PHYSICS

AS Topics

By

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Topic 1

Physical Quantities and Units

(a) All physical quantities are represented as a product of a numerical magnitude and a unit e.g mass = 10 kg.

(b) The following six base quantities and their units will be used throughout in this study.

mass (kg), Length (m), time (s), Current (A), temp (K)
amount of Substance (mol).

(c) A large number of quantities are derived from base quantities and are represented by derived units.

e.g speed = $\frac{\text{distance}}{\text{time}}$, the unit is $m s^{-1}$ (derived)

Force = mass x acceleration, Unit of force = N = $kg\,m s^{-2}$

Pressure = $\frac{\text{Force}}{\text{area}}$, the unit of pressure is Pa = $N\text{-}m^{-2}$ or $kg\,m s^{-2}$

(d) All equations used to represent physical quantities and their relationship with other quantities must be correct for numerical magnitude as well as for units i.e the equations can be checked by checking their homogenity with respect to units e.g if $P = CV + KV^2$; P represents pressure of a gas and V is velocity. C and K are constants, then

$[P] = CV$ i.e units of P = Units of CV

$[P] = CV^2$. Hence units of C and K can be worked out.

(e)

(f) Some multiples of base and derived units are;

10^3 = kilo	10^6 = mega	10^9 = giga	10^{12} = tera		
10^{-1} = deci	10^{-2} = Centi	10^{-3} = milli	10^{-6} = micro	10^{-9} = nano	10^{-12} = pico

(g) Estimated numerical magnitude of some physical quantities;

Mass of an apple ≈ 200 g

weight of a man ≈ 800 N

A wavelength in I.R ≈ 2×10^{-6} m

Power of hair dryer ≈ 1000 Watt.

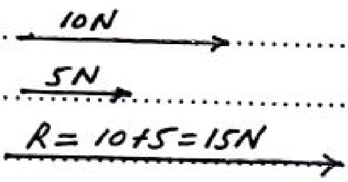
(k) Scalar Quantities:- These quantities which have magnitude only. e.g mass, speed, time, temperature, pressure, work and any form of energy such as K.E, P.E, heat energy, density, area, and volume.

Vector Quantities:- These quantities which have magnitude as well as direction e.g force, velocity, acceleration, momentum, displacement, magnetic flux and electric field strength.

Scalers are added, subtracted directly.

Vectors are added, subtracted by special rules.

(i)



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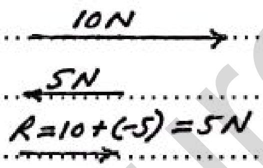
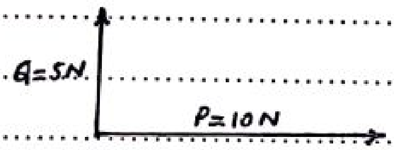
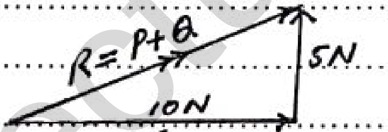
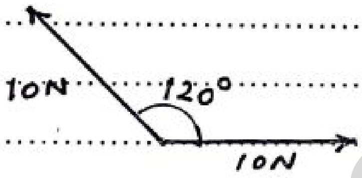
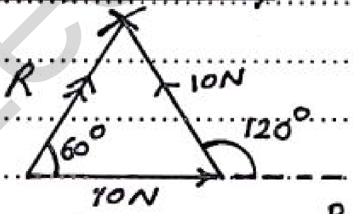


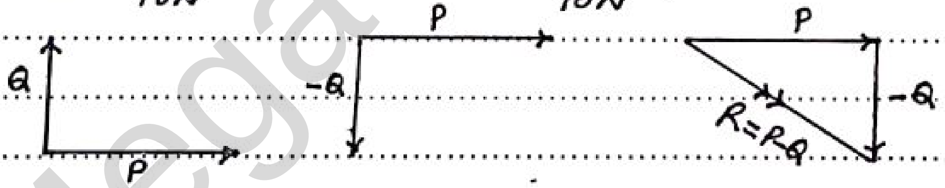


Find R by

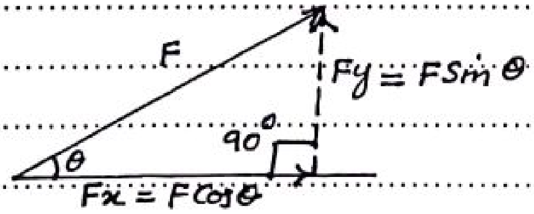








(l) A vector can be resolved into two rectangular Components



Topic 2

Measurement Techniques

(d). **A Reading:** It is a single determination of the value of an unknown quantity (the actual reading in an experiment).

A Measurement: It is the final result of the analysis of a series of readings. Any measured quantity has some degree of error in it called its uncertainity (we use UN for uncertainity).

e.g. length = 34.7 ± 0.1 cm, 0.1 gives UN in measurement.
diameter = 3.62 ± 0.01 mm

0.1 and 0.01 is called absolute error in respective values.

Fractional Error = $\frac{0.1}{34.7}$ and $\frac{0.01}{3.62}$

Percentage Error = $\frac{0.1}{34.7} \times 100$ and $\frac{0.01}{3.62} \times 100$

Errors are of two types:

Systematic Error:- These are due to some faults in the system i.e. the instruments, conditions of experiment, or due to observer.

(i). Zero error in the instruments.
(ii). Stop watch too fast or slow.
(iii). A meter calibrated at different conditions.
(iv). Personal error e.g. reaction time of observer.

Systematic errors are present in all readings and are not reduced by taking average of a large number of readings. Their effect on the measurement is to give an inaccurate result.

Random Errors:-

These are the errors made by the observer or person doing the experiment. These errors may be positive or negative and their magnitude is not constant.

(i). Parallax Error:-
(ii). using a micrometer and applying different pressure for repeat readings of dia of a wire.
(iii). Measuring a length when temperature is not constant.

The random errors are averaged out by taking a large number of readings and then using the average value.

Precision and Accuracy

Precision:- To obtain measurement of a physical quantity various readings are taken and a mean value is calculated. ($\bar{x}$). If data is such that the readings are close to their average value, $\bar{x}$, readings are precise or have a good precision, i.e when average deviation $[\bar{d}]$ is small.

A good precision is achieved by making careful observations while taking readings in an experiment e.g use of hand lens etc.

Accuracy:- A measurement is accurate if it is close to actual value. The accuracy is given by % error. The smaller the error, the higher the accuracy.

Example:- Measurement of g, acceleration due to gravity gives following results.

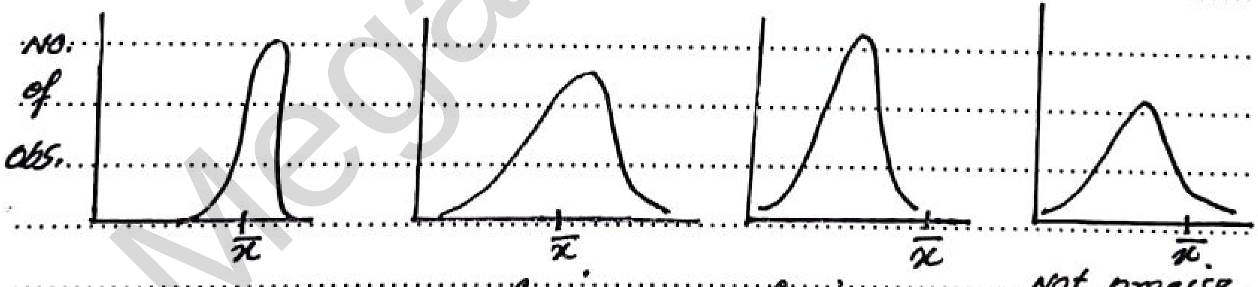
(i) $g = 8.6,\ 8.4,\ 8.8,\ 8.5,\ 8.7$ Precise, Not accurate $\bar{g} = \frac{43}{5} = 8.6$

(ii) $g = 9.8,\ 9.9,\ 9.6,\ 9.7$ Precise and accurate.

(iii) $g = 9.4,\ 9.8,\ 10.2,\ 9.5$ not precise, accurate $\bar{g} = 9.7$

(iv) $g = 8.0,\ 8.4,\ 8.8,\ 9.2$ not precise, not accurate.

The following graphs represent the example further, for a measurement which has $\bar{x}$ as actual value.



Precise & Accurate — Not Precise Accurate — Precise Not accurate — Not precise Not accurate

Compound Error:- In order to calculate result of an exp. certain measured quantities are added, subtracted, multiplied and divided according to formula. The final error in the answer is called compound error. The following rules are used;

Addition or Subtraction:- when values are added or subtracted, their uncertainities are added.

Examples:- (i) $\theta_1 = 25.4\ ^\circ C$ $\theta_2 = 65.2\ ^\circ C$

they are represented with their uncertainities as

$\theta_1 = 25.4 \pm 0.2\ ^\circ C$ $\theta_2 = 65.2 \pm .2\ ^\circ C$

Adding $\theta_1 + \theta_2 = 25.4 + 65.2 = 90.6\ ^\circ C$

Adding UN $\Rightarrow 0.2 + 0.2 = 0.4\ ^\circ C$

Answer $\theta_1 + \theta_2 = (90.6 \pm 0.4)\ ^\circ C$

(ii) Two lengths l_1 & l_2 are measured

$l_1 = (10.6 \pm 0.1)$ Cm $l_2 = (16.8 \pm 0.1)$ Cm

The difference $l_2 - l_1 = 16.8 - 10.6 = 6.2$ Cm

Adding UN $\Rightarrow 0.1 + 0.1 = \pm 0.2$ Cm

Answer of Subtraction $= (6.2 \pm 0.2)$ Cm

Multiplication or Division:- when values are multiplied or divided their % UN are added to give % UN in the answer. Fractional UN's can also be added to give the fractional UN in the answer. If fractional UN is multiplied with the calculated value, the answer gives the compound UN (Absolute UN) in the measurement.

Example 1 the dimensions of a box are given below:

$l = (5.0 \pm 0.2)$ Cm, width, $b = (4.0 \pm 0.1)$ Cm, height, $h = (8.0 \pm 0.2)$ Cm

Volume of Box $= l \times b \times h = 5.0 \times 4.0 \times 8.0 = 160\ Cm^3$

Maximum % error in V $= \frac{0.2}{5.0} \times 100 + \frac{0.1}{4.0} \times 100 + \frac{0.2}{8.0} \times 100 = \pm 9\%$

Volume of the box $= 160\ Cm^3 \pm 9\%$

The absolute error in the volume is calculated as;

Max. Fractional Error $= \frac{0.2}{5.0} + \frac{0.1}{4.0} + \frac{0.2}{8.0} = 0.09$

Absolute error in volume $= 0.09 \times 160 = 14.4\ Cm^3$

Reported answer: Volume of Box $= 160 \pm 10\ Cm^3$

Examples:- length of Elastic Band before stretching $L_0 = 50.0 \pm 0.1$ Cm

" " " " after " $L_s = 51.6 \pm 0.1$ Cm

(a) Calculate change in length with UN

$L_s - L_o = 51.6 - 50.0 = 1.6$ Cm UN $= 0.1 + 0.1 = 0.2$ Cm

$L_s - L_o = 1.6 \pm 0.2$ Cm

(b). Calculate fractional change in length:

$$\frac{L_s - L_o}{L_o} = \frac{1.6}{50.0} = 0.032$$

(c). Calculate the uncertainity in the answer in (b)

$L_s - L_o = 1.6$ UN in $L_s - L_o = \pm 0.2$

Fractional UN in $L_s - L_o = \frac{0.2}{1.6}$, Fractional UN in $L_o = \frac{0.1}{50.0}$

Fractional UN in $\frac{L_s - L_o}{L_o} = \frac{0.2}{1.6} + \frac{0.1}{50.0} = 0.125 + 0.002 = 0.127$

Absolute UN in $\frac{L_s - L_o}{L_o} = 0.127 \times 0.032 = 0.004$

Reported answer $\frac{L_s - L_o}{L_o} = 0.032 \pm 0.004$

* * * *

Section II

Topic 3 Newtonian Mechanics.

(a) Displacement:- Distance moved in a specified direction or shortest distance between two points. Unit metre, m. It is vector.

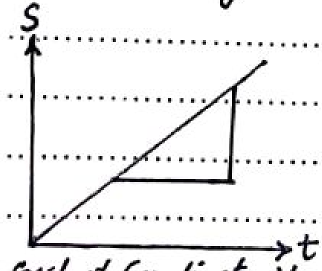
Speed:- Rate of change of distance or distance moved per unit time.

$speed = \frac{distance}{time}$ Units of speed ms^{-1}. It is scalar.

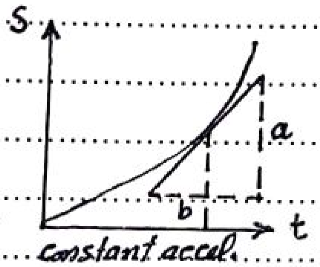
Velocity:- Rate of change of displacement or Distance moved in a specific direction in a unit time. Unit ms^{-1}. It is a vector quantity.

Acceleration:- The rate of change of velocity. units ms^{-2}. It is vector.

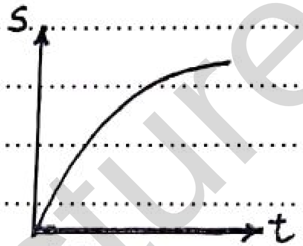
(b) The data of moving objects can be displaced as displacement-time and velocity-time graphs.



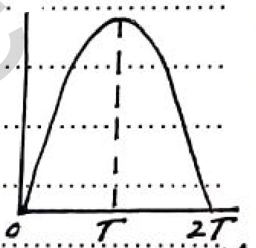
Constant Gradient = V



constant accel.
gradient = a/b

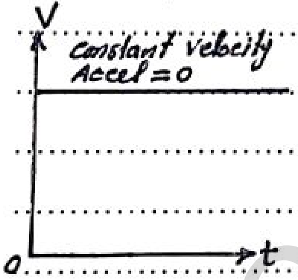


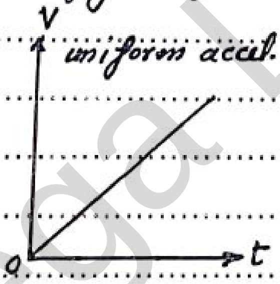
Motion under constt deceleration

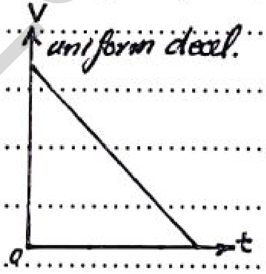


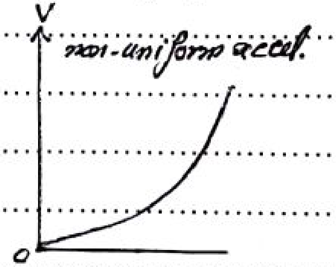
Motion of projectile particle projected up and return to ground

we can find velocity from gradient or slope of displacement-time graph.



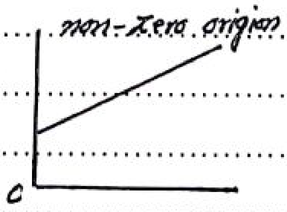


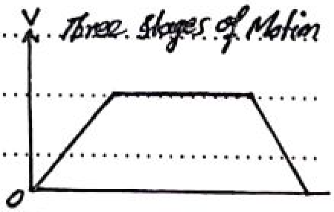




acceleration = gradient or slope

distance = area under velocity time graph and time.





Equations of Motion:-

① u = initial vel., v = final vel., a = acceleration, t = time, s = displacement

$acceleration = \frac{final\ vel. - initial\ vel.}{time} \Rightarrow a = \frac{v-u}{t} \Rightarrow \boxed{v = u + at}$ — I

② If initial and final velocities are given and accel is uniform

$Av.\ Velocity = \frac{u+v}{2}$, If starting from rest $\langle V \rangle = \frac{V}{2}$

And if total distance and total time are known

$$Avg.\ vel = \frac{Total\ distance}{total\ time}$$

$s = V_{av} \times time$

using $V_{av} = \frac{v+u}{2}$ and $t = \frac{v-u}{a}$ (1st. eq. of motion)

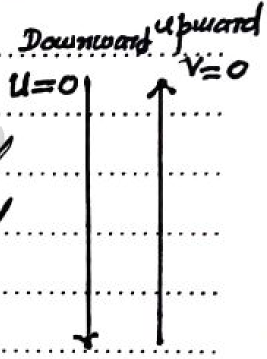
$s = \left(\frac{v+u}{2}\right)\left(\frac{v-u}{a}\right) \Rightarrow s = \frac{v^2-u^2}{2a} \Rightarrow \boxed{v^2 = u^2 + 2as}$ — II

③ $s = V_{av} \times t$

$s = \frac{v+u}{2} \times t = \frac{u+u+at}{2} \times t \Rightarrow \boxed{s = ut + \frac{1}{2}at^2}$ — III

Three equations of motion can be used to solve problems relating uniformly accelerated motion in straight line.

(g) <u>Motion Under Gravity:-</u>



when a body is projected upward against the gravity or allowed to fall freely in Earth's gravitational field, all equations of motion I, II & III can be used with g replacing a and s by h.

$v = u + gt \qquad h = ut + \frac{1}{2}gt^2 \qquad v^2 = u^2 + 2gh$

For a freely falling body eq. III can be written as

$h = \frac{1}{2}gt^2$

and used to calculate distance moved in time t, the time of free fall.

g, gravitational field strength = accel. due to gravity

In Earth's field it is $9.81\ ms^{-2}$.

For Free fall, initial vel → u = 0. This equation is valid for bodies falling from small heights above the ground, where gravitational field ~~may be~~ can be considered uniform, and when air resistance is also ignored.

(h) Force with which a body is attracted towards Earth is called weight.

Gravitational field strength is force of attraction for 1 kg mass. Its value is $9.8\ N\ kg^{-1}$

Acceleration due to gravity is acceleration experienced by a freely falling body i.e $9.8\ ms^{-2}$ produced by gravitational force of attraction.

Hence force exerted on m kg mass is given by

$F = ma$ Newton's Second Law

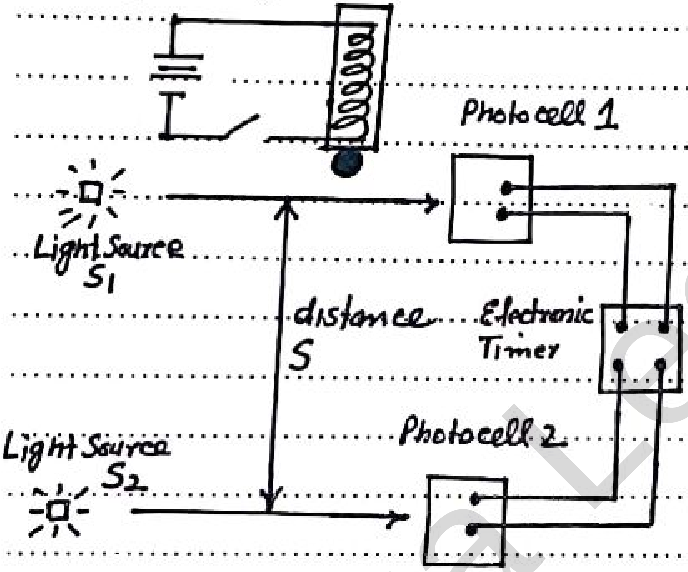
$W = mg$ w is weight of body

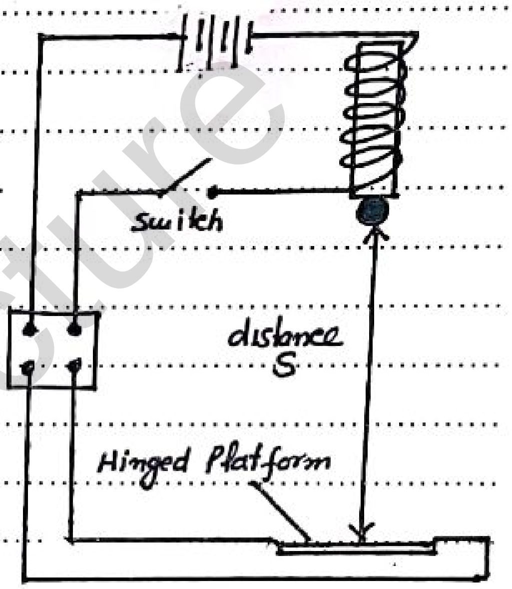
SI unit of weight is Newton, mass is measured in kg

$g = 9.81\ m s^{-2}$ on and close to the surface of Earth.

weight of 1kg = 9.8 N, weight of 10 kg = 98 N

(2) To describe an experiment, measuring acceleration of free fall.





when ball falls through light beam 1, timer is set on, and when it cuts through beam 2, it turns off. Reading of time noted to travel by falling through distance S.

when switch is opened, the ball falls and timer gets on. When the ball falls on platform, it opens the timer circuit which is then off.

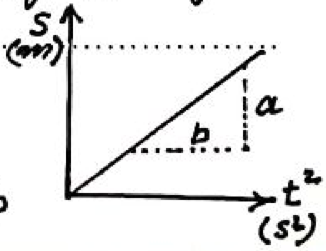
Different readings are taken for time and distance fallen (Each reading for new distance by adjusting). Data is written in a table of values of distance S and time t. A graph of 's' against 't²' should be a straight line through the origin.

Equation of free fall $S = \frac{1}{2} g t^2$

$y = m x$

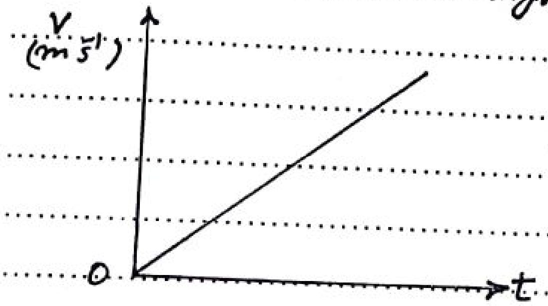
gradient $= \frac{1}{2} g$

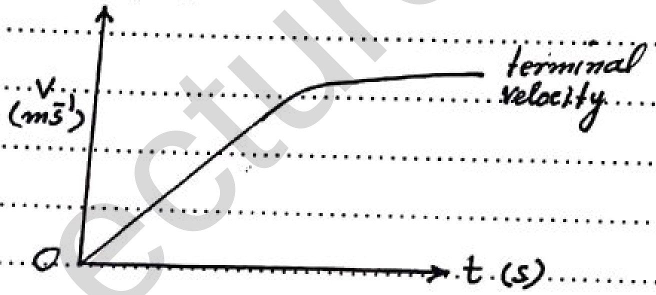
$g = 2 \times$ gradient $= 2 \times$ value of a/b



A source of error can be the measurement of distance with a metre rule. Each reading can be taken twice and average found for better accuracy.

(j). For a freely falling body, acceleration of free fall is assumed to remain constant when we ignore air resistance. This is reasonable assumption for short distance of fall. In actual practice when air resistance is not ignored, accel. decreases from an initial value of $9.8\ ms^{-2}$ to zero as the air resistance (drag) increases with speed. Hence a falling body attains a terminal velocity. v-t graphs shown below:





(K). Motion in a Circle:- Motion of a body about a fixed point so that its distance from fixed point remains constant.

A body moving in a circular path at a constant speed is constantly changing its direction. A force which keeps a body in circular path and directed towards centre of circle is called centripetal force.

Acceleration of body conducting circular motion, due to change of direction is also directed towards the centre of the circle, called as centripetal acceleration.

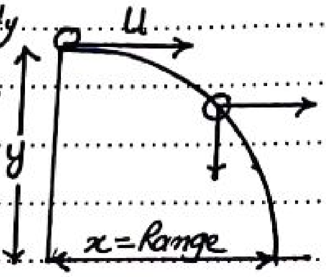
Centripetal force, $F_c = \frac{mv^2}{r}$ where m = mass in kg

v = velocity in ms^{-1}

Centripetal acceleration, $a_c = \frac{v^2}{r}$ r = radius of path in m

Centripetal acceleration acts ⊥ to the direction of motion.

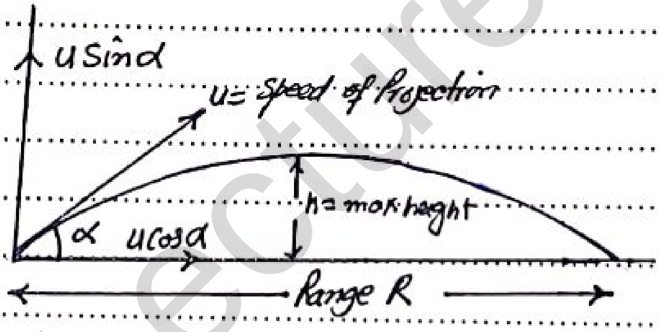
Projectile Motion:-



A body projected horizontally with a velocity U, moves under a perpendicular acceleration, and takes up a parabolic path. Horizontal velocity remains constant and vertical velocity increases from initial value zero. The following equations are valid.

(i) $y = \frac{1}{2} g t^2$ (ii) $x = ut$ (iii) $y = \frac{1}{2} g \frac{x^2}{u^2}$

This is in absence of air resistance. If air resistance is taken into account, range will come out to be less.



A body projected at an angle α with the horizontal with a velocity u has the following equations valid for its motion.

Initial vertical velocity = u Sin α

Constt horizontal velocity = u Cos α

Maximum horizontal distance, Range, $R = \frac{u^2 \sin 2\alpha}{g}$

Maximum height reached $h = \frac{\sin^2\alpha}{2g}$

time to reach maximum height $t' = \frac{u \sin\alpha}{g}$

Total time of flight, $t = \frac{2 u \sin\alpha}{g}$

* * * * *

Topic 4

Dynamics

(a) There are three laws of motion called Newton's Laws of motion

First Law:- Every body continues to be in a state of rest or of uniform motion in a straight line unless it is acted upon by an external force.

Second Law:- Rate of change of momentum of an object is directly proportional to applied force and occurs in the direction of applied force.

Third Law:- Action and reaction are equal and opposite. or To every action there is equal and opposite reaction. or when two bodies interact, they exert equal and opposite forces on each other.

(b) In order to define the effect of an applied force on a body, the mass of body is considered. This is because it is difficult to stop or set in motion a body which has a large mass.

Inertia:- Resistance of material objects to change their state of rest or of uniform motion.

Greater is mass of a body, longer is inertia. Therefore the mass of a body is often called as inertial mass.

(c) Newton's Law of Universal Gravitation:- this law states Any two particles of matter attract each other with a force which is proportional to product of their masses and inversely proportional to square of distance between them.

Mathematically,

$$F = \frac{G m_1 m_2}{d^2}$$ where G is gravitational const.

m_1, m_2 are masses of bodies in kg and d = distance between the masses.

Unit of force is Newton. For a body of mass m kg on the surface of Earth, the value of the force of Earth's attraction on it is called its weight

$F = \frac{G m M_E}{r_E^2}$ and $F = W = mg$
where F is force of Earth's attraction and g is g.f. Strength

$\Rightarrow g = GM_E/r_E^2$

using $G = 6.67 \times 10^{-11}\ N\,m^2\,kg^{-2}$, $M_E = 6 \times 10^{24}\ Kg$, $r_E = 6.4 \times 10^{6}\ m$

$g = 9.81\ N\,kg^{-1}$ on the Earth, g' of moon $= 1.6\ N\,kg^{-1}$

weight of a body on the surface of a planet depends upon gravitational field strength.

(d) Momentum: is product of mass and velocity.

$p = m\,v \quad (kg\,m\,s^{-1})$

Momentum is often written as linear momentum to mean the quantity when velocity is taken in a straight line (in one dimension). Any deflections in other directions or components of velocities are not involved after a collision.

(e) Derivation of 2nd Law of motion.

For a body of mass m, acted upon by a force to change velocity from u to v in a time t.

Change in momentum $= mv - mu$

Rate of Change of momentum $= \frac{mv - mu}{t} = m\frac{(v-u)}{t} = ma$

From second Law

Rate of change of momentum ∝ Force

$\frac{mv - mu}{t} \propto F$ or $\left(\frac{mv - mu}{t}\right)K = F$

Taking Force $F = 1N$ when it produces an acceleration of $1\ m\,s^{-2}$ in a mass of 1kg in equation $F = K\,ma$ makes $K = 1$ and we get final equation $F = ma$

Since $\frac{mv - mu}{t} = F \Rightarrow$ Change in momentum = Force × time

Impulse is defined as change in momentum

Impulse = Force × time = Change in momentum

when we apply this equation $F = ma$ to the force of gravitational attraction on a body of mass m, we get

$F = ma \Rightarrow W = mg \quad (g = 9.81\ m\,s^{-2})$

(f) In F=ma, the acceleration produced is in the direction of force.

(g) The Principle of Conservation of Momentum:-

when two bodies interact, their total momentum remains constant provided no external forces are involved. The laws can be applied to collisions which may be elastic, partially elastic or inelastic.

Elastic Collisions:- A collision is elastic when

(i) total K.E before collision = total K.E after collision

(ii) total momentum before collision = total momentum A.C

Total momentum remains constant in any type of collision but K.E doesn't remain constant and changes to other forms of energy like sound, heat etc.

There are two ways of checking if a collision is elastic or not:-

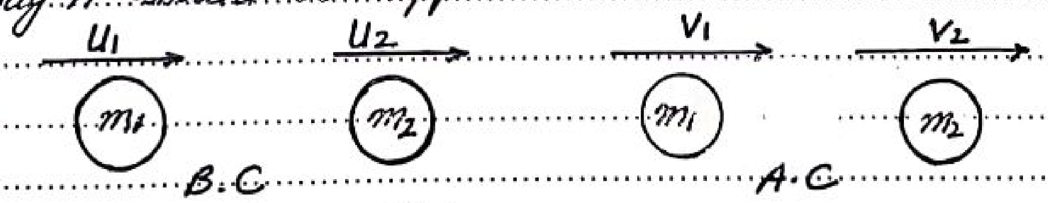
* Check by calculating the K.E of the colliding bodies before and after collision using K.e formula $E_K = \frac{1}{2}mV^2$. E_K is a scalar quantity.

* For bodies undergoing elastic collision, the relative speed of approach = relative speed of separation.

Rel. speed of approach = Difference of the two speeds

= Speed of body A − Speed of body B

Similarly relative velocity after collision is vector subtraction of the two velocities. For elastic collisions following account must be learnt by heart alongwith the way it should be applied



For perfectly elastic collision

$$u_1 - u_2 = -(v_1 - v_2)$$

$$u_1 - u_2 = v_2 - v_1 \quad \text{———} \quad (I)$$

Rel s velocity of approach = rel. velocity of separation

while using the law of restitution, the numerical magnitude of answer as calculated from I is used.

(i,j) while considering collisions, the systems must be considered e.g a ball falling on a plate on the ground and then bouncing off. When momentum change of ball is considered, the change in direction of motion (downward → upward) must be taken with appropriate sign, and laws of conservation of momentum must be then applied to the ball and plate taken as system. If ball gains momentum upwards, the plate must have gained an equal momentum downwards.

* * * *

Topic 5

Forces

(a) Gravitational Field:- In the space around material objects (e.g. Earth) a field of force is present which is known as gravitational field. In this field a force of attraction acts on a mass present. Close to the surface of Earth the field is uniform, therefore an almost constant force is exerted on masses. Gravitational force due to Earth's field is given by

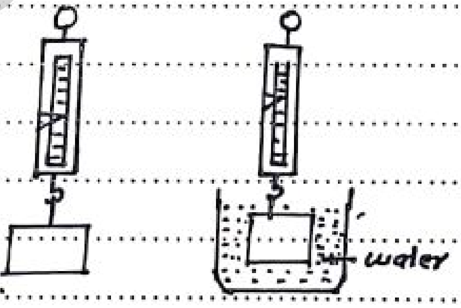
$F = \frac{G M_E}{r_E^2} \times m$ on a mass m on or close to Earth surface

Electric Field:- This field of force which exist around charged bodies. The force due to charge Q_1 on another charge Q_2 at a distance r is given by Coulomb's Law:

$F = K \frac{Q_1 Q_2}{r^2}$ where $K = 9 \times 10^9 \ m F^{-1}$

A charge present in an electric field experiences a force which can be of attraction or repulsion.

(b) Concept of upthrust:-



weight of object in air $= 10N = W_{air}$

weight of object in water $= 7N = W'$

Loss in weight $= 10 - 7 = 3N$

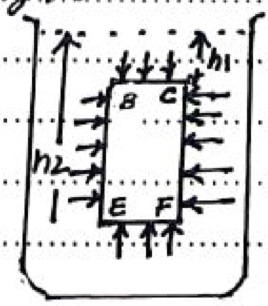
upthrust = weight of fluid displaced.

Pressure = Force/area Pressure in a fluid $= \rho h g$

where ρ = density, g = accel due to gravity, h = depth of fluid

The pressure at a given depth in a liquid acts equally in all directions. By keeping these two definitions in mind, we can explain the origin of upthrust in a liquid.

Consider an object immersed in a liquid of density ρ.



Let the area of surface $BC = EF = A$

Force due to liquid on surface BC is due to depth h_1 of liquid on it and is given by

$F_1 = \rho g h_1 A$

Similarly force on surface EF is due to depth h_2

$F_2 = \rho g h_2 A$

Resultant force $F = F_2 - F_1 = \rho g A(h_2 - h_1) = $ upthrust
Since $h_2 - h_1 = h$, the height of object and $A h =$ volume of object = volume of liquid displaced.
$\rho g A h =$ weight of liquid displaced = upthrust
which is Archemiedes's principle.

(C) Force of friction exists between two objects sliding or moving relative to each other. Friction opposes the relative sliding motion of one body on the other. Friction depends upon the nature of surfaces in contact and is independant of area of contact and speed of motion.

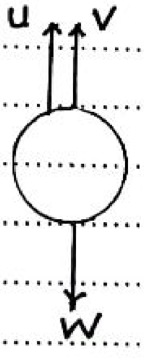
Fluid Friction:- viscous drag is called fluid friction. It is force which acts on a moving body in a fluid or on a stationary object in a moving fluid. viscous drag depends on the speed of motion of object relative to the fluid and for velocities which are non-turbulent given by the formula

$$F = 6\pi\eta a v$$

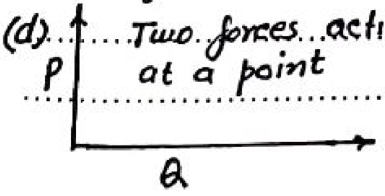
where η = Constant of viscosity, a = radius of the object
v = speed

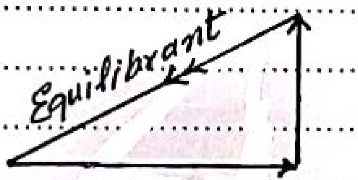
For a body which is falling freely in air, initial acceleration is almost equal to g, with small value of upthrust U, the body accelerates and gains speed. Accordingly drag force increases quickly and soon

$U + V = W$ holds good. Since now there is now zero resultant force, hence the object now moves with a steady terminal velocity.



(d)





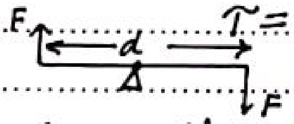
Forces in equilibrium

(e). Centre of Gravity:- of a body is that point through which entire weight of a body seems to act.

It is that point at which entire force due to gravity seems to act or the point of application of the resultant force due to gravity on the body. It is possible to balance a body at its centre of gravity. The verticle line through C.G lies directly under the point of suspension of a body in equilibrium.

(f). Couple:- Two equal and opposite parallel forces not acting at the same point constitute a couple. Couple produces a rotation. The turning moment due to couple is called torque, given by

Moment or Torque of couple = One force x arm of couple



$T = F \times \perp$ distance between the forces.

$= F \times d$

(g). Force which produces moment or rotation is called turning force. The turning effect is called turning moment. Torque or moment of force is defined as product of force and perpendicular distance between line of action of force and pivot / fulcrum.

Principle of Moments:- when a body is in equilibrium under the effect of a no. of forces, sum of clockwise moments about a point is equal to sum of anticlockwise moments about same point.

Conditions for Equilibrium:-

1. with three non-parallel forces acting on an object a closed triangle can be drawn to represent the forces in magnitude and direction.
2. The algebric sum of the moments of all the forces about any point is zero.

3. The algebric sum of resolved components of all the forces in any direction is zero.

(h) when a system is in equilibrium, there is no resultant force and no resultant torque.

(i) when it is stated that body is uniform, its C.G lies at its geometrical centre and weight act at that point. Principle of momentum can be applied taking any point as the fulcrum/pivot and equating clockwise and anticlockwise moments.

* * * *

Topic 5

Energy:- Work, Energy, Power

(a) Energy is capacity to do work. Energy can take up many different forms and can change forms.

Law of conservation of Energy:- Energy cannot be created or destroyed, it can change from one form to another, sum total remains constant in all transformations.

Example: G.P.E at height → K.E in a fall → Internal Energy heat and sound after impact.

Electrical Energy → Light, heat in a bulb

→ Magnetic energy in electromagnet

→ Sound energy in loud speaker.

Chemical Energy in fuel → heat energy in burning gases → Mechanical energy in engine → K.E of Car + Heat energy in air

(b) **Work:-** work is done when point of application of a force moves in the direction of force

Work = Force x Distance Unit: Joule

Joule: One Joule work is done when a force of 1N acts on a body and body moves 1m in its direction 1J = 1N-m

(c) When a gas expands against a constant external pressure P by an amount ΔV, work done by the gas is

$W = P \cdot \Delta V$ P = Pressure in Pa or $N m^{-2}$

$= N \cdot m^{-2} \cdot m^{3}$ ΔV = Change in volume in m^3

$W = N\text{-}m$

(d) **Kinetic Energy:-** $E_K = \frac{1}{2} m v^2$

K.E is energy possessed by a body due to its motion.

A body of mass m is acted upon by a force F to accelerate it by a and change its velocity from u=0 to v in time t, moving a distance S. Work = F x S

$v^2 - u^2 = 2as \Rightarrow S = \frac{v^2}{2a}$ and $F = ma$

$Work = ma \times \frac{v^2}{2a}$

Work done = gain in $E_K = \frac{1}{2} m v^2$

(e) $E_k = \frac{1}{2} m v^2$ = Energy possessed by a body moving with velocity V

E_K = Joule, m = mass in kg, v = velocity in ms^{-1}

(f) Gravitational Potential Energy:- It is energy possessed by a body due to its position in a gravitational field. e.g G.P.E is contained in a body which is present at height Δh above the surface of earth.

$$\Delta E_P = mg\Delta h$$

E_P = G.P.E in Joules, m = mass in kg, g = grav. field strength $9.8ms^{-2}$

Δh = height from the surface of earth in m.

In general G.P.E of a mass m at a point in a gravitational field is defined as work done to bring mass m from infinity to that point, in the field.

Gravitational Potential:-

work done per unit mass to bring the mass from infinity, as given by:

$$\text{Gravitational Potential} = -\frac{GM}{r}$$

In earth's field M = mass of Earth

r = distance from centre of earth of a point at which Potential is defined.

$$G.P, V = -\frac{GM}{r}$$

$$G.P.E, U = -\frac{GM \times m}{r} \quad , \quad G.P.E, U = mV$$

Relation between G.P.E, U and gravitational force F is given by

$$F = -\frac{du}{dr} \quad \text{or} \quad U = -\int F.dr$$

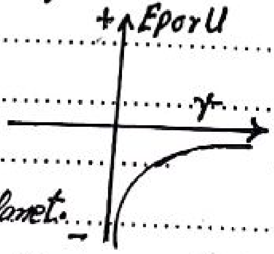
Gravitational force is rate of change of G.P.E

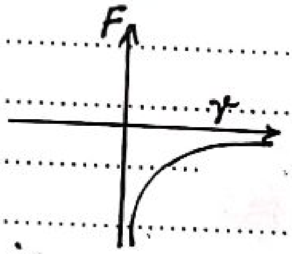
Relation between G.P and G.F.S (g)

$$g = -\frac{dV}{dr} \quad \text{or} \quad V = -\int g\,dr$$

G.F.S is rate of change of Gravitational Potential.

The gradient of U against r graph gives -ve of force acting on mass m at a distance r from centre of planet.





G.P.E of mass m at the surface of earth is

$$U_0 = -\frac{GMm}{r_E}$$ where M = mass of earth.
r_E = radius.

Electrical Potential Energy:– Coulombs Law of electrostatic forces $F = K\frac{Q_1Q_2}{r^2}$ where Q_1, Q_2 are charges in coulombs, r is the distance between them, $K = Const = 9\times10^9\ m\,F^{-1}$

Electric Potential:– It is defined as the work done on a unit positive charge to move it from infinity to a point in the field. It is a scalar quantity. Electric potential at a point which lies at distance r from a charge Q is given by

$$V = \frac{Q}{4\pi\varepsilon_0 r} \quad \text{in vacuum.}$$

If Q is a positive charge, V is positive

Q is a negative charge, V is negative

when another charge Q' is placed at that point, its electric potential energy is given by;

$$E_P = \text{Electric potential} \times \text{Charge} = \frac{QQ'}{4\pi\varepsilon_0 r}$$

Rate of change of pot. energy with distance, Force $= -\frac{dE_p}{dr}$

Rate of change of Electric potential with distance, E.F.S., $E = -\frac{dV}{dr}$

Elastic Potential Energy:– $E_p = \frac{1}{2}F.e$ F = Force, e = extension

within elastic limit, $F \propto e \Rightarrow F = ke$

$$E_P = \frac{1}{2}ke^2 \quad \text{where } k = \text{Elastic Constant}$$

Store energy is the work done in producing extension and it can be calculated from the area under plotted line and extension axis on a F–e graph

(b). (i) work = Force × distance

$$W = F \times S$$

when a body is moved up against gravity, force overcome is equal to weight mg, of the body of mass 'm'. If it is moved up by a distance h, work done against the gravity by above formula $W = mgh$. This work is stored in the body as potential energy (gravitational) at the height 'h' and is released as K.E if the body falls.

(i) Kinetic Theory: All objects are composed of molecules. According to kinetic theory these molecules are in a constant state of some kind of motion depending upon state (solid, liquid, gas) of the object. Thus moving molecules have kinetic energ

The molecules are made up of protons (nuclei) and electrons. There is a field of electrostatic attraction and repulsion between neighbouring molecules. Since they are experiencing a field of force, the molecules possess potential energies. The sum total of k.e and p.e of molecules constitute total energy which is called internal energy of the substance.

In an ideal gas, since the intermolecular forces are assumed to be negligible, the internal energy of an ideal gas comprises only of kinetic energies of molecules and hence depends on temperature of gas.

(k) Work Done on and by Machines:–

In all practical machines, work done on the machine is called input work. It is given by

Input = Effort × distance moved by effort.

work done by the machine is called output, it is given by Output = Load × distance moved by the load

There is always some work/energy loss in the process. This is due to

(i) friction in moving parts – work lost as heat to machine and surrounding.

(ii) work done in lifting in some parts of machine along with the load

(iii) Energy lost as heat energy e.g in motor coils or in magnetic reversals in a transformer or as eddy currents etc.

Due to these unavoidable energy losses machines are never 100% efficient. The efficiency of a machine may be calculated by following formula.

$$\text{Efficiency} = \frac{\text{work output}}{\text{work input}} \times 100$$

Since Power $= \frac{\text{work}}{\text{time}}$ or $\frac{\text{Energy transferred}}{\text{time}}$ Js^{-1} or watt.

Efficiency can also be written as

$$\text{Efficiency} = \frac{\text{Power output}}{\text{Power input}} \times 100$$

$$\text{Power} = \frac{\text{Work}}{\text{time}}$$

But work = Force × distance

$$\text{Power} = \frac{\text{Force} \times \text{distance}}{\text{time}}$$

Power = Force × Velocity

$$P = FV$$

* * * *

Topic 9

Phases of Matter

(a) Density: is defined as mass per unit volume.

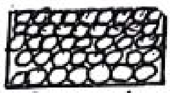
Density = mass/volume Units: $g\,cm^{-3}$ or $kg\,m^{-3}$

It is a scalar quantity.

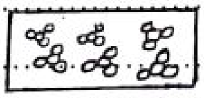
(b) States of Matter

There are three states of matter. Solid, liquid & gas.

Kinetic Model for Solids:-

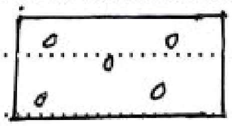


Close-packed orderly arrangement of molecules. little space between the molecules. Strong intermolecular forces of attractions. No freedom of movement. Only restricted movement (vibrations) about their mean position. Due to close pack arrangement of molecules, the solids in general have high densities.



Kinetic Model for Liquids:- The molecules move about often clusters. Still the intermolecular forces are operative, but are relatively weaker. The molecules have greater freedom of movement and can move about exchanging their K.E with their neighbours. The intermolecular spaces are relatively larger than in solids but are same within the clusters. Therefore densities of liquids are comparable to those of solids. It is also evident from the fact that a big change in volume does not occur when a solid melts to a liquid.

Kinetic Model of Gases:

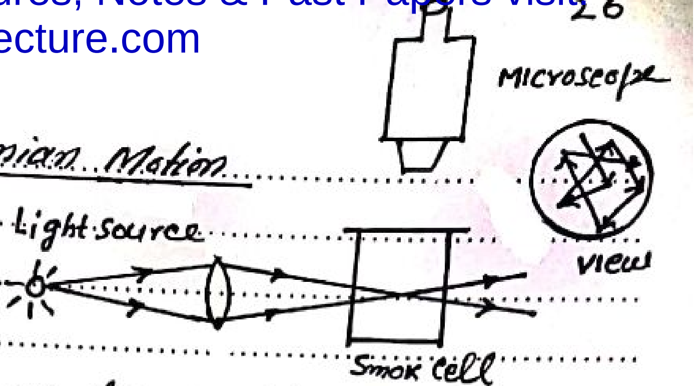


Intermolecular spaces are much larger than the size of molecules. No forces of attraction or repulsion are present. Molecules are completely free to move about and can fill up any available space. No orderly arrangement of molecules is possible. They are randomly moving in all directions. The densities of gases are therefore very low. By comparison their densities are as follows: Solid : liquid : gas

1000 1000 1

(d) Expt: To demonstrate Brownian Motion

Some smoke is trapped in a glass cell alongwith air, and slide cover.



A strong beam of light is shone from a side on the smoke cell and observed with a microscope from above.

Observation: Bright specks of light seen in random motion. The specks of light are smoke particles scattering light. They are being constantly bombarded by randomly moving air molecules from all sides and change the direction towards the resultant force acting on them.

The expt. provides visual evidence of the random motion of molecules of air. Otherwise invisible even under a microscope. If experiment is performed at a lower temperature, slower movement of smoke particles is observed. If larger particles are used, the movement is almost not visible. Because of larger particles forces balance out from all sides to make resultant force zero.

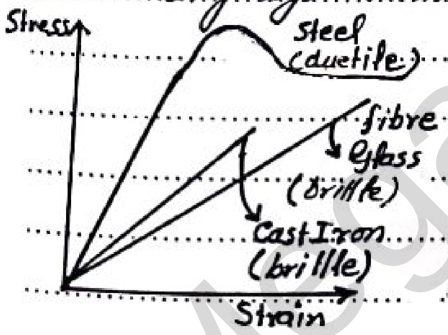
(e) Crystalline Solids:- These are solids in which solid structure is formed by repeatition of a basic crystal unit structure over and over again throughout the three dimensional lattice. Here the particles making up the crystal (atoms, molecules or ions) set up a 3-D arrangement of basic crystal unit which is then repeated throughout the solid e.g cubic, face centered cubic, hexagonal close pack etc. Metals are usually crystalline solids. Here 3-D regular arrangement of atoms in space exists. Such solids are malleable, ductile and elastic.

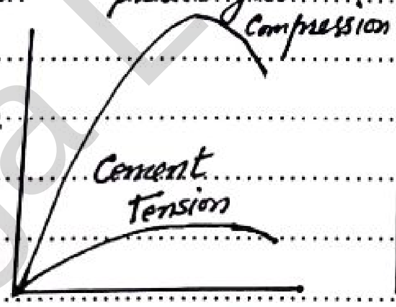
Non-crystalline Solids:-

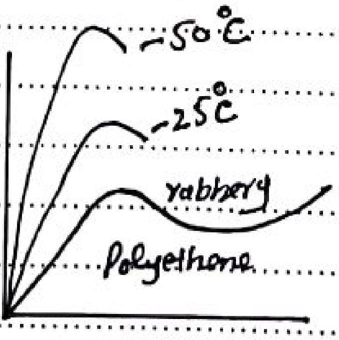
These include non-crystalline or semi crystalline polymeric materials. In polymeric materials, very large molecules are involved which may be branched or un-branched, and in making up the solid structure create some short range ordered arrangement. These solids therefore softens over a range of temperature (instead of having a sharp melting point). The disordered or less orderly placed parts of structure require less energy to become soft as compared to other parts of same structure where some crystalline characteristics are present. At ordinary and low temperature these solids are brittle and break as soon as their elastic limit is reached. However at higher temperature they show rubbery behaviour.

<u>Amorphous Solids:-</u>

The amorphous solids have completely disordered arrangement of particles e.g glass which is referred as super cooled liquid. In the characteristics random movement of liquid-glass, cooling causes the molecules to become slow and "freeze" where they are and hence no arrangement of any type is created in the solid structure. Amorphous materials are brittle. They break without any deformation plastic flow.







Metals and glass have high Young modulus and low elastic strain. Plastic have low Young modulus (less stiff) larger elongation and do not obey Hook's Law.

Toughness → Ability to resist crack growth.

Hardness → Resistance to plastic deformation

Stiffness → Young's Modulus = Stress/Strain

Tensile Strength → Breaking point Stress (maximum)

Elastic deformation → Reversible deformation. Hook's Law obeyed.

Plastic deformation: Permanent deformation.

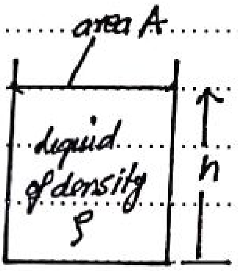
Ductile Material: Show large plastic deformation before breaking.

Brittle Material: No plastic flow, breaks after its elastic limit.

(f) Pressure:- Pressure is defined as force exerted per unit area of a surface perpendicularly. $P = F/A$ where pressure is measured in $N\,m^{-2}$ or Pascal. $1\,Pa = 1\,N\,m^{-2}$

Kinetic model of gases assumes gases are composed of millions of fast moving molecules. These molecules move in straight lines until they collide with other molecules or container walls to change their direction of motion. The molecular collisions are perfectly elastic. Each collision causes a tiny force to be exerted on container wall. Each molecule collides many times in a second and a very large number of other molecules are also colliding for a substential force to be exerted on the walls. The average force exerted per unit area makes the pressure.

(g) (h) Let there be column of liquid of density ρ, be resting on a surface with area A, and column height h.



The force exerted at the base of container is equal to weight of liquid on it

$$\text{Force} = mg \quad \text{but } m = \rho V$$

$$F = \rho V g \;, \quad \text{Also } V = hA$$

$$F = \rho A h g$$

$$\text{Pressure} = \frac{F}{A} = \frac{\rho \cancel{A} h g}{\cancel{A}} = \boxed{\rho h g}$$

(i) Melting:- when a certain amount of energy is given to the particles of a solid, they vibrate vigorously and at melting temperature break away, so that the lattice collapses, solid changes to a liquid. Boiling occurs at a certain temp. of a liquid called boiling point. Hence bubbles freely form throughout the bulk of liquid and it quickly changes to vapour. Heat energy is constantly required.

Evaporation is the slow change of state of a liquid to vapour which takes place at the surface and occurs at all temps. Evaporation causes the temperature of liquid to drop.

* * * *

Topic 10

Deformation of Solids

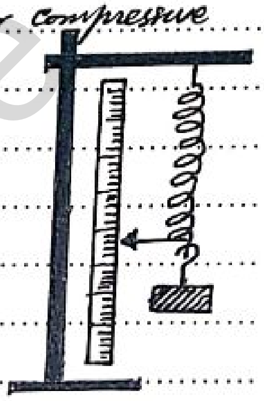
(a) Consider a wire suspended by a firm support in the ceiling and a weight is suspended at the lower end of wire. The weight produces a force which produces an extension in the wire.

A spring can be held in a clamp on a stand at one end and extended by a weight at the other.

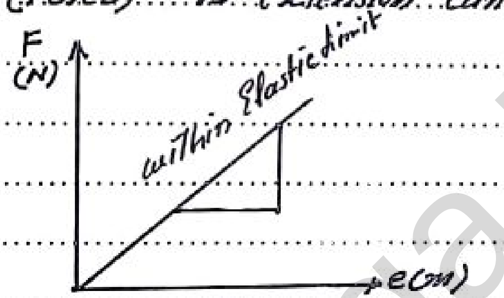
A weighing machine has a spring which is compressed with a weight in the pan.

The compression and extension of a spring and the extension of a wire due to force is called as deformation.

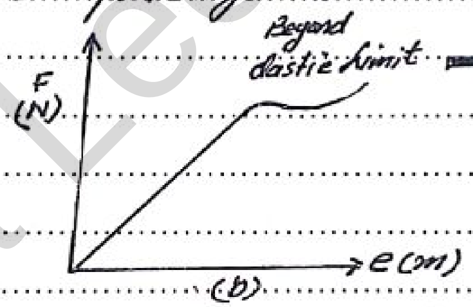
Deformation/extension along the length is called tensile or compressive if length decreases



(b) The apparatus shown in the diagram can be used to investigate the behaviour of a spring by increasing load. Many readings of extensions can be taken using different load in the pan. A graph of load (Force) vs. extension can be plotted from data.



(a)



(b)

At first the graph of force F vs. e is straight line we deduce

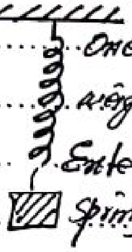
Hook's Law:-

The extension is proportional to the force if proportional limit is not exceeded.

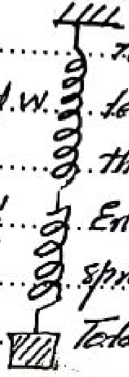
In figure (b) force-extension graph is linear initially and changes to curve later. The end point of straight line is called elastic limit of the spring. upto this point spring returns to original position on removing the load.

Spring Constant: The slope of F-e graph in the straight line part gives Force per unit extension, F/e. This quantity is called spring constant. Its unit is $N\text{-}m^{-1}$.

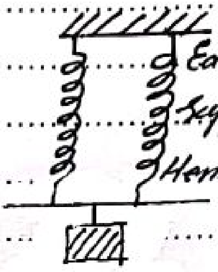
Following conditions must be considered carefully:



One spring
weight suspended W.
Extension = e
Spring Const $K_1 = \frac{W}{e}$

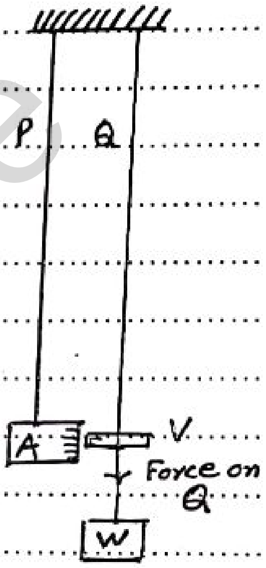


Two similar springs
tension is same
throughout.
Extension in each
spring = e
Total Extension = 2e



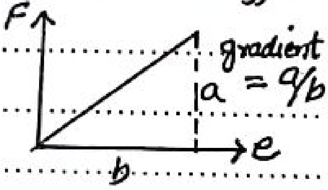
Each spring
Support a force $\frac{W}{2}$
Hence Extension $= \frac{e}{2}$

Expt. to determine Young's Modulus:-



Two long thin steel wires P, Q are suspended from a rigid support. The wire P is kept taut by weight A and carries a m.m scale. The wire Q carries a vernier scal V which measures the small extension e in the length of wire Q when a load W is increased, which increases the force F in the wire. The extension e and weight W producing it are carefully measured. A loading and unloading reading taken for each load.

A graph of load F against average extension is plotted. A straight line passing through origin is obtained. length and diameter of wire measured. (dia taken at 10 diff positions)



Area of C.S = πr^2 or $\frac{\pi}{4}d^2$

Some definitions are:

Tensile force: Force acting at right angle to the C.S

Stress(σ): Force/Area ($N\text{-}m^{-2}$) or Pa Also called Tensile stress.

Strain(ε): Extension/original length, e/l $\varepsilon = e/l$

within the elastic limit, wire obeys Hook's Law

$$\text{Stress} \propto \text{Strain} \Rightarrow \frac{\text{Stress}}{\text{strain}} = A = \frac{F/A}{e/l} \text{ or } \frac{Fl}{Ae}$$

this Constant A is called Young's Modulus (E)

$$E = \text{gradient} \times \frac{\text{length}}{\text{area}} \quad \text{where gradient} = F/e$$

(e) Elastic and Plastic Deformation:- Upto the elastic limit the force extension graph is a straight line. If we continue increasing load a stage comes when there is suddenly large extension. This hapens where elastic limit is exceeded. Further loading brings abaut large extension and wire thins out & snaps.

Elastic Deformation:- when wire returns to original length after the load is removed. The strain energy stored in the wire as molecular P.E is then fully recovered.

Plastic Deformation:- when the wire is permanently deformed and doesint come back to original length even after the removal of load. The energy stored in the wire in the plastic deformation is lost as heat to the surroundings.

Ultimate Tensile Stress:-

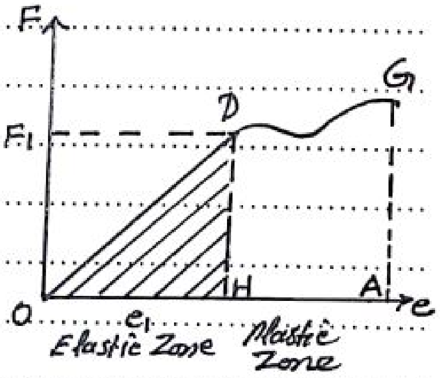
It is maximum stress that the wire/material can withstand before breaking.

Graph F vs e and energy measurements:-

Energy stored during elastic deformation $= \text{Area of } \triangle ODH$

$= \frac{1}{2} \times \text{base} \times \text{height}$

$= \frac{1}{2} F \times e$ or $\frac{1}{2} k e^2$



The total energy stored can be calculated from linear (elastic) and non-linear (plastic) parts of F-e graph. Total work done or energy stored if wire extends from O to A is still given by area ODGA.

Topic 13

Waves

(a) If one end of a rope is tied to a hook in a wall and other end is moved up and down, a wave is seen to travel along the rope.

The same process can be done with a slinky (spring) which takes up the form of a moving wave.

A small stone is thrown on the surface of water in pond, ripples (surface water waves) travel outward from the point of impact of stone

surface water waves are generated in the lab on a water tray called ripple tank. The waves are generated by a straight or ball ended dipper which periodically touches the water surface and hence can generate a wave train. The waves are observed with the help of a lamp on the top of glass tray containing water and a white card board sheet underneath on the floor.

The hand moving up & down and the dipper of the ripple tank generate a disturbance in the particles of the medium.

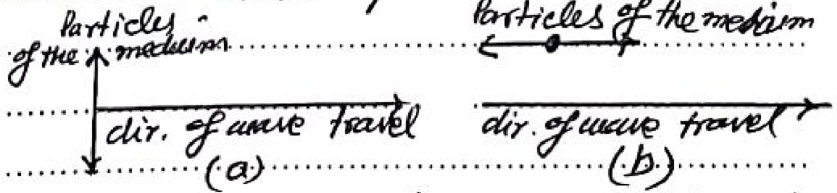
Progressive or Travelling Wave:- It consists of a disturbance moving from a source to surrounding places. As a result energy is transferred from one point to another.

There are two types of progressive waves:

Transverse Waves:- Particles of the medium oscillate perpendicular to the direction of waves travel e.g a figure

Longitudinal Waves:-

Particles of the medium oscillate parallel to the dir. of wave travel.



Classification:-

Mechanical Waves:- are produced by a vibrating body in a material medium and are transmitted by the particles of the medium vibrating accordingly e.g waves on rope, stretched strings and on slinky are mechanical waves, examples of transverse waves.

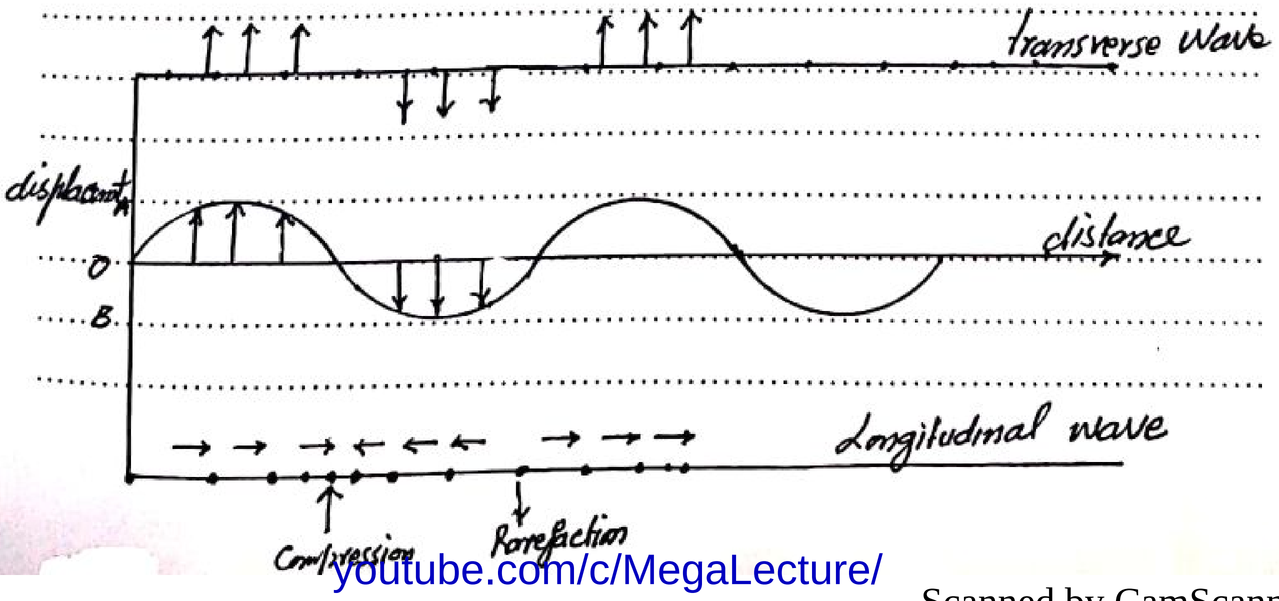
Sound waves in air and other materials and waves on slinky springs when had is moved back & forth are mechanical waves but longitudinal in nature.

Electromagnetic Waves:- these waves consist of a disturbance in the form of varying electric & magnetic field. No material medium is required and these can travel more easily in vacuum. Radio signals, light and x-rays, microwaves are all examples of electromagnetic waves. Microwaves can be generated by a high frequency a.c oscillator (10,000 M.HZ). The oscillator feeds a small aerial in a rectangular metal tube, called a wave guide, which opens into a horn at one end. The radiation which is emitted has a wavelength of 3 cm. Another unit contains a detector and can be used to receive and detect microwaves. Another non-directional receiver is known as Probe Receiver.

Graphical Representation of Waves:-

(b) A displacement - distance graph of a transverse mechanical wave shows the displacement y of the vibrating particles of the transmitting medium at different distances x from the source at a certain instant.

Similar graph can be used to represent a longitudinal wave motion, when the displacement towards right of the particles is given as +tive and that towards left is given as -tive (+ upward and - downward in the graph)



* **Transverse Wave:-** Points of maximum + displacement are called crests. Points of max -tive displacement are called troughs.
* **Longitudinal Waves:-** Regions of high particle density are called compression and regions of low particle density are called rarefactions.
* **Amplitude:-** The maximum displacement of each particle from its undisturbed position is called amplitude (given as OA or OB in the graph)
* **Wavelength (λ):-** Distance between two consecutive points which are in step, i.e have the same phase or the distance between two successive crests or troughs is wavelength.
* For a longitudinal wave it is distance between two consecutive compressions or rarefactions.
* **Frequency:-** The number of complete vibrations produced per second by the source of disturbance is called its frequency. It is also defined as number of wave crests crossing any point per second.

Show that $v = f\lambda$

when source completes one vibration, one wave is generated and the disturbance spreads a distance λ from the source. If source vibrates with a frequency 'f', then f waves will be produced per second, and wave advances a distance λ in one second.

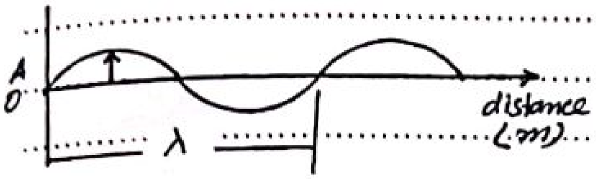
Since speed is the distance moved by wave in one second

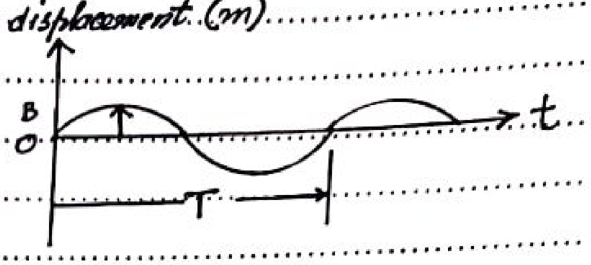
$v = f\lambda$ This relation holds for all wave motions.

v = wave speed ($m\,s^{-1}$)
f = frequency in Hertz (s^{-1})
λ = wavelength in m.

Displacement Time Graph:- Displacement is the distance of rest position of vibrating particles in a wave motion. A displacement time graph may also be drawn for wave motion. This shows how the displacement of one particle at a particular distance from the source varies with time.

If particle vibration is a simple harmonic type, the graph is a sine curve.





Distance OA or OB = amplitude

In displacement-distance graph λ = wavelength

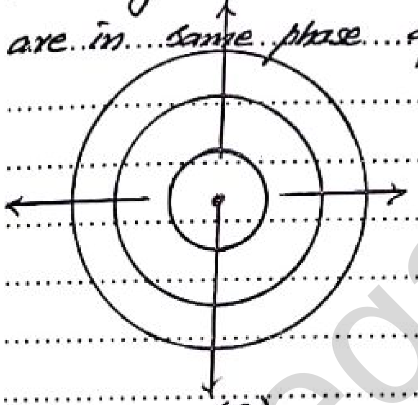
In displacement-time graph T = Time period.

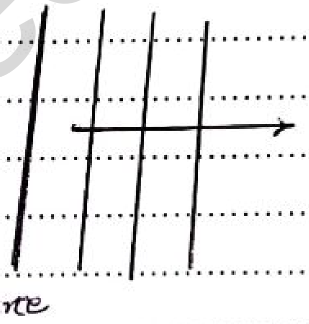
Time Period:- Time taken to complete one vibration.

Since $f = \frac{1}{T} \Rightarrow v = f\lambda$ or $v = \frac{\lambda}{T}$

Wavefront:-

A wavefront is line or surface which is drawn perpendicular to an advancing wave in such a manner that all points on a wavefront are in same phase of their vibrations.


(a)

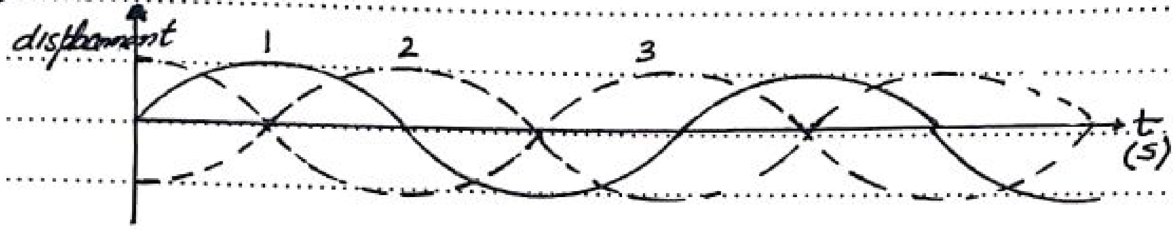


A point source produces circular wavefronts as shown (a)

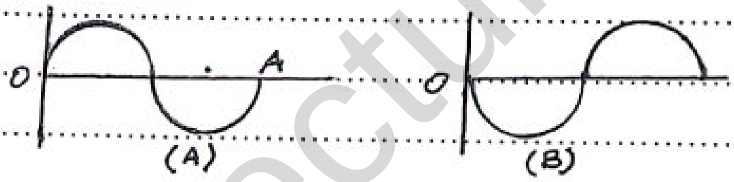
A line source creates straight wavefronts (in ripple tank)

The wavefronts may be drawn to represent the surface through the crests of the waves. The distance between consecutive lines (wavefronts) is wavelength.

Phase Difference:- Phase difference is always described in term of a given reference i.e. one wave is given and phase difference of second wave is described from the first wave is described from the first wave as how much lag or lead it has over the first one. This lag or lead can be given in term of a fraction of a time period or in term of phase angle in degrees or in radians or in terms of fraction of a wavelength. Consider the set of following waves:



In moving from O to A, One complete wavelength is moved. One complete time period elapses. An angle of 2π radians or 360° is traced. It leads to the following concepts:



The waves represented by A and B are;

(i) having a phase difference of π radians or 180°

" " wave path difference of 180°.

" " difference of T/2 (Half a time period)

Whether a second wave has a phase lead or lag, can be checked by anyone of these criteria depending on the given data. For reference graphs of figure above.

Curve 1 is the reference wave.

wave 2 has a 90° or π/2 phase lag on wave 1

wave 3 has a 90° or π/2 phase lead on wave 1

(f) waves transfer energy from one point to another. Radiowaves bring energy in the form of e.m. waves to our T.V. sets, Sound waves bring sound energy from the speaker to the listeners ear. The amount of wave energy is represented in terms of its intensity.

Intensity of Waves:- Intensity of a wave is defined as the amount of energy in Joules reaching any surface per second per unit area perpendicularly:
i.e Intensity is defined as energy travelling per second per m^2 area perpendicularly

$\frac{J}{s}$ = watt ⇒ Intensity = $\text{Watt}\ m^{-2}$

It is called Power Flux.

Larger is the amplitude of vibration of a source, more will be the energy carried by the wave. The mathematical relationship between the two is:

$$\text{Intensity} \propto (\text{amplitude})^2$$

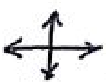
If two sources are to be compared; then

$$I_1 \propto A_1^2 \quad \text{and} \quad I_2 \propto A_2^2$$

and $\frac{I_1}{I_2} = \left(\frac{A_1}{A_2}\right)^2$ can be used

Intensity of a wave is inversely proportional to the square of its distance from the source simply due to geometrical spreading $I \propto \frac{1}{r^2}$

Polarization of Waves:- A transverse wave due to vibration in one plane is said to be plane polarised. Electromagnetic waves e.g light waves have vibrations in many planes. This light is ordinary or unpolarised. All these vibrations may be summed up in two ⊥ directions as

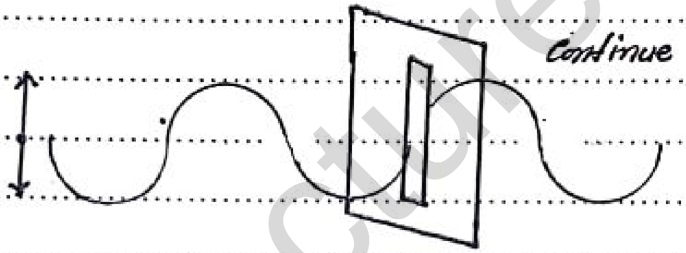


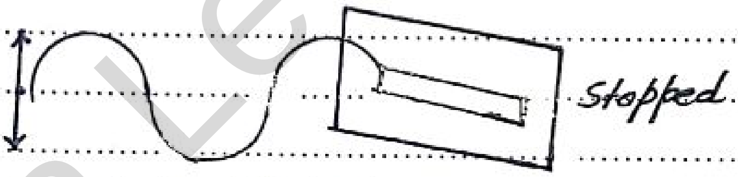
vertical and horizontal when the ray travel ⊥ and into the plane of paper. When this light is passed through a special crystal, called polariser, it allows vibrations in one plane, vertical or horizontal to pass through. Therefore the intensity of light is reduced. A second polariser with its axis perpendicular to the first one will completely cut off the light.

The polarisation of microwaves can also be studied. The wave guide produces polarised waves when they are passed through a grill of vertical rods, a vertical probe detector gives a high reading but when grill is rotated to make rods horizontal the polarised waves stop and reading on the detector is low.

Since transverse waves have vibrations ⊥ to the direction of wave motion, only transverse waves can be plane polarised as indicated below.

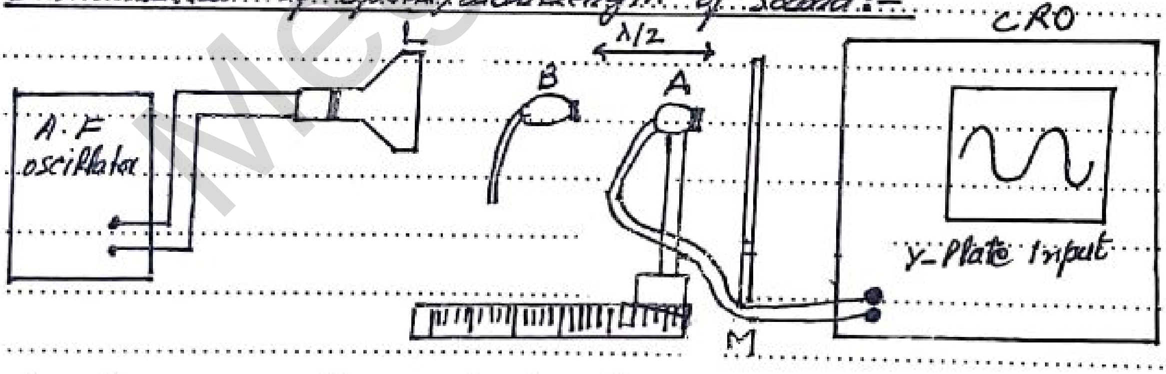
Longitudinal waves are produced by vibrations parallel to the wave travel direction. Hence they will pass through the aperture in any orientation and therefore they cannot be polarised.





(J) & (K)

<u>Determination of speed/wavelength of Sound:-</u>



Sound waves of constant frequency such as 1500 Hz travel from a loud speaker L towards a vertical board M. Here the waves are reflected and interfere with the incident waves. Two waves travelling in opposite directions produce a stationary wave.

between the board M & L.
A small microphone positioned in front of board, is connected to the Y-plate of an oscilloscope. As the microphone is moved back from M towards L, the amplitude of the waveform on the screen increases to a maximum at one position A. This is the antinode of the stationary wave, when microphone is moved on, the amplitude diminishes to a minimum (a node) and then increases to a maximum, again at position B, the next antinode. The distance between antinodes is $\lambda/2$. So by measuring the average distance d between successive maxima, the wavelength λ can be found. Knowing the frequency f from the a.f generator, the speed V of the sound can be calculated from $V = f\lambda$

Determination of frequency from calibrated oscilloscope.

This method involves use of microphone and a CRO. The This sound, of which frequency is to be found is produced in microphone and fed to CRO (if need via a pre-amplifier) which is set on a suitable known time-base range. By noting the number of cycles of a.c on a certain length of time scale, the frequency of unknown sound can be worked out by comparison with 50 Hz a.c trace.

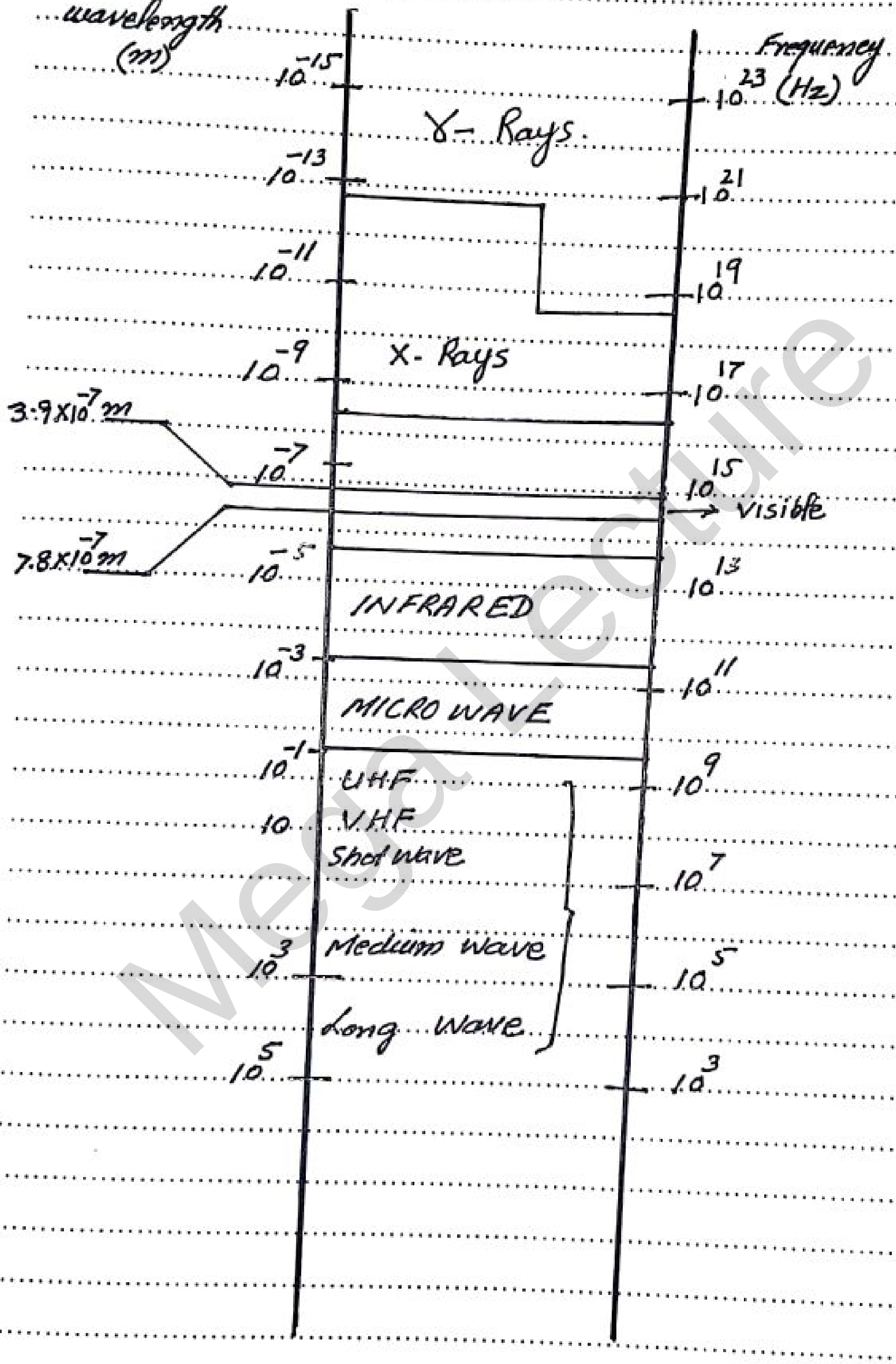
(8) Electromagnetic Waves:- 1. E.m. waves consist of varying electric and magnetic field. The two fields are perpendicular to each other and to the dir. of wave travel. Each field vibrates at same frequency, the frequency of wave.

2. All e.m. waves travel at the same speed in vacuum $2.99 \times 10^8 \text{ ms}^{-1}$

3. E.m waves are unaffected by electric & magnetic field.

4. E.m waves travel in straight lines (within the limits set by diffraction.

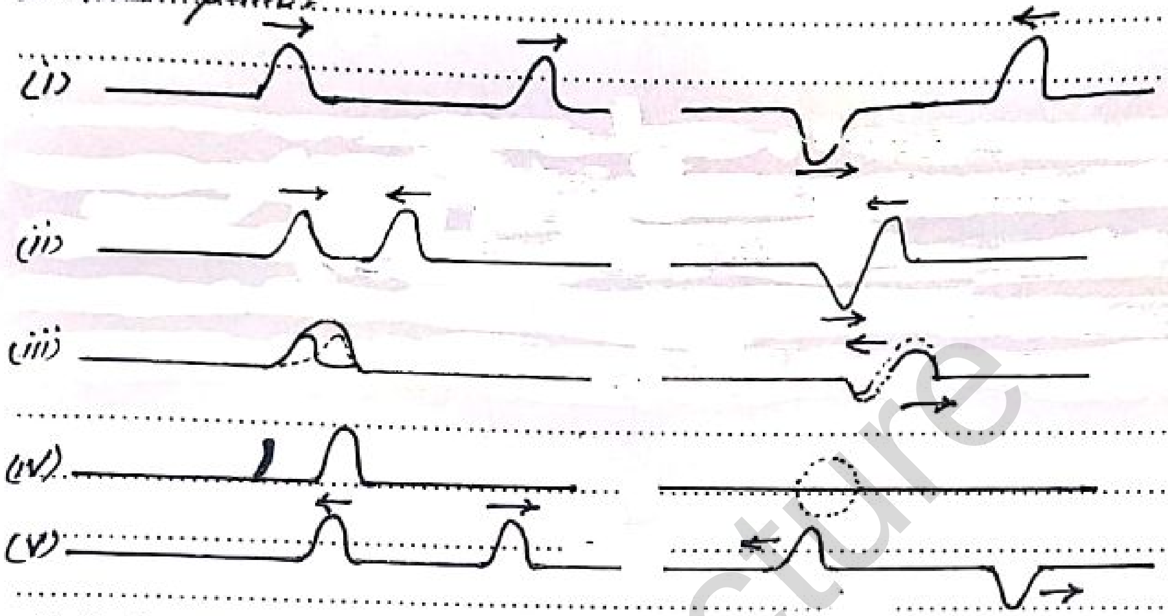
Electromagnetic Spectrum:— The whole range of frequencies of e.m. waves constitute e.m. spectrum.



Topic 18

SUPERPOSITION

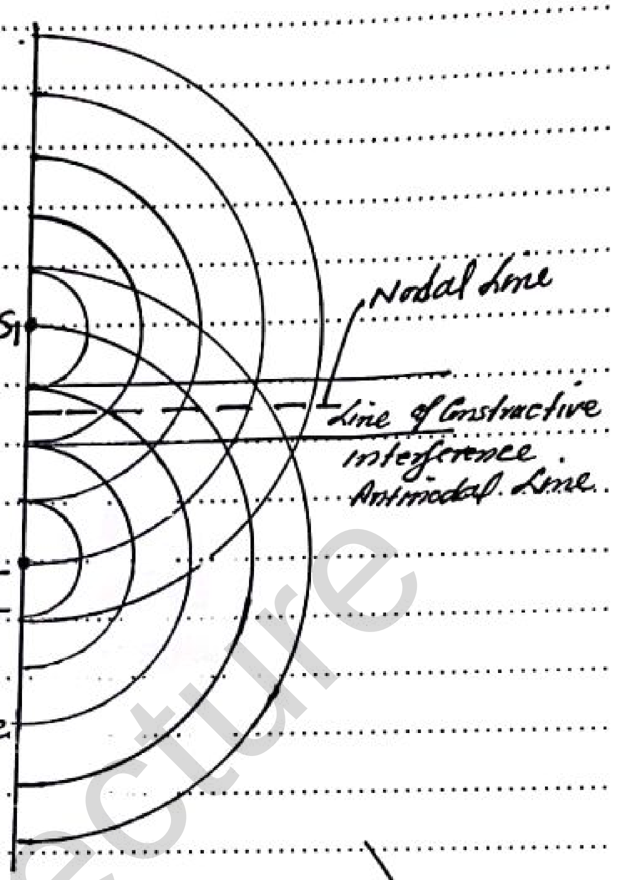
Principle of Superposition:- Pulses and waves pass through each other unaffected, and where they cross the total displacement is vector sum of the individual displacements due to each pulse at that point.



Interference:- In a region where wave-trains from berent sources cross, superposition occurs giving re-inforcement of the waves at some point and cancellation at others. The resulting effect is called an interference pattern or a system of fringes. **Coherent Sources** have a constant phase difference which mean they must have the same frequency, and for complete cancellation to occur the amplitudes of the superposing waves they produce must be equal. In practice the coherent sources are derived from a single source.

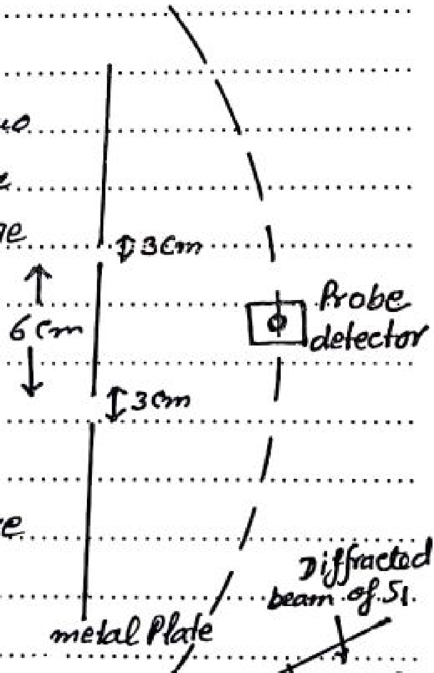
Interference of water waves:- can be studied in a ripple tank using two small spheres attached to the same vibrating bar. Circular waves are produced and make an interference pattern on the screen underneath the table. The line of reinforcement i.e constructive interference is produced where the crests of wave from S_1 are superposed by crests from S_2. A line of cancellation occurs when crest from S_1 is meeting trough from S_2. These are respectively called antinodal and nodal lines. diagram on next page.

It can be shown that separation of of nodal and antinodal lines increases
(i) as the distance from S_1 and S_2 increases.
(ii) Smaller the separation of S_1 and S_2.
(iii) as the wavelength increases (or the frequency decreases)



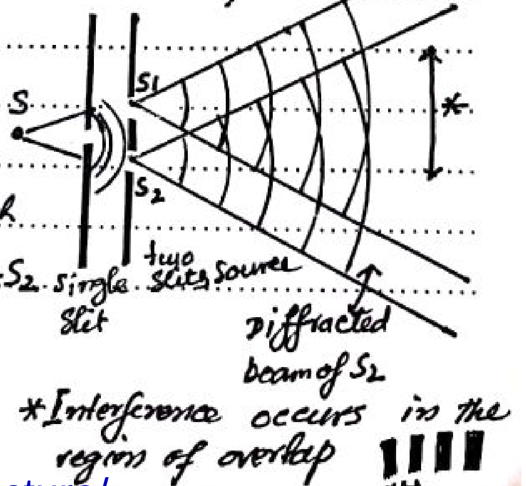
Interference of E.M Waves:-

A wave guide producing 3.cm microwave and a probe detector are used. Interference occurs between two wave trains emerging from 3 cm wide slits which act as two coherent sources. The receiver detects the maxima and minima of the fringe pattern as it is moved around; if it is minimum and waves from one of the slits are cut off, at once the signal increases to clearly indicate that the minimum was due to destructive interference.



Interference of Light:-

Double Slit Experiment:-
Monochromatic light from a source is passed through single slit S which is vertical and then through slits S_1+S_2.



*Interference occurs in the region of overlap which are very close and parallel to S. S_1 and S_2 act as two coherent sources, diffraction occurs and interference of two diffracted beams produces fringe pattern of alternate bright and dark bands. These fringes can be observed on a screen or at cross wire of an eye piece. If either S_1 or S_2 is covered, the bands disappear. The average fringe spacing y is found by measuring across as many fringes as possible with a travelling eye-piece. A meter rule is used to measure D, the distance of screen from double slit, a the slit separation. a is measured directly with a travelling microscope.

Hence y is fringe spacing, D is distance between double slit source and screen, a slit spacing and λ wavelength of monochromatic light, then

$$\lambda = \frac{ay}{D}$$

Further Points:-

(i) Fringes are observed anywhere in the overlapping region. They are called non-localised fringes.

(ii) If white light is used, each colour produces its own set of fringes which overlap. Central bright fringe is white.

(iii) Since λ of red is longer than blue, red fringe spacing is larger than blue fringe spacing.

(iv) Narrow slits produce better diffraction, greater interference and more fringes but they are less bright, since less light can pass through.

(v) If source slit S is moved nearer to double slit, the separation of fringes is un-affected but they become brighter.

(vi) Since $y = \frac{\lambda D}{a}$. If a is diminished, separation increases.

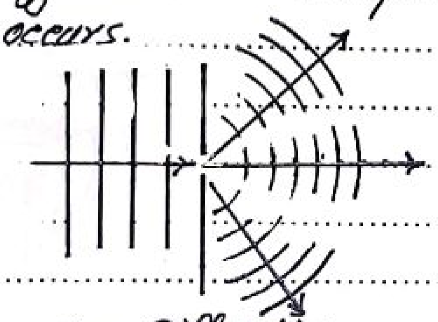
(vii) If one of the slits is covered, fringes disappear.

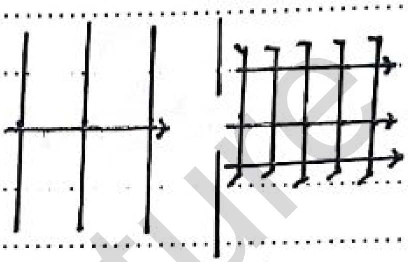
(viii) Since intensity of light is proportional to A^2, and in a bright fringe is $2A$, the intensity of light in a bright fringe is $\propto (2A)^2$ or $4A^2$.

Diffraction:-

(a) The spreading of waves when they pass through an opening or round an obstacle into regions where we would not expect them is called diffraction.

(i) Diffraction of water waves can be studied in a ripple tank, with a barrier placed in the water tray in the path of straight waves. When wavelength (distance between wavefronts) is large compared to aperture size, there is no or little diffraction. When aperture is narrow, appreciable diffraction occurs.

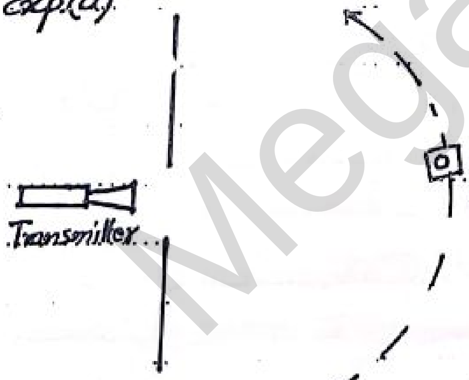

More Diffraction


Less Diffraction

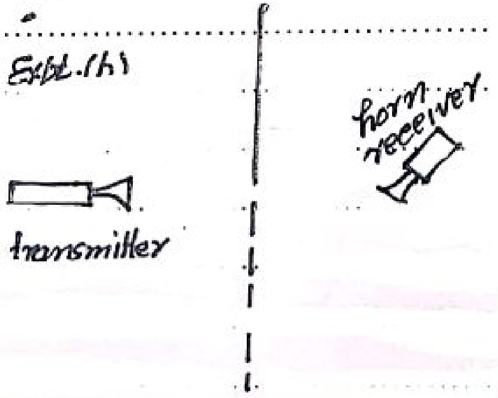
(ii) Diffraction of Electromagnetic Waves:-

Diffraction of microwaves at a slit may be shown with following appratus.

Exp.(a)



Expt.(b)



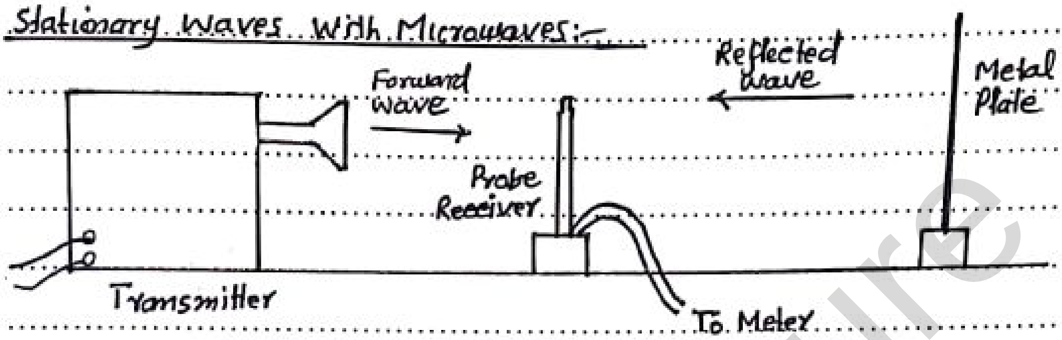
Spreading into regions of geometric shadow behind the slit is greatest when the slit width is comparable with the λ of microwave i.e 3cm.

In expt.(b) the plate cuts of the signal to the receiver but when a second plate is solid in the dotted position leaving a 3-6 cm slit between the plates, the signal at once increases.

(v) The wavelength of standing waves is twice the distance between successive nodes or antinodes and is equal to the wavelength of either of progressive waves.

(vi) Large amounts of energy are stored locally in standing waves and becomes tapped with the waves. There is no energy transmission.

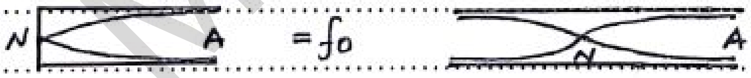
Stationary Waves With Microwaves:-



waves from transmitter are superposed on those reflected from the metal plate. If the plate is slowly moved towards or away from the transmitter, the signal at the receiver varies and the distance moved by the reflector between two consecutive minima (nodes) equals half the wavelength of microwaves.

Stationary Sound Waves:- Stationary longitudinal waves in a column of air in a pipe are the source of sound in wind instruments. The vibrations can be fundamental mode or overtones. The 'stopped end' must be node.

Fundamental Mode



In both sets the wavelength of wave in fundamental and first overtone is different.

(d). use of diffraction grating to determine wavelength of light :-

A diffraction grating is glass or metal plate, with large number of close parallel lines drawn on it. These lines are equidistant and act as slits. It provides a valuable way of studying spectra.

width of slit or clear space = a + width of opaque line = b

Slit spacing = a+b = $\frac{1}{\text{number of lines per metre}}$ = d.

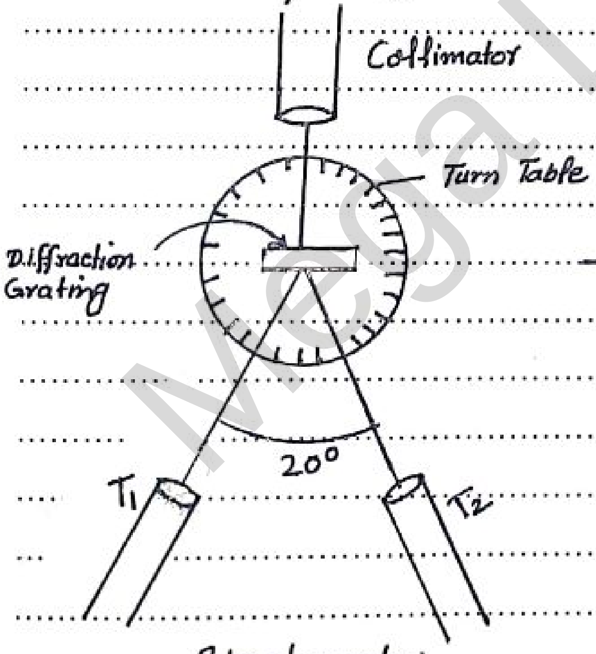
A spectrometer can also be used to measure wavelength of light with proper adjustment of telescope & Collimator for parallel light and levelling of turntable, central bright image is formed. First and second order spectra are obtained on both sides of central image.

The angular position of images are measured and equation used is;

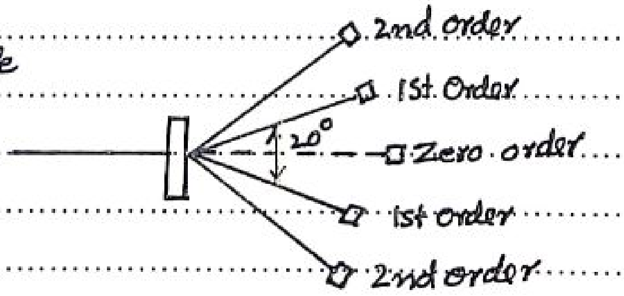
$$d\sin\theta = n\lambda \qquad n = 1,2,3 \text{ etc}$$

where

d = slit spacing and λ = wavelength, n = order of image



Spectrometer



* * *

Topic 17

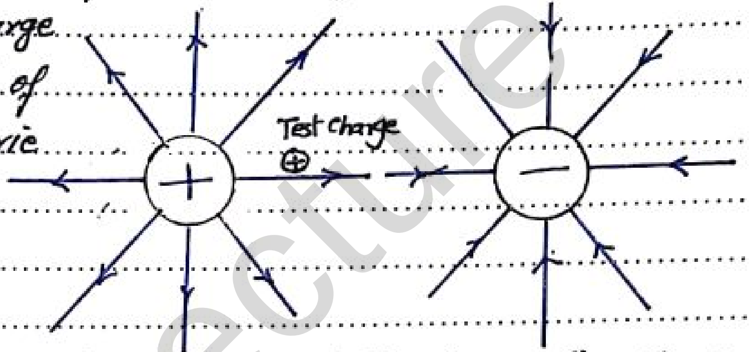
Electric fields

(a) space around a charge contains a "field of force". This is known as "electric field". This field produces a force on other charge present in this field. Force per unit charge is known as "field strength".

Like gravitational and magnetic fields, the electric fields are also represented by "lines of force".

Electric Line of force is the path along which a positive charge will move in an electric field, if the charge is free to move.

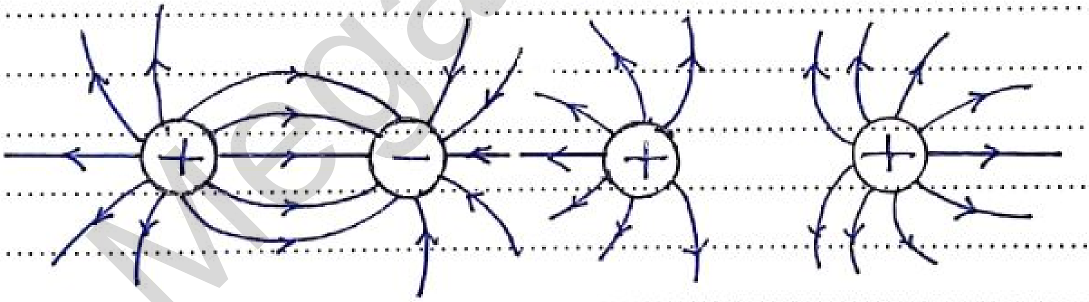
Some electric fields are represented as follows:-



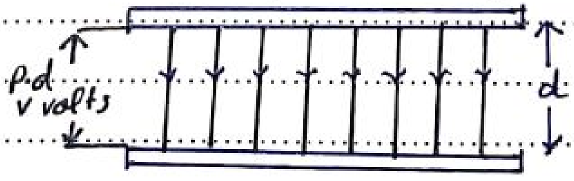
A small test positive charge is repelled by the field of a positive charge. Electric lines of force are always away from the positive charge.

A test positive charge is attracted by the field of a negative charge. Lines of forces are always directed towards the negative charge.

Like charges repel and unlike charges attract.



The field between two parallel, charged metal plates is uniform.



Potential difference between the plates = V volts.

Distance between the plates is d metres, then electric field strength E is given by

$$E = \frac{V}{d} \quad (\text{volts-metre}^{-1})$$

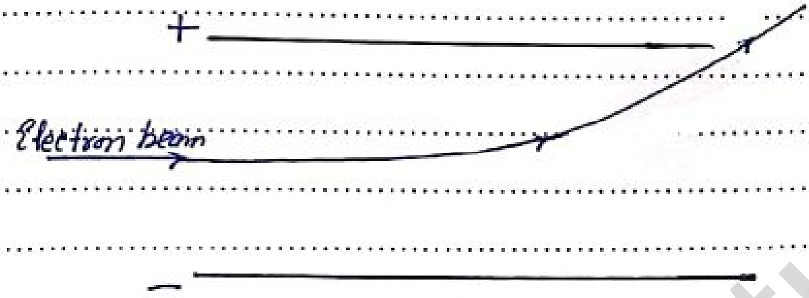
Electric field strength is defined as force per unit charge.

Therefore $E = F/q \Rightarrow F = Eq$

Unit $N\text{-}C^{-1}$

$E = \frac{V}{d} = \frac{F}{q} \Rightarrow F = \frac{V}{d}q$

In a uniform electric field a negative charge (a beam of electrons) will be deflected towards the positive plate in a parabola.



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Current of Electricity

(a) when a wire is connected to a cell a current flows in the wire, because electrons start moving in the wire. since the electrons carry charge and is measured as rate of flow of charge. I in a conductor current is flowing from A $A \xrightarrow{I} B$ to B, the negative charge is flowing from B to A. The direction of I. Conventional current is always opposite to the direction of flow of electrons.

current = charge/time

(b) unit of current is ampere and of charge is coulomb.

(c) when a current of 1A flows in a conductor for 1 second, a charge of 1 coulomb flows.

Charge = current x time

$Q = It$ where Q = Charge in Coulomb

t = time in second

(d) Potential Difference :— P.d may be defined as the difference in electric level between two points. As the temp. difference leads to heat flow and pressure difference causes liquid flow. Similarly pot diff. causes electrons to flow. Unit of p.d is volt.

work done per unit charge to move a charge from one point to another in an electric field, is called P.D. Two points are said to be at p.d of 1 volt if 1 joule work is done to carry 1 coulomb charge between these points.

Defn. The potential difference V between two points in a circuit is the amount of electrical energy changed to other forms of energy when unit charge passes from one point to th other.

In general if a charge Q coulombs flows in a part of circuit across which there is a p.d of V volts, then energy change W (in joules) is given by

$W = QV$

If Q is in the form of steady current I (in amperes) flowing for the time t (in seconds) then $Q = It$ and $\boxed{W = VIt}$

Since $W = QV$, it follows that $V = \frac{W}{Q}$

(e) p.d = work done per coulomb charge.

(f) Power is defined as rate at which work is done.

$$Power = \frac{work\ done}{time} = \frac{energy\ transfered}{time}$$

or Power of a device is the rate at which it converts energy from one form into another.

Since $W = VIt$

$$P = \frac{W}{t} = \frac{VIt}{t} \Rightarrow \boxed{P = VI}$$

Also $V = IR$ and $I = V/R \Rightarrow \boxed{P = V^2/R}$ or $\boxed{I^2R}$

The last two equations are used if all the electrical energy is converted into heat (called a pasive resistor) to calculate the rate of production of heat.

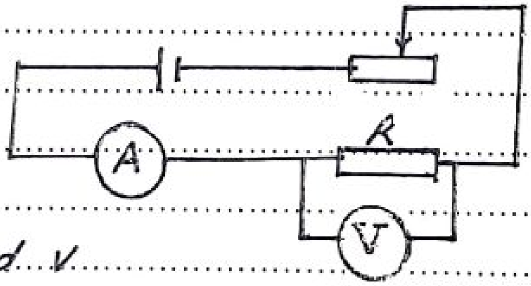
(g) Resistance is opposition to the flow of current by a conductor. The resistance of a conductor is defined as ratio of the p.d V across it to the current I flowing through it.

$R = V/I$ Unit of resistance is Ohm: (Ω)

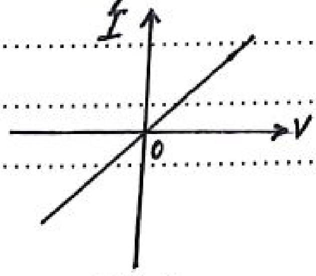
One Ohm is resistance of a conductor which allows a current of 1 ampere when a p.d of 1 volt is applied across it.

(h)

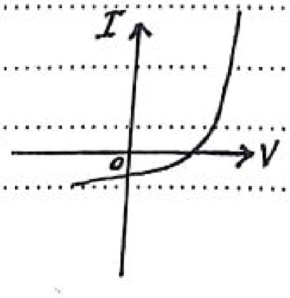
(i)



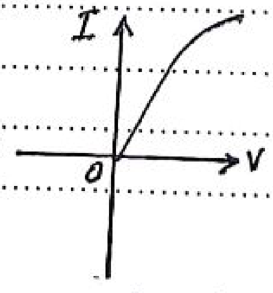
using the circuit shown, p.d V across R can be varied and corresponding current I is measured. A graph of I against V shows the relationship between these two quantities and is called characteristic of the component.



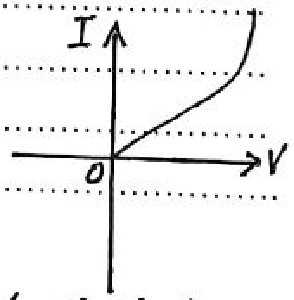
(a) Metal



(b) Semiconductor diode



(c) Filament lamp



(d) Thermistor

(a) Metals and alloys which give straight line I-V graph are called Ohmic Conductors. For them $I \propto V$ and V/I = Constant. They obey Ohm's Law which states that the resistance of a metallic conductor does not change with p.d, provided the temperature is constant.

(b) Semi-Conductors allow current in one direction but stops it in opposite direction. It is a non-Ohmic conductor.

(c) The resistance of a filament lamp as the current increases because then the temperature rises. In general resistance of metals and alloys increases with the temperature.

(d) Thermistors are made of semi-conductors and I-V graph bends upwards i.e their resistance decreases sharply with the increase in temp.

(l) Concept of Resistivity:- $R = \frac{\rho L}{A}$ where
R = resistance of a conductor in Ohms.
l = length of conductor in m
A = area of cross section in m^2
ρ = Resistivity in ohm-m or Ω-m.

(m) when a battery of cells or generator is connected in a circuit it generates p.d's over all circuit components, some p.d is required to drive the current through the internal resistance of the battery as well.

Electromotive Force:- Emf is defined as the energy transferred by the source in driving charge across a complete circuit.

$$\text{EMF} = \frac{\text{work done by source}}{\text{Charge conveyed round circuit}} \quad J\text{-}C^{-1} \text{ or volt}$$

If a device has EMF, E and passes a charge Q in a circuit, the total electrical energy liberated is W, then EMF $= \frac{W}{Q} \Rightarrow W = EQ$

If a current I is flowing, $Q = It$ and hence total elect. energy liberated $= W = QE = EIt$

total electrical Power generated, $P = \frac{W}{t} = EI$

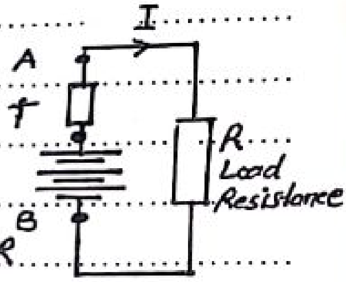
It leads to following equations

$$P = EI \quad \text{and} \quad E = \frac{P}{I}$$

So the EMF of a device is the ratio of electrical power it generates to the current which it delivers.

EMF and P.D can both be defined as the ratio of power to current. The unit of EMF is watt per Ampere or volt

Current Formula:-



Total Power supplied by the source = EI

The power delivered to the external resistor is called output power.

The value of output Power $= IV_{AB} = I \times IR = I^2R$

The power delivered to the internal resistor $r = I^2r$

$$EI = I^2r + I^2R$$

$$E = Ir + IR \quad \Rightarrow \quad I = \frac{E}{R+r}$$

Efficiency:- The ratio of power output (Pout) to the power generated (Pgen) is called efficiency.

$$\eta = \frac{P_{out}}{P_{gen}} \quad \frac{IV_{AB}}{IE} = \frac{V_{AB}}{E}$$

$$V_{AB} = IR = \frac{E}{R+r} R$$

$$\eta = \frac{ER}{R+r} \times \frac{1}{E} \quad \text{or} \quad \frac{R}{R+r}$$

This equation can be used to find how power output varies with R.

⇒ Power output to load resistance R is max when $R = r$

when R is very large compared to internal resistance r, the terminal p.d V_{AB} approaches a const. value equal to EMF.

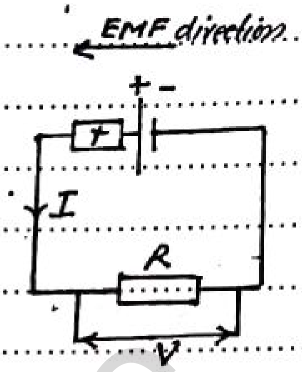
⇒ when R is small compared to r, output power is small.
⇒ when R is large compared to r, output power is large.

General Statement:–

$$E = IR + Ir$$

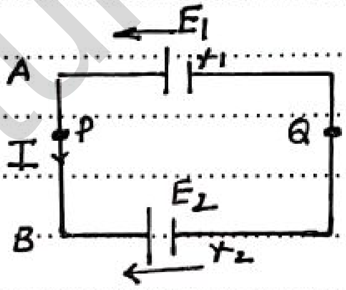
$$E = V + Ir$$

$$\boxed{V = E - Ir}$$ V is terminal p.d



If battery is connected to another battery of larger EMF, a current flows in the battery against its EMF.

$E_1 > E_2$ Current flows from A to B.



value of terminal p.d V_{PQ} is calculated as
In terms of battery A with EMF E_1

$$V_{PQ} = E_1 - Ir_1$$

and in terms of battery B with emf E_2 (Here the current is flowing in opposite direction

$$V_{PQ} = E_2 + Ir_2$$

* * *

Topic 20

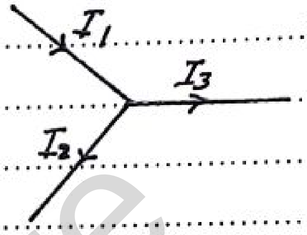
D.C CIRCUITS

(a). Circuit Symbols

(b). Drawings of Circuits

(C). Kirchoff's First Law:- A network is a complicated system of electrical conductors. First law refers to any junction in network. It states that the total current flowing into the junction is equal to the total current leaving the junction.

$I_1 = I_2 + I_3$



The law follows from the fact that electrical charges do not accumulate at the points of network. It is often put in the following form:

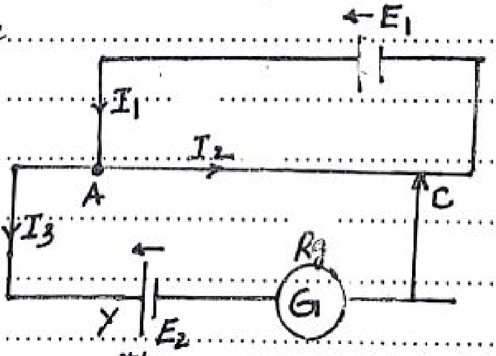
Algebric sum of currents at a junction of a circuit is zero. A current towards the junction is + whereas current away from the junction is −. $I_1 - I_2 - I_3 = 0$

Kirchoff's first law is a statement of conservation of charge.

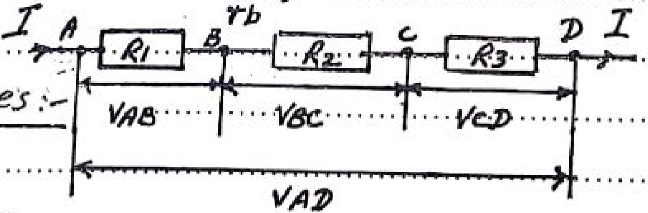
(d). Kirchoff's Second Law:- Round a closed loop in a circuit, the algebric sum of EMF's is equal to the algebric sum of all the p.d's in that circuit.

This law is law of conservation of energy e.g consider loop ACYA, going clockwise along the loop,

(RAC is resistance of part AC of wire)



$E_2 = R_{AC} I_2 - I_3 R_g - I_3 r_b$



(e) (f) Resistors in Series:- Three resistors are shown joined in series, carrying a current I. If VAD is p.d across whole system, the electrical energy supplied to the whole system per second is IV_{AD}. This is equal to the electrical energy per second in all the resistors

$$IV_{AD} = IV_{AB} + IV_{BC} + IV_{CD}$$

$$V_{AD} = V_{AB} + V_{BC} + V_{CD}$$

From Ohm's Law, individual potential differences are given by $V_{AB} = IR_1$, $V_{BC} = IR_2$, $V_{CD} = IR_3$

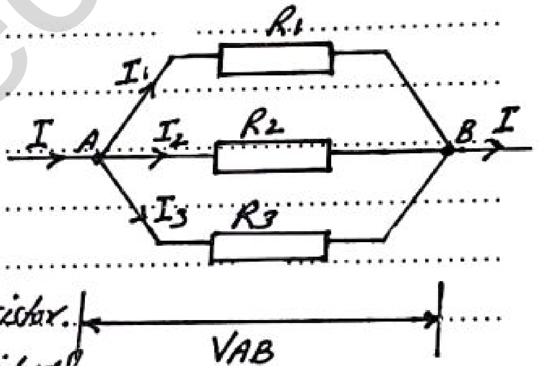
$$V_{AD} = IR_1 + IR_2 + IR_3$$

$$V_{AD} = I(R_1 + R_2 + R_3)$$

$$\frac{V_{AD}}{I} = R_1 + R_2 + R_3 = R$$ where R is effective resistance.

To learn (i) current is same through all resistors in series.
(ii) Total P.D = Sum of individual P.D's.
⇒ Total Resistance = Sum of individual resistances.

(g) (h) Resistors in Parallel:-



To learn:
when resistors are joined in parallel:
(i) P.D same across each resistor.
(ii) Total current = Sum of individual currents.
(iii) Effective resistance less than least individual resistance.

$$I = I_1 + I_2 + I_3$$

Now $I_1 = \frac{V_{AB}}{R_1}$, $I_2 = \frac{V_{AB}}{R_2}$, $I_3 = \frac{V_{AB}}{R_3}$

$$I = V_{AB}\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$\frac{I}{V_{AB}} = \frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$ where R is effective resistance in the combination. In special condition of two resistors R_1 and R_2 joined in parallel, effective resistance R is given by the formula $R = \frac{R_1R_2}{R_1+R_2}$

with cell E_1 connected in the gap DF, a current flows in the centre zero galvanometer. The position of sliding contact C is varied to get zero deflection on G. The length l_1 is noted. The procedure is repeated with cell E_2 and l_2 found.

$$\frac{\text{EMF of } E_1}{\text{EMF of } E_2} = \frac{l_1}{l_2}$$

If one of the cells used is a weston Cadmium standard cell which has EMF of 1.02 V, EMF of unknown cell can be found as

$$E_1 = 1.02 \times \frac{l_1}{l_2}$$

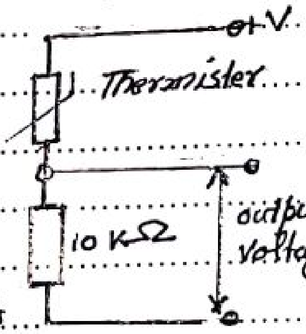
* * * *

In the dark LDR has high resistance, and the voltage on it is high, leaving higher voltage on the output terminals. But as the light shines on LDR, its resistance decreases and so does the voltage on output load. Hence at the output terminals there is a lamp which will light up in the evening when light conditions are poor.

Thermistere:- A thermister is a temp dependent resistance. It has high resistance at low temperature and ~~high~~ low resistance at higher temperatures.

This unit can be used in fire alarms and a simplified form of the circuit may be the following.

If temperature becomes high, the resistance of thermister decreases, and output voltage becomes high, sufficient to ring the fire alarm which is connected at the output terminals.

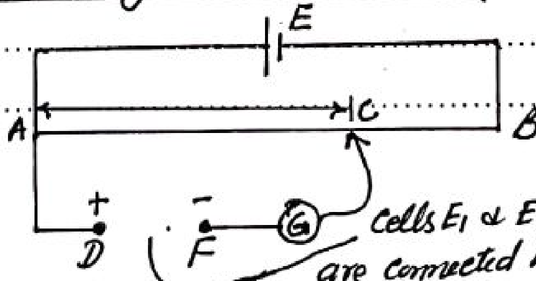


(f) Potentiometer:-

It is a piece of apparatus which can be used for comparing the p.d's. It consists of 1m long resistance wire mounted on a board between thick cu strips and a mm scale for measuring the distance from one end of wire to the position of sliding contact or jockey. A 2volt lead cell is connected to the wire so that a steady current flows through it. Since the wire is uniform, its resistance per cm is constant, the p.d across a length l is proportional to l. i.e $V \propto l$

To Compare EMF of two Cells using a Potentiometer:-

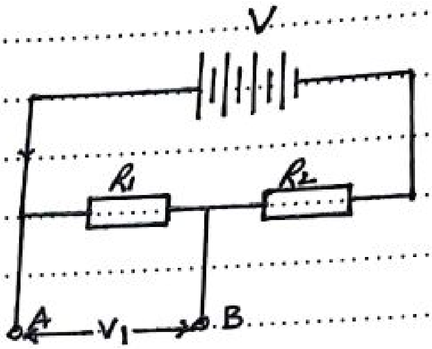
with the circuit shown there will be a p.d between D and F equal to that between A and C on wire.



Cells E_1 & E_2 are connected in this gap

(i) Application of Kirchoff's law to solve simple circuit problems.

(j) Potential Divider Circuits:-



Assuming internal resistance of cell is negligible

EMF = Circuit Current x total resistance

$V = I(R_1+R_2)$ and $V_1 = IR_1$

therefore $\frac{V_1}{V} = \frac{IR_1}{I(R_1+R_2)}$

$\Rightarrow V_1 = \frac{R_1}{R_1+R_2} V$

This is useful in the circumstances where the only available supply provides a greater voltage than the required by the electrical device (load) being used.

The load is connected across the terminals A and B and values of R_1 and R_2 are suitably selected.

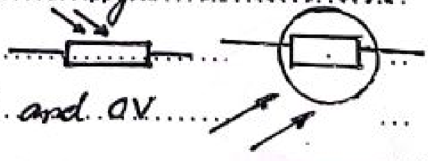
R_1 and R_2 can be replaced by rheostat or a length of resistance wire (as in a potentiometer), the ratio R_1/R_1+R_2 can be changed continuously.

LDR:-

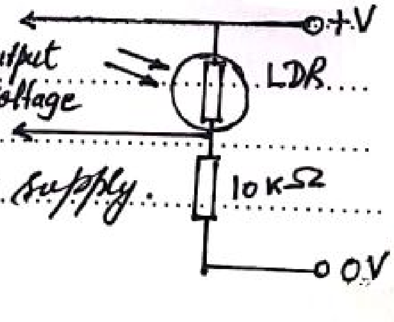
A light dependant resistor (LDR) is sensitive to light. It contains a semi conducting material and when exposed to light, its resistance decreases because due to light (energy) more electrons are released to conduct better. Therefore LDR has high resistance in dark and less resistance in light.

The following circuit shows the use of potential divider and LDR for automatic switching of street light circuit on.

circuit symbol for LDR



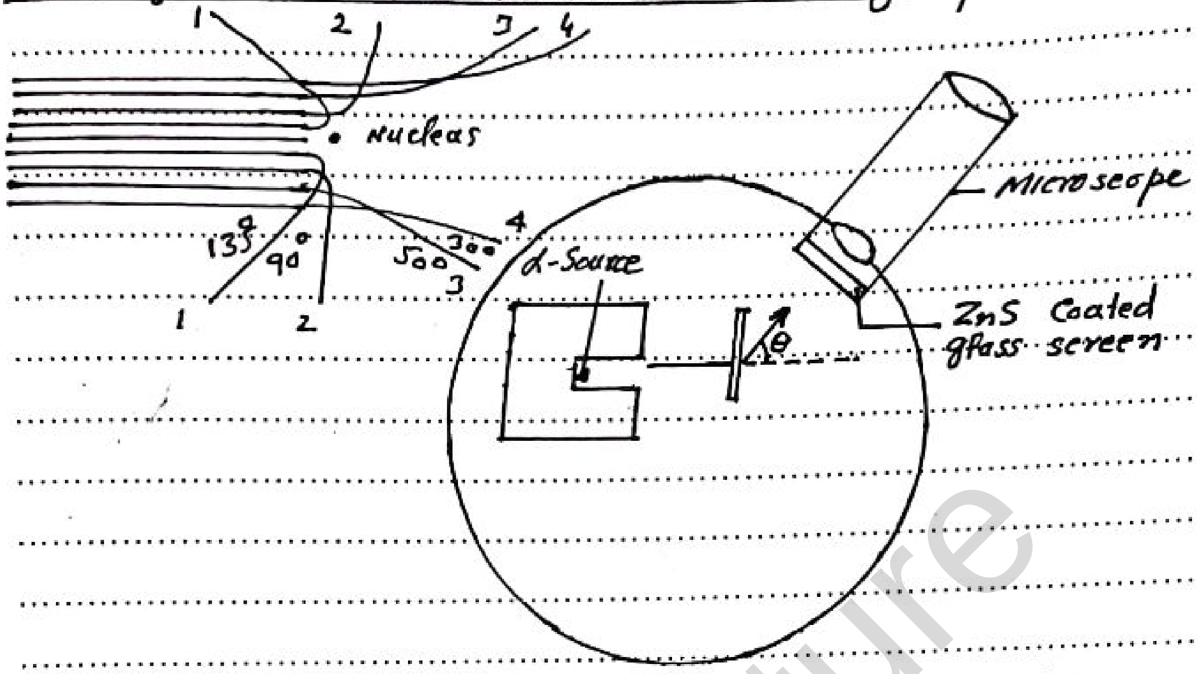
Note: supply voltage is shown as positive V and 0V to emphasise that the negative terminal is to be regarded as a zero level of voltage or potential. The actual supply is a battery or low voltage power supply.



Topic 27

Nuclear Physics

(a) Geiger and Marsden α-Particle Scattering Experiment:-



In 1909 Rutherford investigated the scattering of α-particles by thin film of heavy metal such as gold in an evacuated tube. A narrow beam of α-particles from a radon source was incident on a gold foil whenever an α-particle hit the ZnS screen a faint flash of light was observed in the microscope. The screen could be rotated about the metal foil and by counting the number of scintillations produced in various positions in equal intervals of time, the angular dependance of the scattering was determined.

The majority of α-particles were scattered through small angles but a few (about 1 in 8000) were deviated by more than 90°.

Conclusions:- 1. It was suggested that large angle scattering accured whenever an α-particle was incident head on to a positively charged core, containing most mass of atom.

Since this core produced an intense repulsion on +α, it must contain all +charge of atom on a very small size of nucleus.

2. Also since most α's go through the foil un-delected or

undergo small angle deflections, most volume of the atom must be an empty space.

(b) An atom is now considered to have the following structure. A compact central core containing all protons and neutrons in a very small volume. The nucleus measures ≈ 10^{-15} m across whereas an atom measures ≈ 10^{-10} m across. Electrons revolve round the nucleus in orbits or shells.

(c) The particles found in the nucleus are called nucleons. Thus protons and neutrons are called nucleons. The number of protons in the nucleus of an atom is called as atomic number. Number of nucleons is called as mass number.

(d) Two atoms having same number of protons but different number of neutrons are called isotopes of each other. Isotopes have similar chemical properties and therefore cannot be separated by chemical methods. Au and Co have only one naturally occuring isotope each. Tin has ten isotopes.

(e) The various isotopes of an element with symbol X are distinguished by using symbol $^{A}_{Z}X$ where A is mass no. and Z is atomic number of Z. e.g $^{4}_{3}Li$, $^{6}_{3}Li$ are isotopes of lithium.

Nuclide is term used to represent a nuclear species i.e a particle which contain a nucleus. Also it is an atom which has certain composition e.g
$^{6}_{3}Li$, $^{7}_{3}Li$, $^{16}_{8}O$, $^{18}_{8}O$ are different nuclides.

Isotopes are nuclides with same number of protons.
Istones are nuclides with same number of neutrons.
Isobars are nuclides with same number of nucleons.

(f) By alpha, neutrons proton bombardment of atom nuclear transformations occurs.

From the law of conservation of mass (nucleon no.) and charge (proton no.), the following different reactions indicate these nuclear transformations.

(g) $^{14}_{7}N + ^{4}_{2}He \longrightarrow ^{17}_{8}O + ^{1}_{1}H$

$^{9}_{4}Be + ^{1}_{1}H \longrightarrow ^{4}_{2}He + ^{6}_{3}Li$

$^{7}_{3}Li + ^{1}_{1}H \longrightarrow 2\,^{4}_{2}He + \text{energy}$

$^{24}_{12}Mg + ^{1}_{0}n \longrightarrow ^{24}_{11}Na + ^{1}_{1}H$

In all nuclear processes, nucleon number, proton number, energy and mass are all conserved.

(h) Radioactivity:- is spontaneous emission of radiation from the nuclei of certain atom. The radiations are emitted when an unstable nucleus disintegrates to aquire more stable state. The disintegration is spontaneous i.e. it cannot be influenced by external factors such as temperature or pressure.

Radioactive decay is a random process.

It means that choice of given nucleus (or a given no. of nuclei) to decay at a given moment of time is without any logical explaination. The random nature of decay is indicated by the flickering of rate metre needle which shows count rate fluctuating about the average value.

(i) α- Particles:-

* These are Helium nuclei. An α is packet of 4 nucleons i.e 2 protons and 2 neutrons. It has 4 units of mass and 2 units of positive charge.

* α- particles cause heavy ionisation in matter.

* They can pass upto 5 cm distance in air and are stopped by a sheet of paper.

- They can produce fluorescence in a mineral and fog photographic film
- α- emission cause a nucleus to change to its daughter product as by the following equations.

$$^{A}_{Z}X \longrightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$$

$$^{228}_{88}Ra \longrightarrow {}^{224}_{86}Rn + {}^{4}_{2}He$$

(II) β- Particles:- These are fast electrons. Any given species of nucleus emits β- particles with a continuous range of energies.

Emission of β brings about the following changes to the nucleus.

$$^{A}_{Z}X \longrightarrow {}^{A}_{Z+1}Y + {}^{0}_{-1}e$$

e.g $^{14}_{6}C \longrightarrow {}^{14}_{7}N + {}^{0}_{-1}e$

- They are easily deflected out of their path.
- They produce lesser ionization in matter.
- They are deflected by electric & magnetic field.
- They produce fluorescence and effect photographic film.
- They can travel upto 500cm in air and 3 mm Al sheet.

γ- Rays:- These are high energy electromagneti radiations.

- Their range in air is infinite
- Stopped by few cm thick block of lead.
- They affect photographic film.
- They are not deflected by electric and magnetic field.

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