi}{A}$

unit of $B = \frac{\phi}{A} = \frac{\text{Weber}}{\text{metre}^2}$ = Tesla (SI unit)

Babita Pradhi (Lect. in Physics)

Unit - 10 Current Electricity

Defⁿ

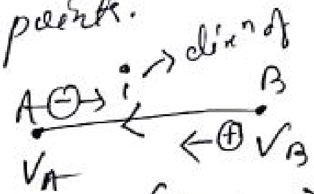
Electric Current:-

An electric current is the rate of flow of electric charge past a point or region.

Defⁿ

or An electric current is said to exist when there is a net flow of electric charge through a region. $\boxed{i = \frac{q}{t}}$, $\boxed{i_{instanteneous} = \frac{dq}{dt}}$

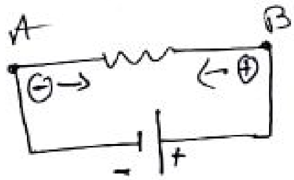
In electric circuits charge is carried by electrons moving through a wire when there exists a potential difference V between two point.



In order to get the continuous current the point B is always maintained with higher potential, & A at lower.

$(V_A < V_B)$

$V_B - V_A = V$



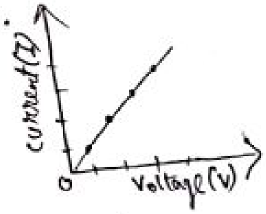
** Unit of i = ampere
Dimension = [A]

Ohm's law:-

It states that at a constant temperature the current passing through a conductor is directly proportional to the potential difference between the two ends of the conductor.

i.e. $\boxed{i \propto V}$ at constant T.

=> $\boxed{i = \left(\frac{1}{R}\right)V}$ —①



Where R is called Resistance of the conductor.

P-10-(2)

Note Resistance :-

The opposition offered by conductor to the current through it is called resistance.

Unit is SI - ohm,

$1\ ohm = \frac{1\ volt}{1\ amp}$, symbol is '$\Omega$'

Application of Ohm's law :-

(1) To determine the voltage, resistance or current of an electric circuit.

(2) Ohm's law is used to maintain the desired voltage drop across the electronic components.

(3) Ohm's law is also used in dc ammeter and other dc shunts to divert the current.

(4) Resistive circuits are analysed using the ohm's law.

(5) Ohm's law application ranges from household appliances like heaters to the high tension wires.

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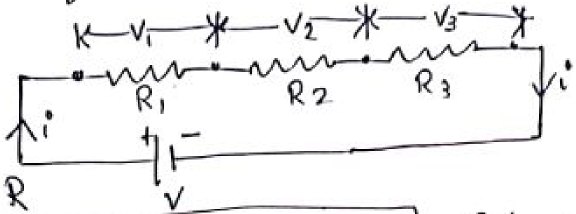
P-10-(3)

Combination of Resistors :-

(1) Series Combination:

No of resistors are said to be connected in Series if same current pass through all of them.



$\boxed{R_{equivalent} = R_1 + R_2 + R_3}$ (If 3 Resistors are given)

→ Unit of resistance is ohm (Ω)

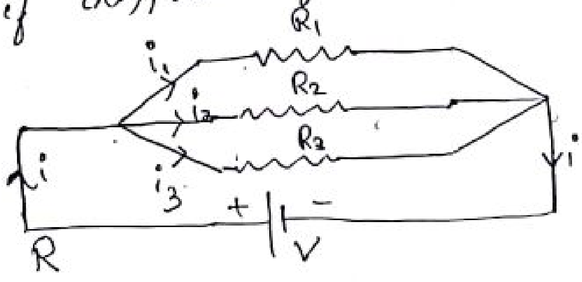
For 'n' number of resistors,

imp $\boxed{R_{equi} = R_1 + R_2 + R_3 + \dots + R_n}$ —— (1)

R_{equi} > individual resistances of each resistor.

(2) Parallel Combination :-

The no of resistances are said to be connected in parallel if different current pass through them.



$$\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$ → for 3 given resistors.

For 'n' number of resistors,

$$\boxed{\frac{1}{R_{equivalent}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}}$$ —— (2)

P-10-4

In parallel, Requivalent is < the individual resistances of each resistors.

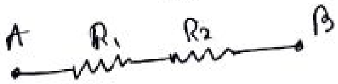
Summary :-

** In series combination total resistance of the circuit is always greater than individual resistances.

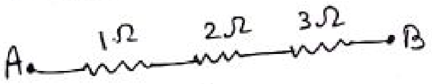
** In Parallel combination total resistance is always less than individual resistances.

Some Simple Numericals on finding Resistance of circuit.

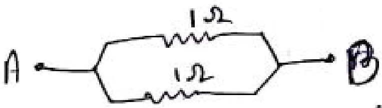
Find the effective / combined Resistances of the following:

(1) 

$R_{equi} = (R_1 + R_2)\,\Omega$

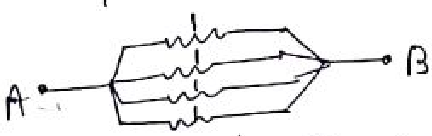
(2) 

$R_{equi} = 1+2+3 = 6\,\Omega$ (Ans)

(3) 

→ R_{equi}, can be found by using parallel combination of resistance..

$$\frac{1}{R_{equi}} = \frac{1}{1} + \frac{1}{1} = 2 \Rightarrow \frac{1}{R_{equi}} = 2 \Rightarrow R_{equi} = \frac{1}{2} = 0.5\,\Omega \text{ (Ans)}$$

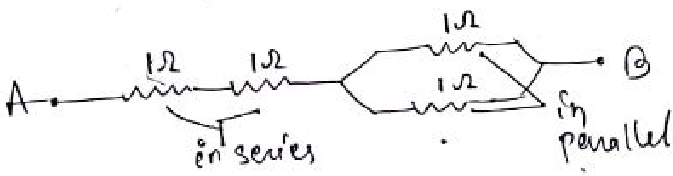
(4) 

here each resistance is 1Ω.

Find Requivalent?

$$\frac{1}{R_{equi}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \frac{1}{R_4} = \frac{1}{1} + \frac{1}{1} + \frac{1}{1} + \frac{1}{1} = 4$$

So $\frac{1}{R_{equi}} = 4 \Rightarrow R_{equi} = \frac{1}{4}\,\Omega$ (Ans)

(5) 

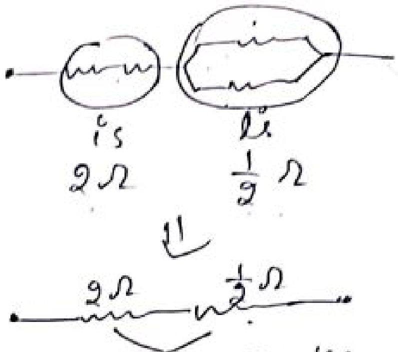
Find Requi?

$R_{equivalent\,series} = 1+1 = 2\,\Omega$

Now $\frac{1}{R_{equi}|_{parallel}} = \frac{1}{1} + \frac{1}{1} = 2 \Rightarrow R_{eq}|_{parallel} = \frac{1}{2}\,\Omega$

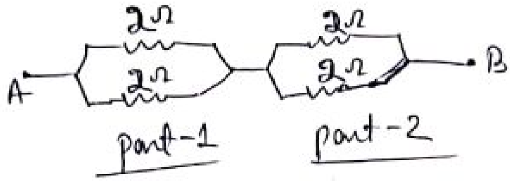
P - 10 - 5

Now in epw question 5.



So $R_{equi\ final} = 2 + \frac{1}{2} = \frac{5}{2}\,\Omega$. (Ans)

6



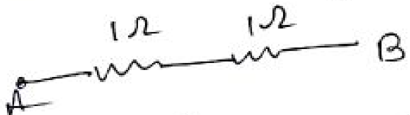
For part-1 in parallel, So $\frac{1}{R_{equi}|_{part 1}} = \frac{1}{2} + \frac{1}{2} = 1$

$\Rightarrow R_{equi}|_{part 1} = 1\,\Omega$

For part-2 in parallel, $\frac{1}{R_{equi}|_{part 2}} = \frac{1}{2} + \frac{1}{2} = 1$

So $R_{equi}|_{part 2} = 1\,\Omega$

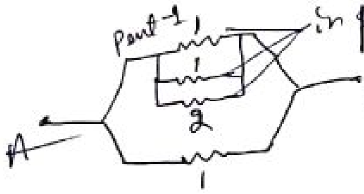
Now Re drawing the diagram,



(which one in series)

So $R_{equi} = 1 + 1 = 2\,\Omega$ (Ans)

7



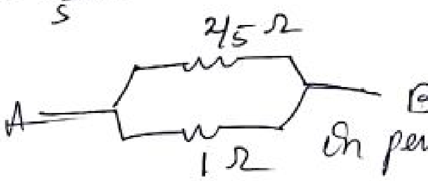
in parallel

each resistance is one (1Ω) & only one is 2Ω.

$$\frac{1}{R_{equi}|_{part 1}} = \frac{1}{1} + \frac{1}{1} + \frac{1}{2} = 2 + \frac{1}{2} = \frac{5}{2}\,\Omega$$

$R_{equi}|_{part 1} = \frac{2}{5}\,\Omega$.

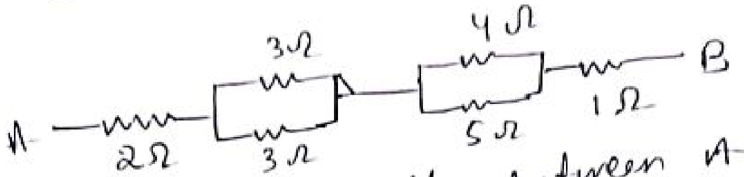
Now Re draw the diagram



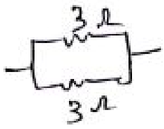
in parallel

So $\frac{1}{R_{equi}} = \frac{1}{\frac{2}{5}} + \frac{1}{1} = \frac{5}{2} + 1 = 7/2$ So $R_{equi} = \frac{2}{7}\,\Omega$

P – 10 (6)

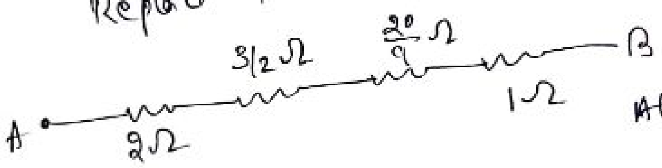
(8)  Find effective Resistance of circuit between A & B.

First solve the Two parallel part.

 $\Rightarrow \frac{1}{R_{equi}} = \frac{1}{3} + \frac{1}{3} = \frac{2}{3} \Rightarrow R_{equi} = \frac{3}{2}\,\Omega$

 $\Rightarrow \frac{1}{R_{equi}} = \frac{1}{4} + \frac{1}{5} = \frac{9}{20} \Rightarrow R_{equi} = \frac{20}{9}\,\Omega$

Replace the circuit with $3/2\,\Omega$ & $\frac{20}{9}\,\Omega$

 All are in series so

$R_{equi} = 2 + 3/2 + \frac{20}{9} + 1 = \frac{36 + 27 + 40 + 18}{2 \times 9} = \frac{121}{18} = 6.72$

So final answer is R_{equi} (betn A & B) is $6.72\,\Omega$.

Imp (9) Sometimes the question will be given in sentence form and you have to draw the diagram then solve.

Ex:- Find the combined resistance of the circuit where two resistances of $1\,\Omega$ are in series and 3 other of $2\,\Omega$ are in parallel with them.

Soln This can be solved by properly understanding the language (English).

correct circuit is important because after than u can solve it.

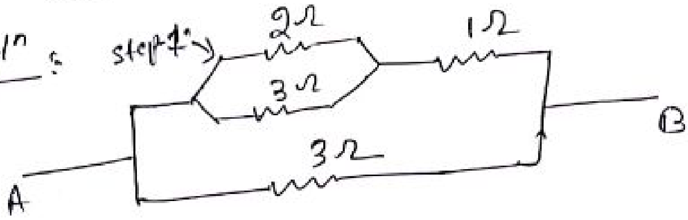
$\frac{1}{R_{11r}} = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} = \frac{3}{2}$

$R_{11r} = \frac{2}{3}\,\Omega$. Now $R_{equi} = 1 + 1 + \frac{2}{3} = \frac{8}{3}\,\Omega$ (Ans)

P-10-(7)

(10) Find the resistance of a circuit in which two resistors of 2Ω and 3Ω in parallel and in series with 1Ω resister and the total combination is in parallel with 3Ω resister.

Sol^n: step 1:

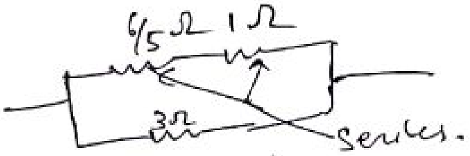


Here 1st draw the sentence 2Ω & 3Ω in parallel. Then attach with 2nd sentence in series with 1Ω resister. Then find the total is in $\parallel^r$ with 3Ω.

$$\frac{1}{R_{\parallel^r \text{step-1}}} = \frac{1}{2} + \frac{1}{3} = \frac{5}{6}$$

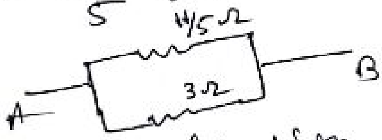
$$\Rightarrow R_{\parallel^r \text{ step-1}} = \frac{6}{5}\Omega$$

Now Redraw



So $R_{series} = 6/5 + 1 = \frac{11}{5}\Omega$

Now Redraw



$R_{equi}|_{final}$ = is the parallel combination

$$\frac{1}{R_{equi}} = \frac{1}{11/5} + 1/3 = \frac{5}{11} + \frac{1}{3} = \frac{15+11}{33} = \frac{26}{33}$$

So $R_{equi}|_{final} = \frac{33}{26}\Omega$ (Ans).

** Practice well to get the best results in examination.

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P-10-(8)

Kirchhoff's law in Electric Circuits:-

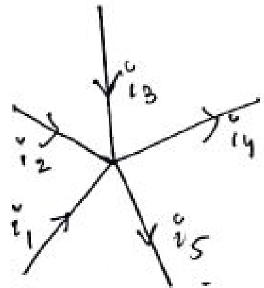
Kirchhoff's gave two laws in connection with electric circuit.

① - **Kirchhoff's current law or kirchhoff's first law** :- (KCL)

It states that the algebric sum of the current meeting at a junction is always zero. i.e. $\boxed{\Sigma i = 0}$

Explanation

In order to find algebric sum of the following conversion is taken in to account.



→ Current towards the junction is taken +ve.

→ Current directed away from junction is taken -ve.

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

$\Rightarrow i_1 + i_2 + i_3 = i_4 + i_5$

i.e. Total incoming current is equal to the total outgoing current. This is based upon the principle of law of conservation of charge.

P-10-9

② – Kirchhoff's Second law or Kirchhoff's voltage law (KVL) :-

It states that in a close electric circuit the algebric sum of emf and potential drop across the resistor is always zero.

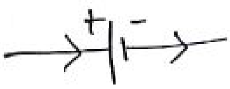
i.e. Sum of the EMF + Sum of potential drop = 0

Mathematically :-

$$\boxed{\Sigma emf + \Sigma iR = 0}$$

Sign Convension :-

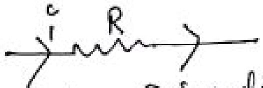
①  (+ve E) (i enter the -ve terminal & leaves +ve terminal then Emf (+ve)

②  (-ve E) (i enters +ve terminal & leaves +ve terminal emf is (-ve)

③ 

→ direction of travel (when direction of travel is along the direction of current ($iR = -ve$)

(iR is -ve)

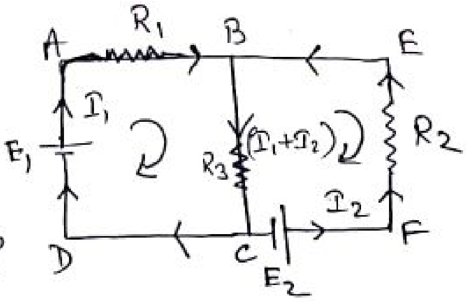
④ 

← Direction of travel (when direction of travel is opposite to i direction.

(iR is +ve) (iR = +ve)

Explanation :-

Applying KVL in "ABCDA" loop



$$E_1 + (-I_1R_1) - (I_1+I_2)R_3 = 0$$

Applying KVL in "BCFEB" loop

$$E_2 + I_2R_2 + R_3(I_1+I_2) = 0$$

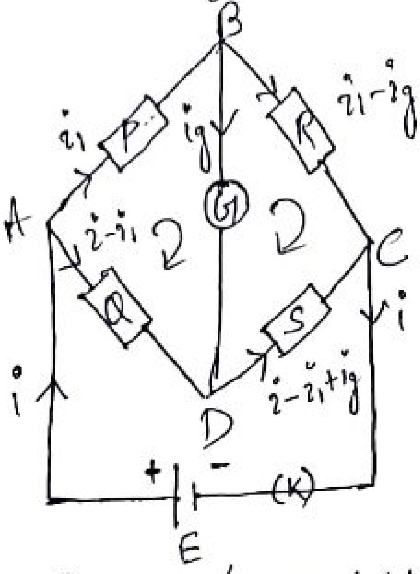
P-10-(10)

Imp

Application of Kirchhoff's law (Wheatstone Bridge)

Wheat-stone bridge is an electronic network used to determine the unknown resistance

Circuit arragement:-



Four resistances P, Q, R & S are connected in four arms of a bridge shaped Square ABCD. A battery with emf E is connected between A & C through key(K). A galvanometer with resistance G is connected between B & D. The current through each branch obtained by applying Kirchhoff's first law.

So Applying KVL in Mesh ABDA.

$$-i_1P - i_gG + (i-i_1)Q = 0$$

$$\Rightarrow i_1P + i_gG - (i-i_1)Q = 0 \quad -(1)$$

Applying KVL in mesh BCDB

$$-(i_1-i_g)R + (i-i_1+i_g)S + i_gG = 0$$

$$\Rightarrow (i_1-i_g)R - (i-i_1+i_g)S - i_gG = 0 \quad -(2)$$

By adjusting the known resistance the current through galvanometer is made zero (Bridge is balanced)

i.e. $i_g = 0$, eq^n (1) reduces to $i_1P - (i-i_1)Q = 0$

$$i_1P = (i-i_1)Q \quad -(3)$$

eq^n (2) reduces to $i_1R - (i-i_1)S = 0$

$$\Rightarrow i_1R = (i-i_1)S \quad -(4)$$

P-10-(11)

Dividing eqn (3) by eqn (4)

$$\frac{i_1 P}{i_1 R} = \frac{(i - i_1) Q}{(i - i_1) S}$$

$$\Rightarrow \frac{P}{R} = \frac{Q}{S}$$

$$\Rightarrow \boxed{\frac{P}{Q} = \frac{R}{S}}$$

This is the balanced condition of wheatstone bridge.

Unit-11 Electromagnetism & Electromagnetic Induction

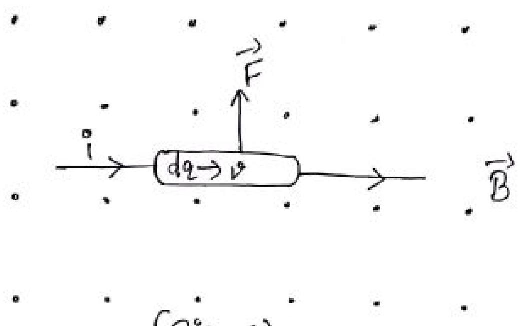
Electromagnetism :-

It is the study of the electromagnetic force, one of the four fundamental forces of nature. It includes the electric force, which pushes all charged particles, & the magnetic force, which only pushes moving charges.

The phenomenon of production of electricity due to magnetism is called electromagnetic induction.

It was observed by faraday that whenever magnetic flux linked with a circuit changes, an emf is induced in the circuit.

Force on a current carrying conductor place in a uniform magnetic field :-



(fig-a)

consider a conductor of length l, carrying a current i, placed in a uniform magnetic field $\vec{B}$ directed inward.

Let dq be a small amount of +ve charge that flow with velocity $\vec{v}$ inside the conductor.

P-11-②

Then force on the charge dq.

$$d\vec{F} = dq\,(\vec{v} \times \vec{B}) \quad \text{—①}$$

Let the charge covers a displacement $d\vec{l}$ in time $d\vec{t}$.

The $\vec{v} = \dfrac{d\vec{l}}{dt}$

$$\therefore d\vec{F} = dq\left(\frac{d\vec{l}}{dt} \times \vec{B}\right)$$

$$= \frac{dq}{dt}\,(d\vec{l} \times \vec{B})$$

$$\Rightarrow d\vec{F} = i\,(d\vec{l} \times \vec{B}) \quad \text{—②}$$

Now the total force on the conductor

$$\vec{F} = \int d\vec{F}$$

$$= \int i\,(d\vec{l} \times \vec{B})$$

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

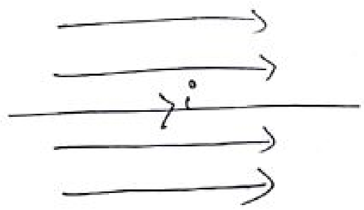
or $\boxed{F = ilB \sin\theta \; (\hat{n})}$

the magnitude of force is given by

$$F = ilB \sin\theta$$

$\boxed{\text{case 1}}$:- $\theta = 0^\circ$, $\sin 0 = 0$, $\boxed{F = 0}$ (minimum)

i.e. no force is experiences by a current carrying conductor held parallel to the magnetic field.



$\boxed{\text{Case-2}}$ If $\theta = 90$, $\sin\theta = 1$

$\therefore F = ilB$ (Maximum)

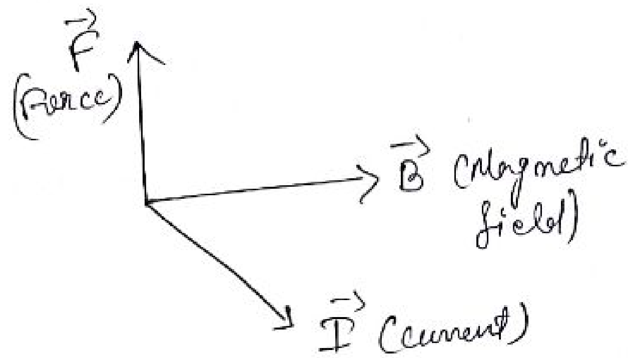
So Maximum force is experience by a current carrying conductor held $\perp$ to the magnetic field.

The direction of force can be obtained either from cross product rule or from Fleming's left hand rule.

Fleming's Left hand Rule:-

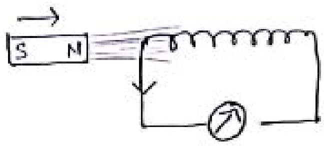
Stretch first finger, middle finger and thumb of your left hand in mutually perpendicular directions, the first finger represents the direction of magnetic field, the middle finger represents the direction of current in the conductor, then thumb represents the direction of force experienced by the conductor.

In our case the direction of force is upward as shown in figure (a).

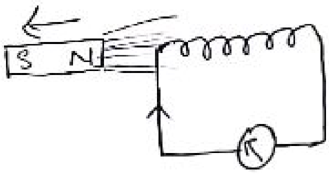


Faraday's Experiment :-

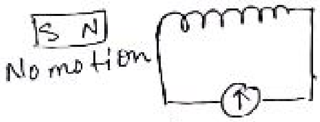
When a bar magnet with north pole is taken nearer to the coil, The Galvanometer (G) shows the deflection in one direction.



When a bar magnet with north pole is taken away from the coil. The G shows the deflection in opposite direction.



When the motion of the magnet is stopped, the G shows no deflection.



Faraday's laws of electromagnetic Induction :-

Faraday gave 3 laws in electromagnetic Induction.

(1) When ever a coil is linked with change in magnetic flux, an emf & hence a current is induced in coil.

(2) The induced emf continue to exist in the coil so long as it is linked with a change in magnetic flux.

P - 11 - (5)

(3) The emf induced in the coil is directly proportional to the -ve rate of change of magnetic flux.

$$e \propto -\frac{d\phi_B}{dt}$$

$$\Rightarrow \boxed{e = -k\frac{d\phi_B}{dt}}$$

The units of e, ϕ_B, t are so choosen that $k=1$

$$\therefore \boxed{e = -\frac{d\phi_B}{dt}}$$

If a coil has 'N' no of ~~turns~~ then $\boxed{e = -N\frac{d\phi_B}{dt}}$

Lenz's law

It gives the direction of induced emf.

It states that the direction of induced emf is such that it opposes the very cause which produces it.

The Lenz's law is accordance with the law of conservation of energy.

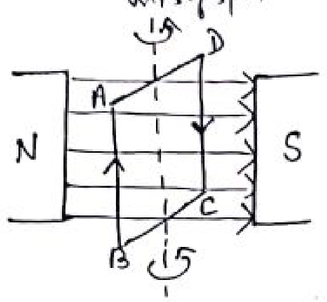
That is why "-ve" sign used in faraday's law.

Flemings right hand Rule:-

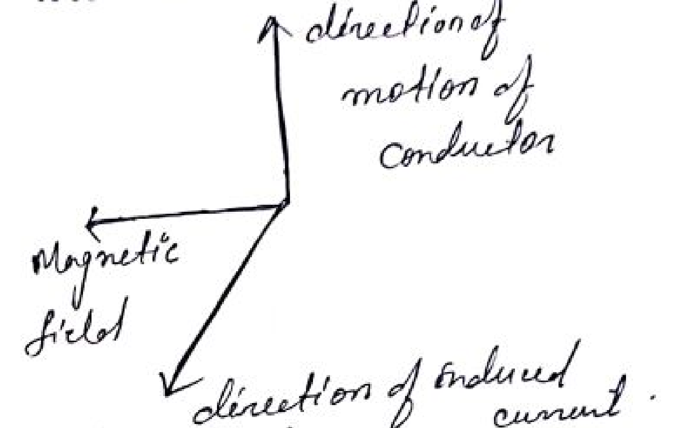
When a conductor moves inside a magnetic field, there will be an induced current in it. If this conductor gets forcefully moved inside the magnetic field, there will be a relation between the direction of applied force, magnetic field & current.

P-11-(6)

Fleming's right-hand rule is applied to determine the direction of the emf generated in a moving conductor when the direction of the magnetic field & the direction of motion of the conductor in the field are known.



Fig(a)



Fig(b)

** Note that fig(a) & fig(b) are independly drawn.
The direction of field shown in fig(a) is from N → S.
In fig(b) the direction of magnetic field is towards left.
Both figure are different, no connection.

Statement [Fleming's right hand rule]

It states that, if you stretch first finger, central finger & the thumb of your right hand in three mutually perpendicular directions, then the first finger points towards the magnetic field, thumb points towards the direction of motion of conductor, the direction of central finger gives the direction of induced current setup in the conductor.

P-11-(7)

Distinction between the Fleming's left hand rule & right hand rule :-

Fleming's Left Hand Rule	Fleming's Right Hand Rule
(1) This rule is applicable to find the direction of force experienced by a current carrying conductor placed in a magnetic field or the direction of motion of the conductor.	(1) This rule is applicable to find the direction of current induced by the motion of a conductor placed in a magnetic field.
(2) Left hand is used for this purpose.	(2) Right hand is used for this purpose.
(3) This rule is the basic principle of motor.	(3) This rule is the basic principle of generator.
(4) Input (known or given) is First/Four finger - direction of magnetic field. Middle/central finger - Current. Output (To be determined) is Thumb - Direction of force or motion of conductor.	(4) Input (known or given) is First/four finger :- Direction of magnetic field. Thumb :- Direction of motion of conductor. Output (To be determined) is Middle/central finger → Direction of Induced current.

Babita Parhi (Lect. in physics)

Unit-12 (Modern physics)

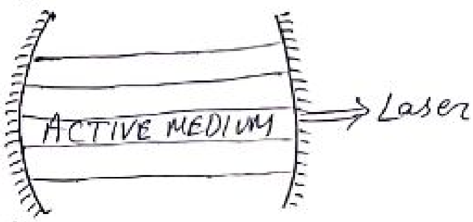
The name LASER stands for :-

L - Light
A - Amplification by
S - Stimulated
E - Emission of
R - Radiation

A laser beam is extremely intense, coherent and highly parallel beam of light. A device which produces this kind of beam is quite often called a Laser.

Principle of LASER SYSTEM

Every laser system consists of an active-medium (solid,
liquid or a gas) having ions/molecules or atoms possessing at
least one meta stable state. The active medium is
placed in resonating cavity having reflectors at it's ends &
an electrical or optical pump to excite the atom of the
medium. The diagram is given in figure ⓐ



Resonating cavity
fig ⓐ

The basic principle of all lasers is to first bring about population inversion, i.e. to have more atoms in the meta-stable state than that in ground state. This is done by supplying suitable energy to the atoms of the active medium with help of a pump.

This process of bringing about population inversion is known as pumping. Out of these many atoms in the meta-stable state, one atom somewhere happens to de-excite emitting a photon known as fluorescent photon.

As this photon happens to pass nearby other atoms, in similar metastable states, stimulates them to de-excite to emit similar photons which in turn make other atoms to deexcite. Before these photons escape from the active medium, they are made to move to and fro in the medium several times a second by relections so as to build up an intense beam of photons by de-exciting more & more atoms of the medium. All photons emitted in this way are found to possess same frequency, dirⁿ & speed as that of primary photon or stimulation photon. This constitutes a laser beam. the pumping is continued to get continuous supply.

Properties of laser beam :-

① Directionality
② Intensity
③ Mono-chromaticity
④ Coherence

These properties are briefly described below.

① Directionality :- Light emitted from conventional sources spread in all directions and to obtain narrow beam of light we make use of circular or rectangular apertures in front of sources.

P-12-(3)

Too much spreading is due to diffraction effects of light. Laser on the other hand, is emission only in one direction. Beam coming from an aperture of diameter 'd' continues moving parallel beam upto distance $\approx d^2/\lambda$, after diffraction effects make it to spread.

If $d = 5$ cm & $\lambda = 6943$ Å, then the laser beam of this wavelength remains parallel upto distance of order of 3.6km from source.

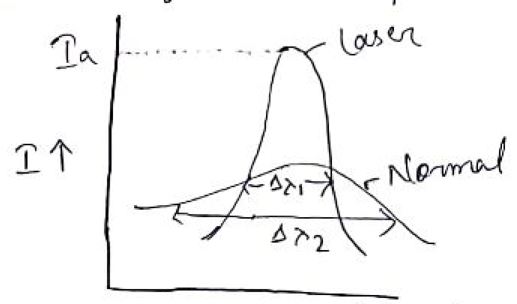
Thus laser beam is highly parallel & directional.

(2) Intensity:-

As the laser beam has the ability of focus over as small as area as 10^{-6} cm^2, so it is highly intense beam. For example a 1 watt laser when focussed over an area 10^{-6} cm^2, has intensity 10^6 watt/cm^2 whereas ordinary 100 watt lamp will not have intensity even of this. Because the light from lamp can't be focussed over an area less than a cm^2.

(3) Monochromaticity:-

Light emitted from a laser is vastly more monochromatic than that emitted from a conventional mono-chromatic sources of light. Monochromaticity is determined by the spread of wavelength around the wavelength corresponding to which intensity is at the peak. It is measured in terms of line width ($\Delta\lambda$) - which is the width of line on λ-I graph at which the intensity becomes half the peak intensity shown (fig-a).



Line width of laser beam
(fig-a)

(4) Coherence: The laser light is highly coherent in space & time. This property enables us to realise a tremendous spatial concentration of light power.

Applications of LASER:-

Laser have many important application:-

* They are used in common consumer devices such as optical disk drives, laser printers, & barcode scanners.
* Laser are used for both fibre optic & free-space optical communication.
* They are used in medicine for laser surgery and various skin treatments.
* Laser are used in industry for cutting and welding materials.
* They are used in military and law enforcement devices for marking targets & measuring range & speed.
* Laser lighting displays use laser light as an entertainment medium.

Wireless Transmission:-

(a) Ground wave :-

A ground wave is a radio wave that travels along earth's surface due to diffraction

It travels better over a conductive surface such as sea water.

It losses increases with increasing frequency - not very effective above 2MHz.

Ground wave is a method of radio wave propagation that uses area between surface of the earth & ionosphere for transmission.

P-12-(5)

(B) Space wave

A space wave can be classified as a direct wave (Line-of-sight) or ground reflected wave.
Because of diffraction, a direct space wave can travel 4/3 greater than line-of-sight.

Definition:-
Space wave propagation is defined for the radio waves that occur within 20km of the atmosphere i.e. troposphere
Comprising of a direct & reflected waves.
These waves are also known as tropospheric propagation as they can travel directly from the earth's surface to the troposphere surface of the earth.

(C) Sky-wave propagation:-
A sky wave is a radio wave that is radiated from a transmitting antenna in a direction towards the ionosphere.
-> waves bounce between the ionosphere via refraction & the ground via reflection.
-> Skywave propagation refers to the propagation of radio waves reflected or refracted back toward earth from the ionosphere (charged layer of upper atmosphere), when high frequency signals enter the ionosphere obliquely, they are back-scattered from the ionized layer as scatter waves.