LECTURE NOTE

PREPARED BY

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DEPT.- MATH & SC.

Lecturer Note - UNIT - I UNITS & DIMENSIONS Engineering Physics -

1.1 Physical quantities A quantitative description of any physical phenomena always involves certain measurable quantities in terms of which the laws of Physics are invariably expressed. Such quantities like force, velocity, the density, charge, temp. and host of others are called observable or physical quantity.

1.2 Fundamental & Derived unit The defination of a physical quantity which is based on a specific procedure of measurement of that quantity is called operational defination.

Certain quantities like length, mass, time, current which can be defined only with operational definations are called fundamental quantities.

On the otherhand those quantities like volume, speed, whose defining operations are based on the use of some other physical quantities are called derived quantities.

1.3 CGS (french System) 1 cm, 1 gm, 1 second
MKS (metric System) 1 m, 1 kg, 1 second
SI Standard internation

Fundamental units.

				Derived units	
(i)	mass	kilogram	kg	velocity	$\frac{m}{second}$
(ii)	length	meter	m		
(iii)	time	Second	S	acceleration	$\frac{m}{sec^2}$
(iv)	electric current	ampere	A		
(v)	Temperature	Kelvin	K.	Force	Kg m sec^{-2}
(vi)	luminosity	Candela	cd.		
(vii)	amount of substance	mole	mol	momentum	Kg m sec^{-1}

1.3 Dimension & Dimension formula

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

Dimensional formula - A dimensional formula is an expression which shows how and which of the fundamental units enter into the units of a physical quantity.

e.g. Area = $[M^0 L^2 T^0]$

acceleration = $[M^0 L^1 T^{2}]$

1.4 Dimensional equations & Principle of homogeneity

Dimensional analysis has been put to following three uses

(i) To convert values of a physical quantities

(ii) To check the correctness of a given relation

(iii) To derive relation betn various physical quantity.

Principle of homogeneity - It states that the dimensional formula of every term on the two sides of a correct relation must be same.

1.5 Checking the dimensional correctness of physical relations

To check the correctness of a given relation, we find the dimensional formula of every term on either side of the relation. If the dimensions are identical, the relation is said to be corr

e.g.

$$S = ut + \frac{1}{2}at^2$$

$$S = [L]$$

$$ut = [LT^{-1}][T] = [L]$$

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

eqn is correct dim....

UNIT-2 SCALARS & VECTORS

2.1 Scalar & vectors quantities, representation, types of vector

Scalar quantities are those quantities which require only magnitude for their complete specification.

e.g. mass, length, volume, density

Vector quantities are those quantities which require magnitude as well as direction for their complete specification.

e.g. Displacement, velocity, acceleration.

representation.

(i) Draw a parallel line to the direction of vector

(ii) Cut a length of the line so that it represents the magnitude of the vector on a certain convenient scale.

(iii) Put an arrow head in the direction of the vector

Types

(I) Null vector. zero magnitude. arbitrary direction. represented by a point.

(II) Equal vectors. If they posses same magnitude & direction

(III) Negative vectors having same length but opposite direction

(IV) co-initial vectors common initial point

(V) collinear vectors common line of action

Parallel vectors (acting in same direction)

antiparallel vectors (acting in opposite direction)

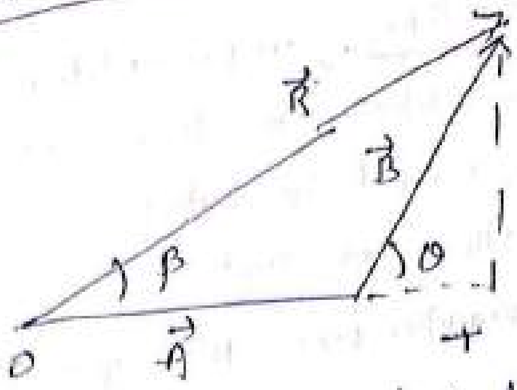
(VI) coplanar vectors vectors situated in one plane

(VII) Localised vectors Initial point is fixed

(VIII) Non localised vector Initial point is not fixed

2.2 Triangle & Parallelogram Law of vector addition

(I)

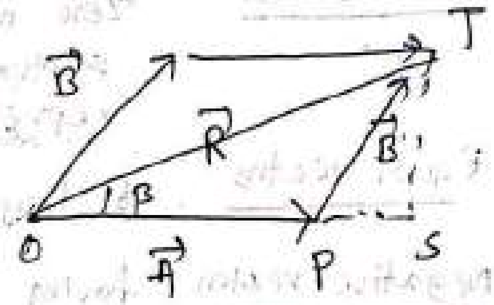


If two vectors are represented by the two sides of a triangle, taken in same order, then their resultant is represented by the third side of the triangle taken in opposite order.

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

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

(II)



It states that, if two vectors acting simultaneously at a point are represented in magnitude and direction by the two sides of a parallelogram drawn from a point their resultant is given in magnitude and direction by the diagonal of the parallelogram passing through that point.

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

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

2.3. Resolution of vectors

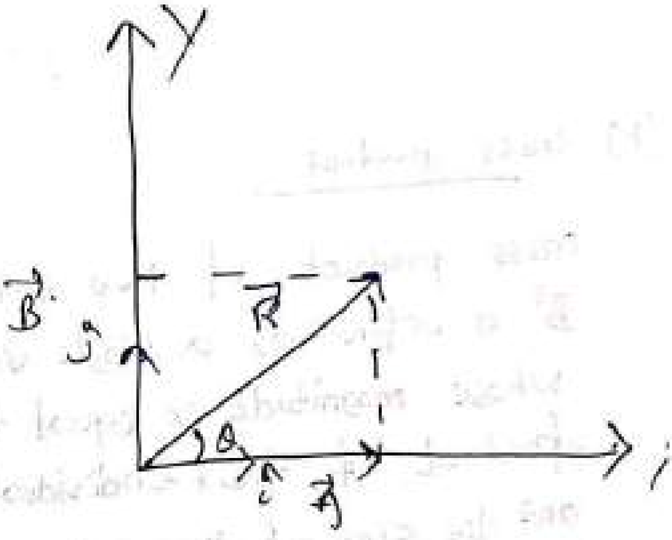
Resolution of vectors is the process of obtaining the component vectors which when combined according to the laws of vector addition, produce the given vector.

Rectangular components: Rectangular components of a given vectors are its components in two mutually ⊥r directions in the plane of the given vectors.

$x = R\cos\theta$

$y = R\sin\theta$

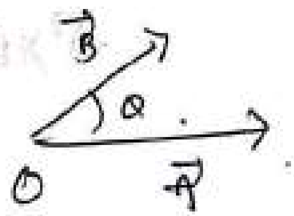
$\vec{R} = (R\cos\theta)\hat{i} + (R\sin\theta)\hat{j}$



Vector multiplication

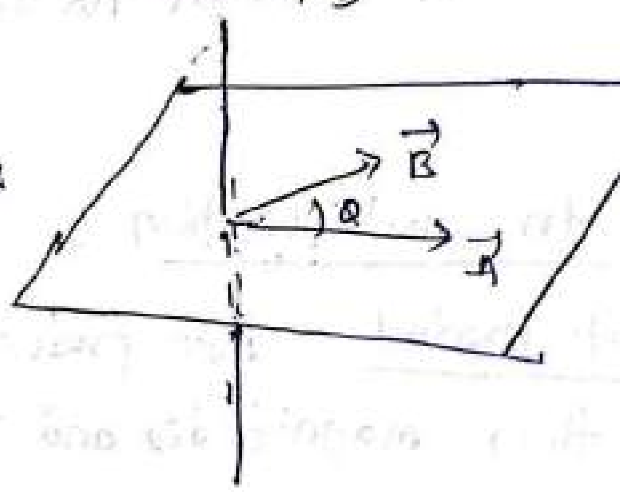
(1) Dot product: Dot product of two vectors is defined as the pro[duct] of their magnitudes and the cosines of the smaller angle between the two.

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



(b) cross product

cross product of two vectors $\vec{A}$ & $\vec{B}$ is defined as a single vector $\vec{C}$ whose magnitude is equal to the product of their individual magnitude and the sine of the smaller angle between them and is directed along the normal to the plane containing $\vec{A}$ & $\vec{B}$



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

UNIT-3 KINAMATICS Engineering Physics:-

3.1 Concept of Rest & Motion

A body is said to be at rest if it doesnot change its position wrt its surroundings.

A body is said to be in motion if it changes positions wrt its surroundings.

3.2 Displacement, Speed, velocity, Acceleration, force.

(A) Displacement of a body is a vector connecting the initial and final positions of the body and directed away from initial towards the final position

(B) Speed of a body is defined as the distance covered by the body in one second.

Average Speed = $\frac{\Delta s}{\Delta t}$

Instantaneous Speed $= \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$

(C) Velocity of a body is defined as the rate of change of displacement.

Average velocity = $\vec{v}_{av} = \frac{\vec{x}_2 - \vec{x}_1}{t_2 - t_1} = \frac{\Delta \vec{x}}{\Delta t}$

instantaneous velocity $\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{x}}{\Delta t} = \frac{d\vec{x}}{dt}$

(I) Uniform velocity - velocity of a body is said to be uniform if it covers equal displacements in equal interval of time.

(II) Non-uniform velocity - Velocity of a body is said to be non-uniform if it covers unequal displacement in equal interval of time.

D) Acceleration is second order derivative of displacement.

$\vec{a} = \frac{d\vec{v}}{dt}$ $\vec{v} = \frac{d\vec{x}}{dt}$

$= \frac{d^2\vec{x}}{}$

(E) Quantitatively force is defined as the product of mass of a body and acceleration of that body.

quantity	formula	dimension	CGS	SI
Displacement	$\vec{S}$	L	cm	m
Speed	v	LT^{-1}	$cm\,s^{-1}$	$m s^{-1}$
velocity	$\vec{u} = \frac{d\vec{s}}{dt}$	LT^{-1}	$cm\,s^{-1}$	$m s^{-1}$
Acceleration	$\vec{a} = \frac{d\vec{u}}{dt}$	LT^{-2}	$cm\,s^{-2}$	$m s^{-2}$
Force	$\vec{F} = m\vec{a}$	MLT^{-2}	$g\,cm\,s^{-2}$	$kg\,m\,s^{-2}$

3.3 Equations of Motion under Gravity

"a replaced with g"

$v = u + gt$ velocity - time relⁿ

$s = s_0 + ut + \frac{1}{2}gt^2$ Displacement - time relation

$v^2 = u^2 + 2gs$ Velocity - Displacement relation

$s_{nth} = u + \frac{g}{2}(2n-1)$ = Displacement in 'nth' second

3.4 Circular motion : Angular displacement, Angular velocity Angular acceleration.

A body is said to be move in circular motion if it moves in such a way that its distance from a fixed point always remains constant. "For direction follow right hand thumb rule" or "screw rule".

Angular displacement of a particle undergoing rotational motion is defined as the angle turned by its radius vector. For Direction - follow "right hand thumb rule" "Screw rule".

Angular velocity ($\vec{\omega}$) of a particle undergoing rotational motion is defined as the rate of change of angular displacement with time.

$$\vec{\omega}_{av} = \frac{\Delta\vec{\theta}}{\Delta t} = \frac{\vec{\theta}_2 - \vec{\theta}_1}{t_2 - t_1}$$

$$\vec{\omega}_{inst} = \lim_{\Delta t \to 0} \frac{\Delta\vec{\theta}}{\Delta t} = \frac{d\vec{\theta}}{dt}$$

Angular acceleration (α) of a body is defined as the rate of change of angular velocity with time.

$$\vec{\alpha}_{av} = \frac{\vec{\omega}_2 - \vec{\omega}_1}{t_2 - t_1}$$

$$\vec{\alpha}_{inst} = \lim_{\Delta t \to 0} \frac{\Delta\vec{\omega}}{\Delta t} = \frac{d\vec{\omega}}{dt}$$

quantity	formula	dimension	CGS	SI
Ang displacement	$\Delta\theta$	~~radian~~		radian
Ang velocity	$\vec{\omega} = \frac{d\vec{\theta}}{dt}$	s^{-1}		radian s^{-1}
Ang acceleration	$\vec{\alpha} = \frac{d\vec{\omega}}{dt}$			radian s^{-2}

3.5 Relation between – Linear & Angular velocity
Linear & Angular acceleration.

$$S = r\theta$$

$$\Delta S = r\Delta\theta$$

$$\frac{\Delta S}{\Delta t} = r\frac{\Delta\theta}{\Delta t}$$

$$\lim_{\Delta t \to 0} \frac{\Delta S}{\Delta t} = r\lim_{\Delta t \to 0} \frac{\Delta\theta}{\Delta t}$$

$$\boxed{V = r\omega}$$

$$v = r\omega$$

$$\Delta v = r\,\Delta\omega$$

$$\frac{\Delta v}{\Delta t} = r\frac{\Delta\omega}{\Delta t}$$

$$\lim_{\Delta t \to 0}\frac{\Delta v}{\Delta t} = \lim_{\Delta t \to 0} r\frac{\Delta\omega}{\Delta t}$$

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

3.6 Projectile .. Examples

A body projected into the space and is no longer being propelled by fuel is called a projectile.

Examples
(i) A bullet is fired from a gun
(ii) A cricket ball thrown into space.
(iii) A bomb or a small bag dropped from an aeroplane

3.7 Expression.

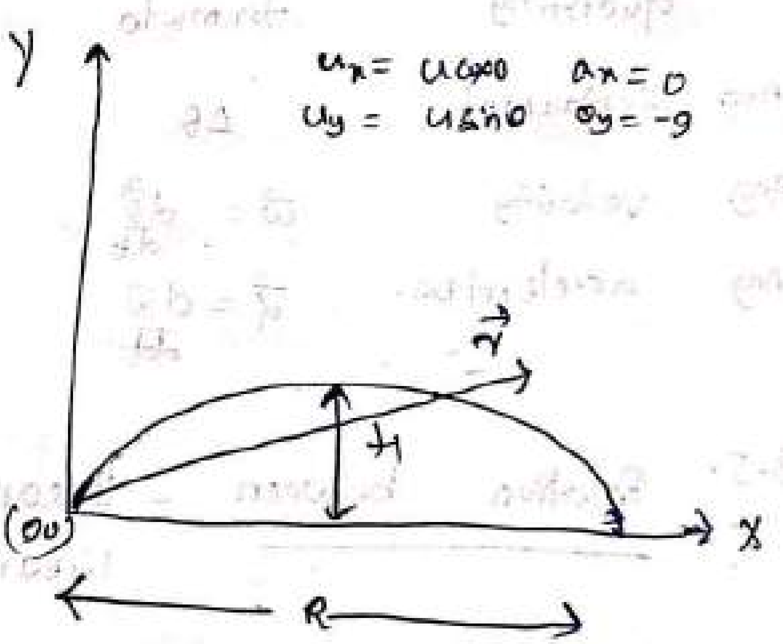
(A) Equation of trajectory

$$\vec{r} = x\hat{i} + \hat{j}y. \quad \text{—— (I)}$$

$$x = x_0 + u_x t + \frac{1}{2}a_x t^2$$

$$x = 0 + (u\cos\theta)t + 0$$

$$\boxed{x = u\cos\theta\, t} \quad \text{—— (II)}$$



$$y = y_0 + u_y t + \frac{1}{2}a_y t^2$$

$$= 0 + u\sin\theta\, t + \frac{1}{2}(-g)t^2$$

$$y = u\sin\theta \frac{x}{u\cos\theta} - \frac{1}{2}g\frac{x^2}{u^2\cos^2\theta}$$

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

(b) Time of flight

$v_y = u_y + a_y t$ $\qquad$ $v_y = 0$

$0 = u\sin\theta + (-g)\frac{T}{2}$ $\qquad$ $T = \frac{T}{2}$

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

(c) maximum height

$$H = y_{max} = \left(y_0 + u_y t + \frac{1}{2} a_y t^2\right)_{max}$$

$$= 0 + u\sin\theta \frac{T}{2} + \frac{1}{2}(-g)\left(\frac{T}{2}\right)^2$$

$$= u\sin\theta \frac{2u\sin\theta}{2g} - \frac{g}{2}\frac{4u^2\sin^2\theta}{4g^2}$$

$$\boxed{H = \frac{u^2\sin^2\theta}{2g}}$$

(d) Horizontal Range

$$R = x_{max} = \left(x_0 + u_x t + \frac{1}{2} a_x t^2\right)_{max}$$

$$= 0 + u\cos\theta\, t + 0$$

$$= u\cos\theta \frac{2u\sin\theta}{g}$$

$$\boxed{R = \frac{u^2\sin 2\theta}{g}}$$

Condition for maximum R

$\sin 2\theta$ = maximum

$\sin 2\theta = 1$

$\sin 2\theta = \sin 90$

$2\theta = 90$

$\boxed{\theta = 45}$

Questions to be asked in the Examination;

i) Establish the relation between v, ω & r and a, α and r.

ii) For what value of 'θ' Range of projectile will be maximum.

iii) Problem based on T, R and H.

UNIT-4 WORK & FRICTION

4.1 Work - Defination, formula & SI units

Work is said to be done if a force acting on a body, displaces the body through a certain distance and the force has some component along the displacements.

$$W = \vec{F} \cdot \vec{S}$$
$$= |\vec{F}||\vec{S}| \cos\theta$$
$$= F_x\hat{i} + F_y\hat{j} + F_z\hat{k} \cdot x\hat{i} + y\hat{j} + z\hat{k}$$
$$= xF_x + yF_y + zF_z$$

- CGS. SI

1 erg = $1 g\ cm^2 s^{-2}$ 1J = $1 kg\ m^2 s^{-2}$

$$\boxed{1J = 10^7 erg}$$

4.2 friction - Defination, concept

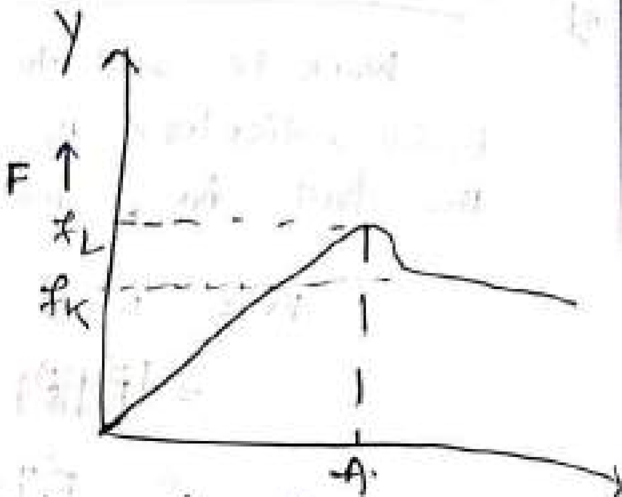
friction is the phenomenon by virtue of which an opposition comes into play between two surfaces when one tends to slide | roll over the other.

force of friction is the force, which comes in to play between two surfaces when one tends to slide | roll over the other.

4.3 Types of friction (static, dynamic), Limiting friction

Static friction is the force of friction between two surfaces so long as there is no relative motion between them.

Limiting friction is the maximum value of force of friction between two surfaces so long as there is no relative motion between them.



Dynamic or Kinetic friction is the friction which comes into play between two surfaces when there is some relative motion between them.

44 Laws of limiting friction

(i) The direction of force of friction is always opposite to the direction of motion.

(ii) The force of limiting friction depends upon the nature of the surface and state of polish of the surfaces in contact and acts tangentially to the surface / interface ~~between the two surface~~.

(iii) The magnitude of limiting friction 'F' is directly proportional to the magnitude of the normal reaction R between the two surfaces in contact ie.

$$F \propto R.$$

(iv) the magnitude of limiting friction between two surfaces is independent of the area and shape of the surfaces in contact so long as the normal reaction remains the same

4.5 <u>co-efficient of friction (μ)</u>

co-efficient of fricton of a pair of surface in contact is defined as the ratio between the limiting friction F to the normal reaction R

$$\mu = \frac{F}{R}$$

4.6 <u>methods to reduce friction</u>

(i) By rubbing and polishing.

(ii) By lubricants

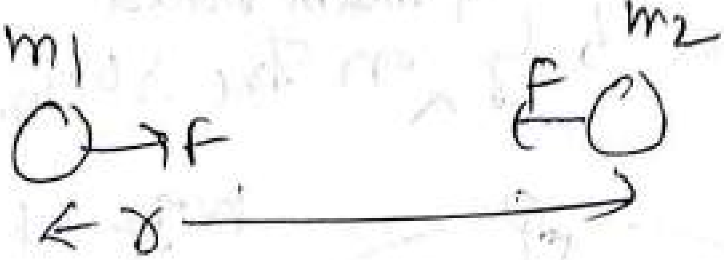
(iii) By converting sliding into rolling friction

(iv) By streamlining.

Unit-5 Gravitation

5.1 - Newton's law of Gravitation:-

The force of Every body attract each other with a force which is directly proportional to the product of their masses & inversely proportional to the square of the distance between them.



$$\boxed{F = G\frac{m_1 m_2}{r^2}}$$

G = universal gravitational const

$= 6.67\times10^{-11}\ \frac{N\times m^2}{kg^2}$

5-2 Universal Gravitational Const

gravitational constant is numerically equal to the force of attraction betn two masses of 1kg each placed at a distance of 1m from each other

$$\boxed{G = \frac{F r^2}{m_1 m_2}} = \frac{N\times m^2}{kg^2}.$$

If $m_1 = m_2 = 1kg$, $r = 1m$ $\boxed{G = F}$

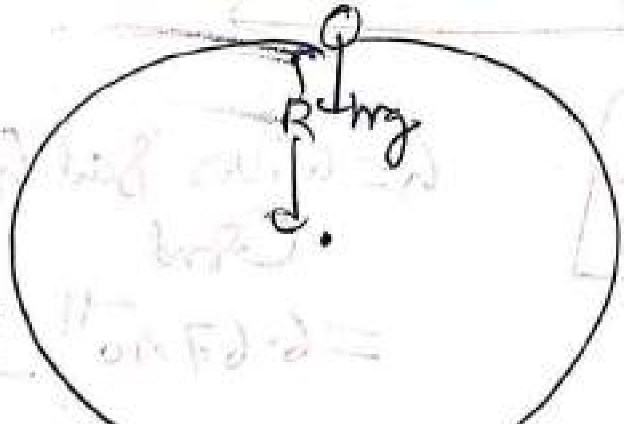
5-3 Acceleration due to gravity (g)

Where ↳ The acceleration due with which the body attract towards the earth surface i.e called as acceleration due to gravity.

$$g = 9.8 m/sec^2 = 980 cm/sec^2 = 32 ft/sec^2$$

5.4 Relⁿ betⁿ g & G :-

Let us Consider a body of mass 'm' placed on the surface of earth.



mg = wt of the body —(1)

According to Newton's law of gravitation

$$F = \frac{GMm}{R^2} \quad (2)$$

Where M = mass of the earth.

equating eqⁿ (1) & (2)

$$mg = \frac{GMm}{R^2}$$

$$\Rightarrow g = \frac{GM}{R^2} \Rightarrow \text{Rel}^n \text{ bet}^n\ g\ \&\ G.$$

5.5 – Mass & Weight :-

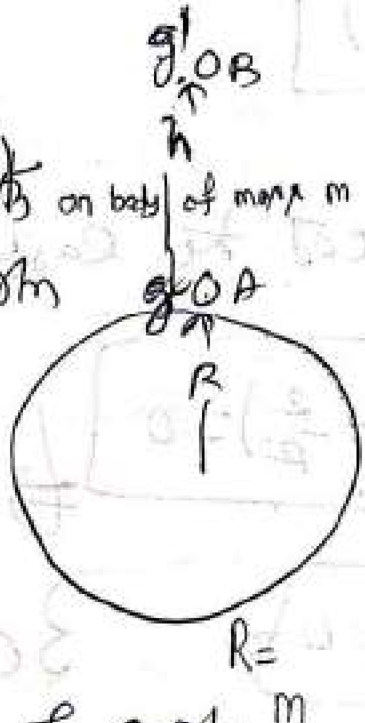
Mass of a body is defined as the amount of matter contained in the body. It is a scalar quantity.
It is denoted by "m"

Weight :- The gravitational force of attraction by the surface of earth on the body is called as weight of the body. It is a vector quantity. It is denoted by W

5.6 Variation of g with altitude :

Let g = Acceleration due to gravity on body of mass m on the surface of earth

g' = Acc^n due to gravity at a height 'h' above the surface of earth



$$g = \frac{GM}{R^2}$$

$$g' = \frac{GM}{(R+h)^2}$$

$$\frac{g'}{g} = \frac{GM}{(R+h)^2} \cdot \frac{R^2}{GM}$$

$$= \frac{R^2}{(R+h)^2}$$

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

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

$$= \left(1-\frac{2h}{R}\right)$$

$$\boxed{g' = g\left(1+\frac{h}{R}\right)^{-2}}$$

If $h \ll R$

$$\boxed{g' = g\left(1-\frac{2h}{R}\right)}$$

Variation of 'g' with depth:-

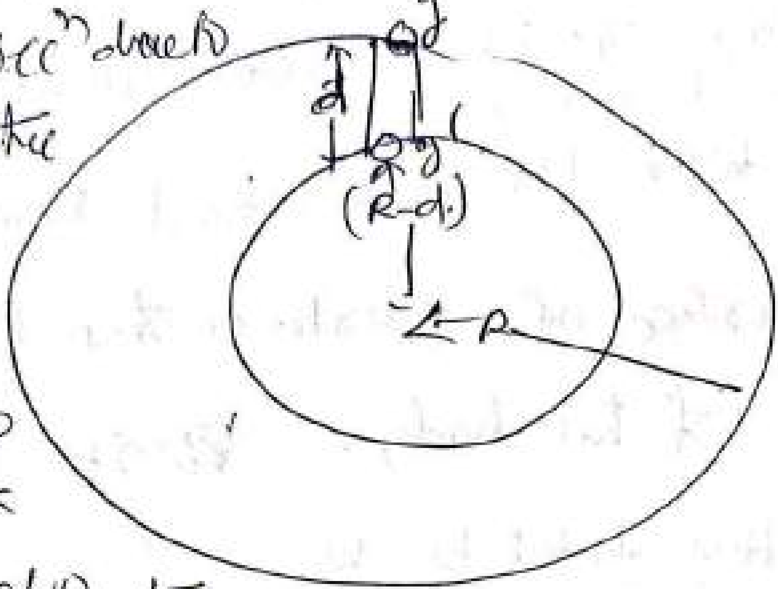
$$g = \frac{GM}{R^2} = \frac{G\frac{4}{3}\pi R^3 \rho}{R^2} = \frac{4}{3}\pi G R \rho$$

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

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

$$\frac{g'}{g} = 1 - \frac{d}{R}$$

Let g = Acc^n due to gravity on the surface of earth.



g' = Acc^n due to gravity at a depth 'd' below the surface of earth.

R = Radius of earth.

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

At the centre of the earth: $d = R$

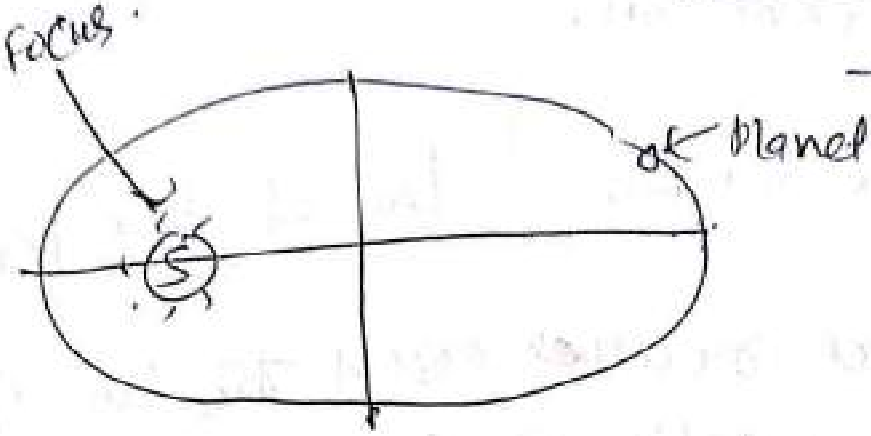
$$\boxed{g' = g\left(1 - \frac{R}{R}\right) = 0}$$

$$\Rightarrow \boxed{W = mg' = 0}$$

$\Rightarrow$ Here Acc^n due to gravity at the centre of the earth & hence the wt of the body at the centre of the earth is zero.

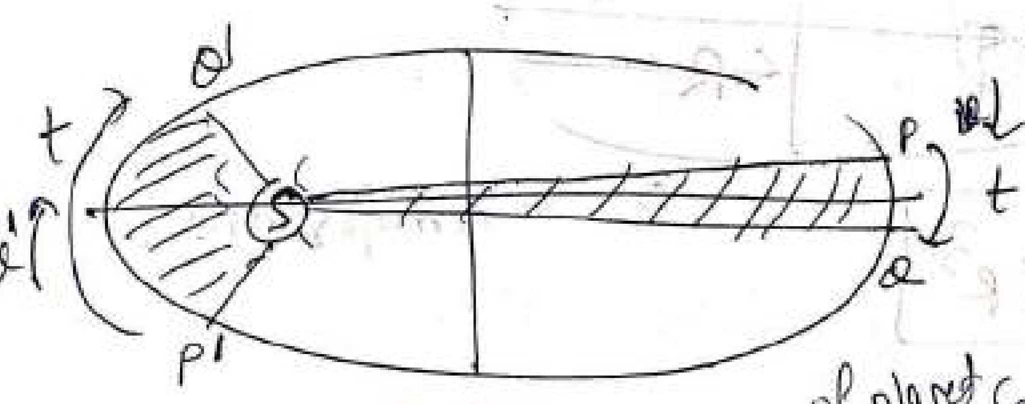
5.7 Kepler's laws of planetary motion:-

i) Kepler's 1st law: (Law of elliptical orbit):-



Planets revolve around the sun in an elliptical orbit with the sun situated at one of its foci.

ii) Kepler's 2nd law:- (Law of areal velocity)



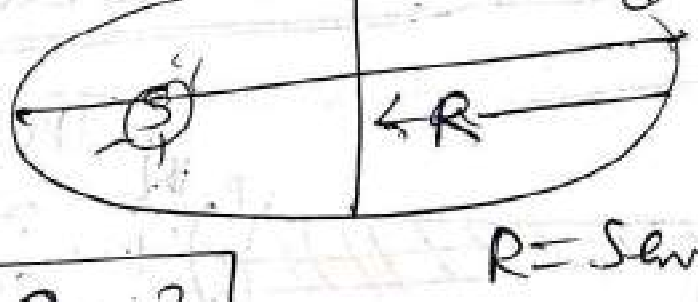
The planet revolves around the sun in such a way that areal velocity of planet is constant i.e the line joining the planet to the sun sweeps equal area in equal interval of time.

i.e $\boxed{v' > v}$

⇒ K.E of planet nearer to sun > K.E of planet far away from sun.

iii) Kepler's 3rd law :- (Law of time period)

The planet revolves around the sun in an elliptical orbit in such a way that the square of the time period is directly proportional to the cube of the semimajor axis.



R = Semimajor axis.

$$\boxed{T^2 \propto R^3}$$

$$\frac{T_1^2}{T_2^2} = \frac{R_1^3}{R_2^3}$$

Q-1- Simple harmonic motion: Motion of a body is said to be simple harmonic if it moves to & fro motion about the mean position and the limit of oscillation on either side of mean posn are equal and acceleration is directly proportional to -ve of displacement.

$a \propto -y$

$\Rightarrow a = -\omega^2 y$ (accn)

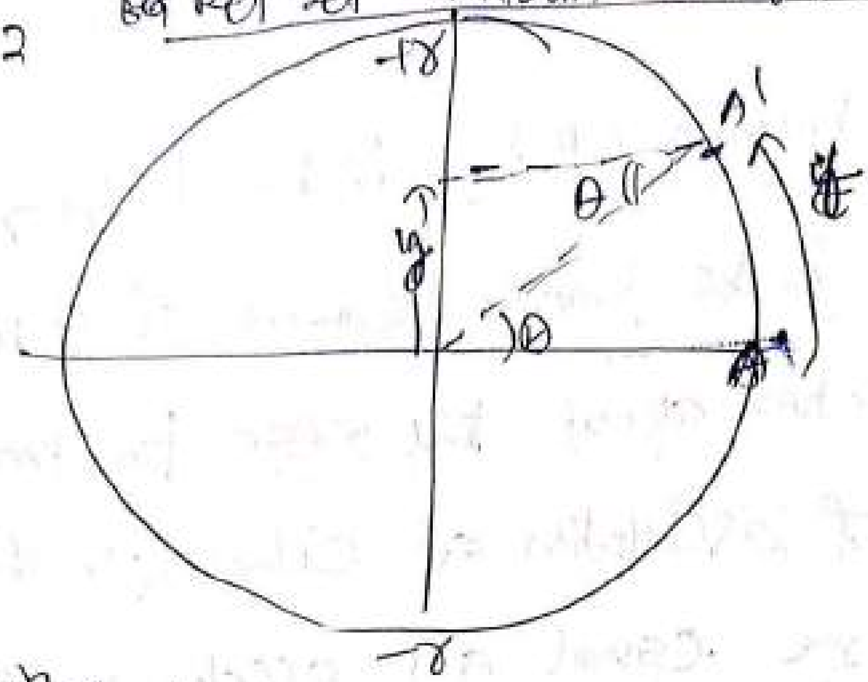
where
ω = Angular frequency

$\omega = \frac{2\pi}{T}$

y = displacement of particle measured from mean posn.

Example:- motion of simple pendulum, motion of a massless loaded spring.

6-2 Relation uniform circular motion with S.H.M.



Eqn of displacement:

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

r = Amplitude of S.H.M
y = displacement of particle at any instant of time is measured from mean pos

Eqn of velocity:

$$V = \frac{dy}{dt} = r\omega \cos \omega t$$

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

$$\cos \omega t = \sqrt{1 - \sin^2 \omega t}$$

$$= \sqrt{1 - \frac{y^2}{r^2}}$$

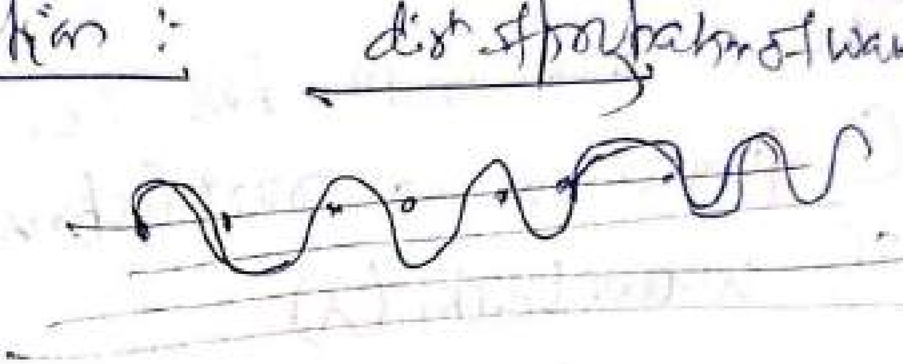
Eqn of acceleration :-

$$a = \frac{dv}{dt}$$

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

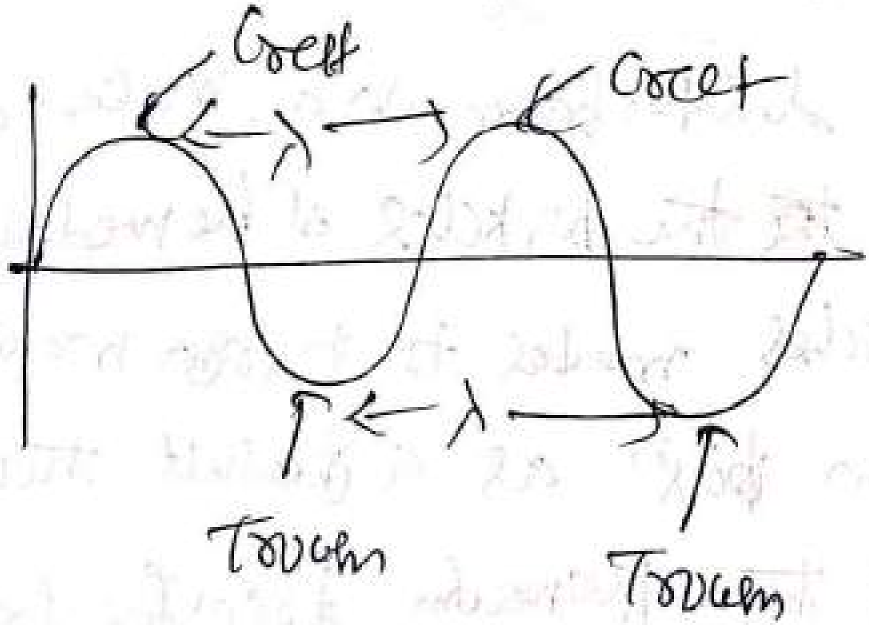
$$a = -\omega^2 y \quad [\text{where } y = r\sin\omega t]$$

5-3 Wave motion :



When the disturbance in a medium due to elasticity of the particles of the medium, the particles move to & from motion about the mean posn as a result the energy along with the momentum transfer from one particle to other particle & so on, is known as wave motion. When the wave propagates the particles of the medium are not moving along with the wave but they are vibrating about their mean position.

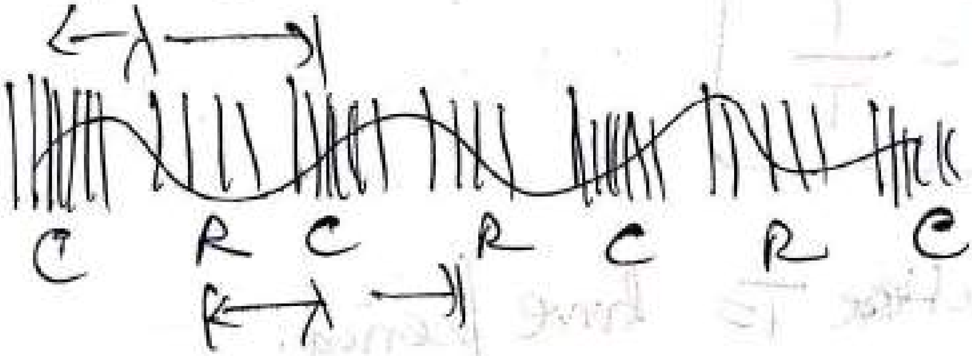
6.4. i) **Transverse wave:-** The type of wave in which the particles of the medium vibrate perpendicular to the dir^n of propagation is called transverse wave. It results in the formation of crest & troughs. The distance betn two consecutive compressions or rarefactions is called as wavelength (λ)



Example:- i) All electromagnetic waves,
ii) Light waves
iii) Micro waves.

ii) <u>Longitudinal wave</u>:- The type of wave in which the particles of medium vibrate parallel to the direction of propagation is called as Longitudinal wave. It results in the formation of Compressions & rarefaction.

The distance betn two Consecutive centre of Compression and rarefactions is called as ~~Longitudinal wave~~ wave length (λ).



<u>Example</u>:- Sound wave.

6.5:- Amplitude:- Maximum displacement of either of mean posn is called as Amplitude.

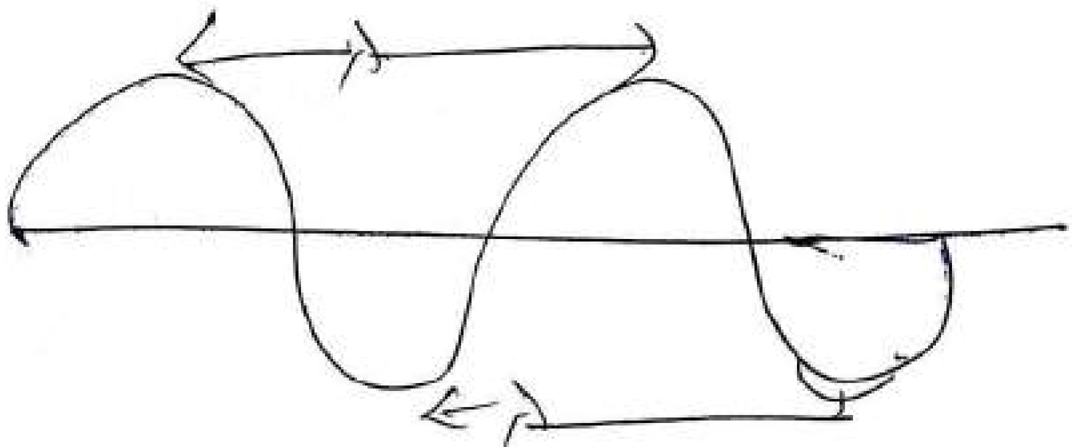
Wave length:- The distance travelled by a wave is called wave length.

Frequency:- The no. of waves or cycles per second is called as frequency.

$$f = \frac{1}{T}$$

where T = time period.

6.6:- Derivation of relation betn velocity, frequency and wave length.



$$v = \frac{\text{wavelength}}{\text{time period}} = \frac{\lambda}{T} = f\lambda$$

$$\boxed{v = f\lambda}$$

- v → vel. of wave
- f → frequency
- λ → wavelength.

Q.7. **Ultrasonics**

Sound of frequency greater than the upper limit of audible range (i.e greater than 20 kHz) is called <u>Ultrasonics</u>.

Properties of Ultrasonics

i) Ultrasonics are Longitudinal in nature

ii) propagation of ultrasonics through medium results in the formation of compressions and rarefactions.

iii) These are waves of ~~very~~ very high frequency having range of 2×10^4 to 10^9 Hertz.

iv) They travel with a speed of sound.

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

Applications of ultrasonics:-

1- Echo Sounding
2- Flaw detection
3- Ultrasonic Welding
4- Diagnostic use.

Question of unit-5 to be asked in examination

(i) Define universal Gravitational constant.
(ii) State Newton's law of Gravitation.
(iii) Dimension formula for G.
(iv) Relation between g and G.
(v) ~~Variation~~ Derive the variation of small g with altitude and depth.

Questions to be asked in examination of unit-

(i) Define SHM. Derive the expression for displacement, velocity and acceleration
(ii) ~~Re~~ ~~Est~~ Establish the Relation betw v, λ and f.
(iii) Comparision between Transverse and Longitudinal wave.
(iv) What is ultrasonic. Write down t properties and Application of ultrason

UNIT - 7 Heat & Thermodynamics

7.1 **Heat & temperature** Heat is a physical quantity that causes an increase in the temp of a body to which it is added and a decrease in the temp of a body from which it is removed provided that the body doesnot change state during the process.

Temperature is a property that determines the direction in which heat will flow if two bodies are kept in thermal contact.

Heat is a form of energy that flows betn a system and its surroundings by virtue of temp difference between them

7.2 **Unit of Heat** calorie - It is the quanity of heat required to raise the temp of one gram of water through one ~~celsius~~ degree centigrade. 1 cal.

SI - Joule. $1J = 10^7 erg$

CGS - erg

7.3 **Specific Heat** It is defined as the amount of heat per unit mass absorbed or rejected by the substance to change its temperature by 1 unit. It is denoted by C.

$$C = \frac{1}{m} \frac{dQ}{dT}$$ SI - $\frac{J}{Kg\,K}$

$$[C] = L^2 T^{-2} K^{-1}$$ CGS $\frac{cal}{g\,°C}$

Specific heat at const of pressure. $C_p = \frac{1}{m} \frac{dQ_p}{dT}$

Specific heat at unit volume $C_v = \frac{1}{m} \frac{dQ_v}{dT}$

7.4 **Change of state, Latent heat**

A transition from one of these phases to another is called a phase change or change of state.

The amount of heat transfered during a change of phase of the substance is called latent heat of transformation for the process.

$$Q = mL.$$

$$L = \frac{Q}{m}$$ $[L] = L^2 T^{-2}$

Scalar quantity

SI unit - Joule / Kg

7.5 Thermal expansion.

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

7.7 Coefficients of linear, superficial & cubical expansions of Solids

(a) linear expansion - A long and thin rod can be considered to be one dimensional if its length is very large compared to its diameter.

let l_0 = the length of rod at 0°C.

l_t = length of rod at t°C

$l_t - l_0 \propto l_0$

$l_t - l_0 \propto t$

$l_t - l_0 = \alpha l_0 t$

$\alpha = \frac{l_t - l_0}{l_0 t}$

Thus co-efficient of linear expansion may, in general be defined as the increase in length per unit length per degree centigrade rise of temp.

Unit. $°C^{-1}$

(b) Superficial expansion A surface having some length and breadth but having negligible thickness can be considered to be two dimensional.

S_0 ≡ area of sheet at 0°C

S_t ≡ area of sheet at t°C

$S_t - S_0 \propto S_0$

$S_t - S_0 \propto t$

$S_t - S_0 = \beta S_0 t$

$\beta = \frac{S_t - S_0}{S_0 t}$

Co-efficient of superficial expansion is defined as the change in area of the surface of unit area at 0°C per degree centigrade rise of temp.

(c) Cubical expansion A body having length, breadth, and thickness is said to be three dimensional.

$V_0 \equiv$ Volume of a cube at $0°C$

$V_t \equiv$ volume of a cube at $t°C$

$V_t - V_0 \propto V_0$

$V_t - V_0 \propto t$

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

Therefore co-efficient of cubical expansion is defined as the change in volume per unit volume at $0°C$, per degree centigrade rise of temperature.

7.8 Relation.

(i) α & β.

$$S_0 = l_0^2 \quad \text{at } 0°C$$

$$S_t = l_t^2 = l_0^2 (1+\alpha t)^2$$

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

$$= \frac{2\alpha t + \alpha^2 t^2}{t} = 2\alpha + \alpha^2 t$$

$$\beta = 2\alpha$$

(ii) α & γ.

$$V_0 = l_0^3$$

$$V_t = l_t^3 = l_0^3 (1+\alpha t)^3$$

$$\gamma = \frac{V_t - V_0}{V_0 t} = \frac{l_0^3(1+\alpha t)^3 - l_0^3}{l_0^3 t} = \frac{1 + \alpha^3 t^3 + 3\alpha t(1+\alpha t) - 1}{t}$$

$$= \frac{\alpha^3 t^3 + 3\alpha t + 3\alpha^2 t^2}{t}$$

$$= 3\alpha + 3\alpha^2 t + \alpha^3 t^2$$

$$\gamma = 3\alpha$$

7.9 Work & Heat.

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

7.10 Joule mechanical equivalent of Heat

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

$$W \propto H$$

$$W = JH$$

where J = Joule's mechanical equivalent of heat.

$$1 J = 4.2 cal$$

$$J = \frac{W}{H}$$

Joule's mechanical equivalent of heat is defined as the amount of work required to produce a unit quantity of heat.

7.11 First law of Thermodynamics

If the quantity of heat supplied to a system is capable of doing work, then the quantity of heat absorbed by the system is equal to the sum of increase in the internal energy of the system & the external work done by it.

$$dQ = dU + dW$$

8.1. Reflection & Refraction — 1. phenomenon by virtue of which ray of light send back to the same medium. 2. phenomenon by virtue of which the ray of light travelling from one medium to another medium suffers a change in velocity.

8.2 Laws of Reflection & refraction

Reflection

It states that 1. incident ray, reflected ray and normal to the incidence all lie on the same plane.

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

It states that 1. Incident ray, refracted ray and normal at the point of incidence all lie in same plane.

$$2. \quad {}^{1}\mu_2 = \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$$

8.3 Refractive index — Refractive index of a medium is defined as the ratio of the velocity of light in air to the velocity of light in medium.

$$\boxed{\mu = \frac{c}{v}}$$

where c = velocity of light in vacuum
v = velocity of light in medium

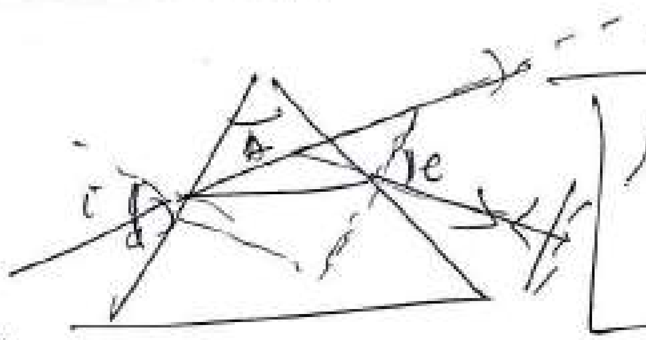
4. Critical angle & TIR (Total internal reflection)

When a ray of light travelling from denser medium to rarer medium for a particular angle incidence in denser medium for which the angle of refraction is 90°, that angle of incidence in the denser medium known as critical angle.

$$\boxed{\mu = \frac{1}{\sin C}}$$

When a ray of light travelling from denser to rarer medium if the angle of incidence in denser medium is greater than critical angle the ray of light send back to the same medium - This phenomenon is called TIR.

5. Refraction through prism



$$\boxed{\mu = \frac{\sin\frac{(A+\delta_m)}{2}}{\sin\frac{A}{2}}}$$

μ = R.I of the prism.

Where A = angle of prism, δ_m = angle of minimum deviation

ELECTROSTATICS & MAGNETOSTATICS

Electrostatic - Defination & concept

study, of nature, behaviour, interaction, properties of a charged ~~of a~~ body at rest is called electrostatic.

Coulomb's law, Unit charge

It states that the electrostatic force of attraction or repulsion between two charged bodies is directly proportional to the product of their charges and varies inversly as the square of the distance between them

$$F \propto q_1 q_2$$

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

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

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

Absolute & Relative permitivity

ϵ = Absolute permitivity of medium

ϵ_0 = Absolute permitivity of vaccum or air

ϵ_r = relative permitivity of the medium.

$$\epsilon_0 = 8.85 \times 10^{-12} N^{-1} C^2 m^{-2}$$

$\epsilon_r = 1$ for air

Relation

$$\epsilon = \epsilon_0 \epsilon_r$$

$$\epsilon_r = \frac{\epsilon}{\epsilon_0}$$

$$K = \frac{1}{4\pi\epsilon_0} = 9 \times 10^9 \ N m^2 C^{-2}$$

$$[\epsilon_0] = [M^{-1} L^{-3} T^4 A^2]$$

CGS $K = 1$

9.4 Electric potential and potential difference

There is a quantity which determines the direction of flow of charge from one body to other irrespective of the amount of charge contained in the two bodies, the quantity called as Electric Potential.

Electric Potential may be defines as the quantity which determines the direction of flow of charge between them.

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

SI - volt $\qquad$ $1\,\text{Volt} = \frac{1J}{1C}$

Potential at any point in an electric field is said to be 1 Volt if one Joule of work is done in moving a charge of 1 C between infinity to that point against the electric field along any path.

CGS stat volt $\qquad$ $1\,\text{stat volt} = \frac{1\,\text{erg}}{1\,\text{stat Coulomb}}$

Potential at any point is said to be 1 esu or statvolt if one erg of work is done in moving a charge of one esu between infinity to that point against the electric field along any path.

Reln $\quad$ $1\,\text{Volt} = 10^8\,\text{stat volt}$

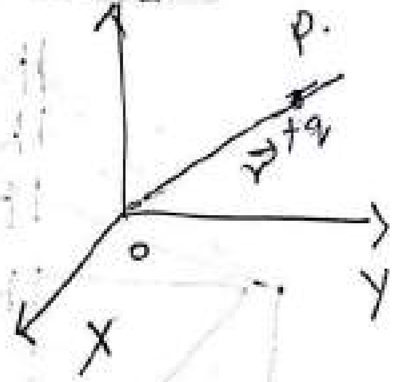
$1\,\text{stat volt} = 3\times10^{10}\,\text{ab volt}$

Electric field, Electric field Intensity

When an electric charge is placed at a point the properties of space around the charge get modified, the modified space around an electric charge is called electric field. The charge is known as the source of electric field.

The strength of an electric field is measured by noting force experienced by an unit positive charge placed at that point. The direction of field is given by direction of motion of an unit positive charge if it were free to do so.

$$\vec{E}(\vec{r}) = \lim_{q_0 \to 0} \frac{\vec{F}(\vec{r})}{q_0}$$



$$\vec{E} = \frac{1}{4\pi\epsilon_0} \frac{q}{r^2} \hat{r}$$

9.5 Capacitance

The capacity of a conductor is defined as the ratio between the charge on the conductor to its potential.

$$C = \frac{Q}{V}$$

When $V = 1$, $C = Q$.

The capacity of a conductor is ~~said to be 1 f~~ is also defined as the charge required to raise it through unit potential.

Unit

S.I. farad. The capacity of a conductor is said to be 1 farad if a charge of 1 coulomb is sufficient to raise its potential through 1 volt.

$$1f = \frac{1C}{1V} \qquad 1\mu f = 10^{-6} f.$$

CGS

esu stat farad.

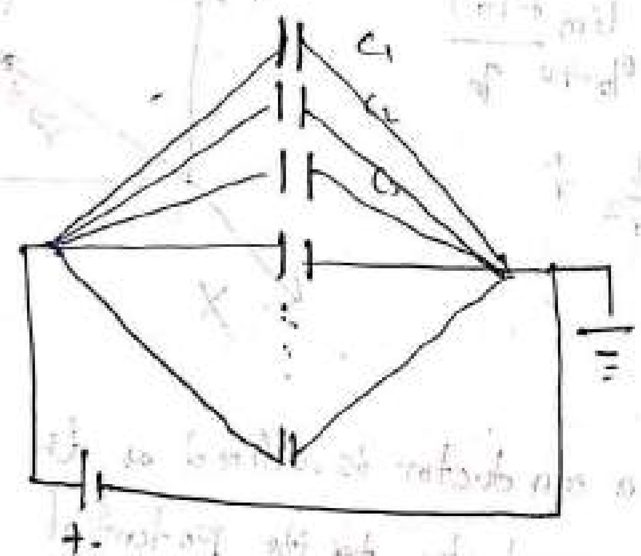
$$1\ \text{stat farad} = \frac{1\ \text{stat coulomb}}{1\ \text{stat volt}} \qquad 1\ \text{farad} = 9\times10^{11}\ \text{stat farad}$$

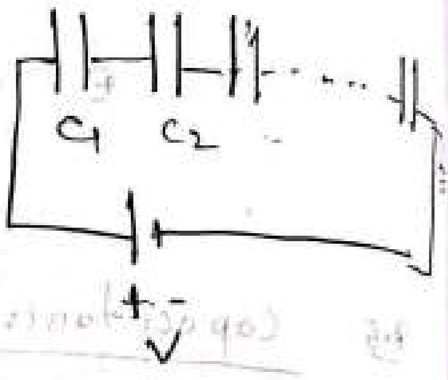
emu ab farad

$$1\ \text{ab farad} = \frac{1\ \text{ab coulomb}}{1\ \text{ab volt}} \qquad 1\ \text{farad} = \frac{1}{10^9}\ \text{abf}...$$

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

9.7 **Series & paralel combination of capacitors**





$$C = C_1 + C_2 + C_3 + \dots$$

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \frac{1}{C_4}...$$

9.8 **Magnet, Properties**

A piece of substance which possesses the property of attracting small pieces of iron towards it is called magnet.

1. Two poles of a magnet.

   magnetic length $(2l) = \frac{7}{8} \times$ geometric length.

2. Attracting property of a magnet.
3. Directional property of a magnetic

South - geographical ...

In existence of isolated magnetic poles.
Nature of force between two poles.
Coulomb law in magnetism.

The magnitude of force between two magnetic poles varies directly as the product of the strengths of their poles and inversely proportional to square of the distance between them.

$$F \propto m_1 m_2$$

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

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

$$F = K \frac{m_1 m_2}{r^2}$$

SI. $K = \frac{\mu_0}{4\pi} = 10^{-7}\ wb\ A^{-1} m^{-1}$

CGS $K = 1$

$\mu_0 = 4\pi \times 10^{-7}\ wb A^{-1} m^{-1}$

Unit pole. SI - A unit pole is that pole which when placed in air at a distance of 1m from a similar pole repels it with a force of 10^{-7}N.

CGS A unit pole is that pole which when placed in air at a distance of 1cm from a similar pole repels it with a force of 1 dyne.

9.10 Magnetic field, magnetic field Intensity. $T = 10^{4}$ Gauss

Magnetic field of any magnetic pole is the region (space) around it in which its magnetic influence can be realised.

Strength of magnetic field at any point is defined as the force experienced by an unit north pole at that point, the direction of field is the direction in which the unit north pole would ...

9.11 Magnetic lines of force.

lines of force is the path along which a unit north pole would move if it were free to do so.

Properties

1. lines of force are directed away from a north pole and are directed towards a south pole.
2. Tangent at any point to the magnetic line of force gives the direction of magnetic intensity at that point.
3. Two lines of force never cross each other
4. The number of lines of force per unit area is proportional to magnitude of strength of field at that point.
5. The lines of force tend to contract longitudinally or lengthwise, Unlike poles attract.
6. The lines of force tend to exert lateral pressure. Like pole repulsion
7. 4π lines of force start from a unit magnetic pole.

Representation of magnetic field

- Uniform MB — Same strength at every point
- Non uniform MB — Different strength at different point.

flux density

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

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

Magnetic flux linked with a surface, is defined as the product of area and component of B ⊥r to the area.

Case-1 $\theta = 90°$

$\phi_B = 0$

No magnetic flux is linked with the surface

Case-2 $\theta = 0$

$\phi_B = BA$.

Maximum magnetic flux is linked.

Unit

SI weber.

CGS maxwell

1 weber $= 10^8$ maxwell

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

Magnetic flux density at any point is defined as number of magnetic lines of force passing through an unit area placed at that ~~placed~~ point of the area is held ⊥r to the direction of lines.

Magnetic flux density inside the material is $B = B_0 + B_m$ (due vaccum) (due to two poles)

Unit

SI. weber per meter²

CGS

Electric current -

The current through a given cross sectional area in a conductor is defined as the time rate of flow of charge through that area.

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

here dq is the net flow of charge through the cross sectional area in the time interval dt

Electric current is a scalar quantity.

$[I] = A$.

SI unit - Ampere.

$1A = \frac{1C}{1S}$.

The current is one ampere, if charge is being transfered at a rate of 1C per second.

Ohm's Law It states that the electric current flowing through a conductor is directly proportional to potential difference across the conductor.

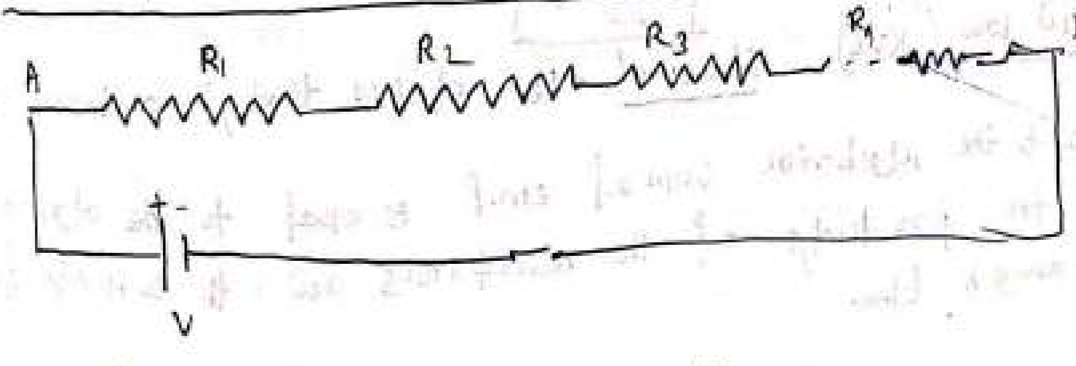
mathematically $I \propto V$

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

$V = IR$

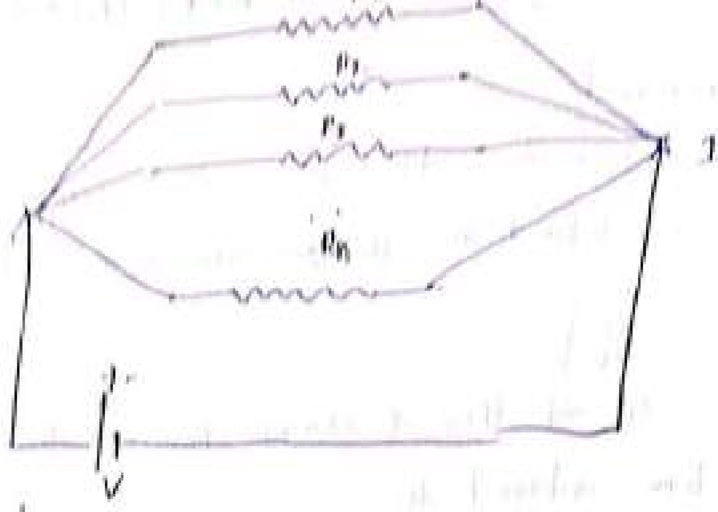
where $\frac{1}{R}$ = proportionality constant. & R is resistance of the conductor.

Series & parallel combination of resistors

i) 

$R_{net} = R_1 + R_2 + R_3 + \cdots + R_n$.

Parallel



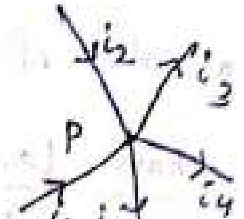
$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n}$$

10.4 Kirchoff's law

First law (KCL)

Statement It states that the algebriac sum of currents meeting at a point

Explanation. To explain this law consider a number of wires connected at a point P. Currents i_1, i_2, i_3, i_4 & i_5 flow through these wires in the directions as shown in fig.



To determine their algebriac sum of electric currents, we follow the following sign conventions.

(i) The currents approching a given point are taken as +ve.

(ii) The current leaving the given point are taken as -ve.

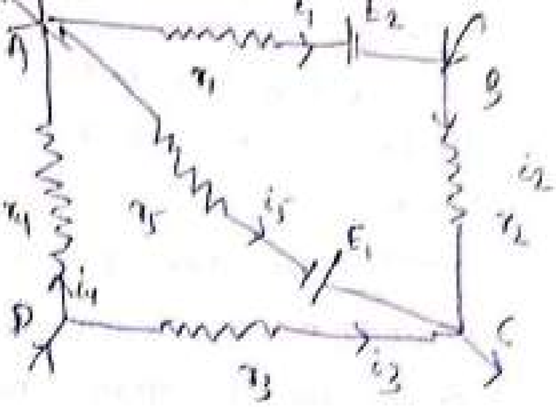
Following these sign conventions we find that i_1 & i_2 are +ve while i_3, i_4 and i_5 -ve.

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

$$\sum_{j=1}^{5} i_j = 0$$

Second law (KVL) Statement - It states that, in a closed electric circuit, the algebriac sum of e.m.f is equal to the algebriac sum of the products of the resistances and the currents flowing through them.

Fig. shows a closed electric circuit ABCD having resistances r_1, r_2, r_3, r_4 & r_5 in the arms AB, BC, CD, DA & AC respectively. i_1, i_2, i_3, i_4, i_5 are the respective currents flowing in these parts in the directions shown by arrow heads.



Two sources of emf's E_1 & E_2 are also connected in the mesh.

In order to use Kirchhoff's voltage ~~through the electrolyte of cell from~~ -ve we shall follow the following sign convention

(i) If the electric current flows through the electrolyte of the cell from -ve to +ve terminal the emf of the cell is taken as +ve. (+E)

(ii) If the electric current flows through the electrolyte of the cell from +ve to -ve terminal, the emf of the cell is take as -ve (-E)

(iii) If the path taken traverse the resistance is along the direction of current, the final point is at a lower potential than the initial point A. The product of current and resistance in this case is taken as -ve (-ir)

(iv) If the path taken to traverse the resistance is against the direction of current, the final point (A) is at potential higher than that of initial point (B). The product of current and resistance in this case is taken as +ve (+iv).

Applying KVL to mesh ABCA,

$$i_1r_1 + i_2r_2 - i_5r_5 = E_1 - E_2.$$

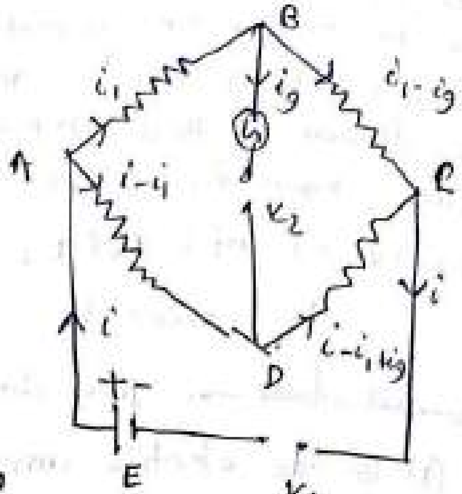
Applying KVL to mesh ACD,

$$i_5r_5 - i_3r_3 - i_4r_4 = E_1$$

General form of KVL $\boxed{\Sigma iv = \Sigma E}$

1Q5 Wheatstone Bridge.

Wheatstone bridge is an electrical arrangement which forms the basis of most of the instruments used to determine an unknown resistance.



Construction: It consists of four resistances P, Q, R & S connected in the four arms of a square ABCD. A cell of emf E is connected between the points A & C through one way key K_1. A sensitive galvanometer of resistance G is connected between the terminals B & D through another one way K_2. After closing the keys K_1 & K_2, the resistance P Q R & S are so adjusted that the galvanometer shows no deflection. In this position the wheatstone bridge is said to be balanced.

Expln: Using Kirchhoff's current law, the distribution of current and their directions through various resistances are as shown in fig.

Applying KVL to mesh ABD.

$$i_1 P + i_g G - (i - i_1) R = 0 \quad \text{—(I)}$$ Zero bcoz no emf in both the circuit.

mesh BCDB $$(i_1 - i_g) Q - (i - i_1 + i_g) S - i_g G = 0 \quad \text{—(II)}$$

Balanced condition

$$i_g = 0$$

So eqn (I) & (II) becomes

$$i_1 P = (i - i_1) R \quad \text{—(III)}$$

$$i_1 Q = (i - i_1) S \quad \text{—(IV)}$$

Dividing

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

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

This is the required condition for the bridge to be balanced i.e. the principle of wheatstone bridge.

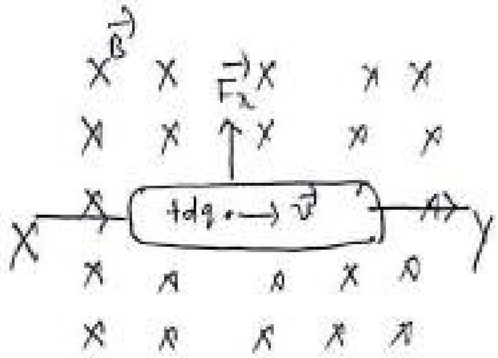
U-II

ELECTROMAGNETISM & EM INDUCTION

(i) Electromagnetism — Electromagnetism is a branch of physics deals with the em force that occurs between electrically charged particles.

Electromagnetism is produced when an electrical current flows through a simple conductor such as a length of wire or cable, and as current passes along the whole of the conductor.

Force acting on a current carrying conductor placed in a uniform magnetic field.



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

$$\vec{F} = \int d\vec{F}$$
$$= i\int d\vec{l} \times \vec{B}$$
$$= i\, \vec{l} \times \vec{B}$$
$$= i\, lB\sin\theta\, \hat{n}$$

Fleming left hand rule — Direction of force $\vec{F}$ also be obtained by applying Fleming's left hand rule which can be stated as:

Stretch first finger, central finger and the thumb of your left hand in mutually ⊥r directions. If the first finger points towards magnetic field, central finger points towards electric current then the thumb gives the direction of force acting on the conductor.

Faraday law of EM induction

Whenever magnetic flux linked with a circuit changes an emf is induced in it. The induced emf exists in the circuit so long as the change in magnetic flux linked with it continues. The induced emf is directly proportional to the -ve rate of change of magnetic flux linked with the circuit.

$$E = -\frac{d\phi_B}{dt}$$

11.4 Lenz law It states that direction of induced emf is s.t. it tends to oppose the very cause which ~~opposes~~ produces it.

11.5 Fleming's Right hand rule. Stretch first finger and the thumb of your right hand in three mutually ⊥ directions. If the first finger points towards the magnetic fields, thumb points towards the direction of motion of conductor, the direction of central finger gives the direction of induced current set up in the conductor.

11.6 Comparison.

UNIT-12

MODERN PHYSICS

1. **Laser & Laser beam** Laser is light amplification by stimulated emission of radiation. A laser beam is extremely intense, coherent and highly parallel beam of light.

2. **Principle**

Population Inversion :- Population inversion is a method in which we there are more atoms in the meta stable state than the ground state.

Optical pumping :- This is done by supplying suitable energy to the atoms of the active medium with the help of pump. The process of bringing about population inversion is known as pumping.

3. **Properties**

- → Directionality
- → Intensity
- → Monochromaticity
- → Coherence

Application

- → Surgery
- → Industry
- → Science
- → Warfare.