Work, Energy and Power

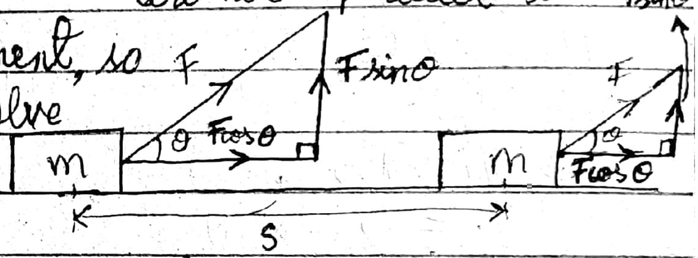
⇒ Work

def:-
Product of force and displacement travelled in the direction of force is called work.

* since the forces here are not parallel to displacement, so we will resolve them into their components

Symbol:- W

formula:-



$$W = \left(\begin{array}{c}\text{component of force}\\ \text{towards displacement}\end{array}\right)(\text{displacement})$$ ⇒ this formula will be in case of an inclined force when $\theta \neq 0$ (when force not // to displacement)

$W = (F\cos\theta)(S) \Rightarrow W = FS\cos\theta$

→ If $\theta = 0 \Rightarrow W = FS\cos 0 \Rightarrow W = FS$ ⇒ this formula will be used when force is not ~~inclined~~ inclined i.e. $\theta = 0°$ (force is either vertical or horizontal) (force // to displacement)

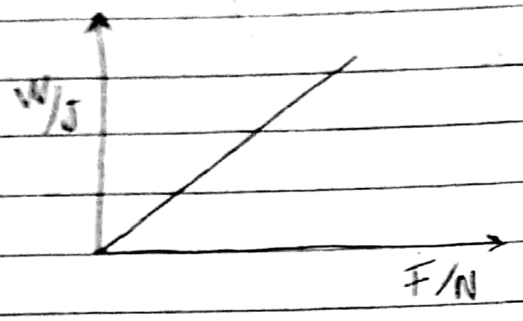
Unit:- Nm or Joule (J)
$1J = (1N)(1m)$

P.S:- Scalar

⇒ Dependance:-

i) Magnitude of force:-

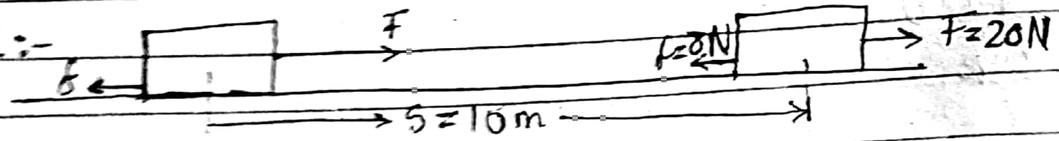
$W \propto F$ for constant displacement (s)



Gradient = displacement

Case 1 :- Work done by a constant force

Ex 1 :-



i) Work done by an applied force

$$W = Fs \cos 0$$
$$= (20)(10)(1)$$
$$= 200\ J$$

(ii) Work done against resistive force

$$W = (f)(s) \cos 180^\circ$$
$$= (8)(10)(-1)$$
$$= (-8)(10)$$
$$= -80\ J \text{ or } 80\ J$$

iii) Work done by a resultant force

$$W = (F - f)(s) \cos 0^\circ$$
$$= (20-8)(10)(1)$$
$$= 120\ J$$

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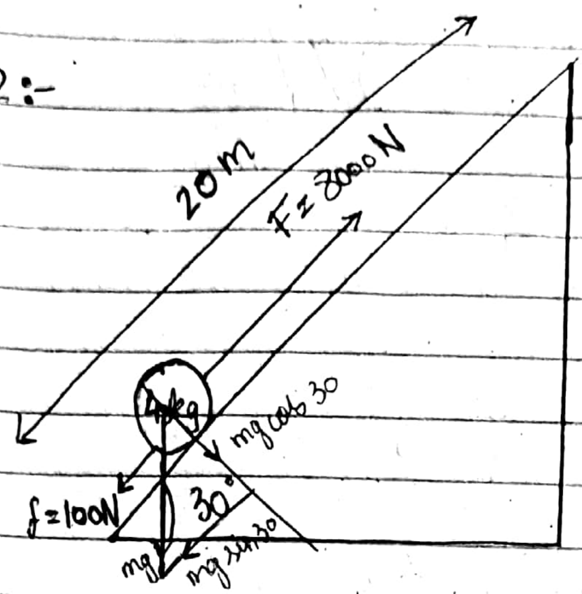
Ex. 2:-



i) Work done against frictional force of 100 N

*ii) Work done against gravitational pull of Earth

iii) Work done by an applied force

iv) Resultant work done by an applied force

i) $W = Fs$
$= 100 \times 20$
$= 2000\ J$

$W = (Fs) \cos 180$
$= (100)(20)(-1)$
$= -2000\ J$

ii) $W = Fs$
$= (4 \times 9.81) \times (20 \times \sin 30)$
$= 392.4\ J$

$W = (mg \sin 30)(s) \cos 180$
$= (4)(9.81)(0.5)(20)(-1)$
$= -392\ J$

iii) $W = Fs$
$= 8000 \times 20$
$= 160000\ J$

iv) $W = Fs$
$= (8000 - 100)(20)$
$= 158000\ J$

$W =$ W by applied force $-$ W by against friction
$= 160000 - 2000$
$= 158000\ J$

Q) A block of mass 20 kg is dropped so that it is moving with a terminal velocity of 80 ms^{-1}. Calculate

(i) Resultant work done
(ii) work done per second by the ~~gravita~~ gravitational pull of earth

(i) 0, due to 0 resultant force

(ii) $\frac{W}{t} = \frac{mgh}{t}$

$P = mg\left(\frac{h}{t}\right)$

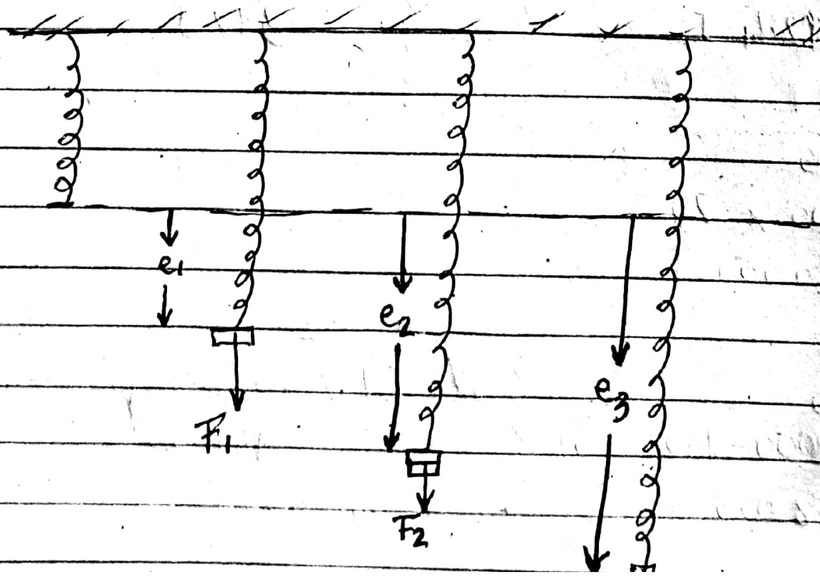
$P = mg(V) \Longrightarrow \left[s = vt \rightarrow v = \frac{h}{t}\right]$

$= (20)(9.81)(80)$

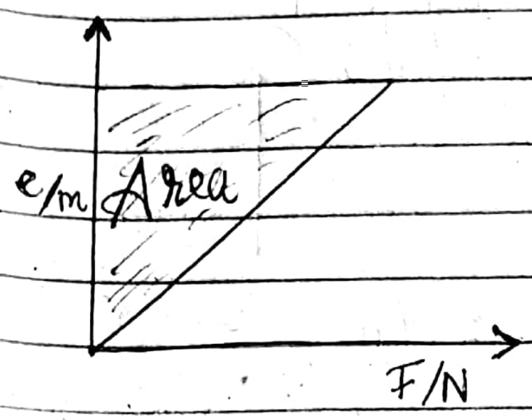
$=$ _______ W

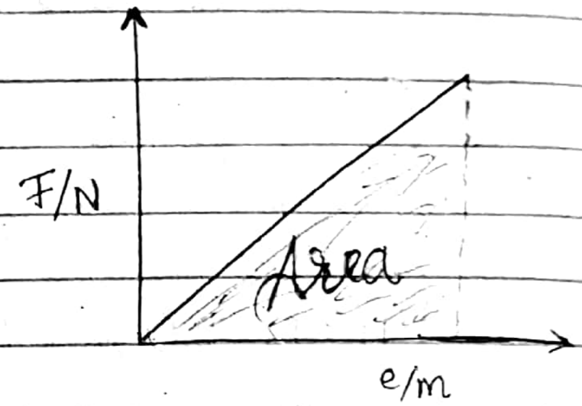
Case 2:- Work done by a variable force

Ex. 1:- Elastic potential energy / strain energy



Since both force/N and displacement (extension)/m ~~values~~ varies, so a graph is plotted b/w them which is a straight line as per Hooke's law





W = Area of F/N graph along with extension axis

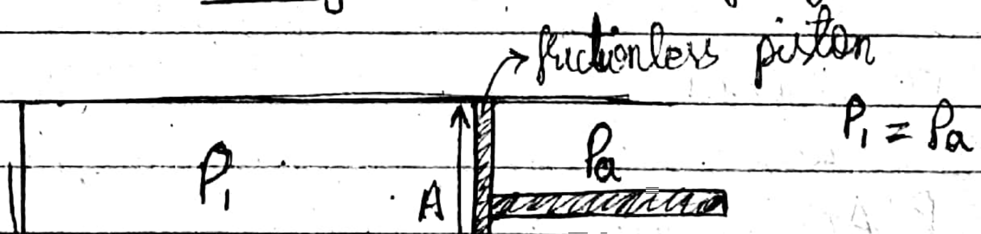
$W = \frac{1}{2} Fe$

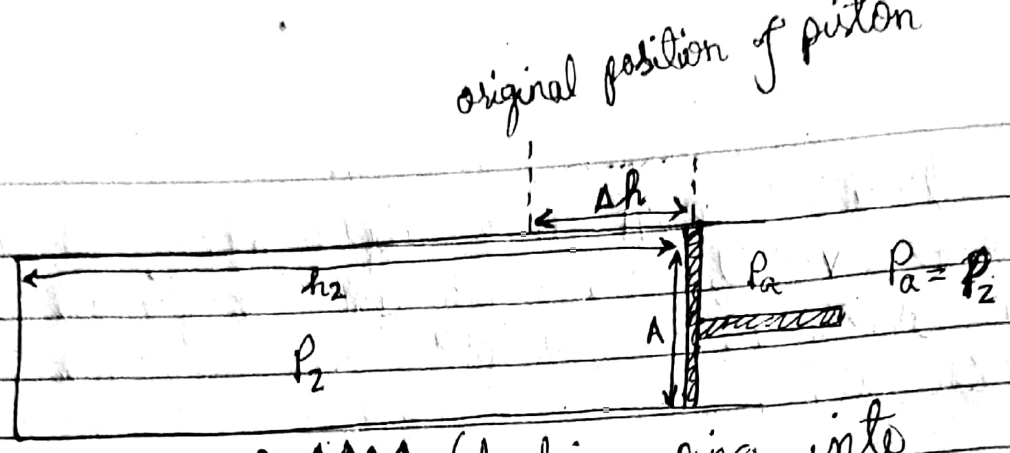
But $F = ke$

$W = \frac{1}{2}(ke)(e) \Rightarrow W = \frac{1}{2}ke^2$

* work will be done on the basis of extension i.e. work is dependant on extension, if no ~~work~~ extension, no work, even if force is being ~~ap~~ applied → thats why area is taken with extension axis.

Ex. 2:- Work done by an expanding gas





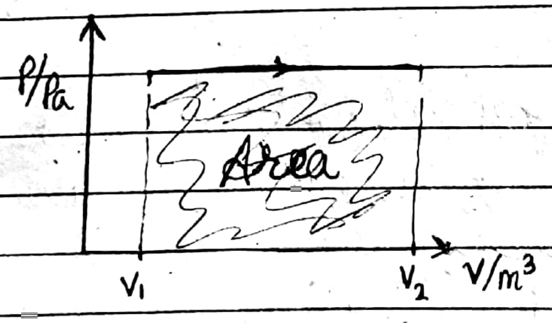
+Q ↑↑↑↑ (heating going into the system)

In equilibrium states,

$P_1 = P_a = P_2$

$\Delta P = P_1 - P_2 = 0$, i.e. no change in pressure

Again the force exerted by the gas particles varies, so a graph is plotted b/w pressure and volume. Work done is obtained by taking the area of graph ~~and~~ along with volume axis



$W = P(V_2 - V_1)$

$W = P\Delta V$

$W = Fs$

$= (PA)(h_2 - h_1)$

$= (PA)(\Delta h)$

$= P(A\Delta h)$

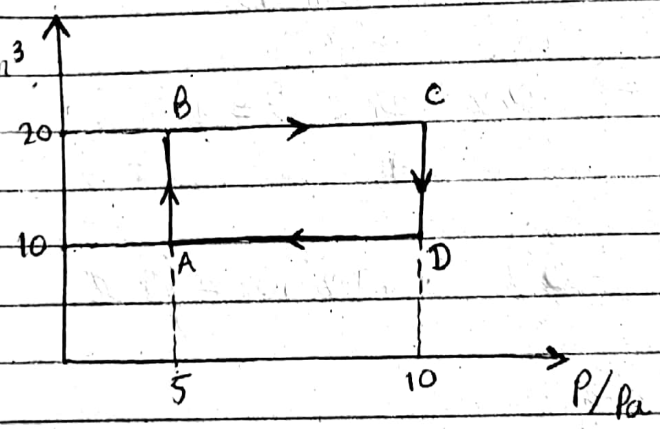
~~W = W~~ $\boxed{W = P\Delta V}$

Note:-

(i) If the volume of gas decreases, ~~then~~ then work is done <u>on</u> the gas which therefore, increases the internal energy of the gas particles

(ii) Work done by the gas ~~increases~~ decrease the internal energy of the gas particles and is obtained when the volume of gas increases.

a)



Calculate

(i) Work done <u>on</u> the gas
(ii) Work done By the gas
(iii) Resultant ~~wot~~ work done on the gas
~~(iv)~~
b) Why no work is done in AD and BC
c) What happenes to the temperature of gas particles as a result of work done on it.

(i) Area of CD along with volume axis
$= (10)(20-10) = 100\ J$

(ii) Area of AB along with volume axis
$= (5)(20-10) = 50\ J$

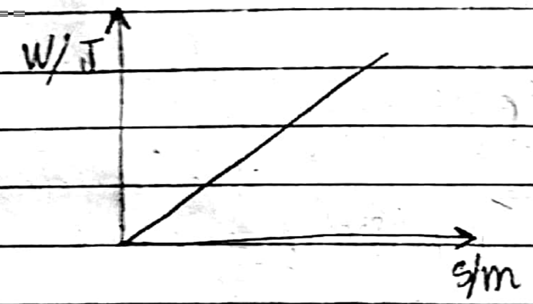
iii) $(10-5)(20-10) = 50\ J$ $W = 100 - 50$
$= 50\ J$

b) Because volume of gas is constant and pressure varies

c) Increases because kinetic or internal energy of the particles increases.

⇒ Dependance of work on displacement

$W \propto s$ for constant force and $\theta = 0°$



Gradient = force

Note :-
Work done is 0, due to 0 displacement
if :-
a) force is applied on an immovable object (e.g. wall)
b) the object return to its original position

⇒ **Energy** ★ one form of energy can't be converted into ~~to~~ other forms unless work is done on it.

Def:-
Ability or capacity of an object to do work is called energy

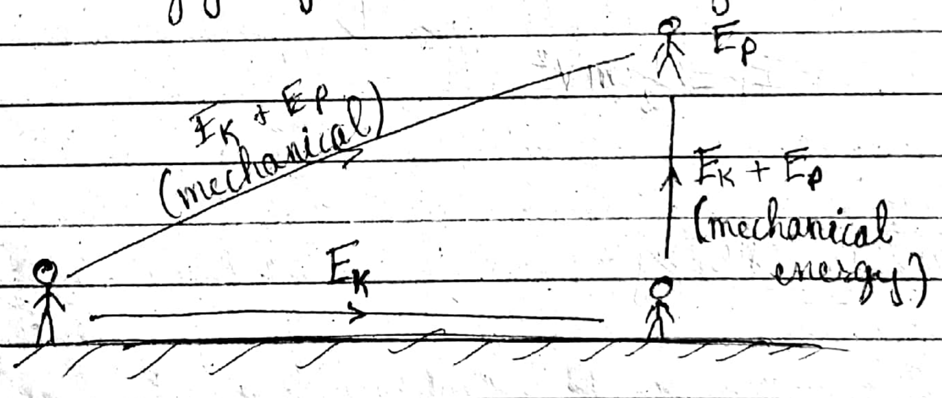
Symbol: E, Q, U

P.S:- Scalar

Unit: Joule (J)

⇒ **Types**

a) **Mechanical energy:-** It is the sum of kinetic and potential energy of ~~the~~ a body



(i) **Kinetic energy:-**
The energy due to motion of a body is called kinetic energy.

Symbol:- E_K

Formula:- $\frac{1}{2}mv^2$ $E_K = \frac{1}{2}mv^2$

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Proof: Suppose a body moves with an initial velocity 'u'. After time 't', its velocity becomes 'v' and it travel a displacement 's' in the direction of Force 'F'

$$\text{Work done} = (F)(s)$$
$$= (m\cancel{a})\left(\frac{v^2 - u^2}{2\cancel{a}}\right)$$
$$= \frac{1}{2} m (v^2 - u^2)$$

This work done becomes the change in E_K so,

$$\Delta E_K = \frac{1}{2} m (v^2 - u^2)$$

If the object starts from rest $(u = 0)$

$$E_K = \frac{1}{2} m (v^2 - 0^2)$$

$$E_K = \frac{1}{2} m v^2$$

⇒ Potential energy

def:
The ability of an object to do work due to change of its position is called potential energy.

a) Gravitational

The ability of an object to do work due to change of its position i.e. height from

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the surface of earth is called gravitational potential energy.

Symbol :- E_p or $G.E_p$

Formula :- $E_p = mgh$

Proof :-
Suppose an ~~object~~ object of mass 'm' is raised to a height 'h' from the surface of earth against its pull.

Work done = (F) (s)

$$W = (mg)(h)$$

This work ~~is~~ done against gravitational pull becomes the $G.E_p$ ~~by~~ by work-energy principle

$$\boxed{G.E_p = mgh}$$

b) Elastic potential energy (only in solids)

The ability of a solid to do work due to change of its position when it is stretched or compressed from its initial position is called elastic potential energy.

Formula :- E_p = Area of F/N − e/m graph along with extension axis

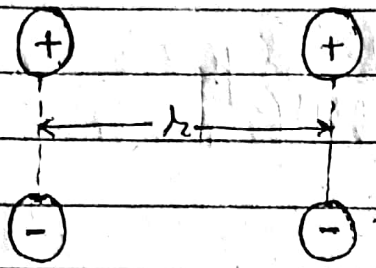
$$E_p = \frac{1}{2} Fe = \frac{1}{2} Ke^2$$

c) Electric potential energy :- (energy b/w 2 charges)

Ability of a charged particle to do work due to change of its position (i.e. distance) from ~~and~~ another charged particle is called electric potential energy.

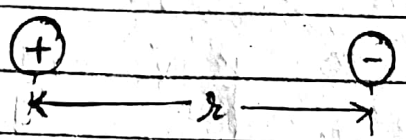
Note :-

1-)



EE_p ↑ if r ↓

2-)



$E.E_p$ ↑ if r ↑

⇒ Internal energy

def :-

It is the microscopic sum of random kinetic energy and electric potential energy of particles of matter is called Internal Energy.

Symbol :- U

→Formula :-

(i) Solids :- U = vibrational E_K + Electric E_p due to bonding

(ii) **Fluids:-** U = Random / translational E_K + Electric E_p due to bonding

Dependance:-

★ In internal energy we consider the microscopic movement of molecules and not the bulk / ~~actual~~ movement or overall movement of the body → difference b/w internal energy and mechanical energy.

a) $\Delta E_K \uparrow$, but $\Delta E_p = 0$, so $\Delta U \uparrow$ if, ~~two~~

(i) heat is provided to matter to ~~two~~ increase its temp $(+Q)$

(ii) Work is done on matter $(+W)$ i.e. hammering / compress / elongate a solid, shake/stir a liquid or compress a gas.

b) $\Delta E_p \uparrow$ and $\Delta E_K = 0$, so $\Delta U \uparrow$ if,

(i) State of matter changes from solid to ~~to~~ liquid to gas due to breaking of bonds and increase in the separation b/w opposite charges.

Note:-

In internal energy we do not consider the bulk/macroscopic movement of the object, but the actual movement of the particles as per kinetic theory model is considered.

⇒ Principle of conservation of energy

Statement :
Energy can neither be created nor be destroyed, but can change its forms and the total energy of the system remain conserve.

Power

Def :-
Work done or ~~enen~~ energy transfer per unit time is called power.

Symbol :- P

Formula :- (i) $P = \frac{W}{t}$

(ii) $P = F\left(\frac{s}{t}\right) \Rightarrow P = Fv$

(iii) $P = \frac{\frac{1}{2}mv^2}{t}$

(iv) $P = \frac{mgh}{t}$

Unit :- Watt (W)

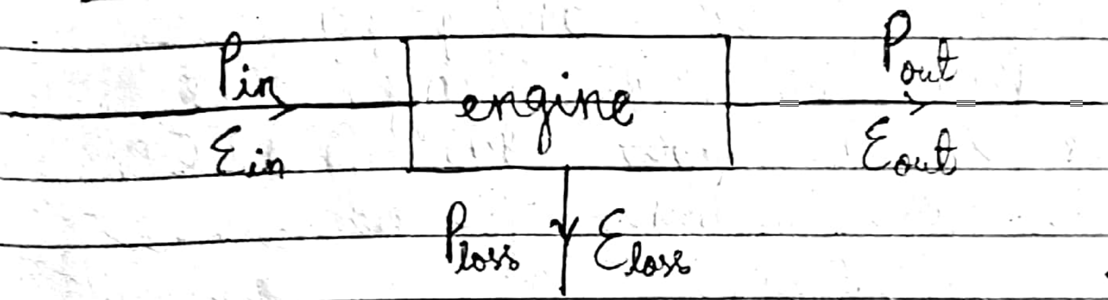
$1W = \frac{1J}{1s}$

P.S :- Scalar

⇒ **Efficiency :-** Ratio of useful energy out or power out to total energy input or power input is called efficiency.

~~Sym~~ ★ symbol not in syllabus

Formula :-



$$\text{Efficiency} = \frac{E_{out}}{E_{in}} \times 100$$

or

$$\text{Efficiency} = \frac{P_{out}}{P_{in}} \times 100$$

Statics

Study of properties of ~~charged~~ bodies/ particles at rest is called statics.

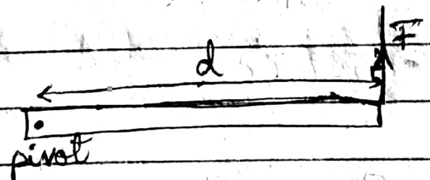
⇒ Moment of a force

def:- The product of force and perpendicular distance from the point of application of force to the ~~axs~~ axis of rotation (pivot) is called moment of a force.

Symbol: τ (Tau) → not in syllabus

Formula: (i) $\tau = (F)(d)$

~~(ii)~~

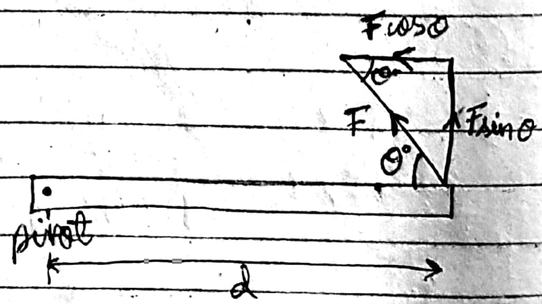


* for this case use $\tau = (F)(d)$

(ii) $\tau = \left(\begin{array}{c}\text{component of force}\\ \text{perpendicular to } d\end{array}\right)(d)$

$= (F\sin\theta)\,(d)$

* for this case use this



Units: Nm

P.S :- vector

direction :- clockwise or anticlockwise

Dependance :-

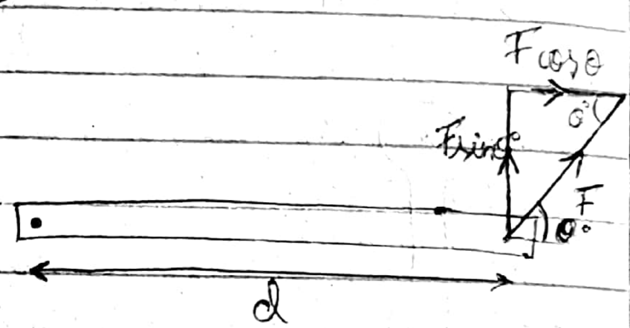
$$\tau = Fd \sin\theta$$

$\tau \uparrow$ if,

(i) $F \uparrow$

(ii) $d \uparrow$

(iii) $\theta \uparrow$



⇒ **Equilibrium :-**

An object is said to be in equilibrium if its acceleration is 0

★ acceleration 0, means ~~no rest~~ resultant force = 0

★ Also that object is either at rest or is moving with terminal velocity.

Conditions :-

1-) Resultant sum of all the forces acting on the object is 0.

$$\Sigma F = 0$$

2-) Algebric sum of clockwise moments must be equal to the algebric ~~sum~~ sum of anticlockwise moments.

$$\Sigma(C \cdot W \cdot M) = \Sigma(A \cdot C \cdot W \cdot M)$$

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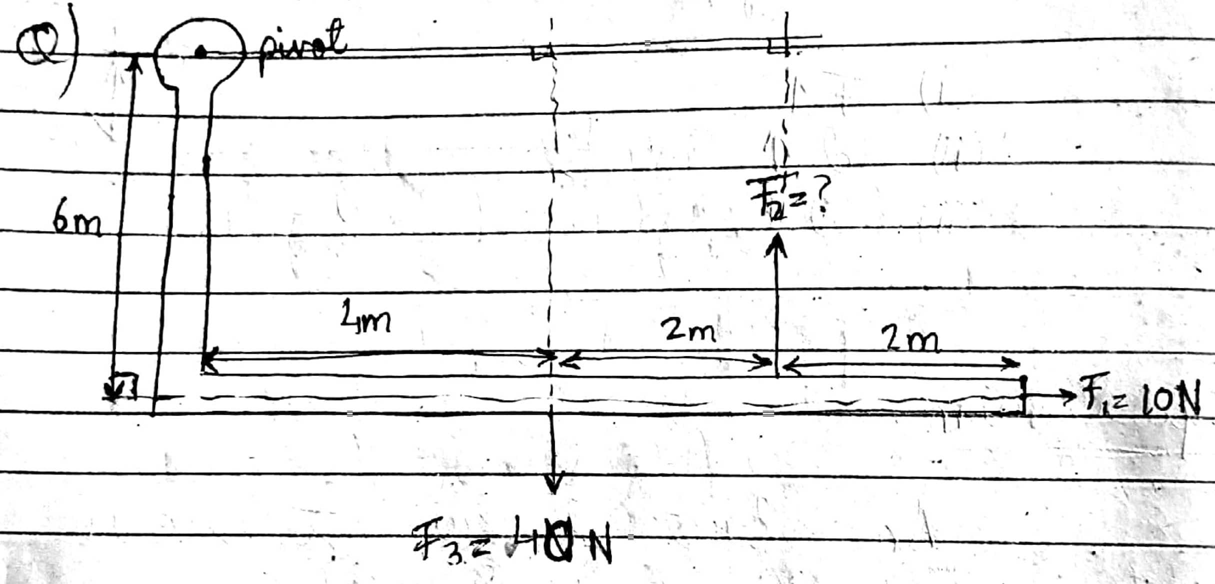
Types :-

a) Static equilibrium :- Object is at rest

b) Dynamic equilibrium :- Object moves with uniform velocity (terminal velocity)

Q)



calculate the magnitude of F_2 if the system is balanced ???

$$\Sigma (A.C.W.M) = \Sigma (C.W.M)$$

$$(F_2 \times 6) + (10 \times 6) = 40 \times 4$$

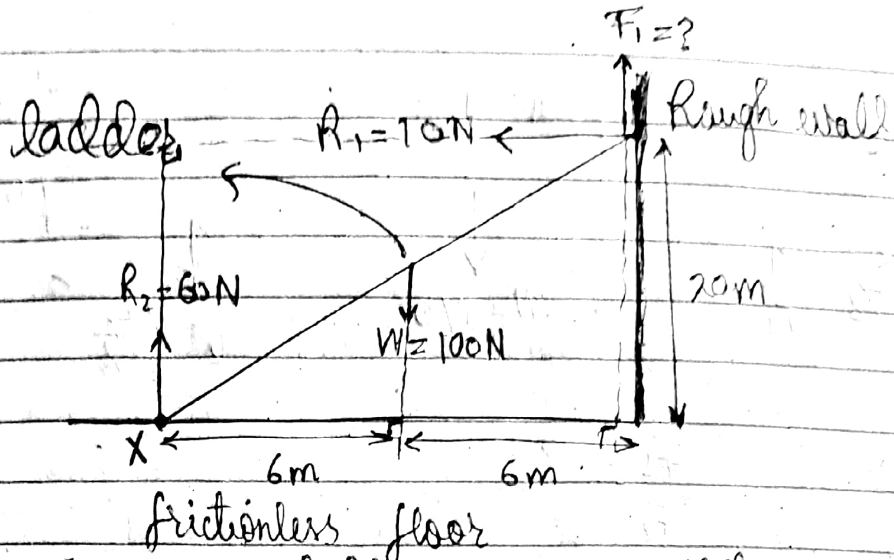
$$\cancel{F_2 = \frac{16}{10 \times 6 \times 6}}$$

$$6F_2 + 60 = 160$$

$$F_2 = \frac{160 - 60}{6}$$

$F_2 =$ ~~16.6 N~~ 16.7 N

Q)



Calculate F_1 if the ladder is in equilibrium ???

* turning effect ~~is~~ is always greater on frictionless surfaces, hence it is to be taken as the pivot point

Hint :- Frictionless point is considered as pivot point

or X

Let $R_2 \uparrow$ be the pivot point

$$C.W.M = A.C.W.M$$

$$100 \times 6 = (10 \times 20) + (F_1 \times 12)$$

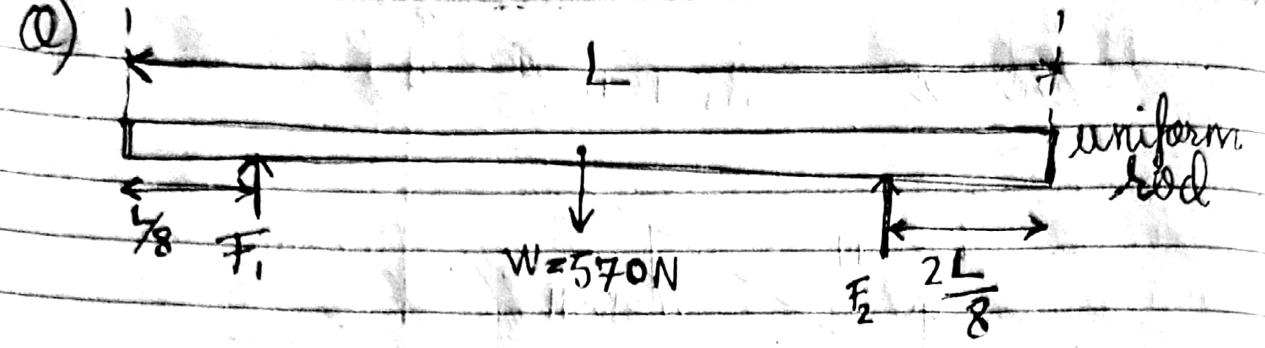
$$600 = 200 + F_1 \times 12$$

$$\frac{600 - 200}{12} = F_1$$

$$F_1 = \frac{\cancel{400}^{100}}{\cancel{12}_{3}}$$

$$F_1 = 33.3\ N$$

Q)



Calculate $\frac{F_1}{F_2}$???

Hint :- C.G be the pivot

$$C.W.M = A.C.W.M$$

$$(F_1)\left(\frac{L}{2} - \frac{L}{8}\right) = (F_2)\left(\frac{L}{2} - \frac{2L}{8}\right)$$

$$(F_1)\left(\frac{4L - L}{8}\right) = (F_2)\left(\frac{4L - 2L}{8}\right)$$

$$(F_1)\left(\frac{3\cancel{L}}{\cancel{8}}\right) = (F_2)\left(\frac{2\cancel{L}}{\cancel{8}}\right)$$

$$\frac{F_1}{F_2} = \frac{2}{3}$$

⇒ Centre of Gravity :-

The point inside or outside the object where its whole weight appears to act is called centre of gravity.

Note :-

1) The centre of gravity of regular objects lie at their geometrical centre

2-) The centre of gravity of irregular objects is obtained by using freely suspension plumb line method.

3-) The moment about centre of gravity due to weight of object is always 0 due to 0 perpendicular distance.

4-) If pivot point is not given in question then centre of gravity is considered as pivot point.

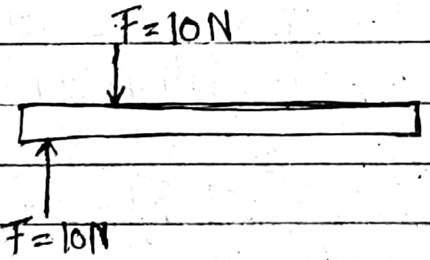
⇒ Couple :-

def:-

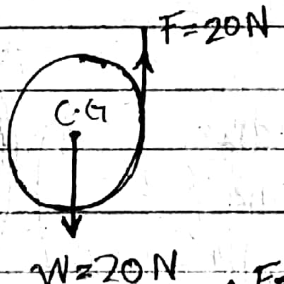
2 equal and opposite forces separated by a perpendicular distance form a couple.

Example:-

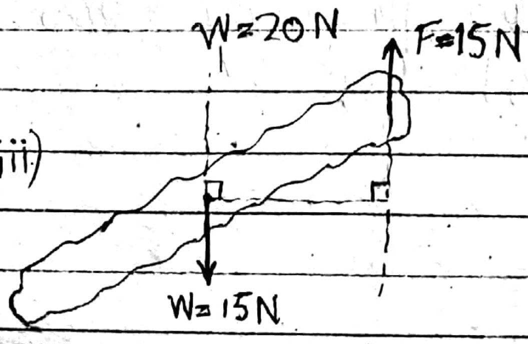
(i)



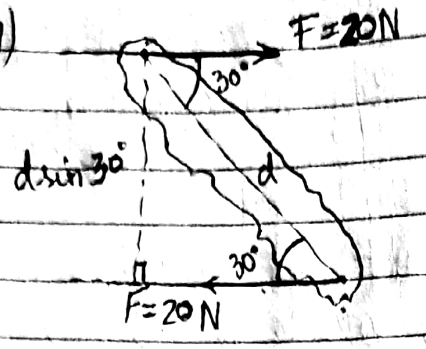
(ii)



(iii)

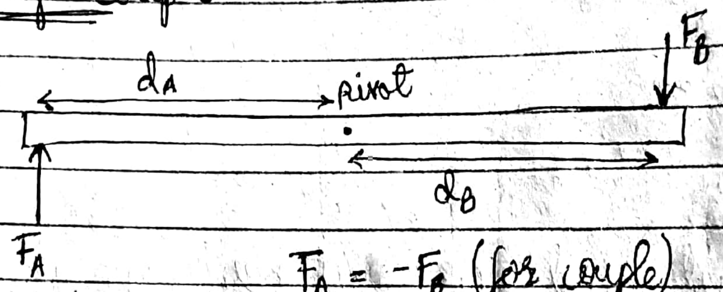


(iv)



★ whenever couple is there, turning effect is produced → couple is associated with turning effect.

Torque of couple



$F_A = -F_B$ (for couple)

Total moment about pivot $= (F_A)(d_A) + (F_B)(d_B)$

$= (F)(d_A) + (F)(d_B)$

$= F(d_A + d_B)$

Torque of couple $= F(d)$

Torque of couple = (magnitude of any one of 2 equal and opposite forces)(perpendicular separation b/w them)

Waves

* wave is basically disturbance in a medium
* not all, waves transfer energy

def:- disturbance in a medium is called wave. (types of)

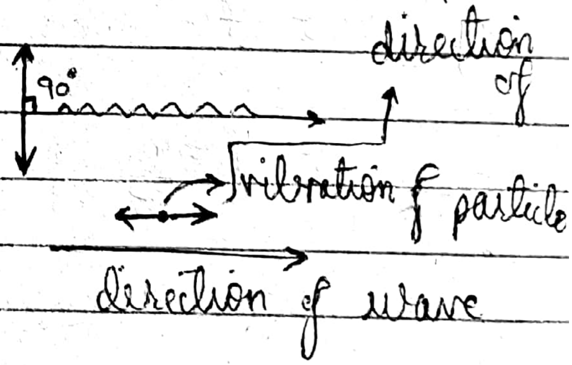
~~Ca~~ Classification of waves

a) On the basis of a state of matter :-

(i) Electromagnetic waves
(ii) material / matter waves

b) On the basis of vibration of a particle :-

(i) Transverse wave ⟶
(ii) Longitudinal wave ⟶



c) On the basis of ~~enen~~ energy transfer :-

(i) Progressive wave (energy is transferred along the wave profile)

(ii) Stationary/standing waves (no energy is transferred)

⇒ Important terms

1-) **Time period**

The time taken to complete one wave is called time period.

Symbol :- T

Unit :- s

P.S :- Scalar

2-) **Frequency**

def :-

No. of complete waves generated by a source per unit time is called frequency.

Symbol :- f

Formula :- $f = \frac{n}{t}$ where n has an integral value i.e. is an integer such as 1, 2, 3, ...

Unit :- s^{-1} or Hertz (Hz)

3-) **Relation b/w f/s^{-1} and T/s**

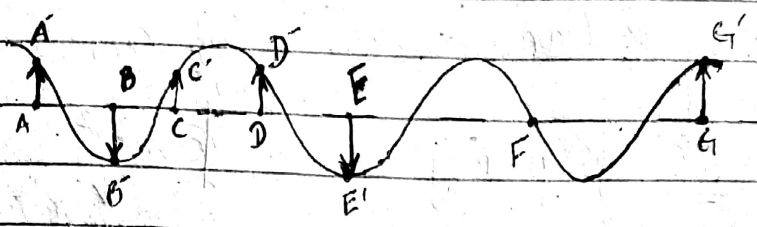
Since $f = \frac{n}{t}$

time period

For one wave, n = 1 and t = T, so $\boxed{f = \frac{1}{T}}$

4-) **Displacement**

def:- Straight directed distance of a particle on wave from its equilibrium position.



5-) **Amplitude**

def:- It is the maximum displacement of a particle on wave from its equilibrium position.

6-) **Intensity**

def:- Energy incident/provided by a wave per unit time per unit perpendicular area is called intensity.

Symbol:- I

Formula:- $I = \dfrac{\frac{E}{t}}{A}$

$$I = \frac{E}{tA} \quad \text{or} \quad I = \frac{P}{A} \quad \left(P = \frac{E}{t}\right)$$

Unit:- $Js^{-1}m^{-2}$ or Wm^{-2}

P.S :- Scalar

Dependance :-

(i) Square of Amplitude

Intensity $\propto$ (amplitude)^2

(ii) Square of frequency

Intensity $\propto$ (frequency)^2

(iii) Inverse square of distance from source

Intensity $\propto \dfrac{1}{\left(\text{distance of area from source}\right)^2}$

Energy of a wave

$E = \frac{1}{2} m \omega^2 x_0^2$

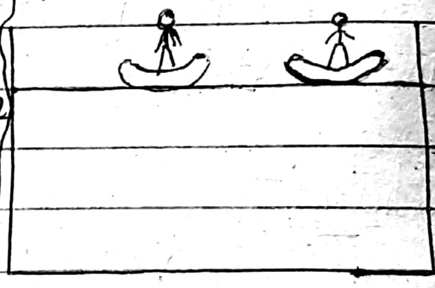
$E = \frac{1}{2} m (2\pi F)^2 x_0^2$

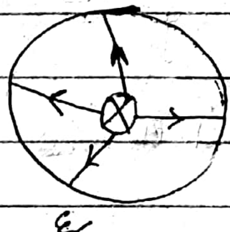
$E = 2\pi^2 m F^2 x_0^2$

$E = (\text{constant}) F^2 x_0^2$

$\boxed{E \propto x_0^2}$ (amplitude)

$\boxed{E \propto F^2}$





$I = \dfrac{E/t}{A}$

$I = \dfrac{P}{4\pi r^2}$

$I = \left(\dfrac{P}{4\pi}\right) \dfrac{1}{r^2}$

$I = (\text{constant}) \dfrac{1}{r^2}$

Monochromatic light source

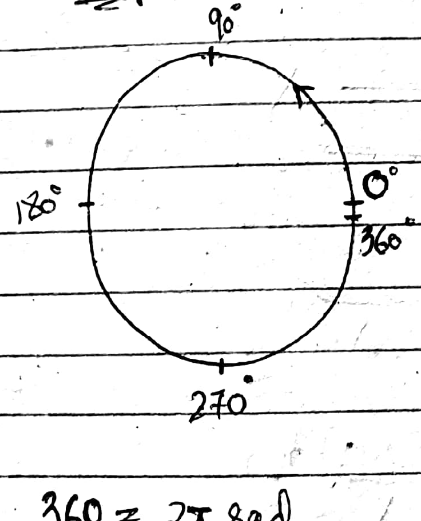
def:- Source which emit light of single ~~frequen~~ frequency (colour) is called monochromatic light source such as sodium light / lamp.

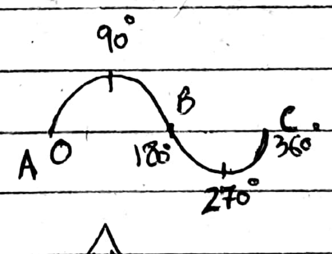
* frequency doesn't alter and is dependant on source, thats why it is written in def and not wavelength, as different colours also have different wavelengths.

Phase angle

Symbol:- Ø

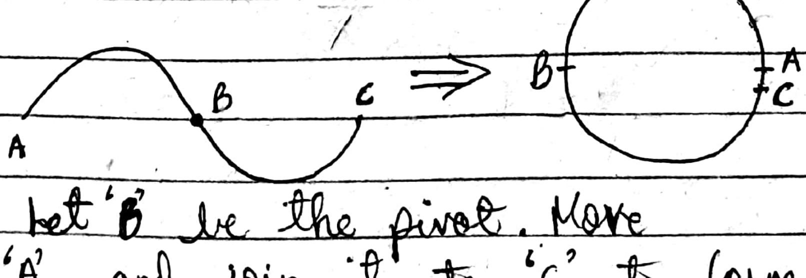
Concept:-





⇑

$360 = 2\pi$ rad

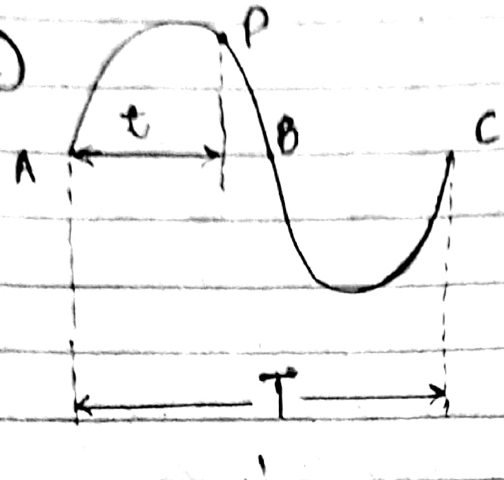


So, a wave also represent 360° or 2π radian

Let 'B' be the pivot. Move 'A' and join it to 'C' to form a circle

Formula analysis:

①

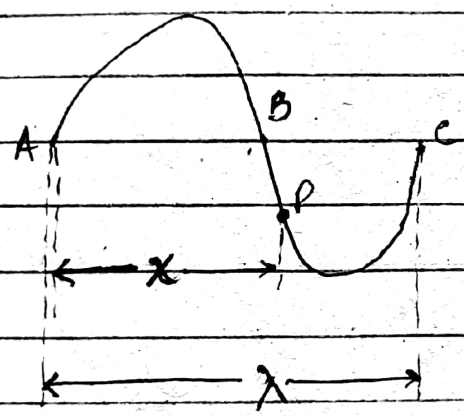


$$360^\circ \text{ — } T$$
$$\phi(?) \text{ — } t$$

So,
$$\frac{\phi}{360} = \frac{t}{T}$$

$$\boxed{\phi = \left(\frac{t}{T}\right) 360^\circ}$$
$$\boxed{\phi = \left(\frac{t}{T}\right) 2\pi \text{ radian}}$$

②



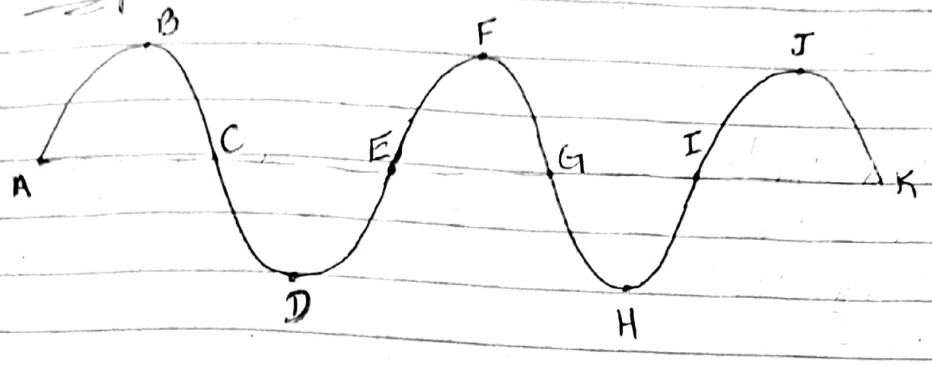
$$360^\circ \text{ — } \lambda$$
$$\phi(?) \text{ — } x$$

$$\frac{\phi}{360} = \frac{x}{\lambda}$$

$$\phi = \left(\frac{x}{\lambda}\right) 360$$
$$\phi = \left(\frac{x}{\lambda}\right) 2\pi \text{ radian}$$

→ *didn't understand it completely

Example:-



$\phi_{AB} \Rightarrow 360°$ or $0°$

$\phi_{AF} \Rightarrow 90°$

$\phi_{CH} \Rightarrow 90°$

$\phi_{EJ} \Rightarrow 90°$

$\phi_{DK} \Rightarrow 270°$

$\phi_{EA} \Rightarrow 360°$ or $0°$

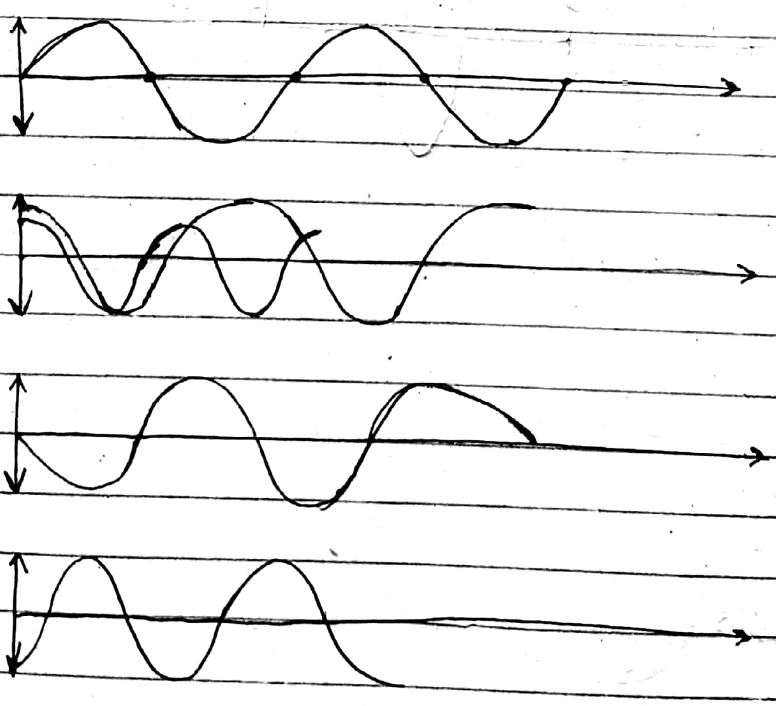
$\phi_{FA} \Rightarrow -270°$

$\phi_{HC} \Rightarrow -270°$

$\phi_{JE} \Rightarrow -270°$

$\phi_{KD} \Rightarrow -90°$

Ex.2:-



$\phi_{AB} = 90 \left(\frac{\pi}{2} \text{ rad}\right)$

$\phi_{AC} = 180^\circ \left(\pi \text{ rad}\right)$

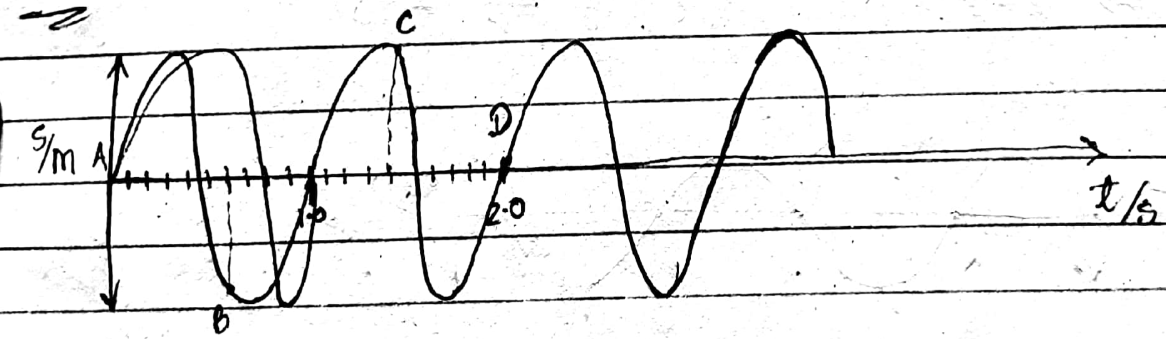
$\phi_{AD} = 270^\circ \left(\frac{3\pi}{2} \text{ rad}\right)$

$\phi_{BC} = 90^\circ \left(\frac{\pi}{2} \text{ rad}\right)$

$\phi_{BD} = 180^\circ \left(\pi \text{ rad}\right)$

$\phi_{CD} = 90^\circ \left(\frac{\pi}{2} \text{ rad}\right)$

<u>Ex.3 :-</u>



$\phi = \left(\frac{t}{T}\right) 360^\circ$

(i) $\phi_{AB} = \left(\frac{0.6}{1.0}\right) 360^\circ = 216^\circ$

(ii) $\phi_{AC} = \left(\frac{1.4}{1.0}\right) 360 = 504^\circ$

$\phi_{AC} = 360 - 504 = 144^\circ$

~~(iii) ϕ_{AD}=~~

i) $\phi_{AD} = \left(\frac{2.0}{1.0}\right) 360^\circ = 720^\circ$

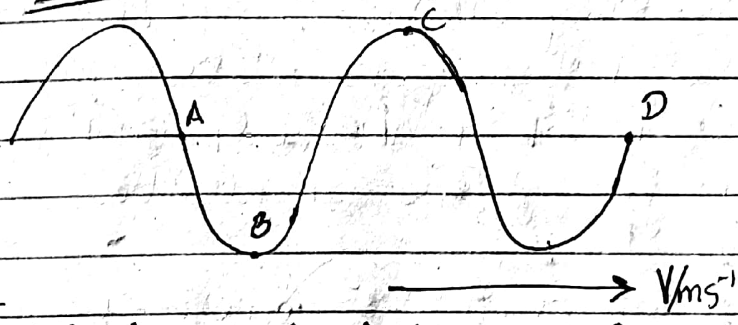
$\phi_{AD} = 720 - 360 = 360^\circ$

v) $\phi_{AC} =$

) $\phi_{BD} =$

i) $\phi_{CD} =$

Leading and Laging Concept



Hint:-

Disturbance level/source of a wave is considered as an enemy. The particles on wave which is closer to ~~enero~~ enemy is leading while the other behind this is laging.

* direction of motion of wave will always be given to us in this concept.

A leads B by 90°

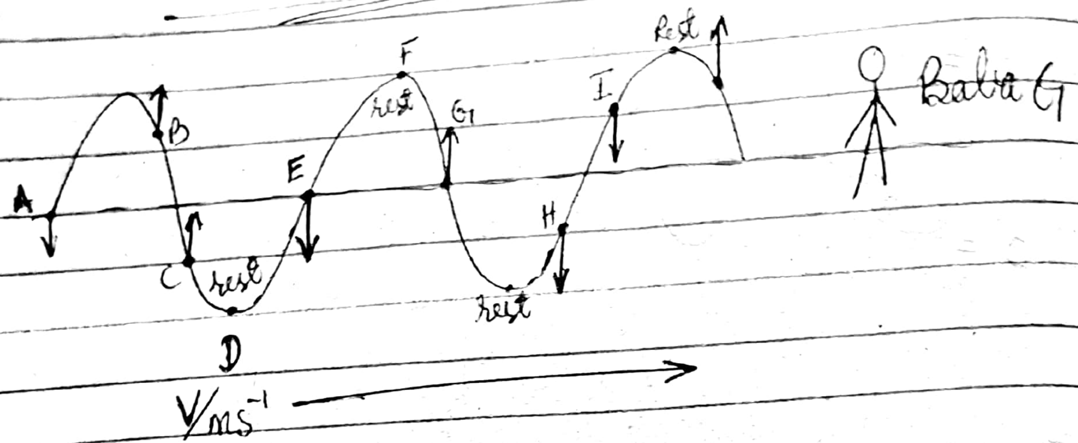
A " C " 270°

A " D " 180°

B " C " 180°

B leads D by 90°
C " D " 270°

Instantaneous motion of a particle of wave



Hint:-
Always study the motion of Baba G against the motion of a wave. The instantaneous motion of Baba G defines the motion of a particle on wave.

★ particle will be at rest ~~where~~ when we plot a tangent, ~~it becomes~~ which is parallel to the equilibrium position

⇒ **Inphase particle**

Note:-
1-) Particles having 0° phase angle in b/w them
2-) Displacement and instantaneous motion of inphase particles are same.

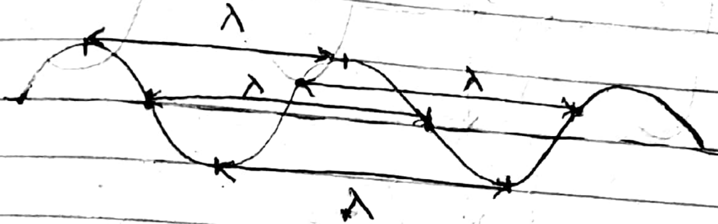
Scanned by CamScanner

⇒ Wavelength

def :-

Distance b/w 2 successive inphase particles is called wavelength.

Symbol :- λ



P.S :- Scalar

Unit :- metre (m)

⇒ Speed of a wave

def :-

distance travelled by a wave per unit time is called speed.

Formula :- $V = \frac{x}{t}$

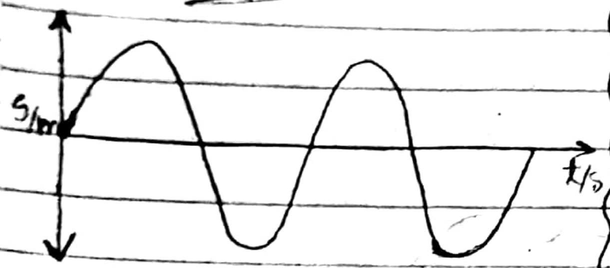
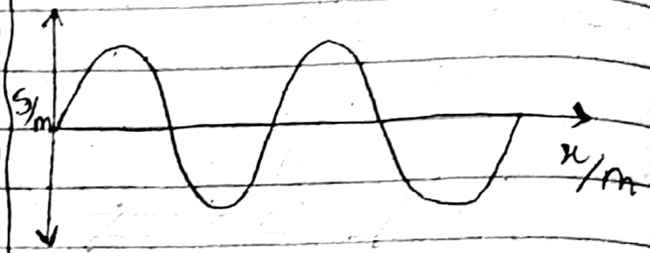
For one wave, distance = wavelength (λ)

time taken = Time period (T)

$V = \frac{\lambda}{T}$

But $\frac{1}{T} = f$ ⇒ $\boxed{V = f\lambda}$

Difference b/w displacement-time graph and displacement - distance graph

Displacement - time graph	Displacement - distance graph
	
Results:-	**Results:-**
★ Instantaneous displacement → y-axis	★ Instantaneous displacement → y-axis
★ time period → x-axis	★ Amplitude → y-axis
★ Amplitude → y-axis	★ wavelength → x-axis
★ frequency → $f = \frac{1}{T}$	
★ Velocity of a particle on wave (Baba G's velocity) → gradient of graph	

Note:-

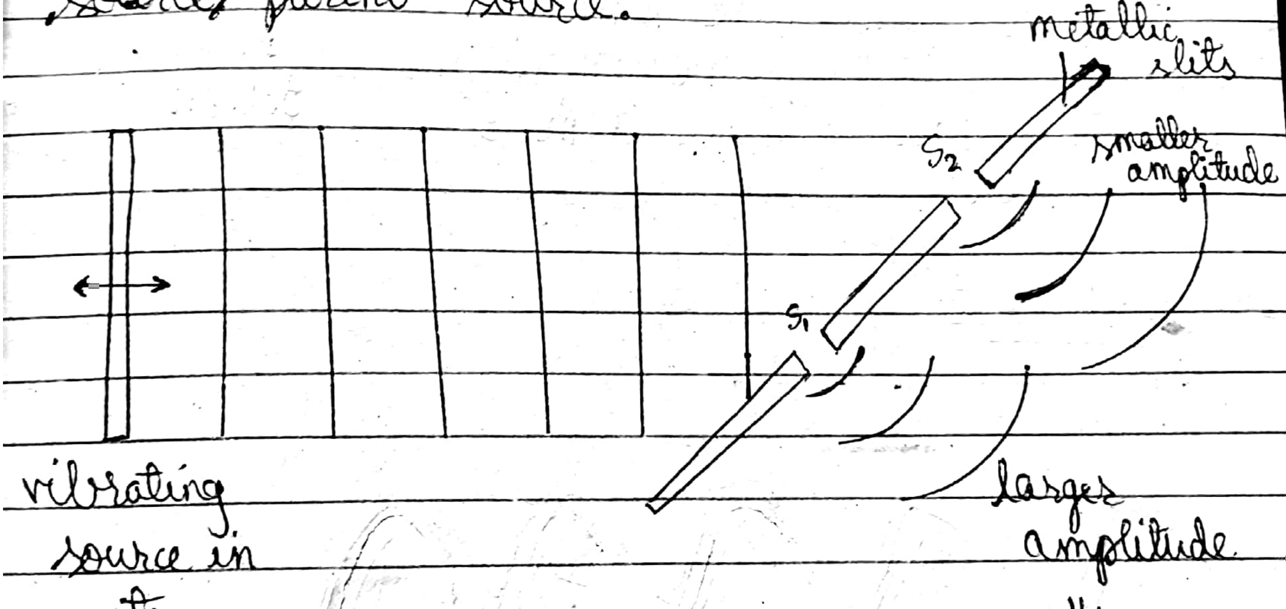
Velocity/speed of a wave is obtained from both graphs.

→ i.e. we have to use both graphs.

⇒ Coherent Sources

def :-
Sources which emit waves having constant phase angle in b/w them are called coherent sources.

Note :-
Coherent sources are derived from a single source and emit waves having constant time period, frequency and wavelength, but amplitude varies due to their position from the main source/ parent source.



⇓

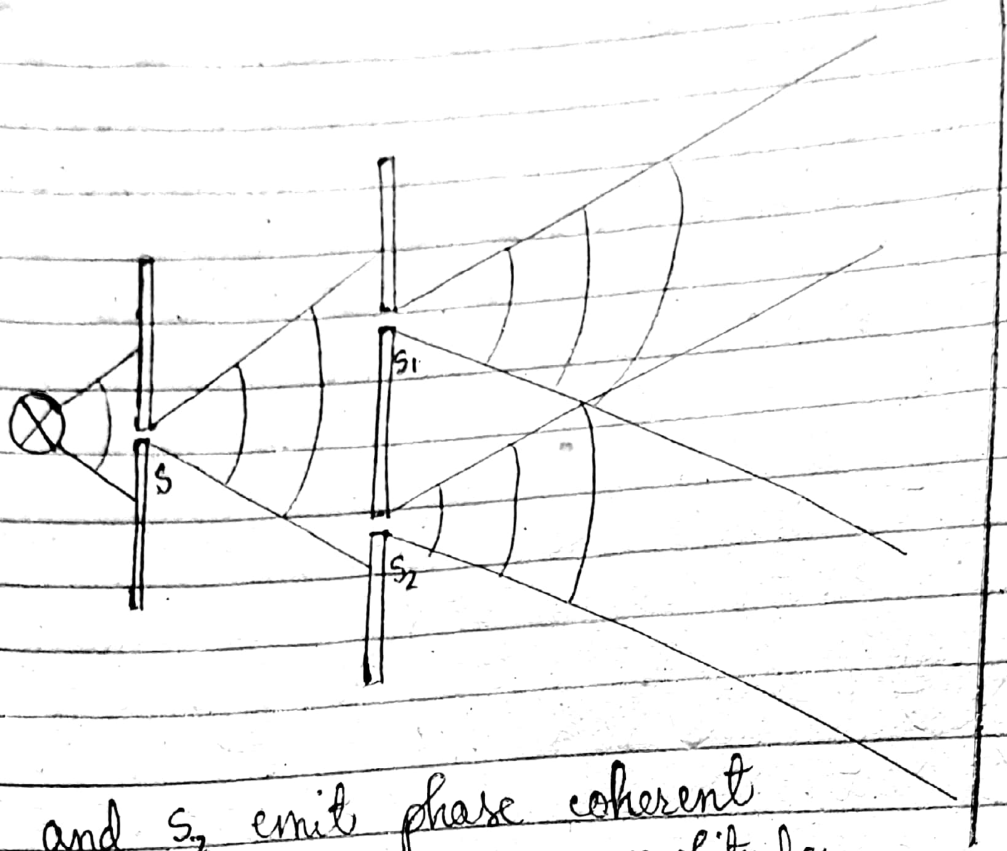
$I \propto A^2$

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

$A^2 \propto \frac{1}{r^2}$ ↑

* decrease in amplitude will be there due to loss of energy

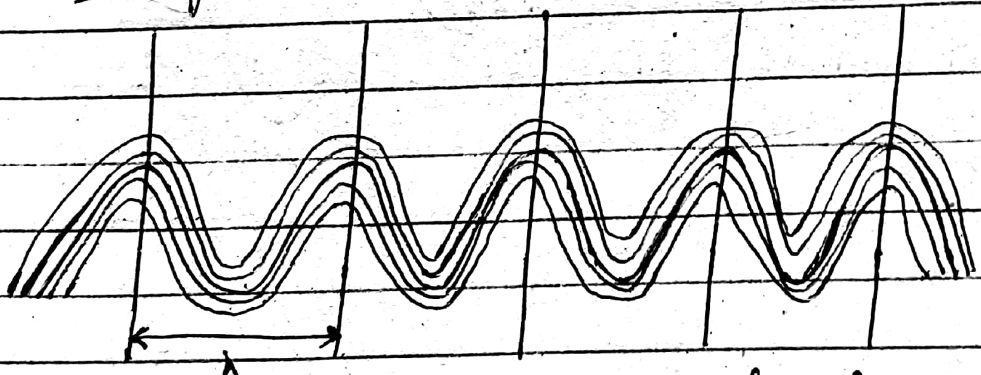
* distance of S_1 and S_2 from main source is not equal, so amplitude is ~~d~~ also ~~is~~ not same



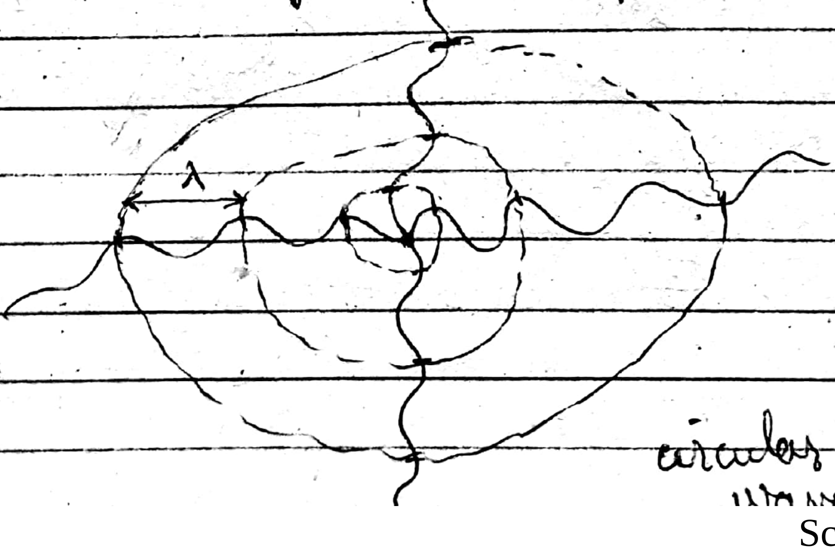
S_1 and S_2 emit phase coherent waves with same amplitudes due to same distance from 'S' (main source)

Screen

⇒ **Wavefront**



plane wavefront

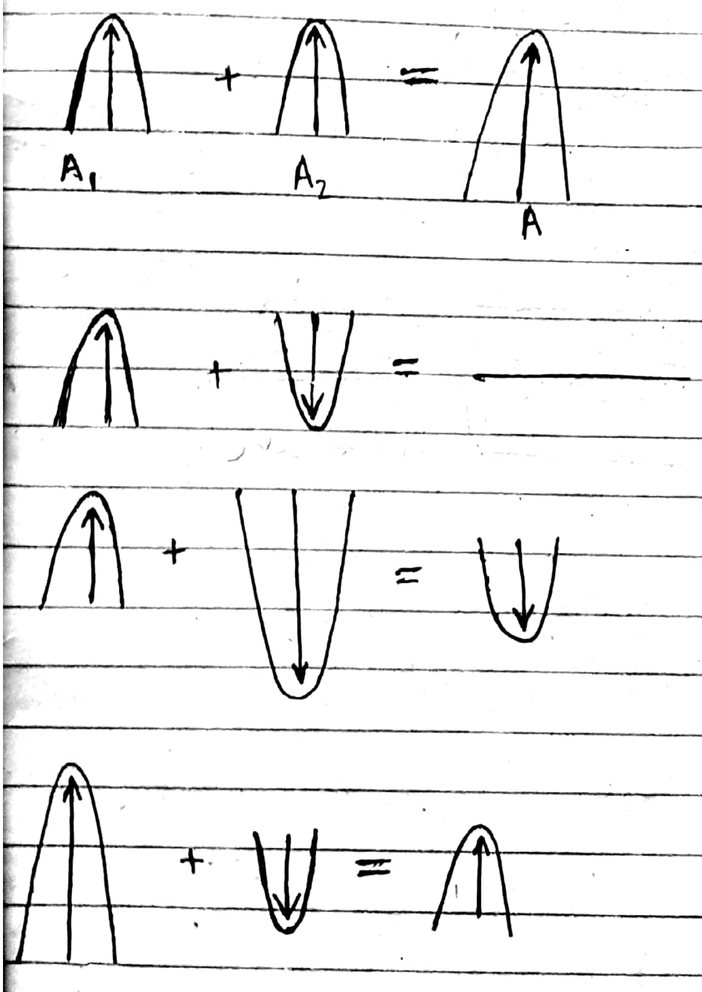


circular wavefront

def:-
Imaginary parallel lines which are passing through inphase particles of multiple waves.

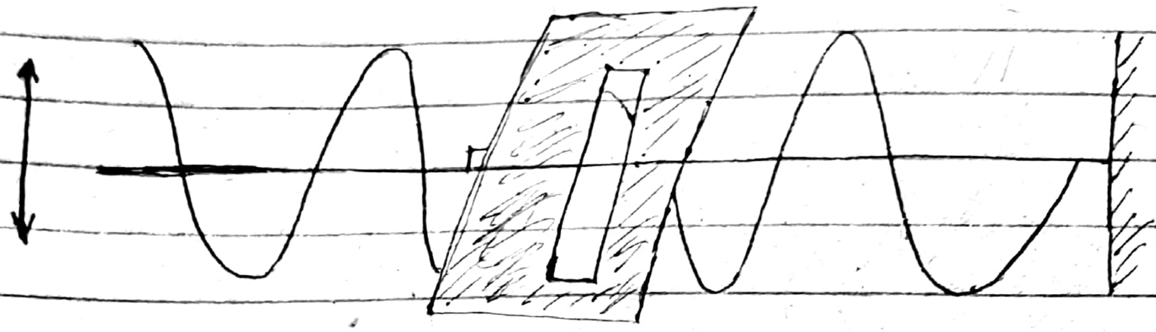
› **Principle of superposition**

Statement:-
When 2 or more waves meet at a point, the resultant wave has displacement which is equal to the vector sum of their individual displacements.

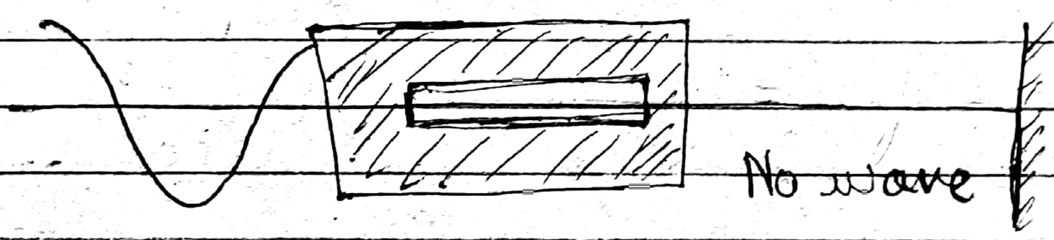


Polarisation

def:- The process to confine a wave to pass through in one plane (only), is called polarisation.



Vertical plane polarised wave



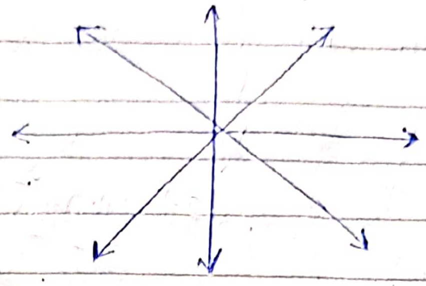
Not a ~~horizontl~~ horizontal plane polarised wave

★ the blocking of wave is not ~~k~~ polarisation

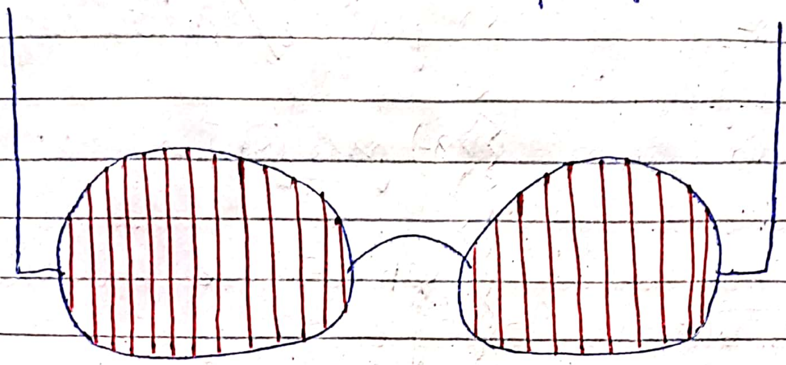
★ longitudnal waves can't be polarised

★ polarisation is of transverse waves.

★ A wave produced moves in all planes and is confined ~~to~~ move in one particular plane by a slit. The blocking of the waves in other planes is not polarisation, but the confinement of wave is 1 plane is polarisation.



motion of light waves
in multiple plane



vertical plane of light pass through the vertical slit and block other planes to reduce the intensity of light incident at an eye.

★ Same principle / concept is used in windscreens of cars to reduce the intensity of light

Note:-

Only transverse waves can be polarised because one ~~can~~ cannot polarise the longitudinal waves

Differences

Transverse	Longitudinal
1) def:- Waves in which displacement of particle is perpendicular to	1) def:- Waves in which displacement of particle is parallel to the

the direction of motion of wave

2) Composition:-

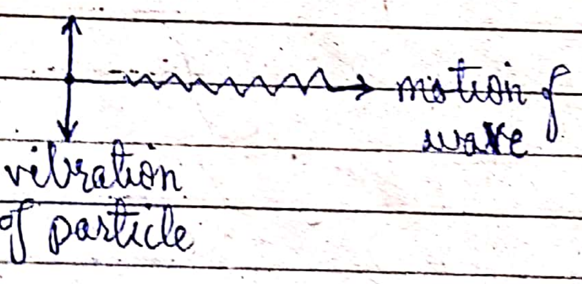
Crest (upper peak) and trough (lower peak)

3) polarisation :-

Can be polarised

4) E.g. :-
All e.m waves, water waves, waves along a string, etc

5) Geographical representation



direction of motion of wave

2) composition :-

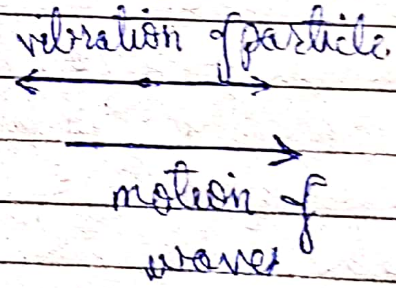
Compression (High pressure / density region)
Rarefaction (low pressure / density region)

3) polarisation :-

Can not be polarised

4) e.g. :- Sound waves

5) Geographical representation.



Interference of Waves

def :- 2 or more waves meet at a point

Superposition of waves which support each other at one point and cancel out the effect of each other at another point is called interference.

Principle :-

Principle of superposition

Conditions for interference :-

1) Waves must be from coherent sources i.e. they have a phase coherence.
constant phase angle

2) Waves must meet at a point

3) Waves must be ~~to~~ of same type

4) If transverse, then they must be polarised in the same plane.

* 2 crest or 2 troughs meet forming a bigger resultant crest or trough respectively
→ this is actually ~~sp~~ supporting
- one crest and one trough meet, ~~cancel~~ cancelling out each others effect

Types of Interference → a) Constructive Interference
→ b) Destructive "

1) Constructive interference :-
def:- Superposition of waves which support each other to provide a resultant wave with greater displacements is called constructive interference.

Conditions :-

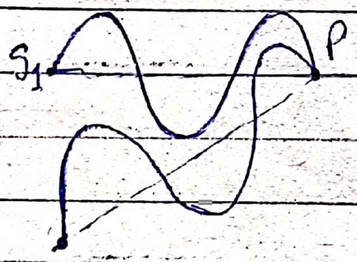
i) Path difference :-

Def: It is the difference of distance travelled ~~tre~~ by both waves from ~~there~~ their sources to their meeting region.

Note:-
Path difference is represented in terms of wavelength.

(ii) Phase difference :-

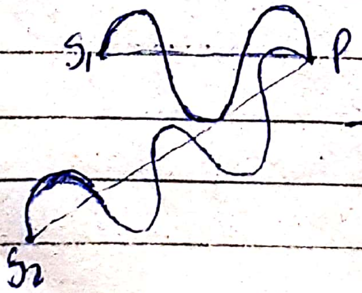
$$\phi = \left(\frac{\text{Path difference}}{\text{wavelength}}\right) 2\pi$$



$\Longrightarrow$

$\text{Path diff} = S_2P - S_1P$
$= 1.5\lambda - 1.5\lambda$
$= 0\lambda$

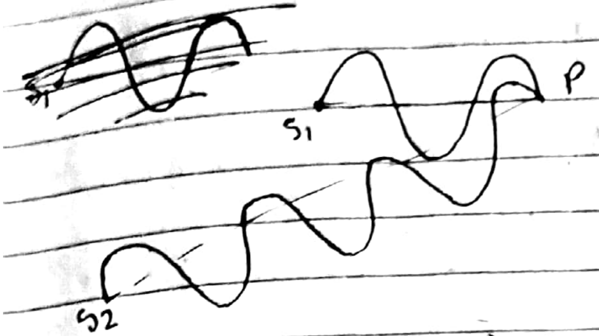
$\text{Phase diff} = \left(\frac{0\lambda}{\lambda}\right) 2\pi$
$= 0$



$\Longrightarrow$

Path diff
$= S_2P - S_1P$
$= 2.5\lambda - 1.5\lambda$
$= 1\lambda$

$\phi = \left(\frac{1\lambda}{1\lambda}\right) 2\pi$
$= 2\pi$



Path diff :-

$S_2P - S_1P$
$= 3.5\lambda - 1.5\lambda$
$= 2\lambda$

phase diff :-

$\phi = \left(\frac{2\lambda}{\lambda}\right) 2\pi$

$= 4\pi$

In general for constructive interference :-

→ path diff :- 0λ, 1λ, 2λ, 3λ --- $n\lambda$
(i.e. integral multiple of wavelength)

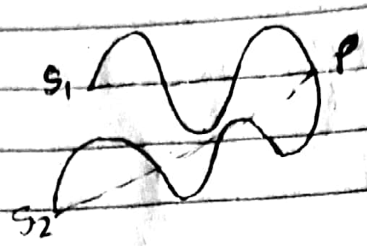
→ Phase diff :- 0π, 2π, 4π --- $2n\pi$
(i.e. even multiple of π)

where $n = 0, 1, 2, 3$ ---

b) Destructive Interference

def :-
Superposition of waves which cancel out each others effect to provide a resultant wave with minimum displacements is called destructive interference.

Conditions :-



Path diff :-

$S_2P - S_1P$

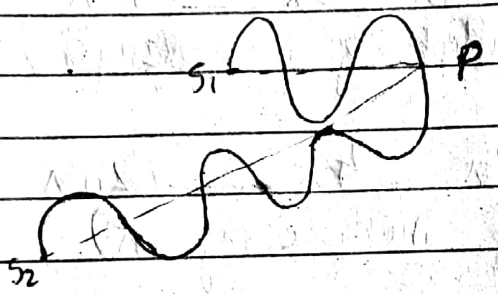
$= 2\lambda - 1.5\lambda$

$= \cancel{1} \; 1\frac{\lambda}{2}$

phase diff :-

$\phi = \left(\frac{\frac{\lambda}{2}}{\lambda}\right) 2\pi$

$= \pi$



path diff :-

$S_2P - S_1P$

$= 3\lambda - 1.5\lambda$

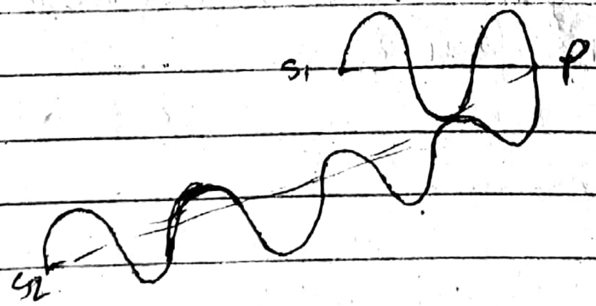
$= 1.5\lambda$

$= 3\frac{\lambda}{2}$

phase diff :-

$\phi = \left(\frac{3\frac{\lambda}{2}}{\lambda}\right) 2\pi$

$= 3\pi$



path diff :-

$S_2P - S_1P$
$= 4\lambda - 1.5\lambda$
$= 2.5\lambda$
$= 5\frac{\lambda}{2}$

phase diff :-

$\phi = \left(\frac{\frac{5\lambda}{2}}{\lambda}\right)2\pi$

$= 5\pi$

Therefore, in general, in a destructive interference,

→ path diff = $\frac{1\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, \frac{7\lambda}{2}$ ---

--- $(2n+1)\frac{\lambda}{2}$ i.e. odd multiple of half wavelength

→ phase diff = $1\pi, 3\pi, 5\pi$ --- $(2n+1)\pi$
i.e. odd multiple of π

Where $n = 0, 1, 2, 3,$ ---

★ for 2 constructive inteference, 1 destructive interference is necessary and vice versa for destructive interference.

~~Interference of Water waves~~

★ where phase diff = 0, there max constructive interference.

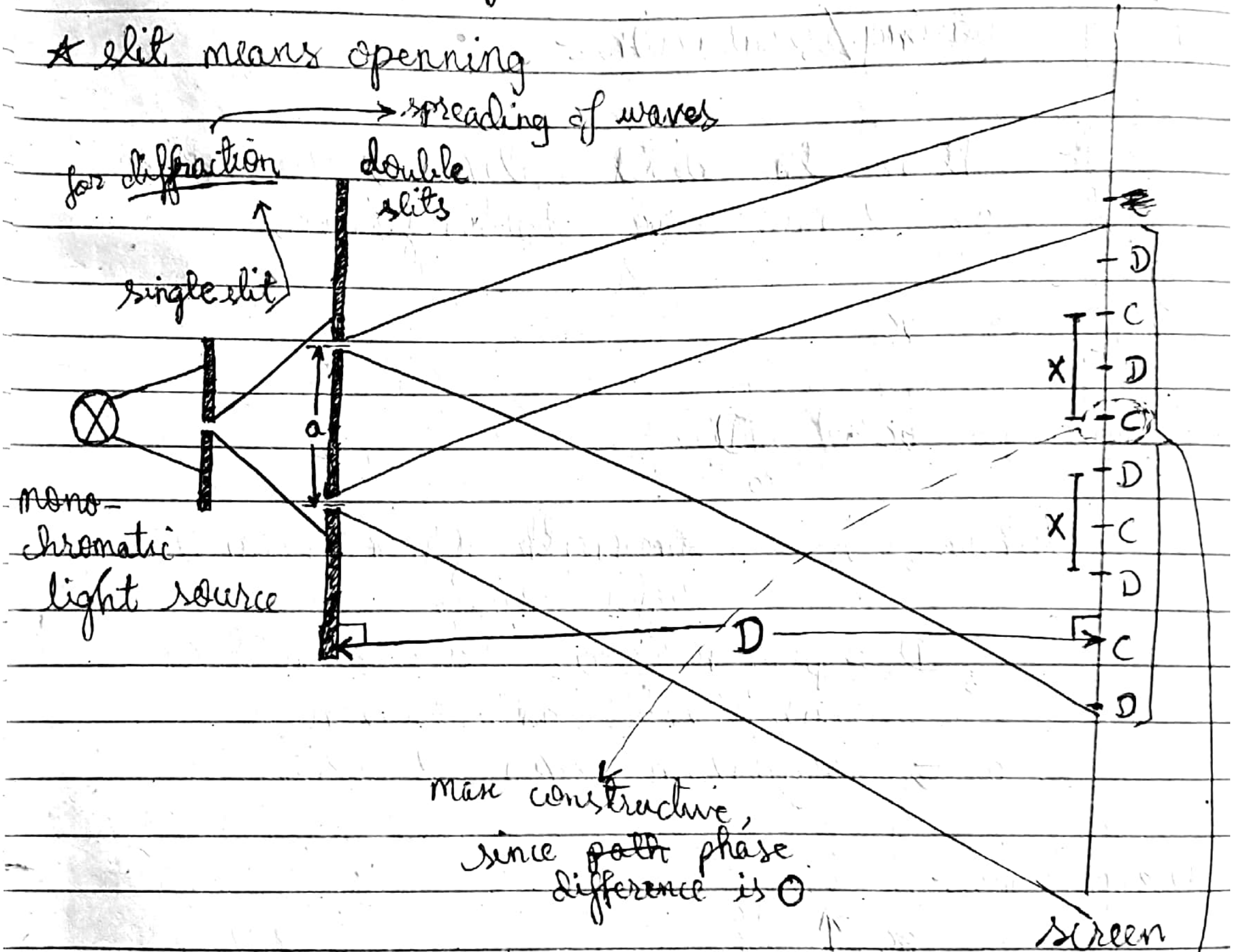
(v.v. imp)

Interference of light waves (Young's double slit experiment)

Significance:-

This experiment is used to measure the wavelength of monochromatic light source.

★ slit means openning



Interference pattern in terms of fringes

Observation:-

Alternate light and dark bands, also known as interference fringes are ~~of~~ observed at the outer screen due to constructive and destructive interference of light waves from coherent sources S_1 and S_2.

★ B/w every 2 constructive interferences, there is a destructive interference and vice verso for destructive interference.

Fringe spacing/separation :-

def:- It is the distance b/w 2 successive bright or 2 successive dark fringes.

Symbol :- x

Formula :- $x = \frac{\lambda D}{a}$

where, $\lambda \Rightarrow$ wavelength of monochromatic light source

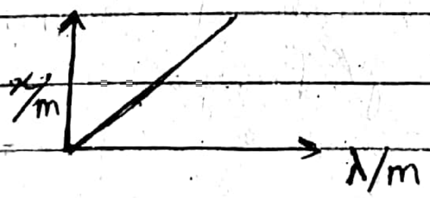
& $D \Rightarrow$ perpendicular separation b/w double slits and screen

$a \Rightarrow$ separation b/w 2 slits

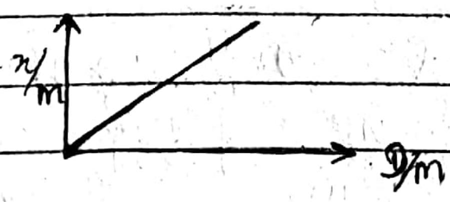
Dependance :-

$x \uparrow$ if,

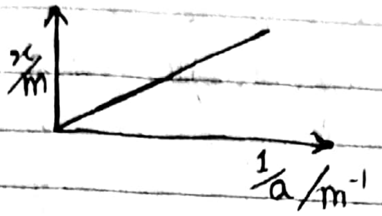
(i) $\lambda \uparrow$

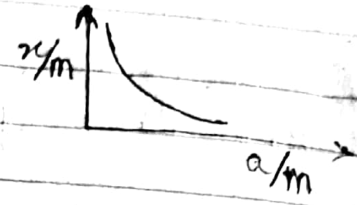


(ii) $D \uparrow$



(iii) $a \downarrow$





Note:-

1-) The Brightness of bright fringe increases with no change in dark fringe which therefore increases the ~~cons~~ contrast b/w them if;

a) **Increase** the intensity of source by increasing its power rating.

b) Decrease the distance 'D' b/w double slits and screen

c) ~~Dis~~ Decrease the distance b/w the source and the slits

d) Replace the light source with one, having lesser wavelength ⇒ Reason:-

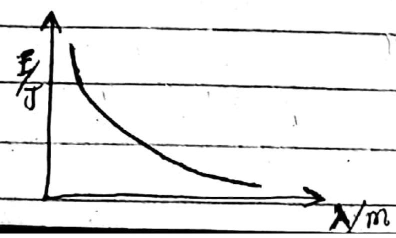
Energy of e.m waves $= E = hf$

But $c = f\lambda \Rightarrow f = \frac{c}{\lambda}$

$E = \frac{hc}{\lambda}$, where $h \Rightarrow$ planck's constant (6.63×10^{-34} Js)

$E = \frac{\text{constant}}{\lambda}$ $c \Rightarrow$ speed of light ($3.0 \times 10^{8}\ ms^{-1}$)

$E \propto \frac{1}{\lambda}$

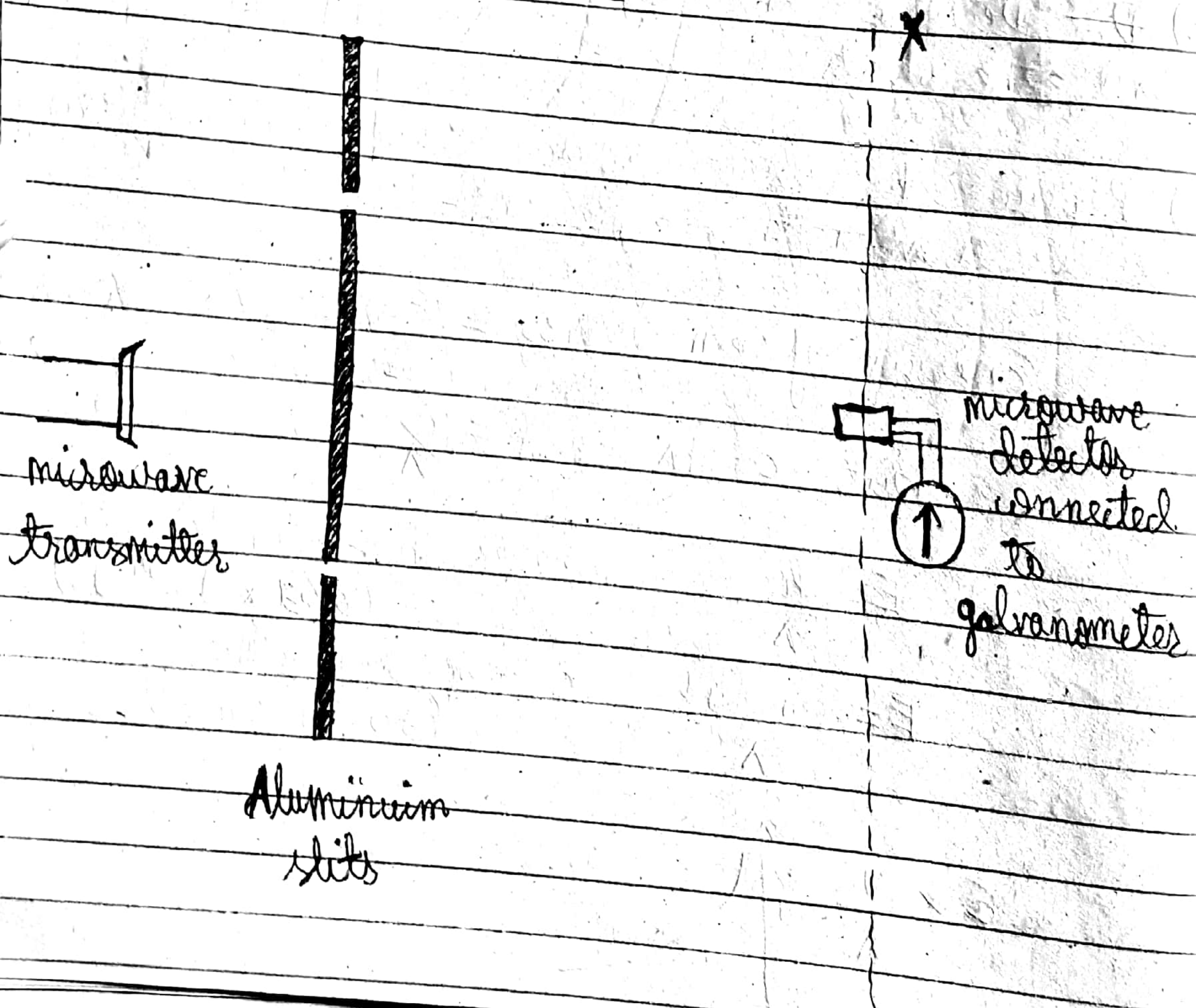


e) size of double slits is increased without varying the separation, 'a' b/w slits.

(J/09)
2-) The ~~darkness of~~ brightness of bright fringe decreases and the darkness of dark fringe also decreases, if the intensity of light incident on one slit of double slits is decreased.

3-) Range of separation b/w double slits is
0.3 to 3 mm i.e.
$3mm \geq a \geq 0.3mm$

Interference of microwaves



Observation :-

The microwave which are incident at the Aluminium slits are not reflected back due to strong absorbtion of Aluminium. The microwaves from 2 slits of Aluminium meet at the screen to exhibit interference. The microwave detector is moved along the line XY which shows regions of maximum and minimum due to constructive and destructive interference of microwaves.

Diffraction

def:- spreading of /out of waves after ~~gap~~ passing through a small gap/aperture or round an obstacle is called diffraction.

Note:-

(i) There is no change in the wavelength, frequency or speed of incident and diffracted wave, but the amplitude or intensity decreases while passing through a medium.

ii) The order of diffraction depends upon the wavelength of incident wave and the size of gap/aperture i.e., greater is the diffraction if the wavelength of wave is greater ~~than~~ than the size of aperture.

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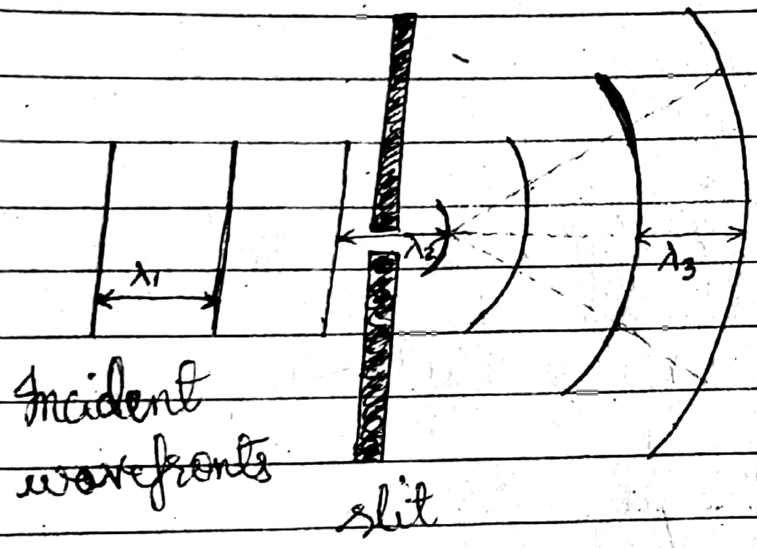
(iii) ~~Diffra~~ Diffraction decreases if the wavelength of wave is lesser ~~than~~ than the size of aperture/gap.

(iv) ~~Shawdo~~ Shadow formation is also due to ~~diff~~ diffraction of waves round ~~at~~ an obstacle.

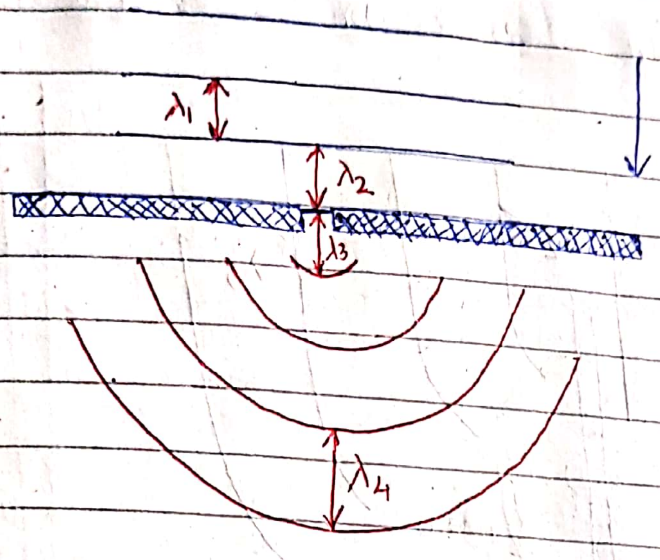
Diffraction pattern :-

a) Diffraction through a narrow ~~gep~~ gap :-



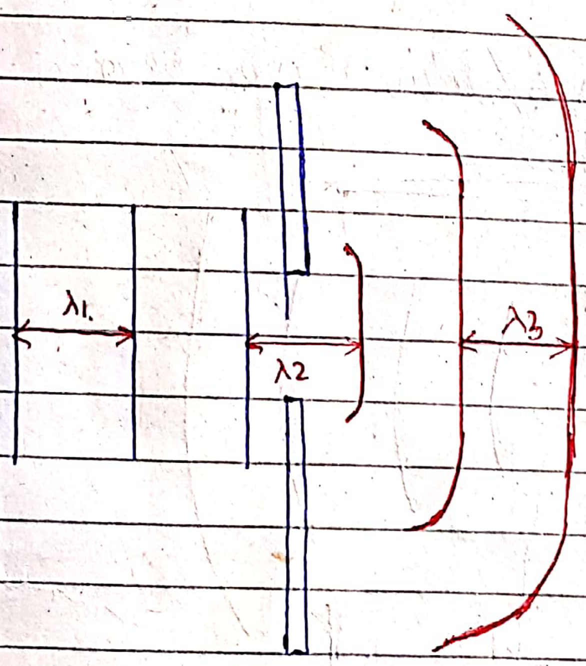
★ dotted lines show spreading of waves

★ $\lambda_1 = \lambda_2 = \lambda_3$
★ greater is the ~~diff~~ diffraction and diffracted waves are circular.



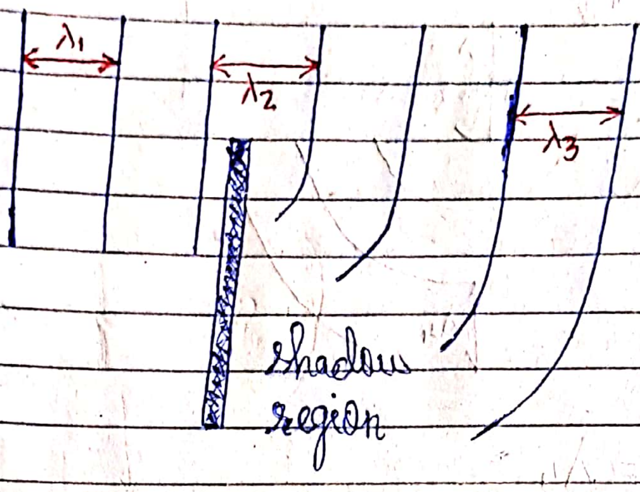
$\lambda_1 = \lambda_2 = \lambda_3 = \lambda_4$

b) Diffraction through a wide gap :-



* $\lambda_1 = \lambda_2 = \lambda_3$
* here is diffraction (Diffracted wavefronts are straight from the middle and curved from edges)

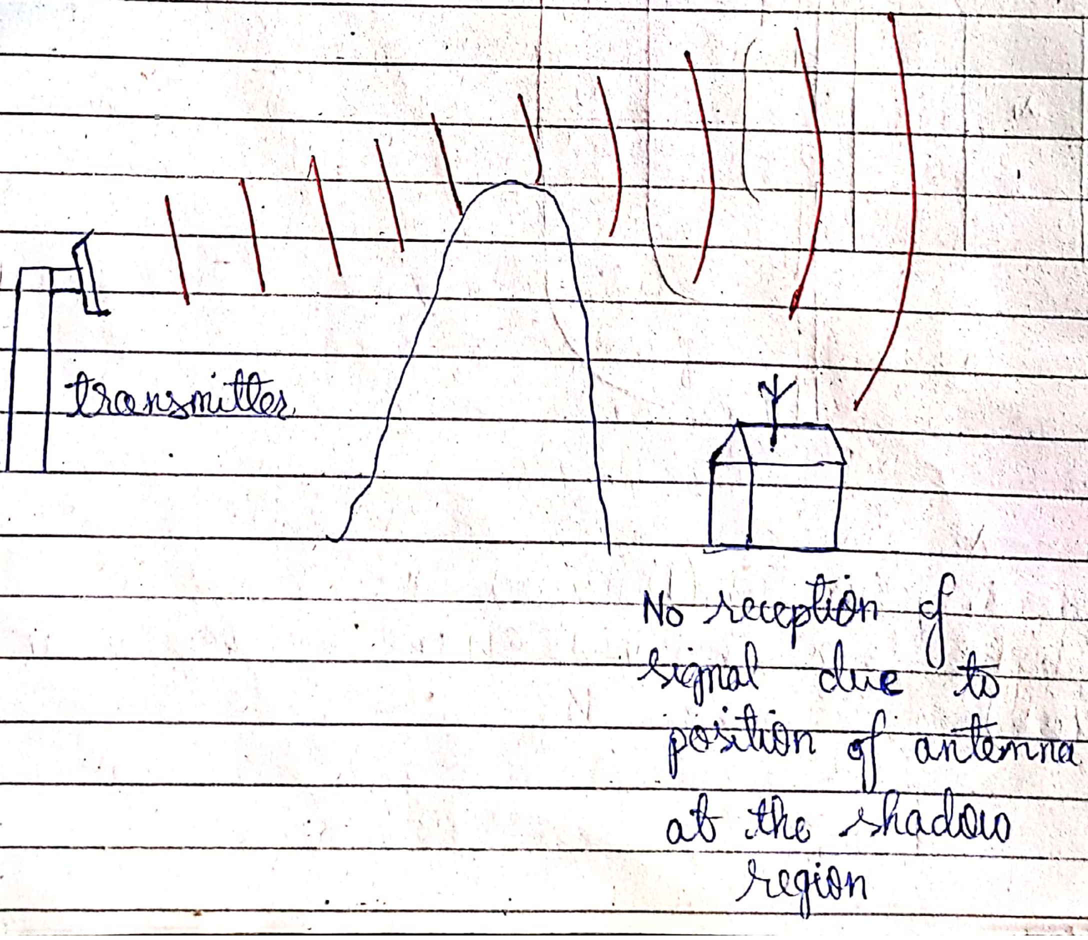
(c) Diffraction round an obstacle :-



★ $\lambda_1 = \lambda_2 = \lambda_3$

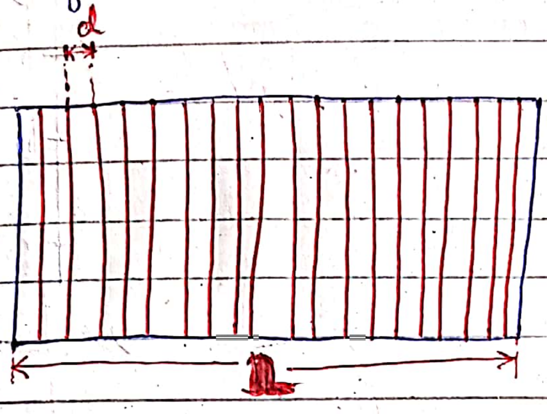
★ diffraction round an obstacle causes ~~shad~~ shadow region.

Diffraction of microwaves/Radio waves round a hill



Diffraction Grating

def :-
A waffer made of glass, plastic or metal having 5000 - 6000 lines per inch ruled on it. Each line behave like a slit and diffract the incident waves which further meet to provide a pattern on screen known as diffraction pattern.

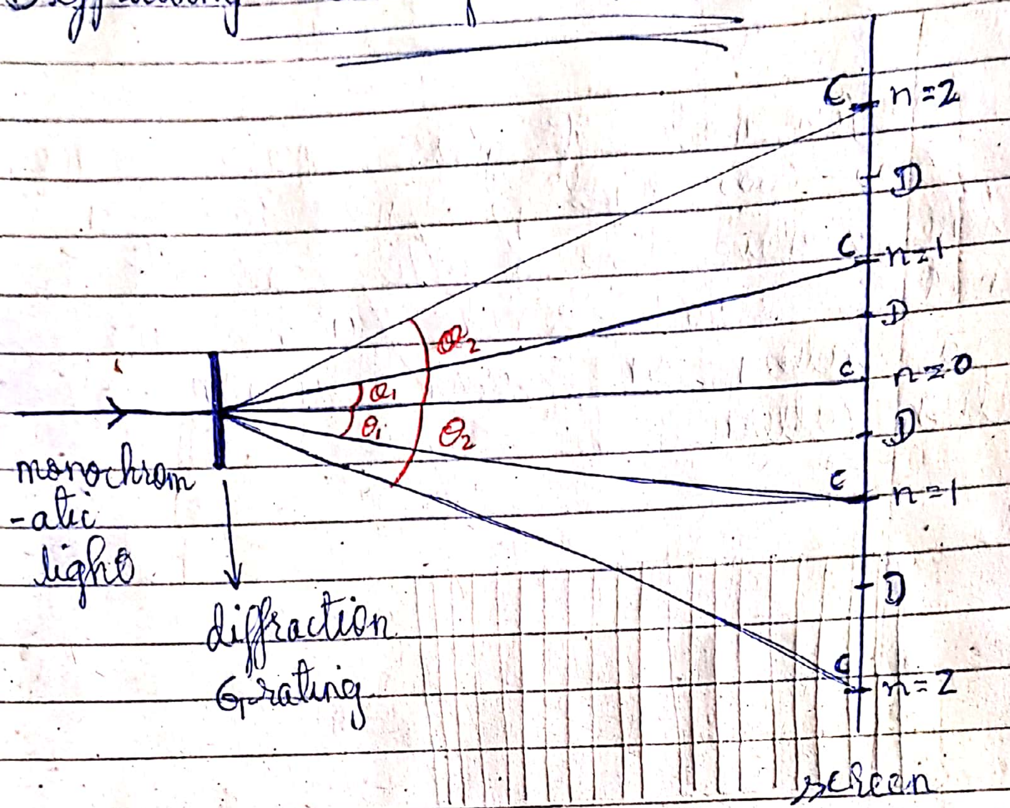


$$Nd = L$$

$$d = \frac{L}{N}$$

i.e. slit separation = $\frac{\text{Length of grating Wafer}}{\text{no. of lines on it}}$

Diffracting through diffraction grating



Observation:-

Monochromatic light is diffracted at different angles through a Grating Wafer and further meet on a screen to provide a pattern known as diffraction pattern with different orders of diffraction

Formula:- $n\lambda = d \sin\theta$

where $n \Rightarrow$ order of diffraction

$\lambda \Rightarrow$ wavelength of monochromatic light

$d \Rightarrow$ distance b/w two successive lines on grating

$\cancel{= N} = \frac{L}{N}$ (length of grating wafer) / (No. of lines on it)

$\theta \Rightarrow$ Angle of diffraction with zero order ($n=0$)

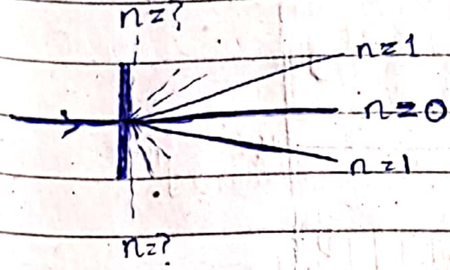
Maximum order of diffraction

Diffraction is maximum if $\theta = 90°$

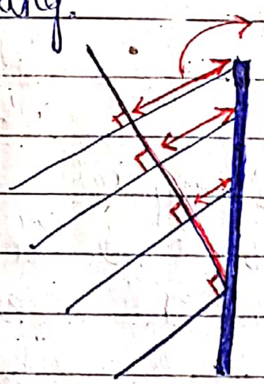
$$n\lambda = d \sin 90$$

$$n\lambda = d$$

$$n = \frac{d}{\lambda} \qquad \text{where } d = \frac{L}{N}$$

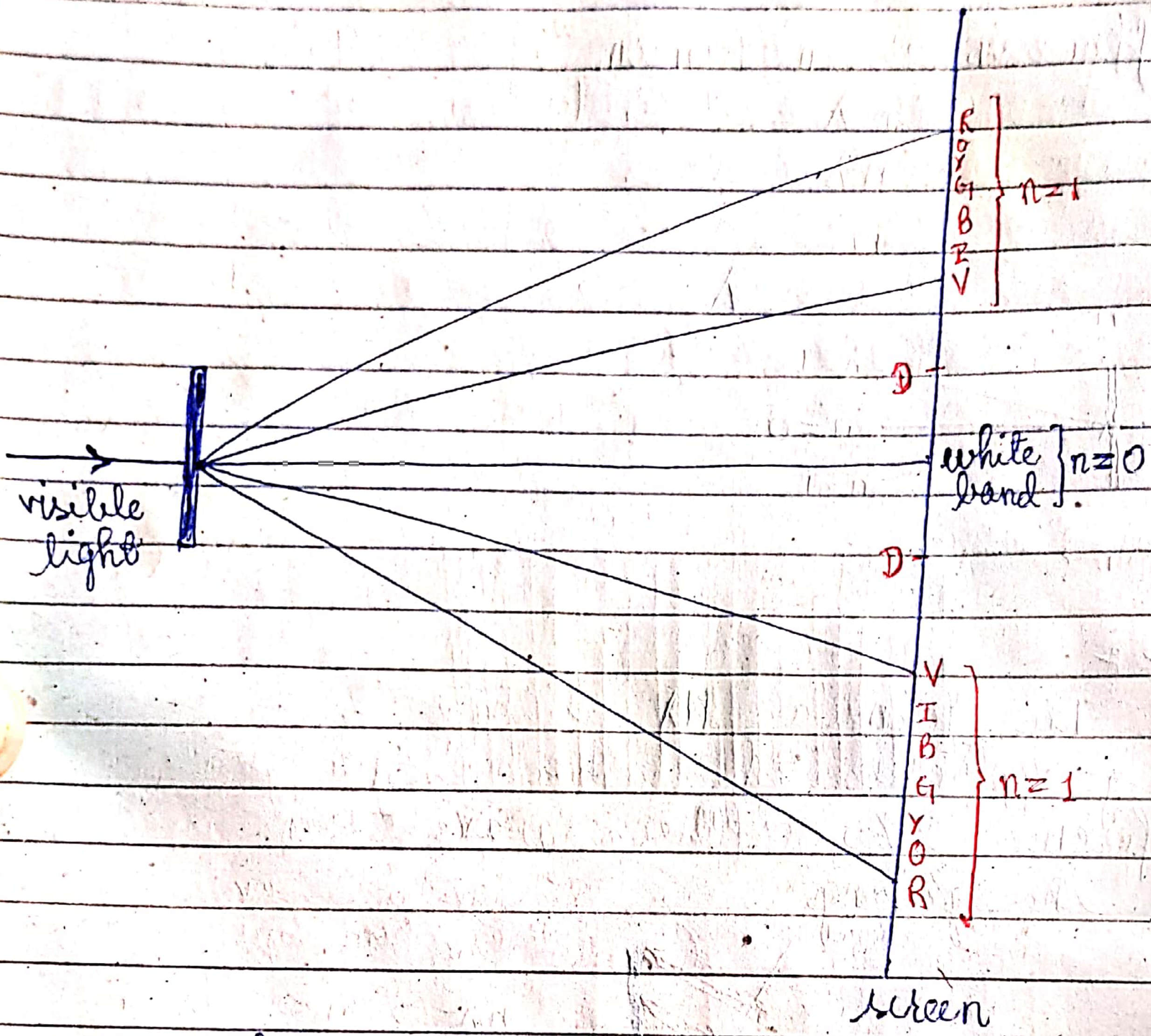


Note:
The formula $n\lambda = d \sin\theta$ is only ~~of~~ applicable where there is no path difference b/w different wave trains incidenting on the grating.



$n\lambda = d \sin\theta$ is not applicable since path difference is varying

Diffraction of visible light through grating



Since white light is composed of 7 component wavelengths and the size of slit on grating is constant, so each colour of white light is diffracted at different angles for the same order of ~~dif~~ diffraction.
Hence, we get a white band for 0 order and a visible spectrum for all other orders of diffraction.
The angle of diffraction of red colour is greatest and of violet is least for the same order.

Electromagnetic Spectrum

def:- Sequence of all transverse waves which do not need a state of matter to travel is ~~are~~ called electromagnetic spectrum.

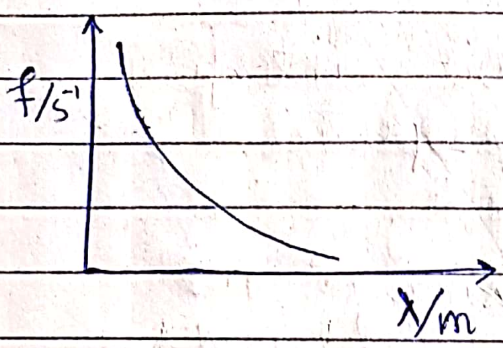
Relative order:-

$$v = f\lambda$$

For e.m waves, $v = c = 3.0 \times 10^{8}\ ms^{-1}$

$$f = \frac{3.0 \times 10^{8}}{\lambda}$$

$$f \propto \frac{1}{\lambda} \quad (\text{as } 3.0 \times 10^{8} = \text{constant})$$



Order	Gamma	X-rays	Ultraviolet	visible	Infrared	micro	Radio
f/Hz	10^{20}	10^{18}	10^{16}	10^{14}	10^{12}	10^{10}	10^{8}
λ/m	10^{-12}	10^{-10}	10^{-8}	10^{-6}	10^{-4}	10^{-2}	$10^{0} = 1$

$\Downarrow$

V	I	B	G	Y	O	R
400	450	500	550	600	650	700

λ/m

Common properties of e.m waves

1-) All e.m waves are transverse waves and therefore can be polarised.

2-) All e.m waves are progressive waves i.e. they transfer energy from one point to another.

3-) All e.m waves do not carry any charge (they do not ~~defle~~ show any deflection in a ~~+~~ electric or magnetic field).

4-) All e.m waves move with the same speed of $3.0 \times 10^{8}\ ms^{-1}$ in air or vacuum.

5-) All e.m waves exhibit interference and ~~diff~~ diffraction properties.

Stationary Waves

~~*~~incident and reflected waves are always 180° out of phase with each other.

def:-

When ~~Z~~ incident and reflected wave having same speed and ~~f~~ frequency, but travelling in opposite direction are superposed, stationary waves are formed.

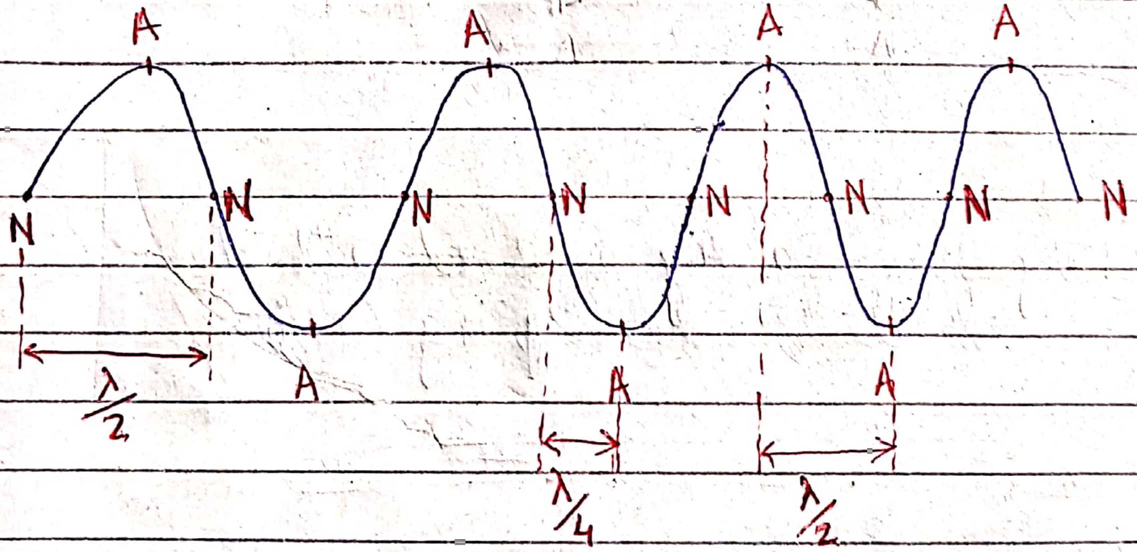
Note :-

1-) The particles on stationary waves, whose displacement remain 0 are called nodes.

2-) The particles on stationary waves whose displacement is maximum and called anti-nodes.

3-) The distance b/w 2 successive nodes or anti nodes is equal to half of wavelength $\left(\frac{\lambda}{2}\right)$.

4-) The distance b/w a node and its successive anti node is equal to quarter of wavelength or $\frac{\lambda}{4}$

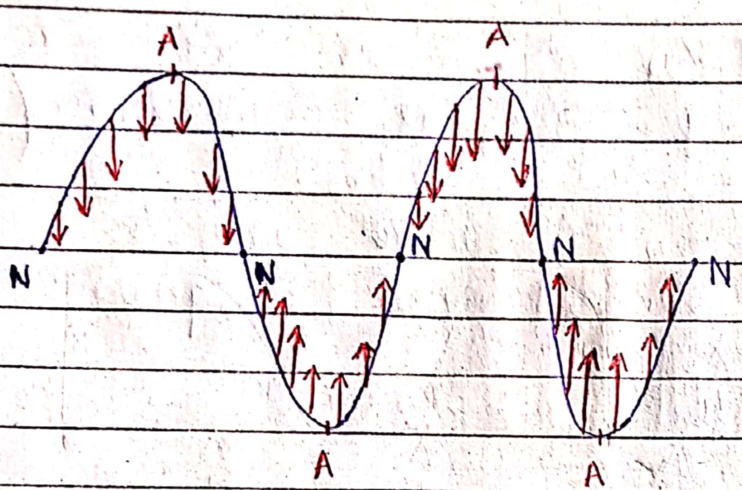


5-) The speed of stationary wave is same as that of superposing progressive waves.

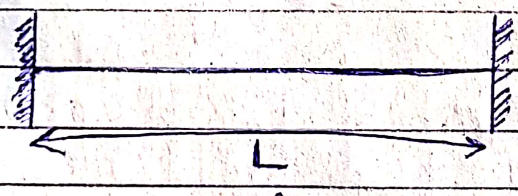
6-) No energy is transferred along the wave profile due to static position of nodes

7) The particles b/w 2 adjacent nodes always move in 1 direction and are inphase with each other.

8) The particles on either side of node are 180° out of phase with each other due to their opposite direction of motion.



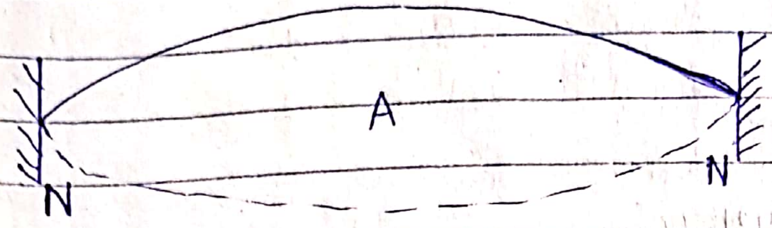
Stationary waves along a ~~strect~~ stretched ~~strett~~ stretched spring (Guitar/sitaar spring)



Length of string b/w 2 fixed points = L

Fundamental node :- The simplest and slowest frequency is called fundamental frequency.

Displace the string aside and release it to produce stationary waves with two nodes at the ends and an antinode in the middle as shown.



Length of string interms of wavelength $= L = \frac{\lambda_0}{2}$

$$\lambda_0 = 2L$$

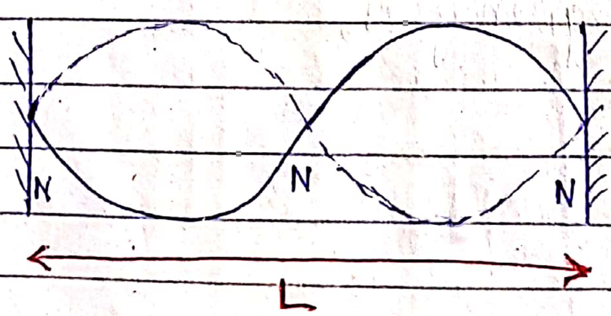
Fundemental frequency is,

$$V = f_0 \lambda_0 \Rightarrow f_0 = \frac{V}{\lambda_0}$$

$$\boxed{f_0 = \frac{V}{2L}}$$

First overtone frequency :-

Fix the string from the middle to make a node and disturb it to produce first harmonic node as shown.



1st harmonic frequency is,

$$V = f_1 \lambda_1$$

$$f_1 = \frac{V}{\lambda_1}$$

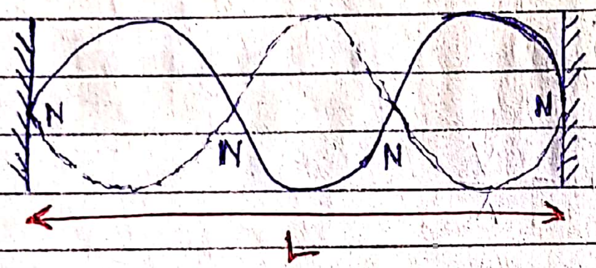
$$f_1 = \frac{V}{\lambda_1}$$

$$f_1 = \frac{V}{L}$$

$$\boxed{f_1 = 2f_0}$$

2nd overtone frequency:

Fix the string from two points to make one ~~node~~ more node as shown.



$$L = \lambda_2 + \frac{\lambda_2}{2}$$

$$L = \frac{3\lambda_2}{2}$$

$$\lambda_2 = \frac{2L}{3}$$

Second overtone frequency is,

$$f_2 = \frac{V}{\lambda_2}$$

$$f_2 = \frac{V}{2L/3}$$

$$f_2 = 3\left(\frac{V}{2L}\right)$$

$$\boxed{f_2 = 3f_0}$$

Therefore, in general, along a stretched string, stationary waves of frequency f_0, $2f_0$, $3f_0$, $4f_0$ ---- nf_0 are produced where, $n = 1, 2, 3, 4$ ---- and represent the no. of loops along the ~~wave~~ wave and

$$\boxed{f_0 = \frac{V}{2L}}$$

★ overtone → is always the multiple of fundemental frequency

Speed of stationary wave along a string

$$V \propto \sqrt{\frac{T}{\mu}}$$

where $T \Rightarrow$ Tension in the string

$\mu \Rightarrow$ Mass per unit length of string

But $V = f\lambda \Rightarrow f = \frac{V}{\lambda}$

So,

$$f \propto \frac{1}{\lambda}\sqrt{\frac{T}{\mu}}$$

Result:-

f (↑) if :-

(i) T (↑)

(ii) μ (↓)

*

Stationary waves in a closed pipe (mouth organ)

Note:-

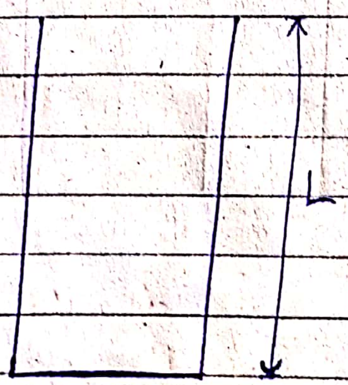
1-) A pipe which is exposed to external atmosphere from one end and closed from the other end is called ~~open~~ a closed pipe. (def)

2-) Stationary longitudnal waves are produced along the pipe when air is blown at or side of open end.

3-) We always get a node at the closed end and an antinode at the open end.

4-) Maximum loud sound is heard at the open end due to position of antinode there.

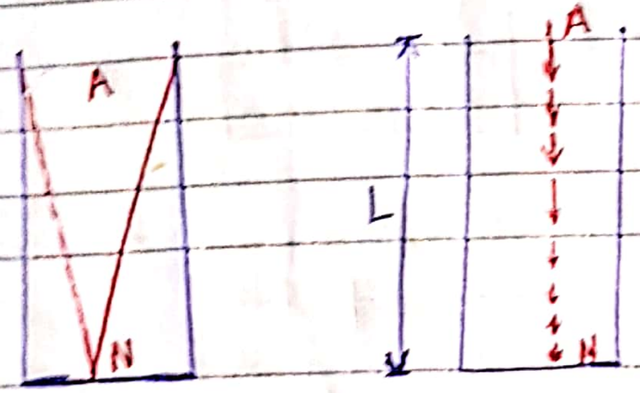
Analysis:-



length of closed pipe = L

Fundamental mode :-

Blow air calmly at or side of open end to get a node and ~~at~~ an antinode as shown



Length of pipe and wavelength are related as,

$$L = \frac{\lambda_0}{4}$$

$$\lambda_0 = 4L$$

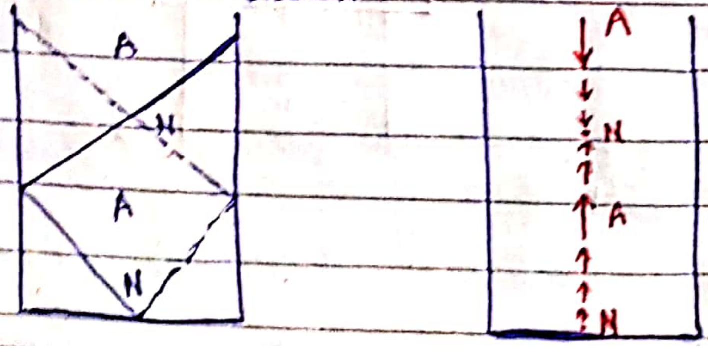
~~first~~ fundamental frequency

$$f_0 = \frac{V}{\lambda_0}$$

$$\boxed{f_0 = \frac{V}{4L}}$$

1st overtone frequency :-

Blow air forcefully to produce first overtone frequency as shown.



$$L = \frac{\lambda_1}{2} + \frac{\lambda_1}{4}$$

$$L = \frac{2\lambda_1 + \lambda_1}{4}$$

$$L = \frac{3\lambda_1}{4}$$

$$\lambda_1 = \frac{4L}{3}$$

But $f_1 = \frac{V}{\lambda_1}$

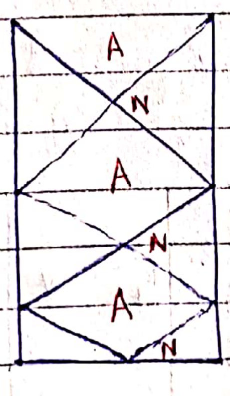
$$f_1 = \frac{V}{4L/3}$$

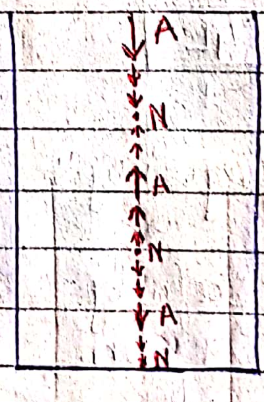
$$f_1 = 3\left(\frac{V}{4L}\right)$$

$$\boxed{f_1 = 3f_0}$$

2nd overtone frequency:-

Now blow air more forcefully.





$$L = \lambda_2 + \frac{\lambda_2}{4}$$

$$L = \frac{5\lambda_2}{4}$$

$$\lambda_2 = \frac{4L}{5}$$

But $f_2 = \frac{V}{\lambda_2}$

$$f_2 = \frac{V}{4L/5}$$

$$f_2 = 5\left(\frac{V}{4L}\right)$$

$$\boxed{f_2 = 5f_0}$$

Therefore, in a closed pipe, stationary longitudnal waves of frequency $f_0, 3f_0, 5f_0, 7f_0 \ldots (2n+1)f_0$ are produced where,

$f_0 = \frac{V}{4L}$ and $n = 0, 1, 2, 3, 4, \ldots$

and represent the no. of nodes

~~Stationary waves in an open~~ pipe (flute)

Note:-

1-) The pipe which is exposed to external atmosphere from both ends is called open pipe

2-) When air is blown at or side of one end, stationary longitudnal waves are produced along the pipe.

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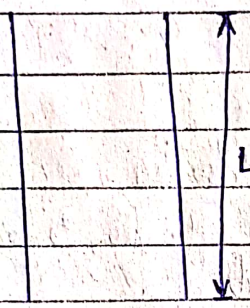
*

3-) We always get an antinode at the open end and a node b/w 2 successive antinodes.

4-) Maximum loud sound is available at the open end due to position of antinode there.

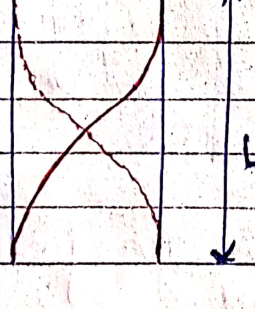
Analysis

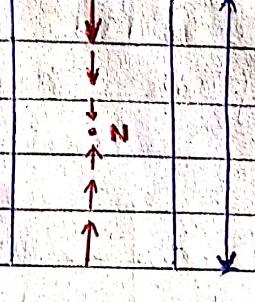


Length of pipe = L

Fundamental node :-

Blow air calmly at / side of open ~~and~~ end to ~~provide~~ produce first overtone frequency as shown.





Length of pipe and wavelength are related

related as,

$$L = \frac{\lambda_0}{2}$$

$$\lambda_0 = 2L$$

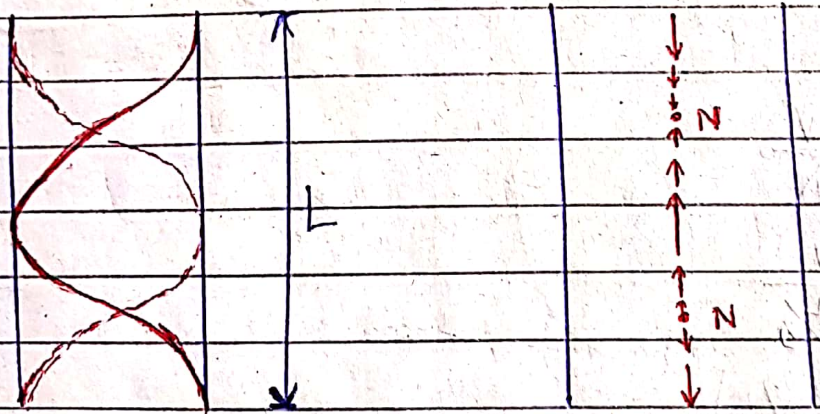
Now $V = f_0 \lambda_0$

$$f_0 = \frac{V}{\lambda_0}$$

$$\boxed{f_0 = \frac{V}{2L}} \text{ ---- (i)}$$

1st overtone frequency :-

Blow air forcefully now.



~~L = 2~~ $L = \lambda_1$

$$f_1 = \frac{V}{\lambda_1}$$

$$f_1 = \frac{V}{L}$$

$$\boxed{f_1 = 2 f_0} \text{ --- from(i)}$$

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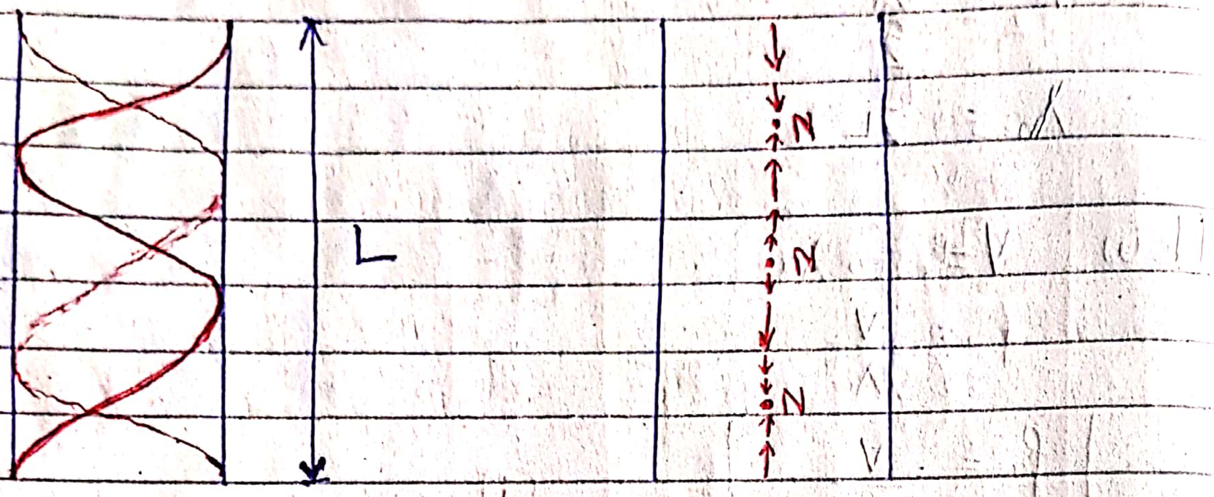
2nd overtone frequency :- Now blow air more forcefully



$$L = \lambda_2 + \frac{\lambda_2}{2}$$

$$L = \frac{3\lambda_2}{2}$$

$$\cancel{L} \; \lambda_2 = \frac{2L}{3}$$

Now,

$$f_2 = \frac{v}{\lambda_2}$$

$$f_2 = \frac{v}{2L/3}$$

$$f_2 = 3\left(\frac{v}{2L}\right)$$

$$\boxed{f_2 = 3f_0} \text{ --- from(i)}$$

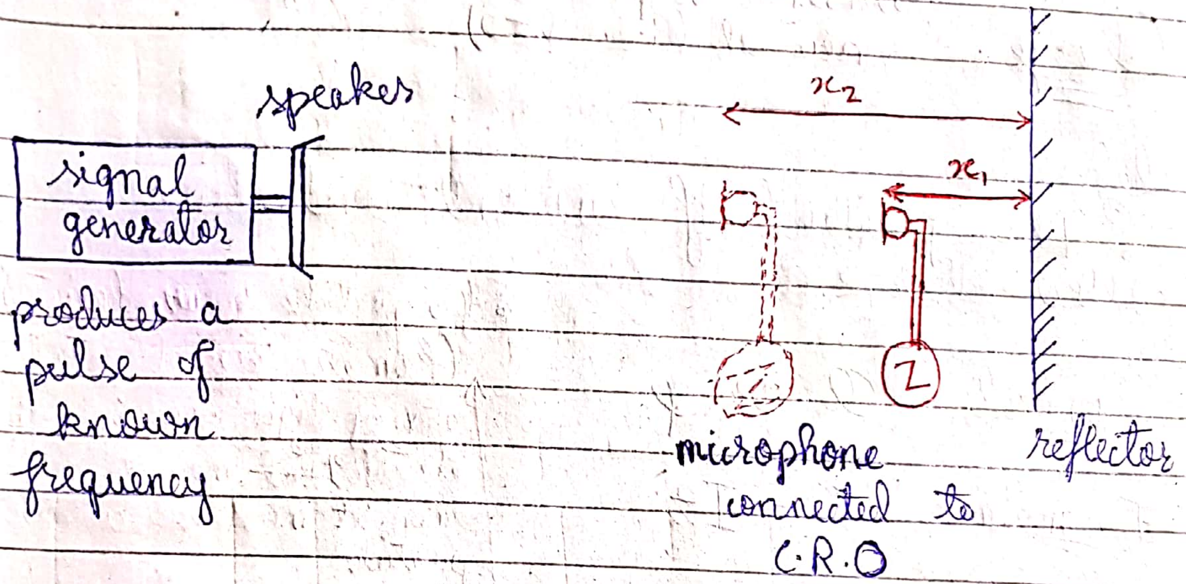
Therefore, in ~~several~~ general, in an open pipe, stationary ~~longitudnal~~ waves of frequency f_0, $2f_0$, $3f_0$, --- nf_0 are produced where,

$n = 1, 2, 3, 4,$ --- and ~~represent the~~

the no. of nodes in b/w open ends and
$f_0 = \frac{v}{2L}$

Measurement of speed of sound by stationary waves

(Nov 2011 — P22)



Move the microphone in the region b/w the speaker and reflector and let the 2 successive antinodes are obtained at distance x_1 and x_2 respectively from reflector.

Distance b/w 2 successive antinodes $= \frac{\lambda}{2}$

$$(x_2 - x_1) = \frac{\lambda}{2}$$

$$\lambda = 2(x_2 - x_1)$$

But $V = f\lambda$

$$V = (\text{frequency from signal generator})(2(x_2 - x_1))$$

$$V = 330\, ms^{-1}$$

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Electrostatics

~~Study~~ : Study of properties of charged particles at rest.

• this is a way ~~how~~ to identify ~~that~~ whether a particle is charged or ~~not~~ neutral (i.e. $Q=0$)

Charge

def:
The product of current and time is called charge.

Symbol : Q or q

Formula : $Q = It$

P.S : Scalar

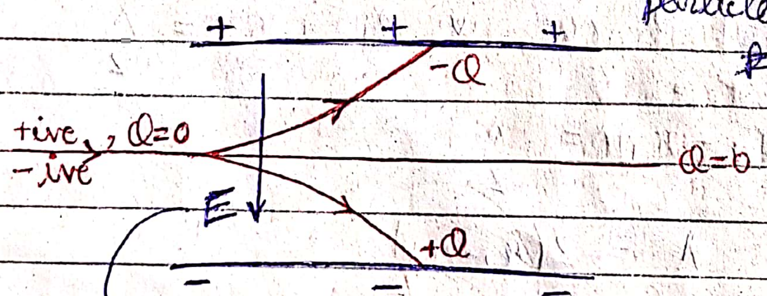
Nature : +ive or −ive

Identification/property :

• If a particle shows deviation (from its original path), even a very slight one, in a electric or ~~and~~ magnetic field, then it must be a charged particle

• If a particle doesn't show any deviation, then it doesn't posses any charge

(i) Behavior of a charged and a neutral particle in a electric field

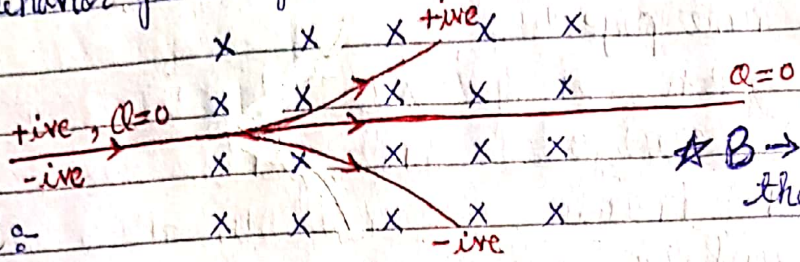


E = electric field

direction of ~~from~~ electric field (from high to low potential) i.e. from +ive to −ive the pathway of or deviation of charged (+ive and -ive) particles is found by applying flemmings Left Hand Rule.

A moving charged particle always deviate ~~fr~~ from its original path in a ~~~~ electric or magnetic field.

(ii) Behavior of a charged and a neutral particle in a ~~~~ magnetic field



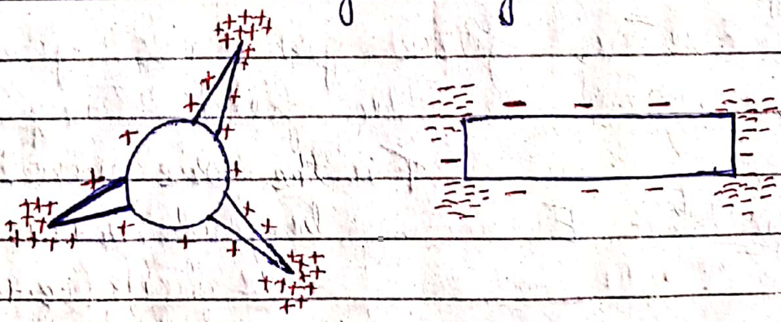
★ B → is directed into the plane of page

Note:-

1-) Charge can neither be created nor be ~~destry~~ destroyed, but can be transferred ~~from~~ from one object to another by contact or by ~~induction~~ induction.
this means either friction or conduction — no physical contact

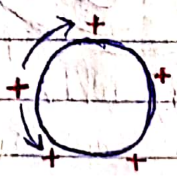
2-) Proton being a massive particle cannot move in solids, but ~~bothe~~ both e^- and protons can move in fluids (liquids and gases) such as electrolysis in a solution and ionisation of air. → Only e^- can move in solids and not protons

3-) Maximum charge is deposited at sharp edges such as in lightning conductors.



4-) Charge is uniformly deposited at regular surface such as in sphere.

this charge experiences an equal repulsive force from the 2 charges next to it thus making $\Sigma f = 0$



★ separation b/w charged particle is same.

4-) → in static electricity, only sphere is the regul[illegible] surface, since in sphere only charge is uniformly depo[illegible]
→ rectangle is **not** a regular surface (in static elec.) as max c[illegible] is deposited at sharp edges, so charge seperation is not unif[illegible]

5-) An object can posses a charge, but is at 0 potential if it is connected ~~to~~ to earth and another charged body is ~~to~~ brought near it.

★ description on next page !!!

6-) Charge can only be deposited at the outer surface and there is no charge even inside a hollow ~~mettalic~~ metallic sphere. → that's why most of the electric wires are only laminated with Cu (i.e. their outer surface is of Cu, but their core is of some other metal, mostly Al) ★ Res

★ Rest on next page

Electric field

Q) define/what is ~~electric~~ field ?

def:- we have to define field as well, since it is also written in Stallis

Region or space around a charged particle where another charge experience a force of attraction or repulsion.

Electric field Strength

def:-

Electric force per unit positive charge is called electric field strength.

F is the force exerted by a charged body (whether +ive or -ive) on a unit +ive charge (i.e. +1C), as shown by the arrow

Symbol:- E

Formula:- $E = \frac{F}{q}$

∘ $q = +1C$

q is the charged particle possesing +1 charge (as per defination) which experiences the force ~~F~~ (i.e. 'F'), whether attractive or repulsive

Unit:- NC^{-1} or Vm^{-1}

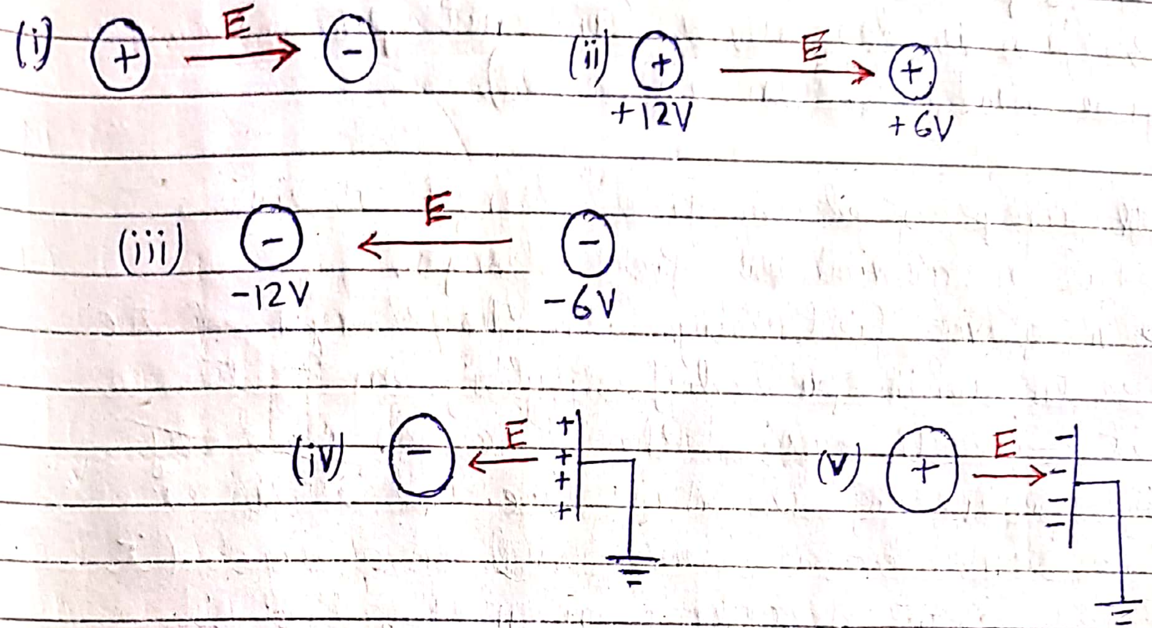
Q

P.S:- vector

Direction :-

From high to low potential i.e. towards the motion of unit +ive charge in the field of another charge.

e.g.:-



★ high and low potential can be b/w similar charges ~~i.e.~~ such as 2 ~~p~~ +ive charges and 2-ive charges, as shown in e.g. (ii) and (iii). → In this case the body which has ↑ voltage / volts / p.d will be at higher potential than the other charged body which will be at lower potential → In case of similar charges, charges doesn't matter, but actually their p.d/volts matter. → In case of +ive and -ive charges, its understood that +ive will be at ↑ potential and -ive at ↓ potential

5-). the body which is connected to earth will always be at 0 potential whether it possess any charge or not, since earth is at 0 potential. e.g. at the surface of earth, we are at 0 potential, but as we move up from earth's surface our potential inceases as Ep ↑ due to ↑ in 'h' (height from earth's surface).

6-) • If we take a piece of wood and cover its surface with water (not pure water), and then connect it to the +ive and -ive terminal of the battery, then it will conduct, since charges are deposited at the outer surface and outer surface is tap water (and not pure water, since pure water is an insulator).

• the concept of electric field strength is similar to that of gravitational field strength.

→ In gravita. field streng. its the strength of the earth which pulls ~~diff~~ everything on it, towards it. → earth exerts the force on a body irrespective of its mass i.e. it will exert the same on a truck and on a cycle (its force is not dependant on mass, but it exerts equal force on all masses).

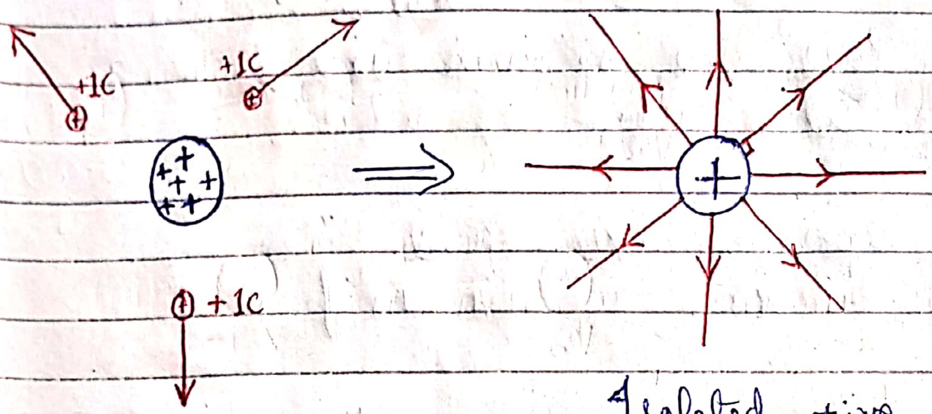
• electric field strength is the strength of ~~it~~ a charged body (whether +ive ~~or~~ -ive) with which it ~~for~~ attracts or repels a charged body having +1 charge.

→ the force (whether attractive or repulsive) is exerted by the charged on the unit +ive charge (i.e. the body having +1 charge).

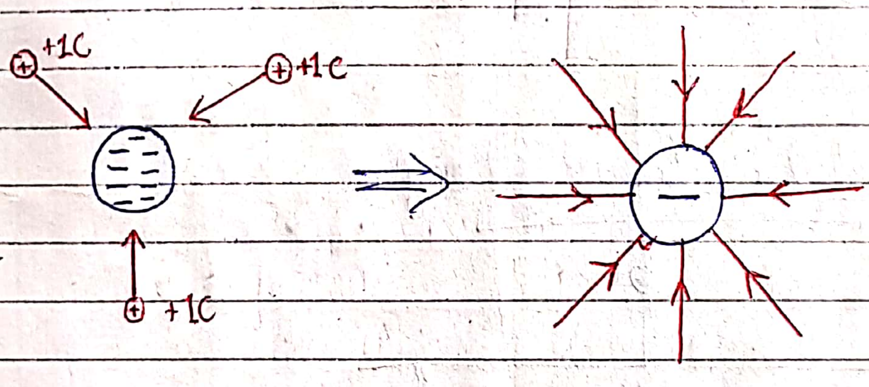
5-) Any body connected to earth will be at 0 potential. And if a charged body is brought near it, then the body will be oppositely charged by induction, but will remain at 0 potential.

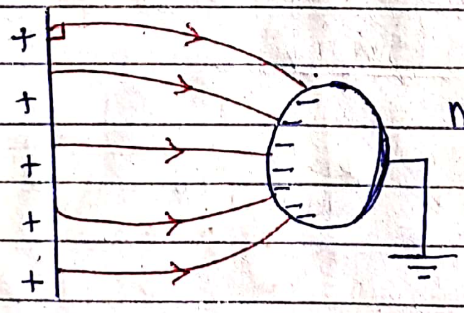
Field Patterns:-

- field lines represent the motion of unit +ive charge



Isolated +ive charge

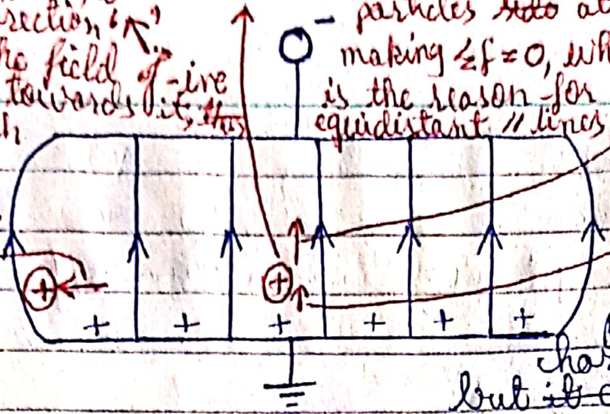




metallic sphere

and due to no equal and opposite force, it moves in this direction '↑'. As it enters the field of -ive plate, it turns towards it, thus thus a curved path.

• this charged particle experiences from the particles ~~at~~ at its sides, thus making $\Sigma f = 0$, which is the reason for equidistant // lines



• this charged particle experiences repulsive force from this side only

Lower metallic plate is +ively charged by induction but ~~it a~~ is at earth potential i.e. 0 potential

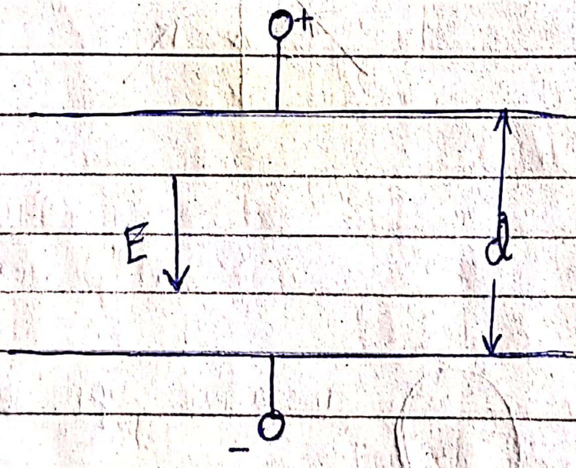
Note:-

1-) Each field line originate and terminate at 90° to the surface of object.

2-) If the separation b/w field lines vary, then this indicate a non-uniform field

3-) Uniform field is represented by equidistant parallel lines such as b/w 2 parallel plates.

Uniform electric field Strength



Work done = Fd

$VQ = Fd$

$\frac{F}{Q} = \frac{V}{d}$

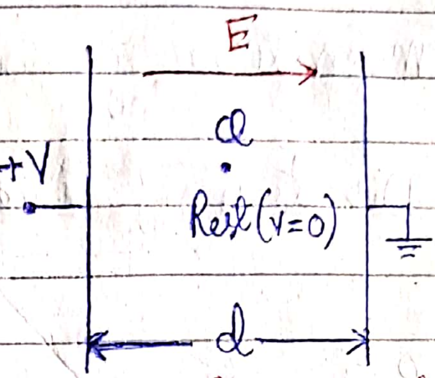
$\boxed{E = \frac{V}{d}}$

V → p.d b/w parallel plates

d → separation b/w plates

~~the~~ Unit:- Vm^{-1} (Volt/metre)

Speed of a charged particle in an electric field ~~a magnetic~~



A charge particle move // to electric field lines.

Since a charged particle initially at rest move along the field line due to electric force. So

Gain in E_K = Loss of Electric E_p

$$\frac{1}{2}mv^2 = VQ$$

$$v^2 = \frac{2VQ}{m}$$

$$v = \sqrt{\frac{2VQ}{m}}$$

$v \Rightarrow$ speed
$V \Rightarrow$ p.d
$Q \Rightarrow$ charge of particle
$m \Rightarrow$ mass of particle

Force on a charged particle in an Electric field

Since $E = \dfrac{F}{q}$ ——— (i)

Also $E = \dfrac{V}{d}$ ——— (ii)

From (i) and (ii):-

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

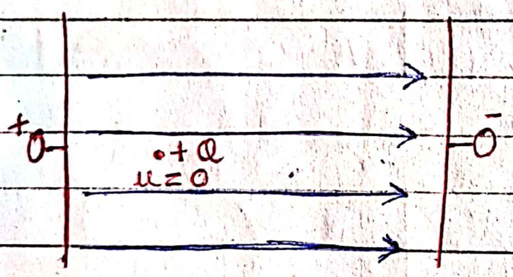
$$\boxed{F = \frac{Vq}{d}}$$

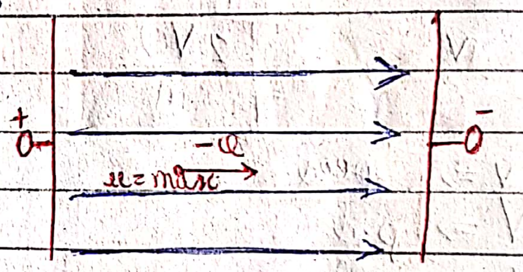
magnitude of force $\Rightarrow$ $F = \frac{Vq}{d}$

Direction of force :- parallel to field lines

Path of a charged particle in a uniform electric field

Case 1 :- $\theta = 0°$





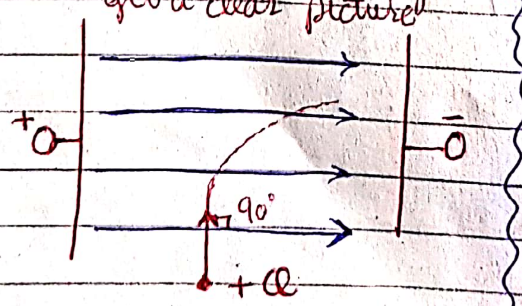
straight line path with uniform ~~accelerat~~ acceleration (increasing velocity)

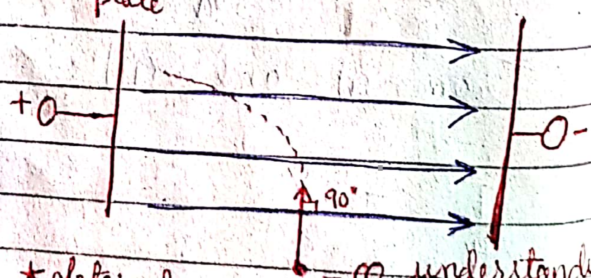
straingth line path with a uniform deceleration (decreasing velocity)

Case 2 :- $\theta = 90°$

*plates drawn just to get a clear picture

*arrows indicate motion of unit +ive charge (i.e direction of E), which is towards -ive plate





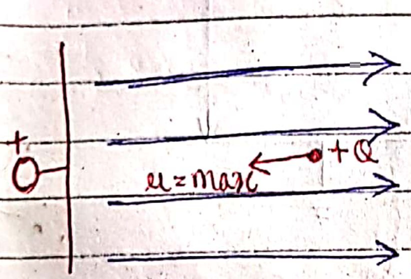
understandi

*plates drawn just for understanding

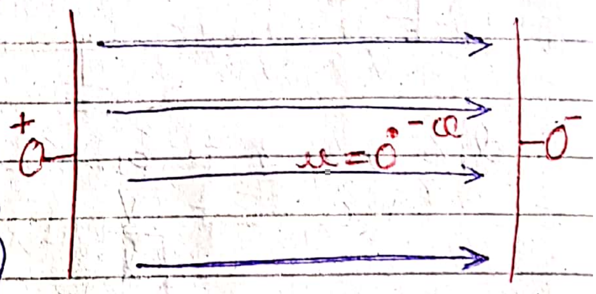
~~Both trace a~~
~~curved path~~
~~opposite~~

Both trace a curved path and move towards the oppositly charged plates

Case 3 :- $\theta = 180^\circ$

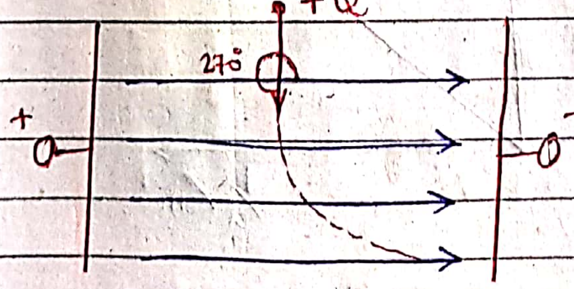


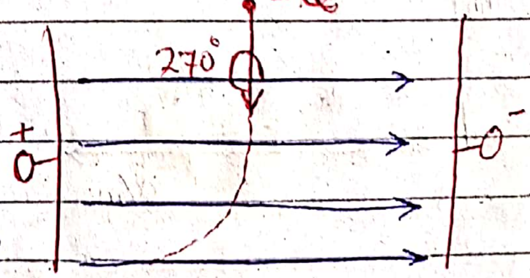
+Q move in a straight line path with a uniform deceleration



−Q moves in a straight line path with a uniform acceleration

Case 4 :- $\theta = 270^\circ$



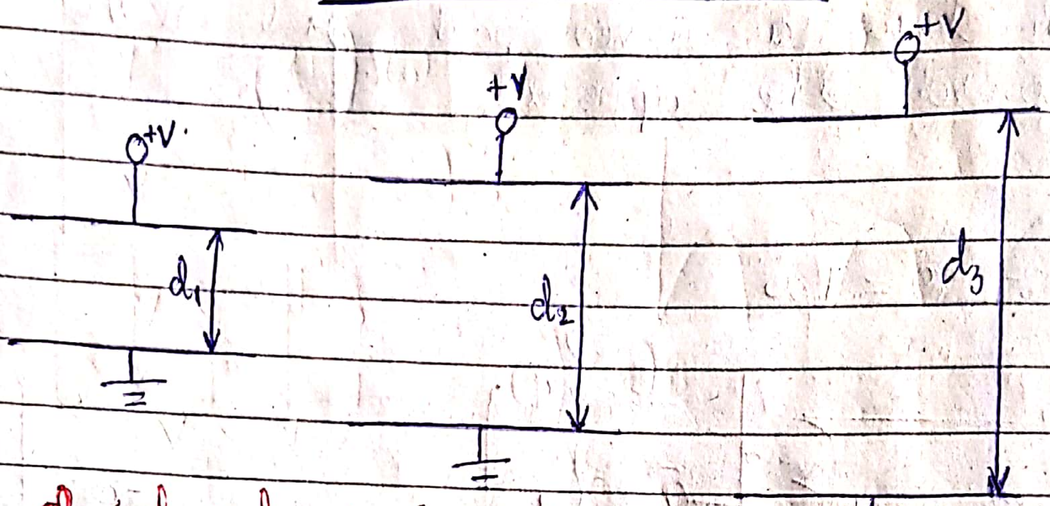


Both charged particles accelerate and move towards oppositely charged plates

* Both trace a curved path

Graphs

a) Electric field strength against distance b/w parallel plates

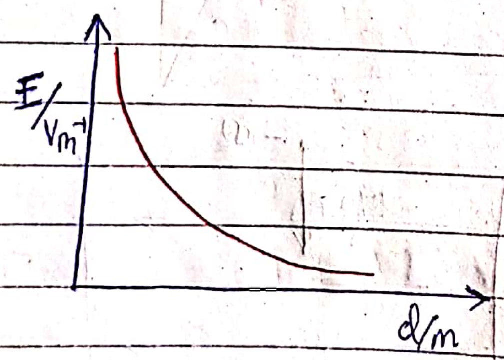


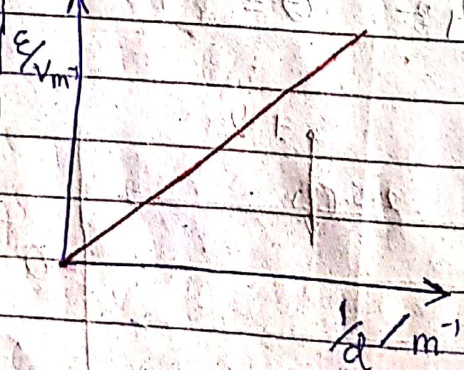
$d_1 < d_2 < d_3 \Rightarrow E_1 > E_2 > E_3$

Since $E = \frac{V}{d}$

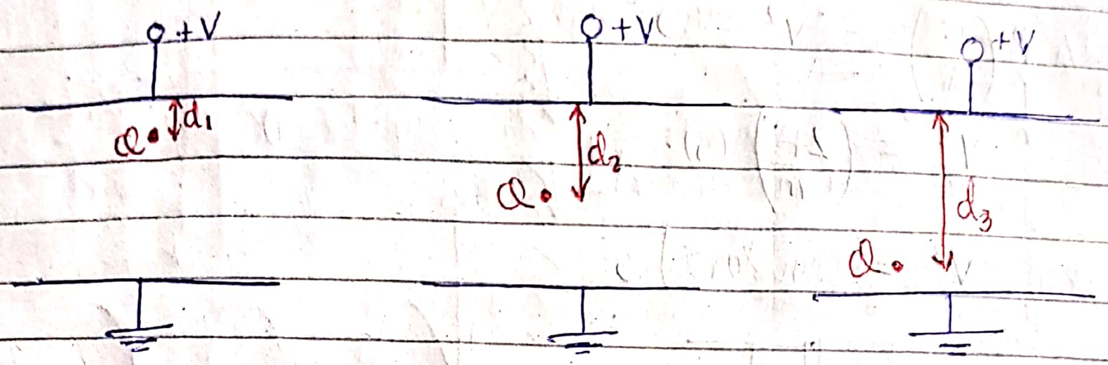
$E = \frac{constant}{d}$

$$\boxed{E \propto \frac{1}{d}}$$

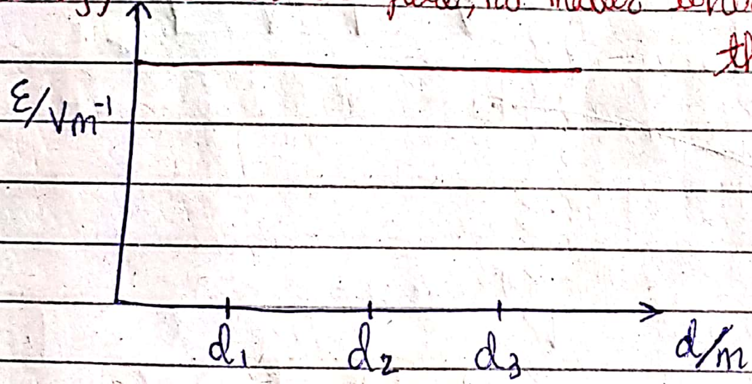




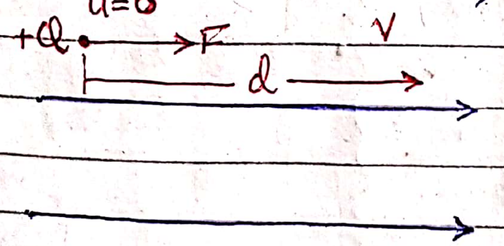
b) Electric field strength against distance of a charged particle for any 1 plate



Since separation b/w parallel plates is constant and electric force / field strength is independant of position of charge particle b/w two plates. So electric field strength remain constant. ★ same concept as that of 'g' (acc due to gravity) → In earth's field, no matter where the body is, the value of g will remain $9.81\ ms^{-2}$



c) Speed against distance travelled by a charged particle in a uniform electric field



Since field is uniform,

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

$$2\left(\frac{F}{m}\right)s = v^2 - (0)^2$$

$$v^2 = \left(\frac{2F}{m}\right)(s)$$

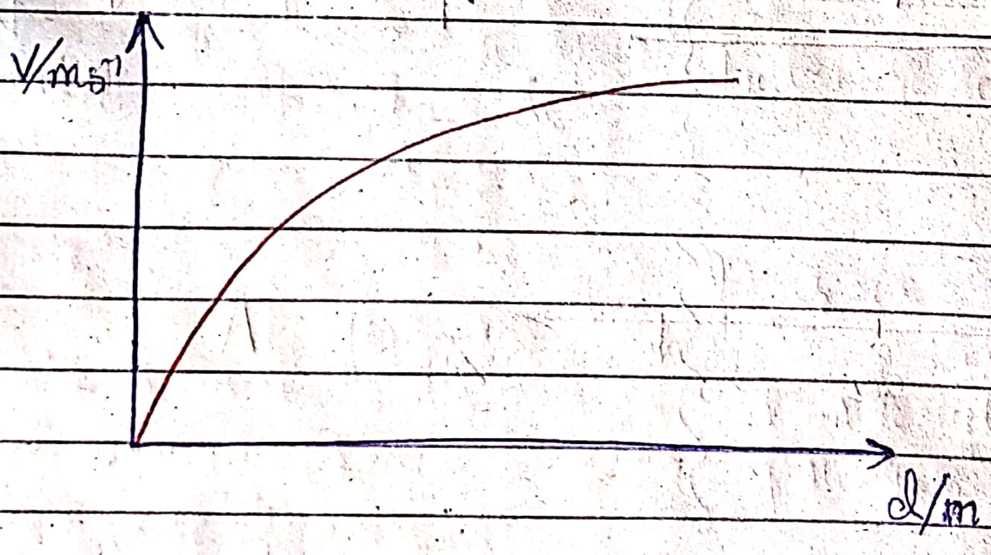
$$v^2 = (\text{constant})\, s$$

$$v \propto \sqrt{s}$$

or $(s = d)$

$$v \propto \sqrt{d}$$

d/m	0	1	2	3	4
v/ms^{-1}	0	1	1.41	1.73	2



Current Electricity

Electric Current:- (Base Qty)

def:-
flow of charged particles ~~(e)~~ i.e. e^- per unit time is called current.

Symbol:- I

Formula:- (i) $I = \frac{Q}{t}$

(ii) If n- charged particles each of charge 'e' flows through a cross-section in time 't', then Total charge $= Q = ne$

Current $= I = \frac{ne}{t}$

Unit:- Ampere (A)

P.S:- Vector

direction:- From high to low potential

Types:-

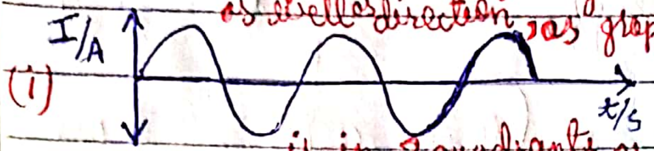
Alternating current (AC)	Direct current (DC)
1-) def:- The current whose magnitude and direction changes many times in a unit time is called	1-) def:- The current which flows in one direction is called DC.

~~At~~ AC.

2) Waveform:-

*(i) is a regular pattern in which magnitude changes regularly as well as direction, as graph is in 2 quadrants or quadrant changes

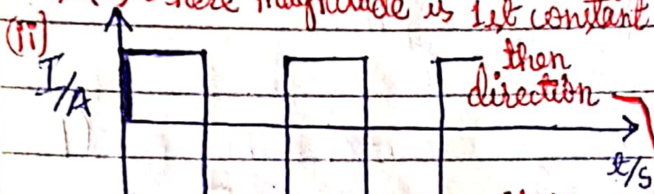
(i)



pure sine wave AC

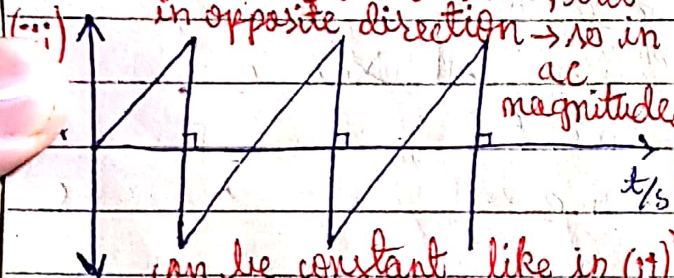
*(ii) → here magnitude is 1st constant then direction changes and then magnitude is of same value and constant, but in opposite direction → so in ac magnitude can be constant, like in (ii)

(ii)



Square wave AC

(iii)



Saw-tooth wave AC

*(iii) → here magnitude inc. uniformly and then direction changes, then it dec. uniformly until reaches 0, then again direction changes and magnitude inc. uniformly ~~until~~ until it reaches max value and then again direction changes and soon.

3) Sources:-

AC generator

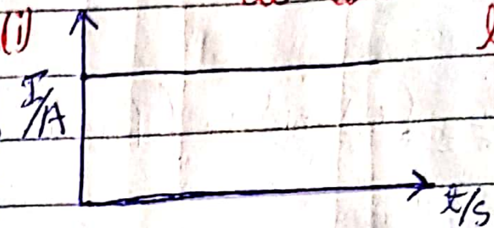
4) Colour code of wires:-

- Live wire (High potential wire) → Brown
- Neutral wire (Low potential wire) → Blue
- Earth wire (zero/earth potential) → green & yellow

2) Waveforms:-

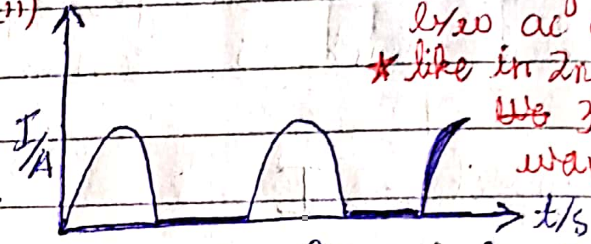
* magnitude do can also vary, but direction remains same → direction is the main dividing line b/w ac and dc.
* like in 2nd and 3rd waveform

(i)



pure DC

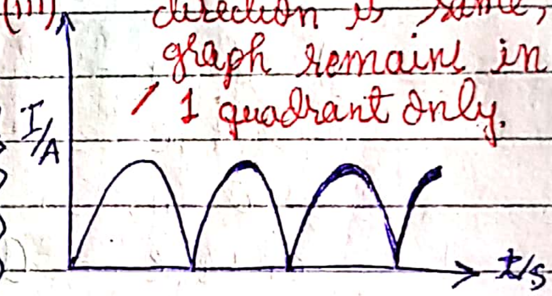
(ii)



Half-wave rectifier's output

magnitude is changing, direction is same, as graph remains in same 1 quadrant only.

(iii)



Full-wave rectifier's output

3) Sources:-

cell, battery, thermocouple, DC generator, etc

4) Colour codes of wires:-

- +ive wire → Red
- -ive wire → Black

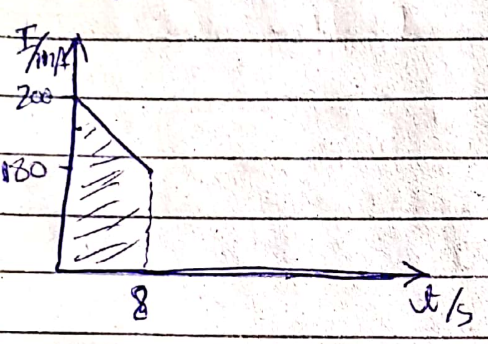
Scanned by CamScanner

Note :-

The area under the current against time graph defines the amount of charge flow.

Q) The current in a wire changes uniformly from 200 mA to 180 mA over a period of 8s. Calculate the charge which flow in this time.

1st method :-



$\text{Area} = \frac{1}{2} \times (200 + 180)(8) \times 10^{-3}$

$= \_\_\_\_\_\_ \ C$

2nd method :-

$\text{Avg current} = \frac{\text{total charge}}{\text{total time}}$

$\frac{200 + 180}{2} = \frac{Q}{8}$

$Q = \_\_\_\_\_\_$

Resistance

def :-

Potential difference per unit current is called resistance.

Symbol :- R → for external resistance

r → " internal "

Formula :- $R = \frac{V}{I}$ where $V \Rightarrow$ p.d / V
$I \Rightarrow$ current / A

P.S :- Scalar

unit :- ohm (Ω)

$$1\,\Omega = \frac{1 \text{ volt}}{1 \text{ Ampere}}$$

Dependance :-

1-) Length of Conductor :-

$$R \propto L$$

2-) Cross-sectional area :-

$$R \propto \frac{1}{A}$$

3-) Nature of material :-

Combining 1 and 2

$$R \propto \frac{L}{A}$$

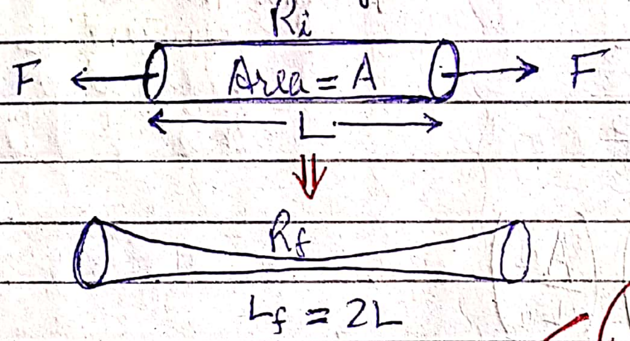
$$R = \rho \frac{L}{A}$$

where 'ρ' is the constant of proportionality and is called resistivity of conductor and depends upon nature of material.

Note :-

- $\rho \approx 10^{-8}\ \Omega m$ for conductor (Cu, Brass, steel, etc)
- $\rho \approx 10^{4}\ \Omega m$ for semi conductor (Ge, Si)
- $\rho \approx 10^{10}\ \Omega m$ for insulator (wood, plastic, etc)

Q) The tensile force is acting on a Copper wire of length 'L' and cross-sectional area 'A' which extend it to a length of 2L, but no change in volume occur. Calculate the ratio of final resistance to initial resistance of wire.



$V = A \times L$

$V = \left(\frac{A}{2}\right)(2L)$

$$\frac{R_f}{R_i} = \frac{\rho \frac{L_f}{A_f}}{\rho \frac{L_i}{A_i}}$$

$$\frac{R_f}{R_i} = \left(\frac{L_f}{A_f}\right)\left(\frac{A_i}{L_i}\right)$$

$$= \left(\frac{2L}{A/2}\right)\left(\frac{A}{L}\right)$$

$$= 4:1$$

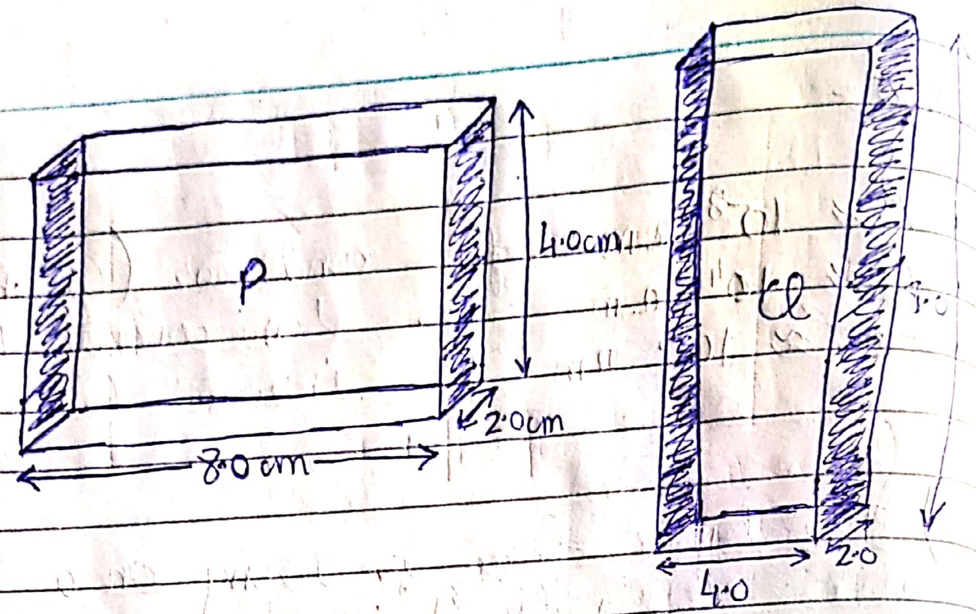
explanation for this equation

★ One says that volume remains equal, so this means that volume of R_f must be equal to the volume of R_i, which is $= A \times L$

★ But in R_f, length is 2L, so ~~to~~ in order to keep the volume same, Area (i.e. 'A') must be divided by 2

★ So, $Vol = \left(\frac{A}{\cancel{2}}\right)(\cancel{2}L) \Rightarrow Vol = A \times L$, ~~hence~~ hence volume is equal.

Q)



P and Q is a same material with same dimensions. Calculate the ratio $\frac{R_P}{R_Q}$ b/w opposite shaded regions of material

★ same material means ρ will be constant → so ρ will be cancelled with each other

$$\frac{R_P}{R_Q} = \frac{\cancel{\rho}\frac{L_P}{A_P}}{\cancel{\rho}\frac{L_Q}{A_Q}}$$

$$= \left(\frac{L_P}{A_P}\right)\left(\frac{A_Q}{L_Q}\right)$$

$$= \left[\frac{8.0}{(4.0)(2.0)}\right]\left[\frac{(8.0)(2.0)}{4.0}\right]$$

$= 4:1$

★ flow of é is from low to high potential i.e. from -ive to +ive

★ flow of current is from high to low potential i.e. from +ive to -ive.

Difference b/w emf and p.d (Voltage)

★ metallic wire contains a lot of free electrons

Emf

★ emf is always of a source

def no. 1

★ Any form of energy converted to electrical energy ⇒ emf

1-) def:-

Any form of energy converted into electrical energy per unit charge is called emf.

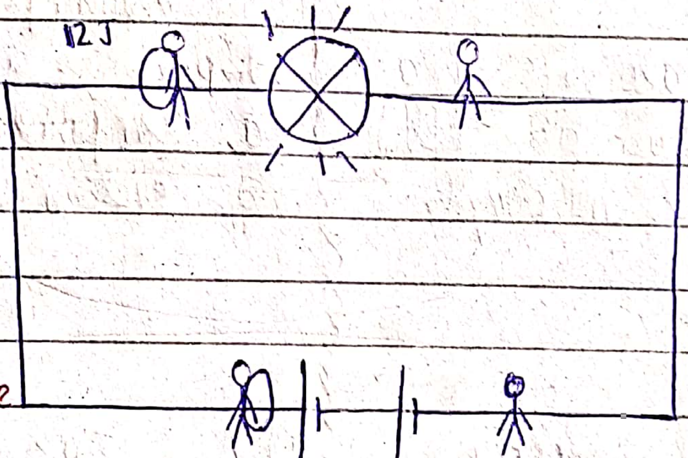
P.d

★ ~~any~~ electrical energy converted or transformed into any other form ⇒ p.d

1-) def:-

Electrical energy converted into any other form per unit charge is called p.d.

12 J



$12V = \frac{12J}{1C}$ i.e.

12 J energy carried/occupied by 1 C of charge (Mr. Coloumb)

★ energy can't be transformed from one form to another unless and until work is done on it (that work is done by Mr. Coulomb)

$$\mathcal{E} = \frac{W}{Q}$$

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

def no. 2

2-) def:-

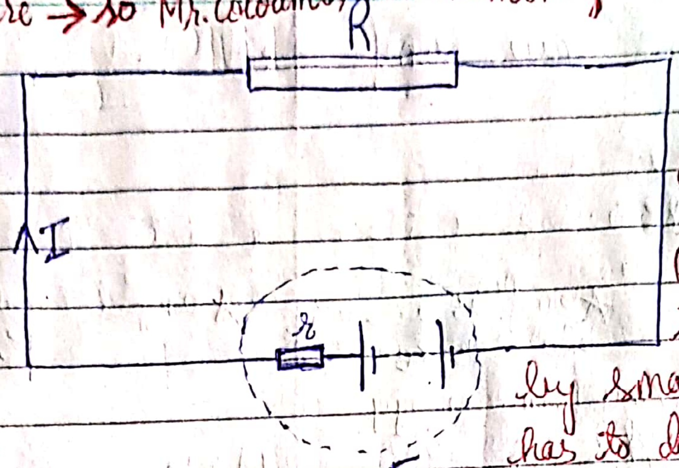
It is the amount of energy dissipated to move a unit charge in a complete circuit ~~is~~ or loop

~~★ It is the energy dissipated by the source~~

2-) def:-

It is the amount of energy dissipated to move a unit charge in an external component or appliance

★ The viscosity (or resistance/opposition) of liquid is more as compared to metallic wire → so Mr. Coloumb, when moving in the fluid, in the battery/cell experiences opposition or resistance (which is represented by small 'r') and has to do work against it (and it



Effective resistance to charged particle $= R + r$

$\mathcal{E} = I(R + r)$

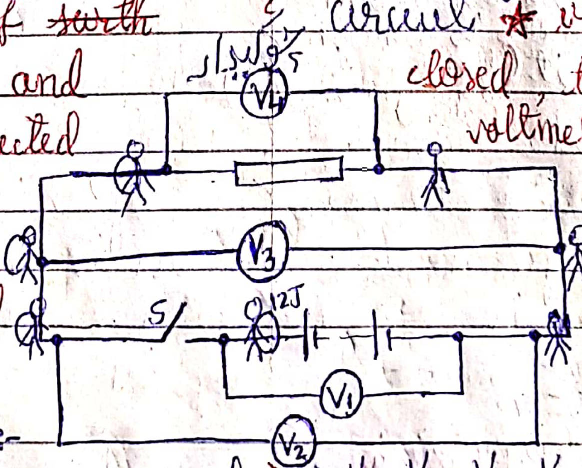
$V = IR$ is how chemical energy is converted to electrical. → e.g. for us even, walking/running in water is difficult

3-) emf is always of a source such as cell, battery, thermocouple, generator, etc

3-) p.d is always across a component, appliance or external circuit

4-) A voltmeter connected across a source measures its emf if no current flows through the circuit → If ~~swith~~ switch is open and voltmeter is connected across source → only then emf will be recorded by the voltmeter

4-) A voltmeter connected anywhere in the circuit measures the p.d of component or circuit ★ when switch is closed then all the voltmeters connected, even the one across the source will measure p.d



When S is open:-
⇒ $V_1 = 12\ V$ and measure emf and $V_2 = V_3 = V_4 = 0$

When S is closed:-
⇒ $V_1 = V_2 = V_3 = V_4 = 12V$ and all measure p.d across resistors

OHM's Law

☆ This law only applies to conductors and not on semi conductors or insulators

Statement :-

The p.d across the ends of a conductor is directly proportional to current, provided physical conditions remain constant

→ physical conditions mean temp, length, ~~er~~ cross sectional area, pressure, etc

Mathematical form :-

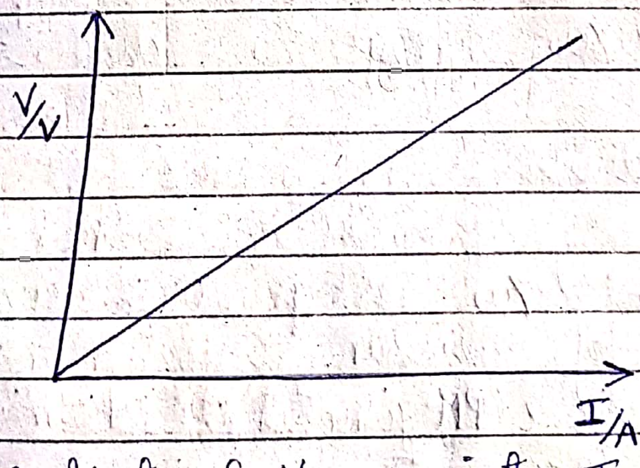
$V \propto I$

$V = RI$

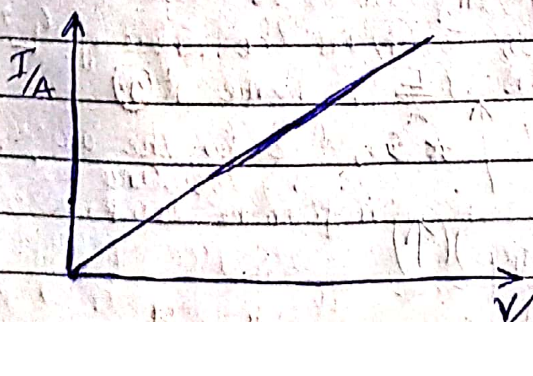
→ $R = \frac{\rho L}{A}$ → flow of current causes heating effect which raises temp and leads to expansion which increases length and changes 'R', which means ohm's law not valid, so all these quantities in the formula of 'R' must also be constant.

where 'R' is the constant of proportionality and is called resistance of ~~a~~ conductor.

graph :-



R = gradient of V/V against I/A graph



R = Reciprocal of gradient of I/A ~~g~~ against V/V graph

Limitations of OHM's Law :-

1-) Ohm's law is only appliable to conductors, not to semi-conductors, insulators or gas discharge tube.

2-) The physical conditions of the conductor such as its temperature, pressure, length, cross-sectional area or stress must remain constant.

Ohmic and Non-ohmic conductors

a) Ohmic conductors :-
Conductors which obey ohm's law and provide a straight line graph from origin b/w voltage and current.

b) Non-ohmic conductors :-
Conductors which provide a curved graph b/w voltage and current due to change of resistance are non-ohmic conductors i.e. diode (PN junction), thermistor, LDR, filament lamp, etc.

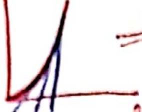
i) Filament Lamp

* ↑ temp leads to expansion, which leads to ↑ in the value of 'L' in $R = \rho \frac{L}{A}$, hence R ↑

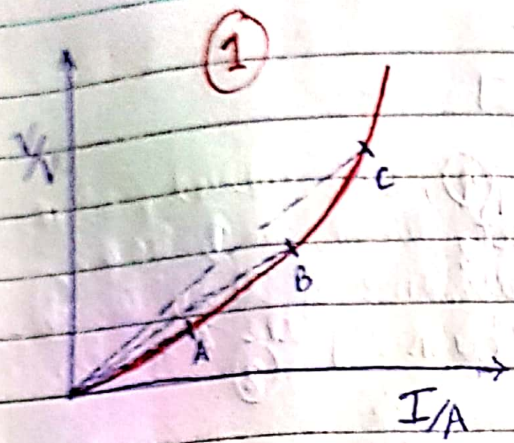
Characteristic :-

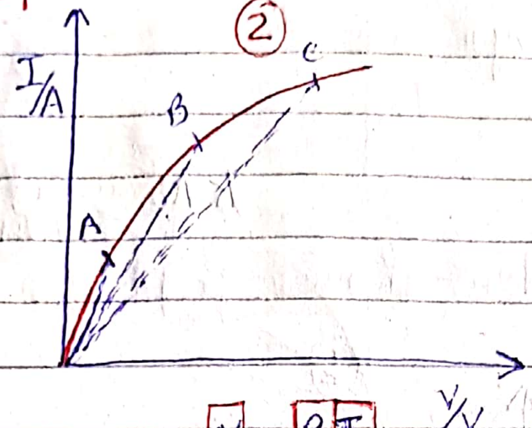
* So, due to the above reason, resistance will ↑ in filament lamp, also or vice versa shown by the 2 graphs ahead.

R_{metal} ↑ if (temp) ↑



⇒ plotting [cut off] gradient is the wrong method, since when we extend it, the intercept is $\neq 0$





Voltage at x-axis ← $\boxed{V} = \boxed{R}\boxed{I}$ → I at x-axis

$\boxed{y} = \boxed{m}\boxed{x} + c$, $c \to = 0$

R = gradient

Note:-
For curved graphs b/w V/V and I/A, draw straight lines from instantaneous points on graph to origin (i.e. 0) and get their gradient

1	2
Relative order of gradient:-	Relative order of gradient:-
$A < B < C$	$A > B > C$
Relative order of resistance:-	Relative order of resistance:- $R = \left(\frac{1}{\text{gradient}}\right)$
$R_A < R_B < R_C$	$R_A < R_B < R_C$

(ii) Thermistor

$$R_{thermistor} \propto \frac{1}{temp}$$

Characteristics:-
A temperature sensor whose resistance decreases with the increase of temperature or vice versa.

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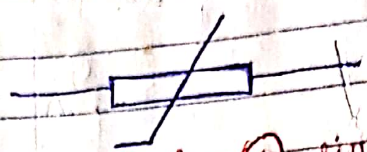
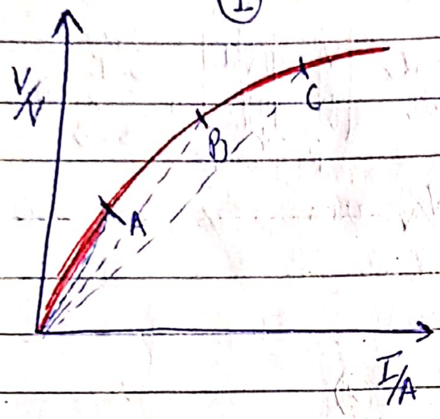
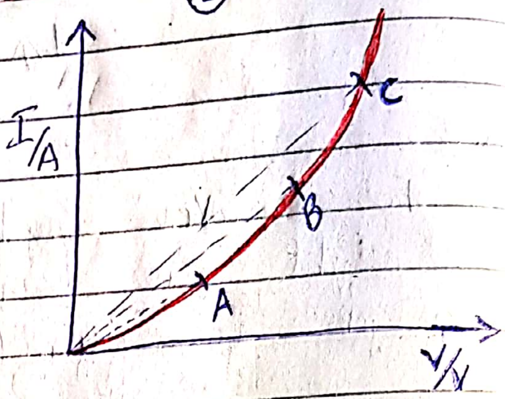
Symbol :-



★ As current (↑), temp (↑), since current produces heating effect, due to inc (↑) temp, resistance of thermistor (↓), as shown by the 2 graphs below

Non-ohmic graph :-

① 

② 

Relative order of gradient :-

A > B > C

Relative order of resistance :-

$R_A > R_B > R_C$

Relative order of gradient :

A < B < C

Relative order of resistance :

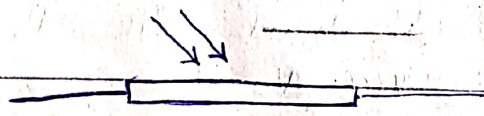
$R_A > R_B > R_C$

(iii) Light dependant resistor (LDR)

Characteristics :- ★ $R_{LDR} \propto \frac{1}{\text{(intensity of light)}}$

R_{LDR} (↓) if (intensity of light) (↑) or vice versa

Symbol :-



Non ohmic graph :- Same as thermistor

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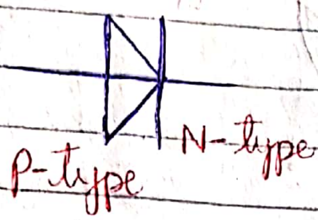
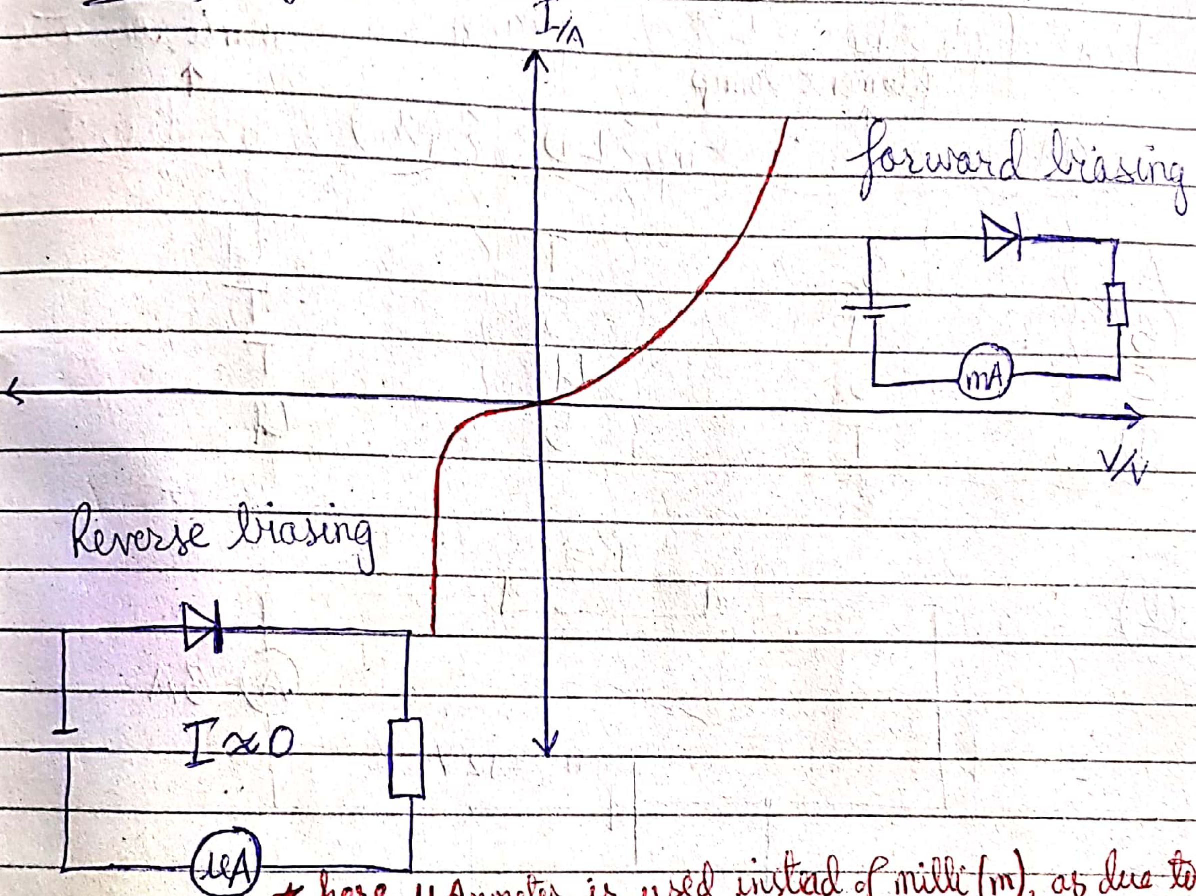
(iv) Semi-conductor Diode

Symbol:



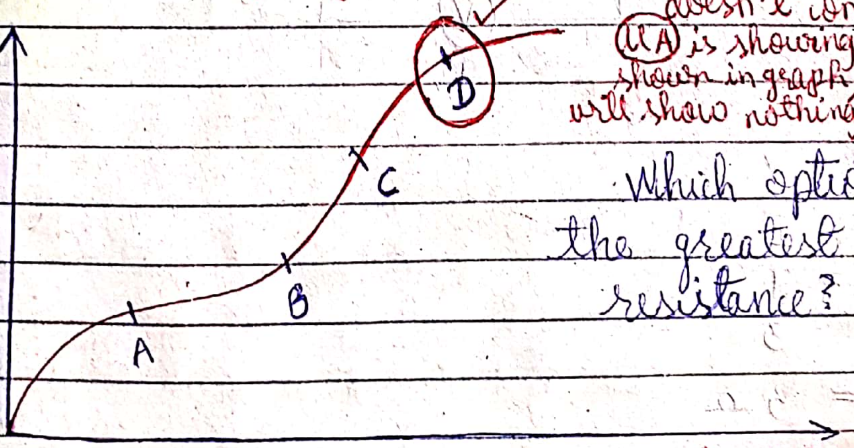
★ the traingle represents the P-type (i.e. positive type) and the straight verticle line represents N-type (i.e. negative type)

Non-ohmic graph:



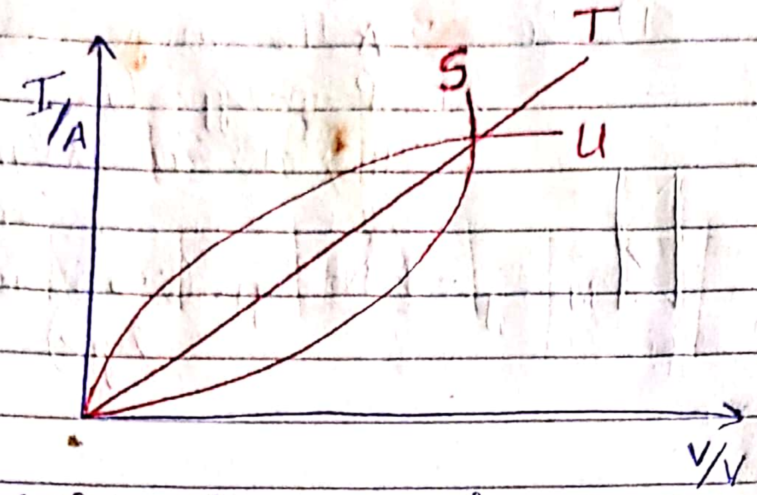
★ here µAmmeter is used instead of milli (m), as due to biasing, current is already very less and in reverse biasing diode doesn't conduct, so (µA) is showing I≈0 (as shown in graph), and (mA) will show nothing at all.

Q)



Which option provides the greatest resistance?

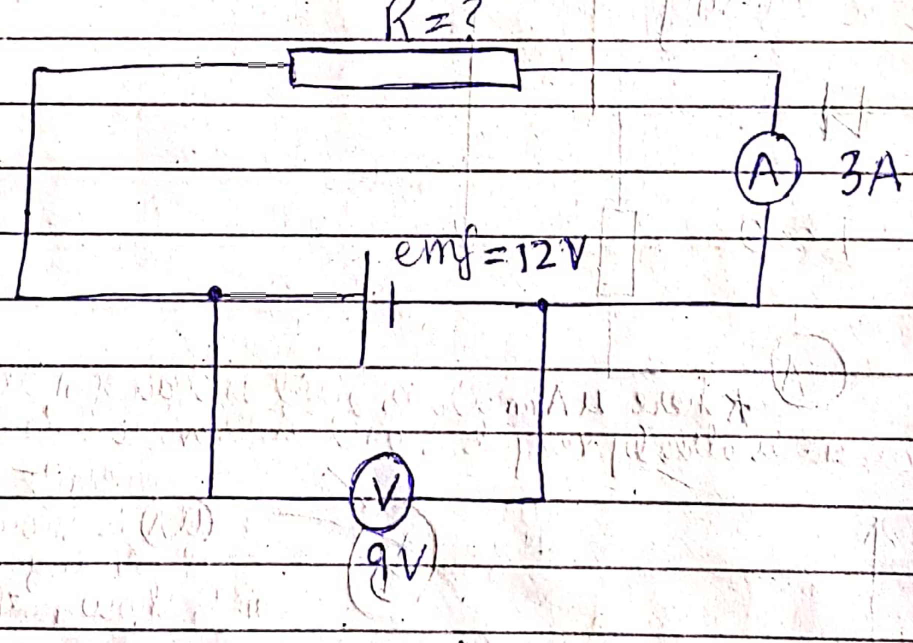
★ draw st. lines from points to origin and get their gradient



Identify the correct graph

	Metal at high temp (filament lamp)	LDR	Metal at low temp (ohmic conductor)
A	S	T	U
B	U	S	T
C	S	U	T
D	T	S	U

Q)



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

$$= \frac{9}{3}$$

$$= 3\,\Omega$$

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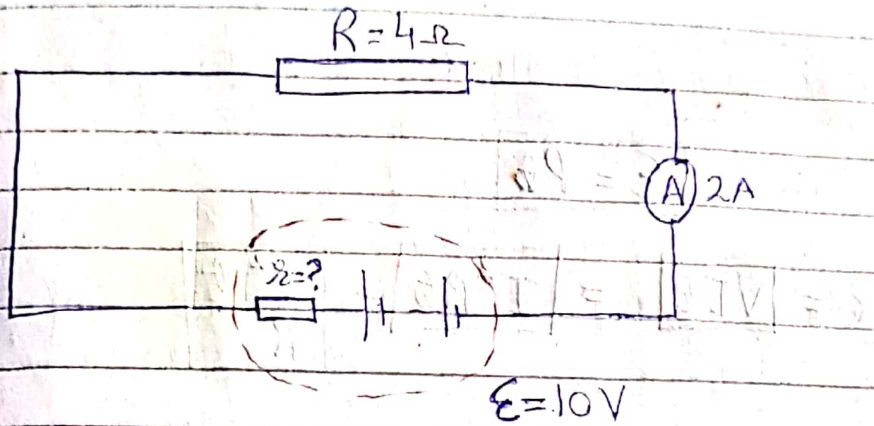
Q)



$$\varepsilon = I(R + r)$$
$$10 = 2(4 + r)$$
$$r = 1\ \Omega$$

Electrical power

def:-
Electrical energy transferred per unit time is called electrical power

Symbol:- P (capital P)

Formula:- $\boxed{P = \dfrac{W}{t}}$

But $W = VQ$

$$P = V\left(\frac{Q}{t}\right)$$

$$\boxed{P = VI}$$

$$P = (IR)(I)$$
$$\boxed{P = I^2R}$$

$$P = V\left(\frac{V}{R}\right)$$
$$\boxed{P = \frac{V^2}{R}}$$

Electrical energy :

Since $\boxed{\mathcal{E} = Pt}$

$$\mathcal{E} = \boxed{VIt} = \boxed{I^2Rt} = \boxed{\frac{V^2 t}{R}}$$

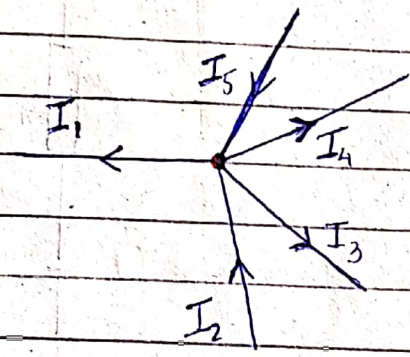
DC Circuits

Kirchoff's first law / Kirchoff's current law

Statement:-

The algebric sum of all the currents entering a junction must be equal to the algebric sum of currents leaving a junction.

Mathematical form:-



Σ(current entering a junction) = Σ(current leaving a junction)

$$I_2 + I_5 = I_1 + I_3 + I_4$$

Note:-

1-) Kirchoff's first law is based upon the principle of conservation of charge. → since current is the flow of charged particles

2-) The effective resistance of resistors in series is proved by using this law.

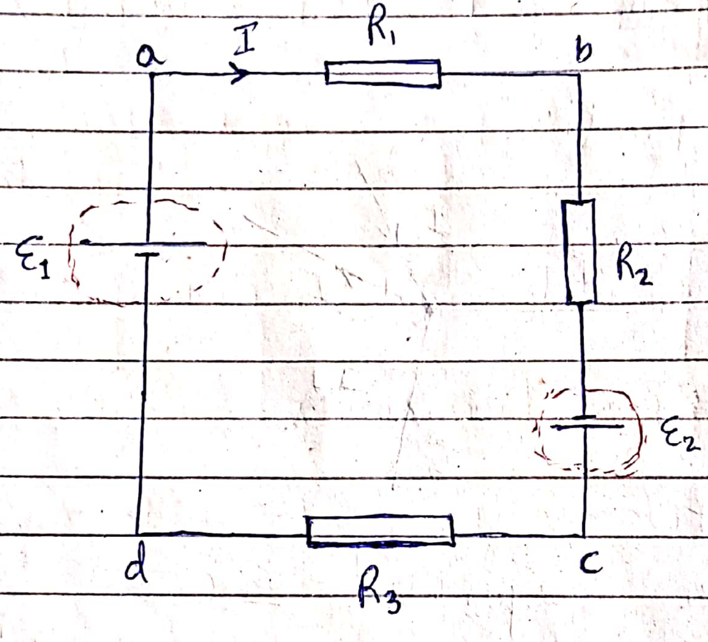
★ emf is b/w 2 terminals (i.e. +ive terminal and -ive), as at +ive terminal Mr. Coulomb will have energy, and at -ive terminal → no energy

Kirchoff 2nd law / Kirchoff's voltage law

Statement:-

The algebric sum of emfs of the sources must be equal to the sum of potential drop or p.d or voltage across components in a closed loop or circuit.

Mathematical form:-



$$\varepsilon_1 + \varepsilon_2 = I(R_1 + R_2 + R_3)$$
$$\varepsilon_1 + \varepsilon_2 = IR_1 + IR_2 + IR_3$$
$$\varepsilon_1 + \varepsilon_2 = V_1 + V_2 + V_3$$
$$\Sigma\varepsilon = \Sigma V$$

Note:-

1-) K's 2nd law is based upon the principle of conservation of energy.

2-) The effective resistance of resistors in parallel is proved by using this law

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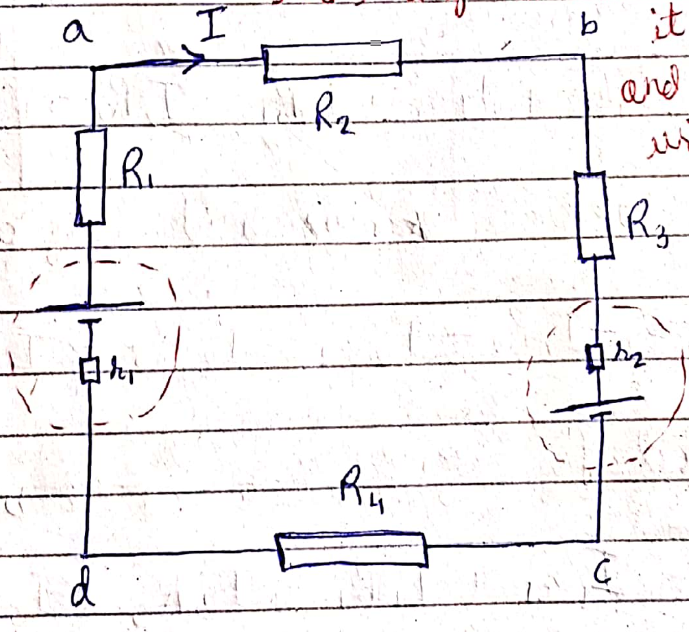
Loop Analysis

Note:

1-) emfs of the sources are added if they draw current in the direction of assumed loop and subtracted if the current drawn by them is opposite to the loop.

2-) We Put +ive sign with currents if it is along the loop and -ive sign if it is against the assumed loop.

a) Single loop analysis:- ★ take 1 direction of current ~~the~~ throughout the loop, even if it is wrong and the answer will turn out to be correct



loop abcda:

$$\mathcal{E}_1 - \mathcal{E}_2 = I(r_1 + R_1 + R_2 + R_3 + r_2 + R_4) \quad —— (1)$$

loop adcba:

$$-\mathcal{E}_1 + \mathcal{E}_2 = -I(r_1 + R_1 + R_2 + R_3 + r_2 + R_4) \quad —— (2)$$

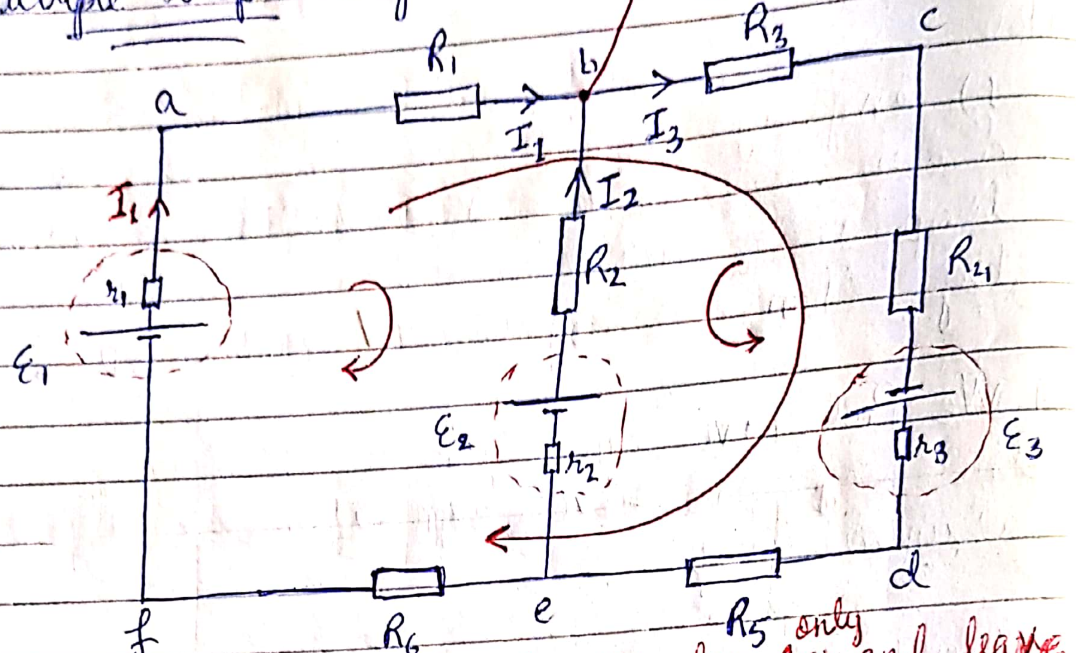
★ if we multiply whole eq (2) with -ive sign → it will be exactly same as (1)

(1) = (2)

★ This is a junction i.e. K's 1st law is applied here

★ $I_1 + I_2 = I_3$ → this means that I_3 is the resultant of I_1 and I_2.

b) Multiple loop analysis:



loop abefa: ★ consider only this loop ~~for~~ and leave the rest of the circuit (i.e. consider only abefa circuit)

$$\mathcal{E}_1 - \mathcal{E}_2 = I_1R_6 + I_1r_1 + I_1R_1 - I_2R_2 - I_2\cancel{R}r_2$$

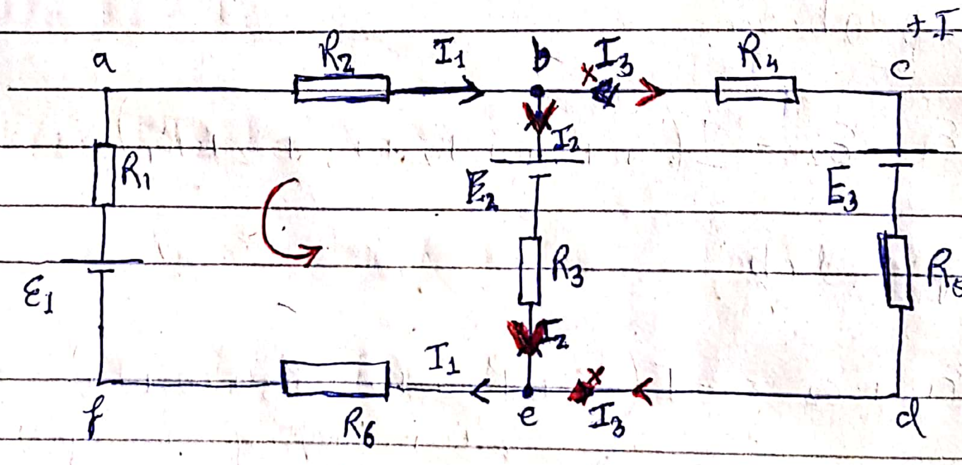
loop ~~cd~~ cbedc: ★ now consider only cbedc loop

$$-\mathcal{E}_3 - \mathcal{E}_2 = -I_2R_2 - I_2r_2 - I_3R_5 - I_3r_3 - I_3R_4 - I_3R_3$$

loop abcdefa: ★ now consider the whole circuit and only leave out the central be ~~fe~~ branch

$$\mathcal{E}_1 + \mathcal{E}_3 = I_1r_1 + I_1R_1 + I_3R_3 + I_3R_4 + I_3r_3 + I_3R_5 + I_1R_6$$

Q)



★ don't look at the +ive and -ive terminals of sources to mark the direction of current, just make sure that K's 1st law is not voilated

a) Mark the directions of current at junction b and e.

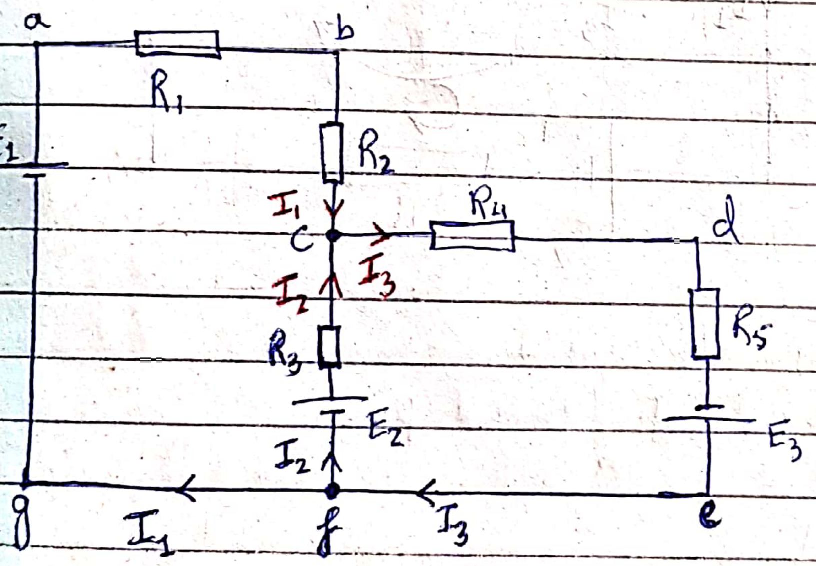
b) Write ~~down~~ ~~the~~ voltage eq. for loop
(i) afeba
(ii) bcdeb
(iii) abcdefa

b) i) $-\mathcal{E}_1 + \mathcal{E}_2 = -I_1 R_2 - I_1 R_1 - I_1 R_6 + I_2 R_3$

(ii) $\mathcal{E}_2 - \mathcal{E}_3 = I_3 R_4 + I_3 R_5 - I_2 R_3$

iii) $\mathcal{E}_1 - \mathcal{E}_3 = I_1 R_1 + I_2 R_2 + I_3 R_4 + I_3 R_5 + I_1 R_6$

Q)



a) Mark the directions of current at junction c and; use K's 1st law to write current eq.

b) use K 2nd law, to write voltage eq for
(i) loop abcfga
(ii) loop dcfed
(iii) loop agfedcba

a) junction c $\Rightarrow$ $I_1 + I_2 = I_3$

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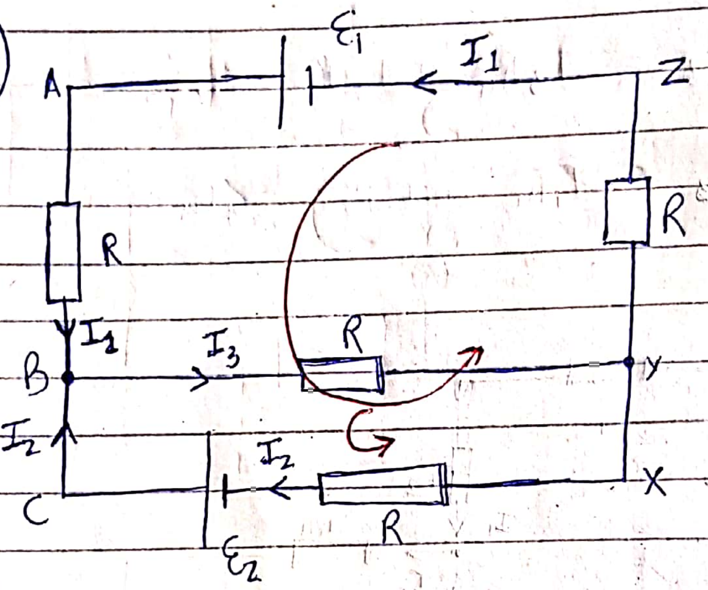
junction $f \Rightarrow \quad I_3 = I_1 + I_2$

b) i) $\mathcal{E}_1 - \mathcal{E}_2 = I_1R_1 + I_1R_2 - I_2R_3$

(ii) $-\mathcal{E}_2 - \mathcal{E}_3 = -I_3R_4 - I_3R_5 - I_2R_3$

(iii) $-\mathcal{E}_1 - \mathcal{E}_3 = -I_3R_5 - I_3R_4 - I_1R_2 - I_1R_1$

($Q_7 \rightarrow$ J-09) b)



(i) Relate I_1, I_2 and I_3
(ii) Write voltage eq. for loop
1-) BCXYB
2-) ABCXYZA

(i) $I_1 + I_2 = I_3$

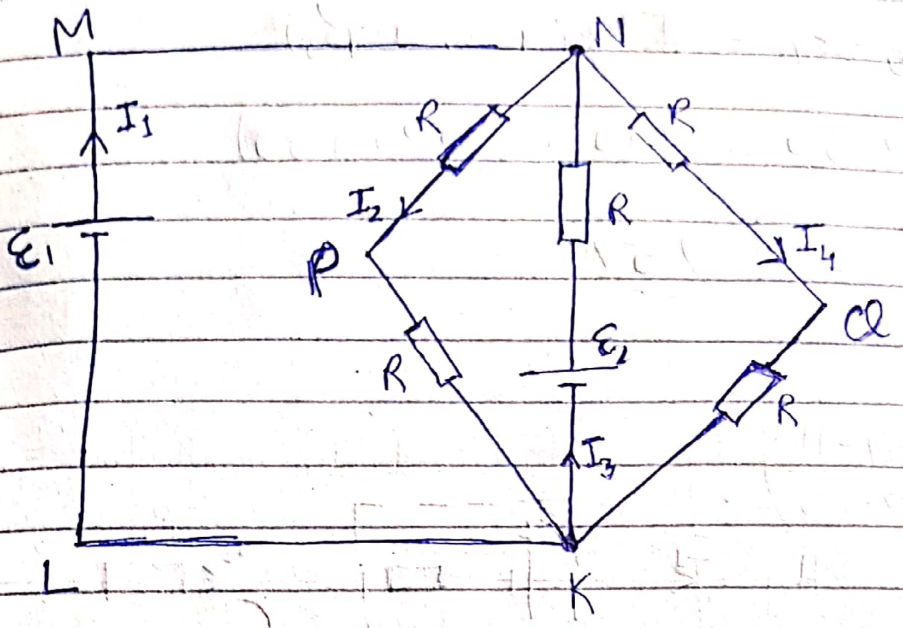
(ii)(1) $-\mathcal{E}_2 = -I_2R - I_3R$

2) $\mathcal{E}_1 - \mathcal{E}_2 = I_1R + I_1R - I_2R$

or

$2I_1R - I_2R$

Q7
J-09/P22



a) Relate I_1, I_2, I_3 and I_4

b) Write eq. for loop

1-) NKLMN

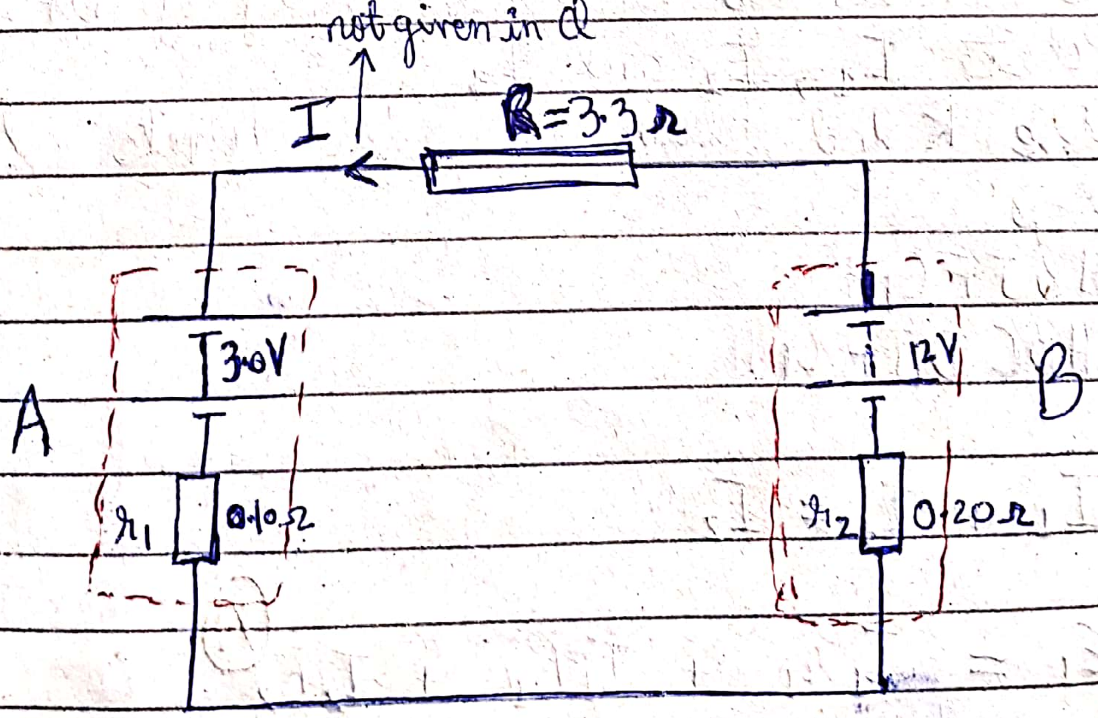
2-) NKQN

a) $I_1 + I_3 = I_2 + I_4$

b) 1-) $-\mathcal{E}_2 = -I_3R - I_4R - I_4R$

2-) $\mathcal{E}_2 = I_3R + 2I_4R$

Q) J-2011
(Q5/b)



Calculate current in circuit by using Kirchoff's law.

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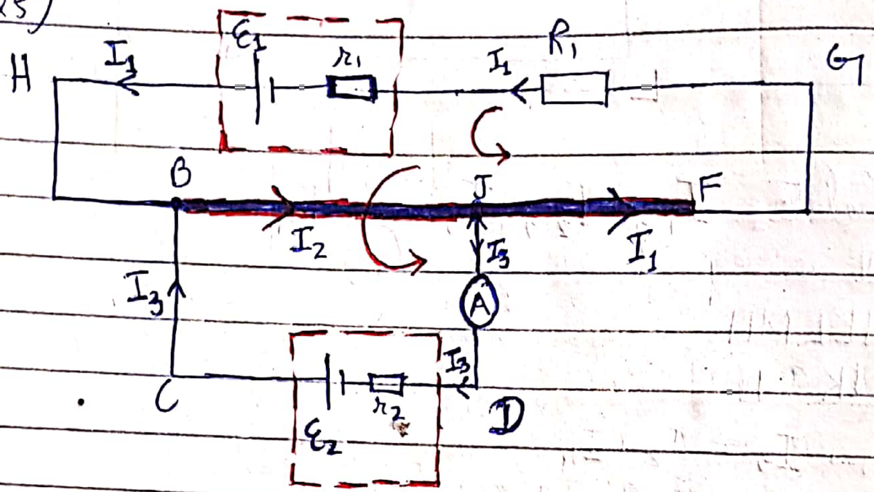
$$\mathcal{E}_B - \mathcal{E}_A = I(r_1 + r_2 + R_3)$$

$$12 - 3.0 = I(0.10 + 0.20 + 3.3)$$

$$I = 2.5\,A$$

Q) Nov-11 P22-Q5



BF is a uniform wire of resistance R_2.
The junction J is half way of BF
a) Relate I_1, I_2 and I_3
b) Use K 2nd law to ~~esri~~ write loop eq for ~~loop~~

1-) HBJFGH
2-) HBCDJFGH

a) $I_1 + I_3 = I_2$

b) 1-) $\mathcal{E}_1 = I_1 r_1 + I_1 R_1 + I_2 R_2$ (X)

$\mathcal{E}_1 = I_2 \frac{R_2}{2} + I_1 \frac{R_2}{2} + I_1 R_1 + I_1 r_1$ ✓

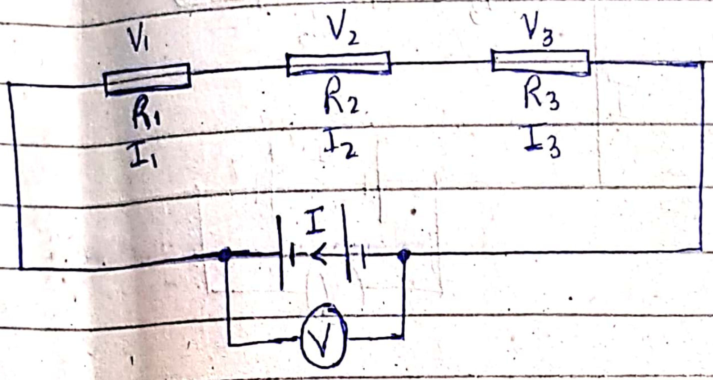
2-) $\mathcal{E}_1 - \mathcal{E}_2 = I_1 r_1 + I_1 R_1 - I_3 r_2 + \cancel{I_2 R_2}\ I_2 \frac{1}{2} R_2$ (X)

$\mathcal{E}_1 - \mathcal{E}_2 = -I_3 r_2 + I_1 \frac{R_2}{2} + I_1 R_1 + I_1 r_1$ ✓

Combination of Resistors:-

Resistances in series:-

Df:-
Combination in which current gets single path for its flow is called series combination.



Properties:-

(i) Current:- Same amount of current flows through each resistor and is equal to the current which flows through the emf source.

$$I = I_1 = I_2 = I_3$$

(ii) p.d / voltage:-
The p.d across each resistor is different as per its resistance but the sum of potential drops/p.d is equal to the emf of source by Kirchoff's ~~1st~~ 2nd law.

$$V = V_1 + V_2 + V_3$$

(iii) Effective Resistance:-

Since $V = V_1 + V_2 + V_3$

$$IR = I_1R_1 + I_2R_2 + I_3R_3$$

But in series, $I_1 = I_2 = I_3$

$$IR = IR_1 + IR_2 + IR_3$$

$$\boxed{R = R_1 + R_2 + R_3}$$

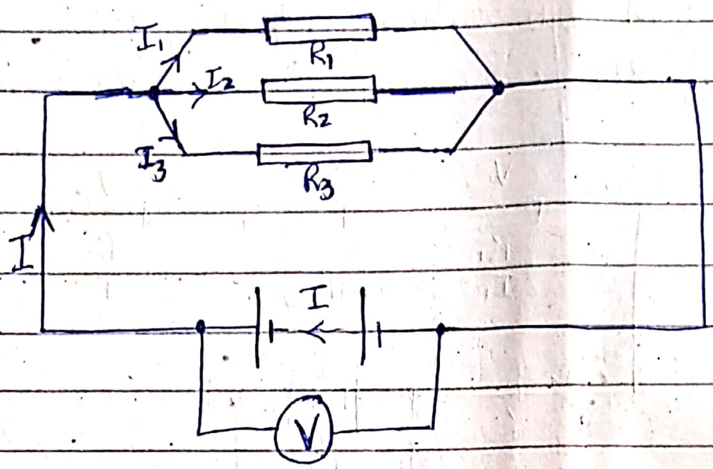
b) Resistances in Parallel

Def:-

The combination in which current gets several paths for its flow is called parallel combination.

~~Properties~~

~~1-) Current:-~~



Properties

1-) Current:- Different amount of current flows through each resistor as per its resistance but the sum of current through each resistor is equal to the current which flows through the emf source by Kirchoff's 1st/Current law.

$$I = I_1 + I_2 + I_3$$

2-) p.d / voltage:-

The p.d across each resistor is same and is equal to the emf of source as per Kirchoff's 2nd law.

$$V = V_1 = V_2 = V_3$$

3-) Effective resistance:-

$$\text{Since } I = I_1 + I_2 + I_3$$

$$\frac{V}{R} = \frac{V_1}{R_1} + \frac{V_2}{R_2} + \frac{V_3}{R_3}$$

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

or $$\boxed{\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

Therefore the effective resistance in parallel is always less than the least resistance of a resistor connected in the combination.

Note:- 1) Effective resistance of n-similar ~~resistors~~ resistances in parallel:-

$$R_n = \frac{R}{n}$$

~~where~~ where, R ⇒ Resistances of single resistor; n ⇒ no. of identical resistors.

2) Effective resistance of two resistors in parallel:-

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$$

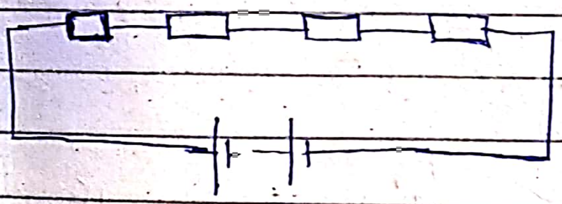
$$\frac{1}{R} = \frac{R_2 + R_1}{R_1 R_2}$$

$$\boxed{R = \frac{R_1 R_2}{R_1 + R_2}}$$

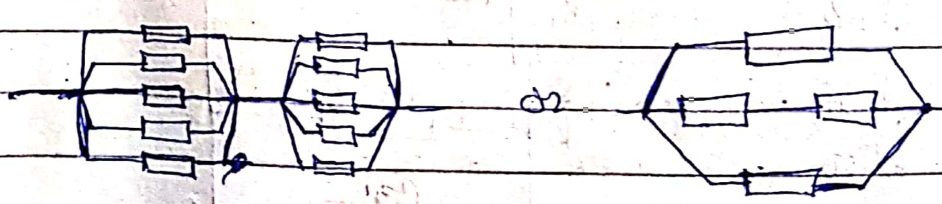
i.e. Effective resistance = $\frac{\text{product of resistances}}{\text{sum of resistances}}$

Q) A no. of resistors each having a resistance of 100 Ω are available. Show their connection in a combination so as to get an effective resistance of:

a) 400 Ω



b) 40 Ω ⇒ $R_n = \frac{R}{n} = \frac{100}{5} = 20$



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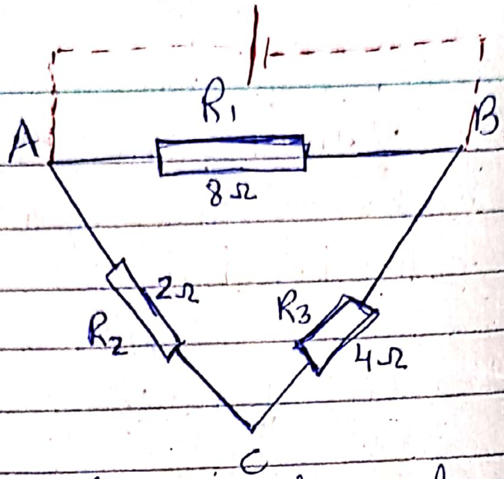
Q)



Calculate the effective resistance b/w:
(i) AB
(ii) BC
(iii) CA

Hint:- Always assume that an emf source is connected across the junctions b/w which the effective resistance ~~to be~~ is to be calculated

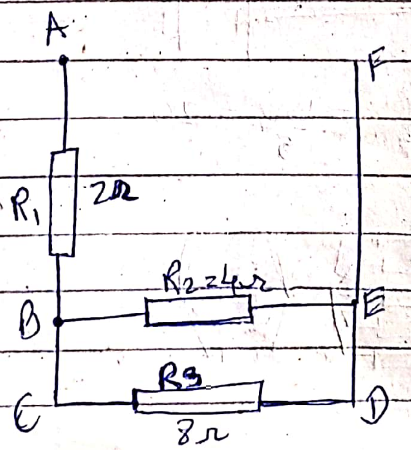
(i) $R_{AB} = R_1 \,//\, (R_2 + R_3)$

$= \frac{(6)(8)}{6+8} = \frac{48}{14} = 3.43\,\Omega$

(ii) $R_{BC} = R_3 \,//\, (R_1 + R_2)$

$= \frac{(4)(10)}{4+10} = \frac{40}{14} = 2.86\,\Omega$

(iii) R_{CA}



R_{AB}
R_{BD}
R_{CD}
R_{AC}

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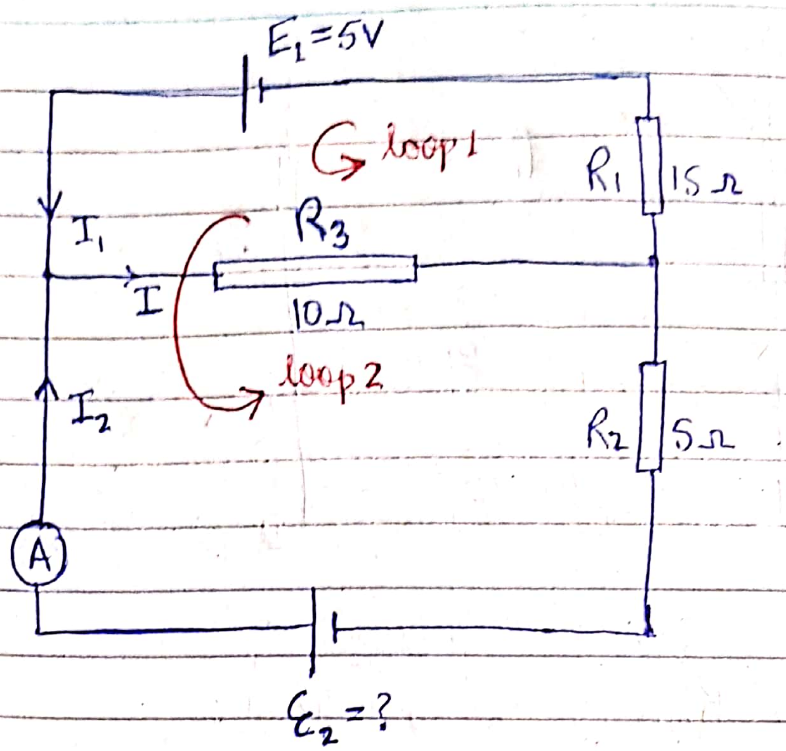
Q)



If the current I_2 is zero. Calculate the emf 'E_2' of source

$$E_1 = 15 I_1 + 10 I \quad \text{—— (1)}$$

$$\mathcal{E}_1 - \mathcal{E}_2 = 0 + 15 I_1$$

loop 1:- $\mathcal{E}_1 = I R_3 + I_1 R_1$

$$5 = (I_1 + I_2) R_3 + I_1 R_1$$
$$5 = 10 I_1 + 10 I_2 + 15 I_1$$
$$5 = 25 I_1 + 10 I_2$$
$$1 = 5 I_1 + 2 I_2 \quad \text{—— (1)}$$

loop2:-

$$\mathcal{E}_1 - \mathcal{E}_2 = - I_2 R_2 + I_1 R_1$$
$$5 - \mathcal{E}_2 = -5 I_2 + 15 I_1 \quad \text{—— (2)}$$

Apply condition i.e. $I_2 = 0$ on (1) and (2)

$$1 = 5 I_1 + 2(0)$$
$$I_1 = \frac{1}{5} A$$

$$5 - \mathcal{E}_2 = -5(0) + 15 I_1$$
$$5 - \mathcal{E}_2 = 15 I_1$$
$$5 - \mathcal{E}_2 = 15\left(\frac{1}{5}\right)$$
$$\mathcal{E}_2 = 2V$$

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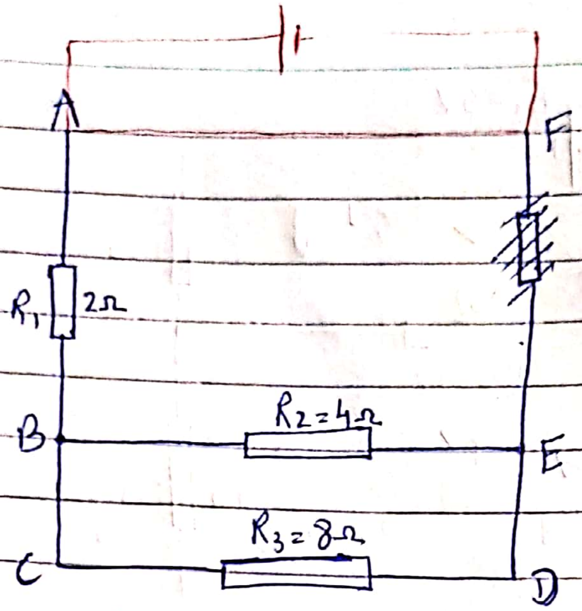
Q)



Calculate effective resistance across:-
(i) R_{AB} (ii) R_{BD} (iii) R_{CD} (iv) R_{AC}

(i) $R_{AB} = R_1 = 2\Omega$

(ii) $R_{BD} = R_2 \parallel R_3$

$$= \frac{(4)(8)}{4+8} = \frac{32}{12} = 2.7\,\Omega$$

(iii) $R_{CD} = R_2 \parallel R_3 = 2.7\,\Omega$

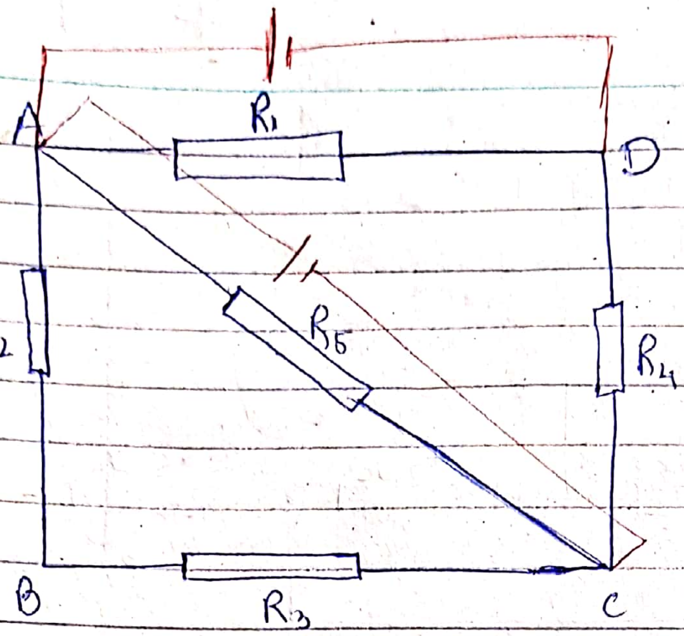
(iv) $R_{AC} = R_1 = 2\Omega$

(V) $R_{AF} = R_1 + (R_2 \parallel R_3)$

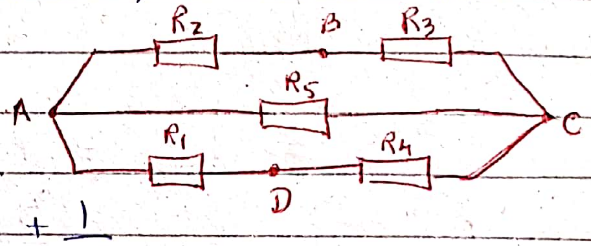
$$= 2 + \frac{32}{12}$$

$$= 2 + 2.7 = 4.7\,\Omega$$

Q)



If $R_1 = R_2 = R_3 = R_4 = R_5 = 5\ \Omega$, Calculate the effective resistance :-



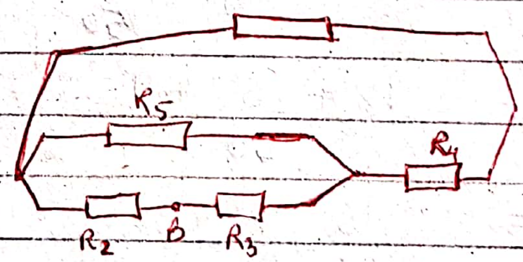
(i) AC

AC ⇒ $\frac{1}{AC} = \frac{1}{5} + \frac{1}{10} + \frac{1}{10}$

$\frac{1}{AC} = \frac{2+1+1}{10}$

$\frac{1}{AC} = \frac{\cancel{4}\,2}{\cancel{10}\,5}$

$AC = \frac{5}{2}\ \Omega$

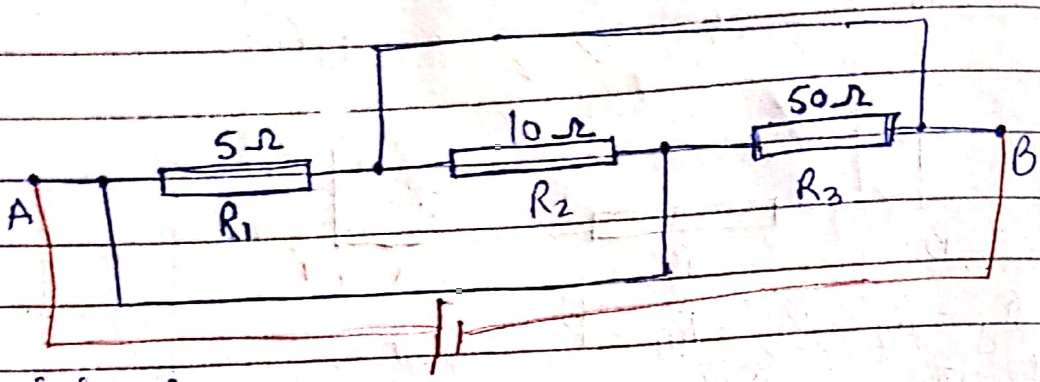


(ii) AD

AD ⇒

(iii) BD ⇒ p.d across $R_5 = 0$, so no current flows through it and its resistance is not taken into account.

Q)



Calculate R_{AB}

$$\Rightarrow R_{AB} = R_1 \parallel R_3$$

$$= \frac{(5)(50)}{5+50}$$

$$= \frac{250}{55}$$

$$= 4.54\,\Omega$$

$$\frac{1}{R} = \frac{1}{5} + \frac{1}{10} + \frac{1}{50}$$

$$= \frac{10+5+1}{50}$$

$$= \frac{16}{50}$$

$$= \frac{50}{16}$$

$$= 3.13\,\Omega$$

Step 1:- Effective resistance of circuit
$$R = R_1 + R_2$$

Step 2:- Current in the circuit by Kirchoff's 2nd law

$$E = I(R_1 + R_2)$$
$$I = \frac{E}{(R_1 + R_2)}$$

Step 3:- Same amount of current flows through each resistor

$$I_1 = I_2 = I = \frac{E}{(R_1 + R_2)}$$

Step 4:- p.d across R_1

$$V_1 = I_1 R_1$$
$$\boxed{V_1 = \left(\frac{E}{R_1 + R_2}\right) R_1}$$

p.d across R_2:-

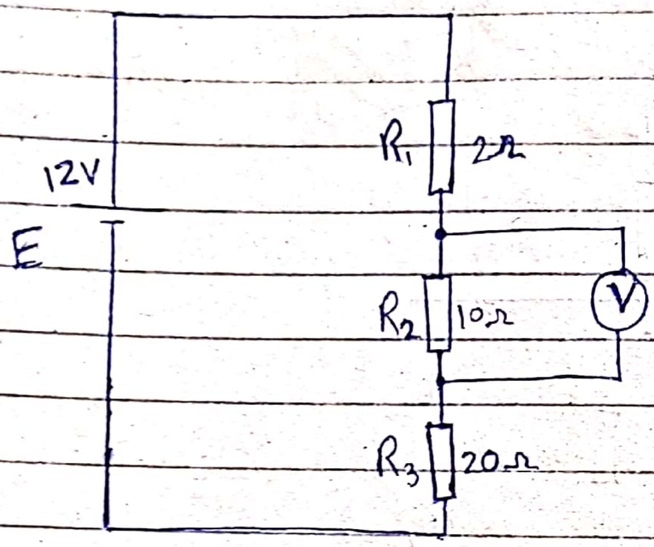
$$V_2 = I_2 R_2$$
$$\boxed{V_2 = \left(\frac{E}{R_1 + R_2}\right) R_2}$$

Results / formula :-

$$p.d = \left(\frac{\text{given resistance}}{\text{sum of resistances in series}}\right) \text{input emf}$$

Practise Q :-

1



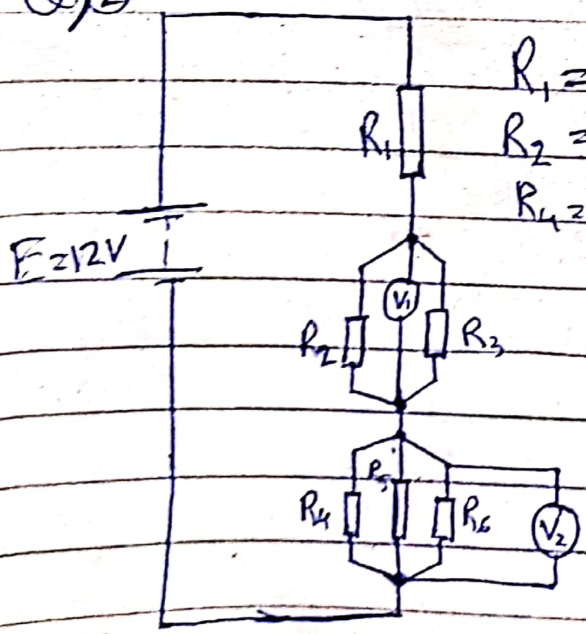
$\cancel{V = 10}$

$$V = \left(\frac{R_2}{R_1 + R_2 + R_3}\right) E$$

$$= \left(\frac{10}{2+10+20}\right)(12)$$

$$= 3.75\ V$$

Q) 2



$R_1 = 2\,\Omega$

$R_2 = R_3 = 20\,\Omega$

$R_4 = R_5 = R_6 = 60\,\Omega$

$$\frac{1}{20} + \frac{1}{20} = \frac{\cancel{2}\ 1}{\cancel{20}\ 10}$$

$$\frac{1}{60} + \frac{1}{60} + \frac{1}{60} = \frac{\cancel{3}}{\cancel{60}\ 20}$$

$\cancel{V_1 = \frac{20}{2+2}}$

$$V_1 = \left(\frac{10}{2+10+20}\right) 12$$

$$= \left(\frac{10}{32}\right) 12$$

$$= 3.75V$$

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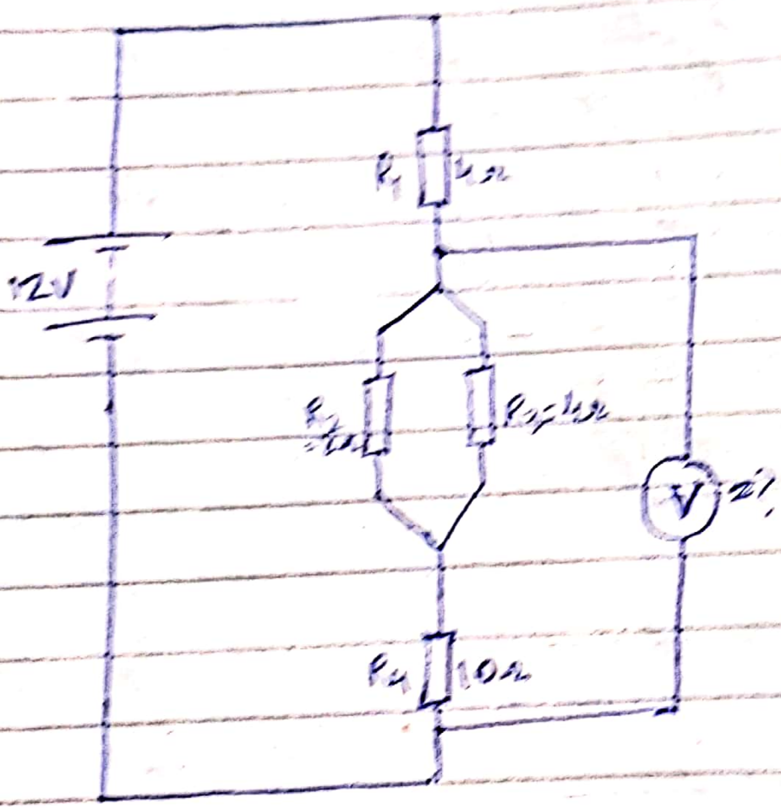
$$V_2 = \left(\frac{R_{456}}{R_1 + R_{23} + R_{456}}\right) E$$

$$= \left(\frac{20}{2 + 10 + 20}\right)(12)$$

$$= 7.5\,V$$

(Q.3)



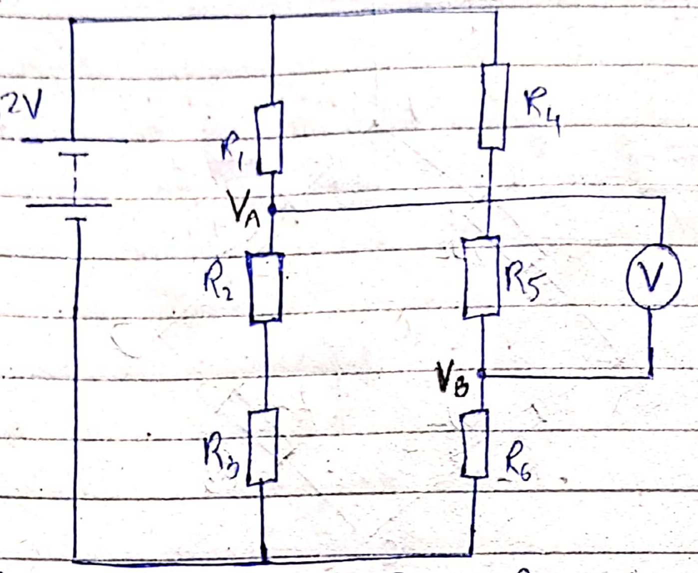
$$\text{Effective } R = 10 + \left(\frac{3\times 2}{3+2}\right)$$

$$\frac{\cancel{4} = 30 + 2}{3}$$

$$= \frac{32}{3}$$

$$V = \frac{R_{234}}{R_T}$$

Q) 4)



If $R_1 = R_2 = R_3 = R_4 = R_5 = R_6 = 10\Omega$

★ potential is taken with reference to earth or -ive terminal, when voltmeter is connected b/w 2 loops

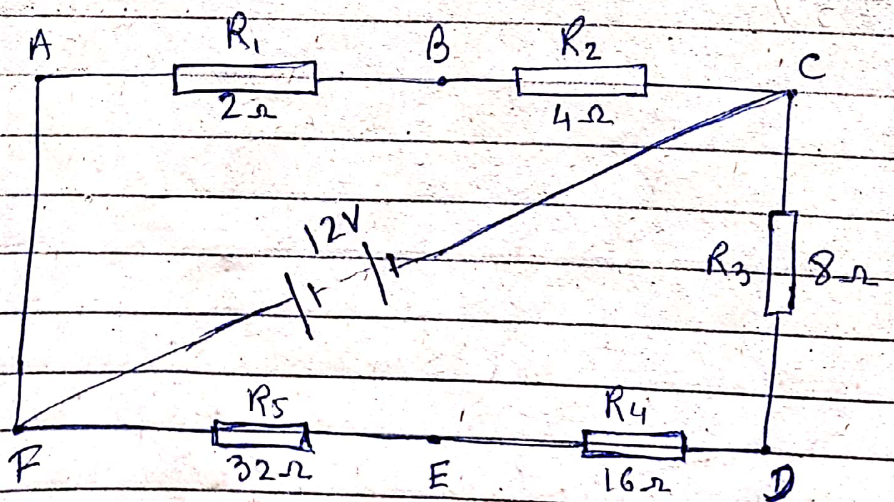
$$V = V_A - V_B$$

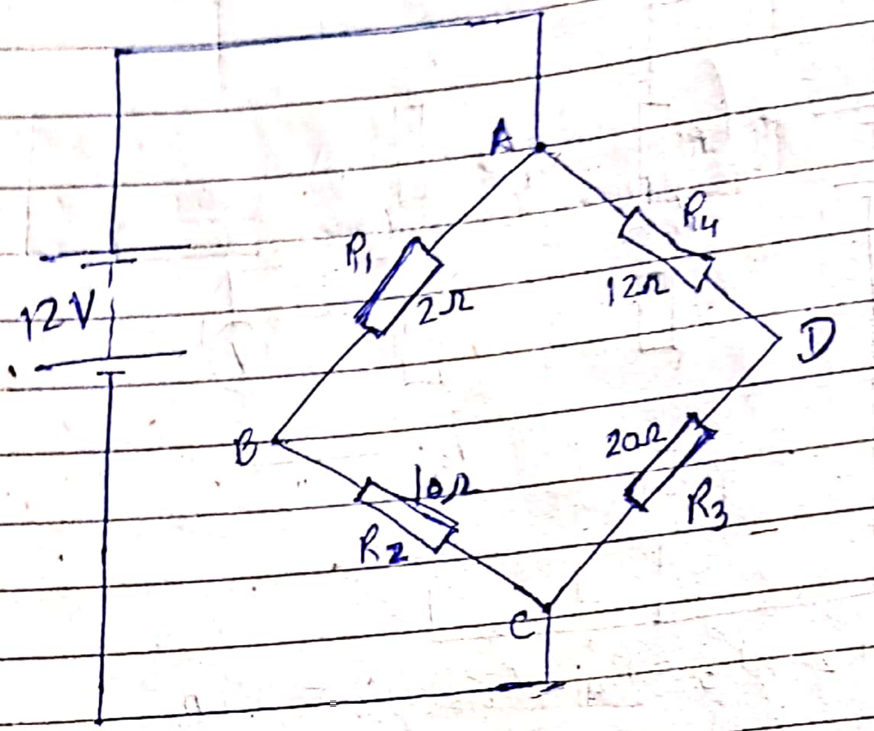
$$= \left(\frac{R_{23}}{R_1+R_2+R_3}\right)E - \left(\frac{R_6}{R_4+R_5+R_6}\right)E$$

$$= \left(\frac{20}{10+10+10}\right)(12) - \left(\frac{10}{10+10+10}\right)(12)$$

$$= 4V$$

Q5)





Calculate
(i) V_{CD}
(ii) V_{BD}
(iii) V_{AC}

(i) $V_{CD} = \left(\frac{R_3}{R_4 + R_3}\right) E$ ~~= 20~~

$= \left(\frac{20}{12+20}\right)(12)$ #

$= 7{\cdot}5\ V$

Calculate

(i) V_{AB}

(ii) V_{ED}

(iii) V_{BE}

(i) $V_{AB} = \left(\frac{R_1}{R_1 + R_2}\right) E$

$= \left(\frac{2}{2+4}\right)(12)$

$= 4V$

(ii) $V_{ED} = \left(\frac{R_4}{R_5 + R_4 + R_3}\right) E$

$= \left(\frac{16}{32+16+8}\right)(12)$

$= 3.43 V$

(iii) $V_{BE} = V_{BC} - V_{EC}$

$= \left(\frac{R_2}{R_1 + R_2}\right) E - \left(\frac{R_{43}}{R_5 + R_4 + R_3}\right) E$

$= \left(\frac{4}{2+4}\right)(12) - \left(\frac{24}{32+16+8}\right)(12)$

$= 2.86 V$

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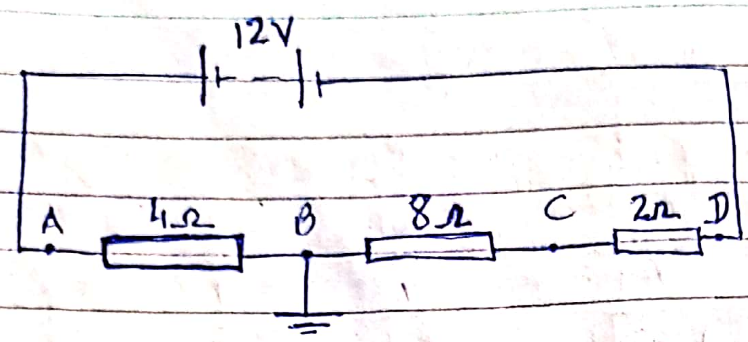
Q)



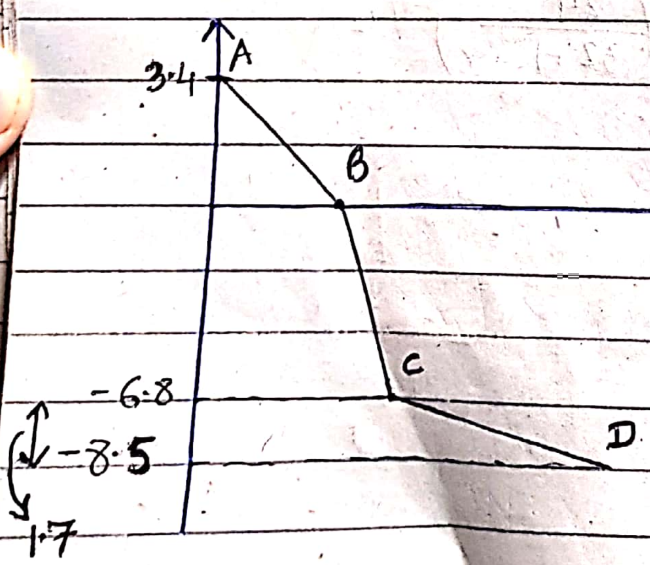
a) Calculate
(i) V_{AB}
(ii) V_{BC}
(iii) V_{CD}

b) Draw the graph of p.d against position A, B, C and D of above figure.

(i) $V_{AB} = \left(\frac{4}{4+8+2}\right)(12) = 3.4\,V$

(ii) $V_{BC} = \left(\frac{8}{4+8+2}\right)(12) = 6.8\,V$

(iii) $V_{CD} = \left(\frac{2}{4+8+2}\right)(12) = 1.7\,V$



★ for potential (energy) earth or -ive is the reference

Sliding wire potentiometer

$$V_{out} = \left(\frac{E}{R_1 + R_2}\right) R$$

I

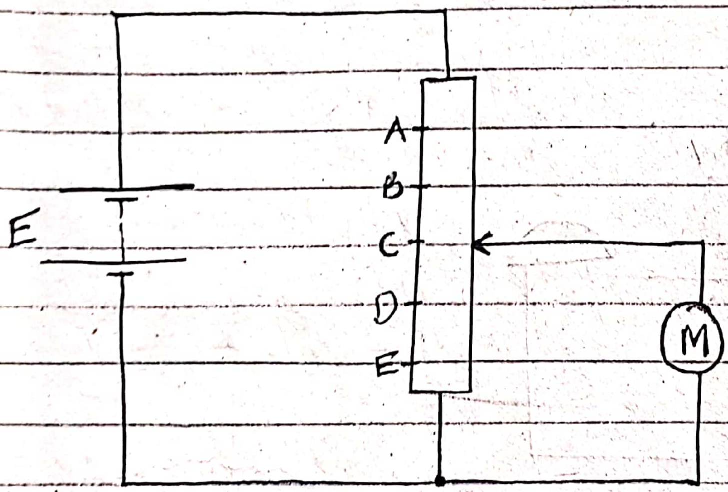
output voltage = (constant current in series) (Resistance)

$V_{out} \propto R$

But $R = \rho \frac{L}{A} \Rightarrow R \propto L$

★ wire made of same material, so ρ constant
★ thickness of wire same/uniform, so A constant, so R directly dependant on L

$$\boxed{\text{So, } V_{out} \propto L \quad \text{i.e. output voltage} \propto \text{length of conductor}}$$



★ length of conductor always taken from earth or -ive potential

Relative speed of motor :-

$V_A > V_B > V_C > V_D > V_E$

Reason:-

length of conductor across (in parallel to) motors

$L_A > L_B > L_C > L_D > L_E$

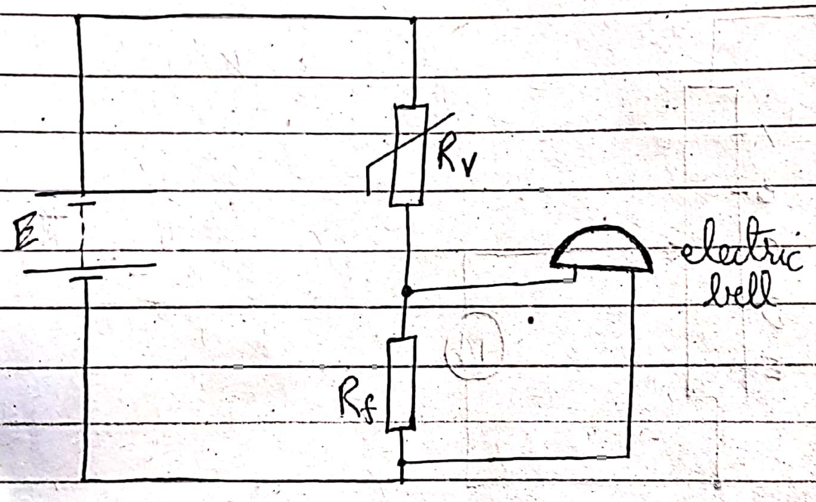
So, resistance of conductor across motor ($R \propto L$):-

$R_A > R_B > R_C > R_D > R_E$

Therefore p.d across motor:-

$V_A > V_B > V_C > V_D > V_E$

Use of thermistor as potentiometer in fire alarm circuit



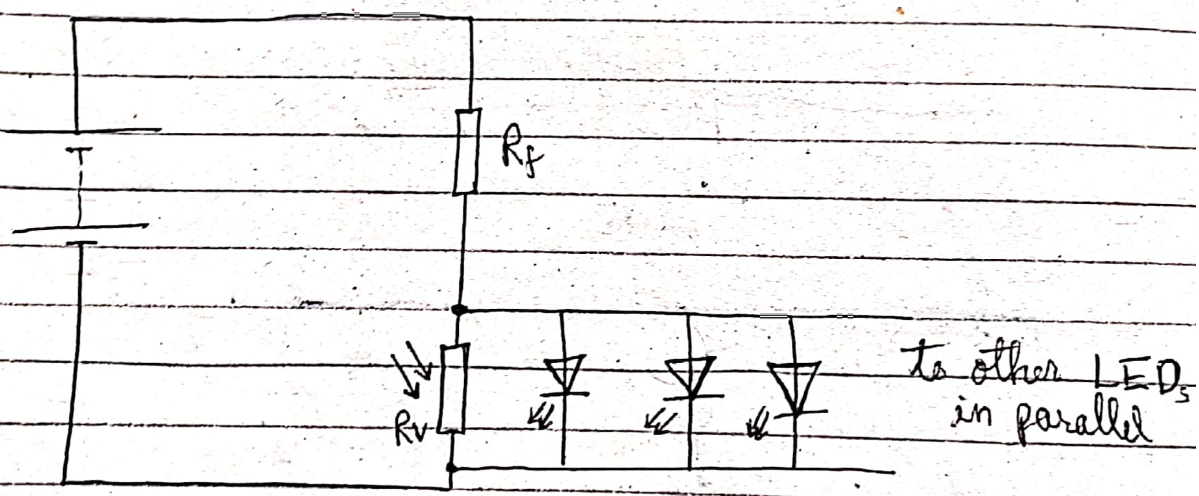
At low temp:-

* $R_V \uparrow$ but R_f remain fixed
* By comparison ($R_V > R_f$)
* By potentiometer principle, $V_{out} \propto R$, (p.d across R_V) > (p.d across R_f)
* This lesser p.d across R_f is even lesser than the operating voltage of bell, so it will not switch ON.

At high temp :-

* ★ $R_V \downarrow$ but R_f, remain fixed
* ★ By comparison $(R_V < R_f)$
* ★ By potentiometer principle, $(V_{out} \propto R)$
  (p.d across R_V) < (p.d across R_f)
* ★ This greater p.d ~~it~~ across R_f is equal to the operating voltage of bell, so it will ring.

Use of LDR as potentiometer in LED circuit



Day time (sunlight) :-

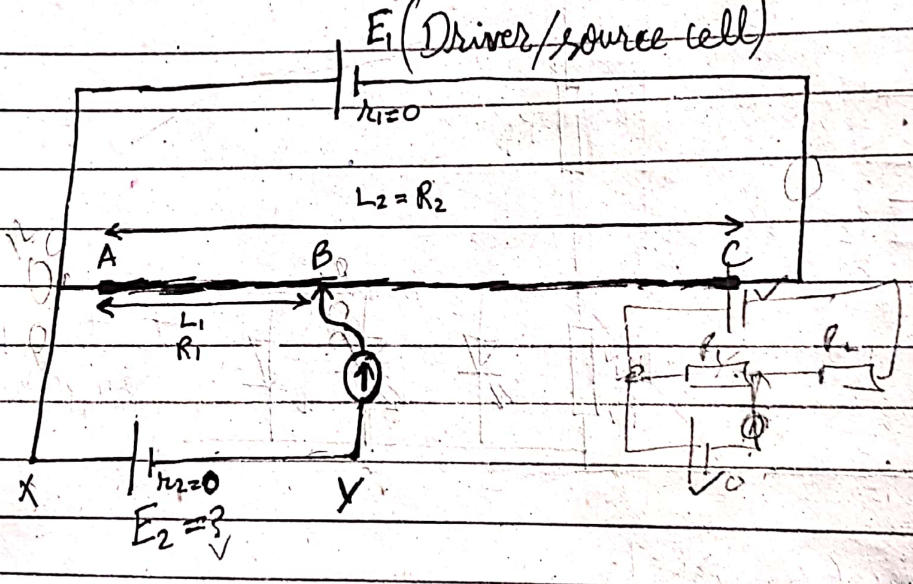
* ★ $R_V \downarrow$, but R_f remain constant
* ★ By comparison, $(R_V < R_f)$
* ★ By potentiometer principle $(V_{out} \propto R)$,
  (p.d across R_V) ~~<~~ < (p.d across R_f)
* ★ This ~~also~~ ~~is~~ lesser p.d across R_V is even lesser than the operating voltage of LEDs, so they will ~~to~~ not emit light.

Night time (Moon light) :-

* $R_V \uparrow$ but R_f remain fixed
* By comparison ($R_V > R_f$)
* By potentiometer principle
  (p.d across R_V) > (p.d across R_f)
* This greater p.d across R_f is equal to the operating voltage of LEDs, so they all emit light with equal brightness.

(Balance method) → in which current becomes 0

Comparison of emf sources ~~of~~ by Null method



Move the sliding contact 'B' ~~th~~ along the wire AC until the galvanometer shows ~~zero~~ zero deflection. So potential difference across AB = p.d across ~~xy~~ XY
i.e. potential at A = potential at X
and " " B = " " Y
So,

$$V_{AB} = V_{XY} = \left(\frac{L_{AB}}{L_{AB} + L_{BC}}\right) E_1 .$$

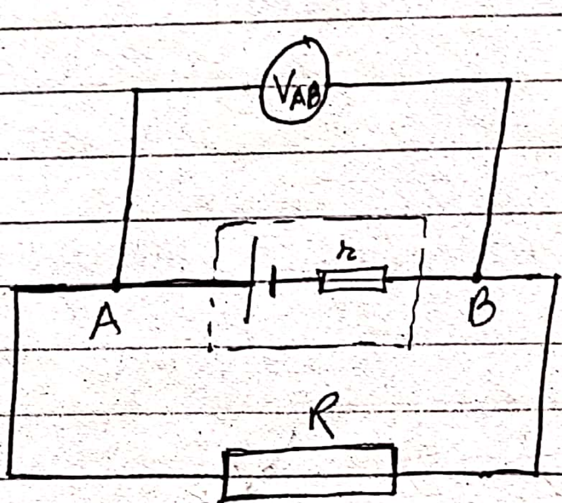
$$E_2 = \left(\frac{L_{AB}}{L_{AC}}\right) E_1$$

$$\frac{E_2}{E_1} = \frac{L_{AB}}{L_{AC}}$$

i.e. $\boxed{\frac{E_2}{E_1} = \frac{L_1}{L_2}}$

Terminal p.d (def):-

It is the ~~potential~~ p.d across the terminals of the cell ~~if it is~~



$$E = I(r + R)$$
$$E = Ir + IR$$
$$E = Ir + V$$

If the source does not provide current to an external circuit i.e. $V = 0$

$$E = Ir + V$$
$$V_{AB} = E = Ir$$

i.e.

terminal p.d = emf of source if it does not provide current to an external ~~cur~~ circuit.

Also, $E = Ir + IR$

$E = $ (voltage loss in the source) $+ V$

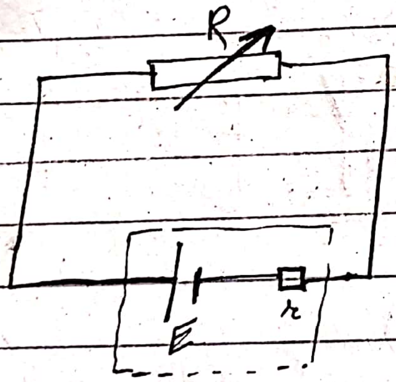
$V = E -$ (voltage loss)

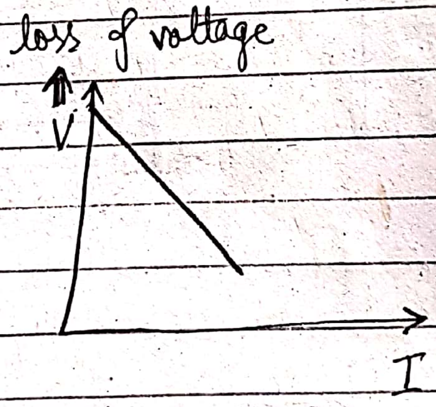
i.e.
the terminal p.d across the cell is always the same as the potential p.d across the external ~~resistor~~ resistance if the internal resistance has negligible value

Note:-
The terminal p.d of the power supply decreases if the current supplied by it increases due to short circuiting

* short circuiting ⇒ high current will pass, as $R = 0$

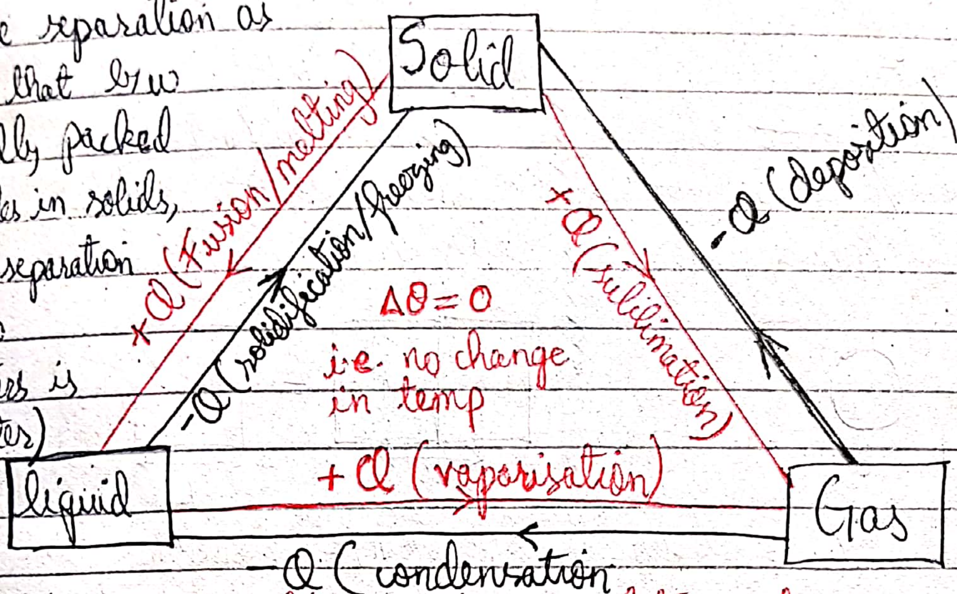
$E = I^2 \underset{=0}{R} t$ ⇒ heating effect produced





MATTER

* avg. separation b/w solids and liquids is same (i.e. the molecules in cluster form in liquid have same separation as the that b/w rigidly packed particles in solids, but separation b/w clusters is greater)



* E_p in case of particles is ~~determin~~ determined by comparing its new position with its original position (i.e. if separation b/w particles greater than original, then E_p ↑, and if lesser, then E_p ↓

Note:-

① If Q = +ive, then ΔU ↑ because

$\Delta U = \Delta E_K + \Delta E_p$

$\Delta E_K = 0$, due to constant temp.

ΔE_p = ↑ due to breaking of bond ~~and/o~~ and/or increase in separation b/w particles.

② If Q = -ive, then ΔU ↓ because

$\Delta E_K = 0$ due to constant temp

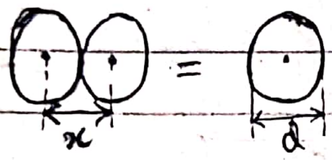
ΔE_p = ↓ due to decrease in the separation b/w particles

③ ~~U(ice)~~ $(U)_{ice} < (U)_{water} < (U)_{steam}$

* U of ice is lesser than water at same temp (i.e. 0°c), as its E_p ↓ due to ↓ separation b/w particles hence it cools pepsi quickly than cold water at same Temp
* Burn of steam ↑ than water at 100°C, as U of steam ↑, since E_p ↑, due to ↑ separation b/w particles.

Relation b/w volume and average separation b/w particles/molecules

Assumption :-
particles ~~are~~ /molecules /atoms ~~are~~ as small spheres



separation b/w particles = diameter of sphere

$$V = \frac{4}{3}\pi r^3$$

$$V = \frac{4}{3}\pi\left(\frac{d}{2}\right)^3$$

$$V = \left(\frac{4\pi}{24}\right) d^3$$

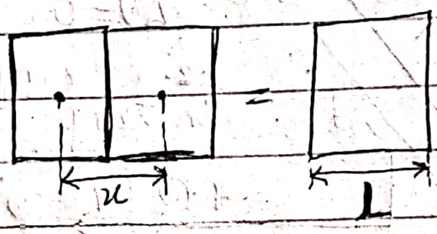
$$V = (\text{constant})\, d^3$$

$$V \propto d^3$$

or $d \propto (V)^{1/3}$

i.e. separation = cube root of volume

Assumption :
particles /molecules/ atoms as ~~a~~ small cubes.



separation = length of cube

$$V = L^3$$

$$L = (V)^{1/3}$$

separation = cube root of volume

Relation b/w density and average separation b/w particles /molecules

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

$\rho = \frac{m}{d^3}$

~~$\rho = 1$~~

$\rho \propto \frac{1}{d^3}$

density $\propto$ (cube of separation)$^{-1}$

$\rho = \frac{m}{L^3}$

$\rho \propto \frac{1}{L^3}$

Density = ~~increase inverse~~ inverse cube of separation

separation = Inverse cube root of density

i.e. $d = \left(\frac{1}{\rho}\right)^{1/3}$ → d and ρ both same

Note :-

	Solid	Liquid	Gas
separation	1	1	10
Density	1000	1000	1

★ ratio of spacing b/w solids and liquids is same

(J-07)

Q/c) $\rho_{liquid\ H_2O} = 1.0\ g\ cm^{-3}$

$\rho_{water\ vapour} = \frac{1}{~~6000~~}\ \frac{1}{1600}\ g\ cm^{-3}$

Determine the ratio :-

a) i) $\frac{\text{volume of water vapour}}{\text{volume of equal mass of liquid water}}$ [1]

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(ii) mean separation of molecules in water vapour [2]
// // // // // liquid water

d) i) State the evidence for the molecules of solid and liquids having approximately the same separation [1]

~~(N-2009 ⇒ P22/Q2)~~
~~(Q) b) density of a metal = 4.5 g cm^{-3}~~
~~A cube of ~~water~~ metal of mass 48g contains~~

b) i) $\frac{V_v}{V_l} = \frac{\frac{1}{\rho_v}}{\frac{1}{\rho_l}} = \frac{\rho_l}{\rho_v} = \frac{1.0}{\frac{1}{1600}} = 1600 : 1$

(ii) $\frac{d_v}{d_l} = \frac{\left(\frac{1}{\rho_v}\right)^{1/3}}{\left(\frac{1}{\rho_l}\right)^{1/3}}$

$= \left(\frac{\rho_l}{\rho_v}\right)^{1/3}$

$= \left(\frac{1.0}{\frac{1}{1600}}\right)^{1/3}$

$= (1600)^{1/3}$

$= 11.7$

d) i) density of solid and liquid is approximately same

(N-09 ⇒ P22/Q2)

(Q) b) density of metal = 4.5 g cm^{-3}
A cube of metal of mass 48 g contains 6.08×10^{23} atoms.

(i) Calculate the volume of cube

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

$4.5 = \frac{48}{V} \Longrightarrow V = 16.7\ cm^3$

(ii) Estimate

1-) volume occupied by each atom in a cube

Total volume = (no. of atoms in a cube) (volume of each atom)

$$10.7 = (6.0 \times 10^{23})(V)$$

$$V = 1.78 \times 10^{-23}\ cm^3$$

2-) the separation of the atoms in the cube

$$d = (V)^{1/3}$$

$$d = (1.78 \times 10^{-23})^{1/3}$$

Melting point:

The max temp at which a solid changes to liquid state.

* temp has a constant value

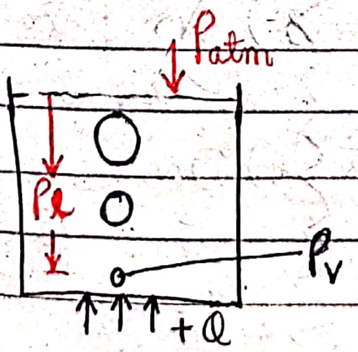
Note:

1-) The addition of impurity and pressure exerted on a solid decreases its melting point.

Boiling point:

The max temp at which the internal vapour pressure becomes equal to external pressure and liquid changes to gaseous state.

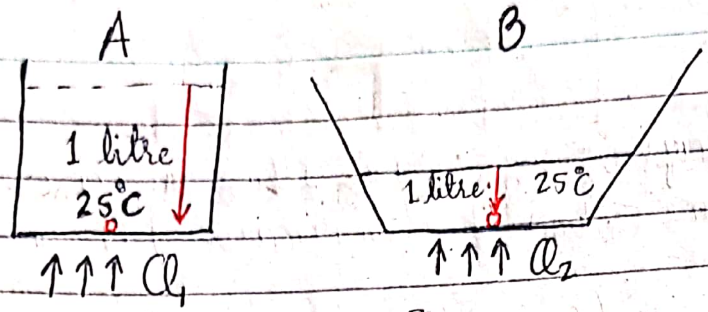
Condition:



$P_{vapour} = P_{atm} + P_{liquid}$

then θ = constant

Liquid $\xrightarrow[\text{(Boiling)}]{}$ Vapour



$Q_1 = Q_2$

Boiling will start quickly in B, as pressure due to liquid column is less in B due to less depth. Hence the condition of internal vapour pressure to external pressure will be satisfied quickly in B.

Note:-

1-) The addition of impurity and pressure exerted on a liquid increases its boiling point.

Difference b/w boiling and evaporation

Boiling	Evaporation
1-) Occurs throughout the liquid	1-) Occurs at the surface of liquid
2-) The temperature of liquid during boiling remain constant	2-) The temperature of liquid during evaporation decreases.
3-) Bubbles are formed	3-) No bubbles are formed
4-) Occurs at a constant temperature.	4-) Occurs at any temperature i.e. below or even at boiling point

5-) Condition of internal vapour pressure to external pressure must be satisfied	5-) No condition of pressure for evaporation

Similarities b/w boiling and evaporation

1-) In both these processes, a liquid changes to vapour state

2-) Thermal energy need to be supplied to increase the rate of evaporation and boiling.

Pressure

force at 90° (i.e. perpendicular force)

Def :- Normal force per unit area is called pressure.

Symbol : P

Formula :- $P = \frac{F}{A}$

Unit :- Nm^{-2} or ~~Pa (Pascal)~~ Pascal (Pa)

Fluid Pressure :-

The force exerted by the fluid particles due to their random collisions per unit area is called fluid pressure.

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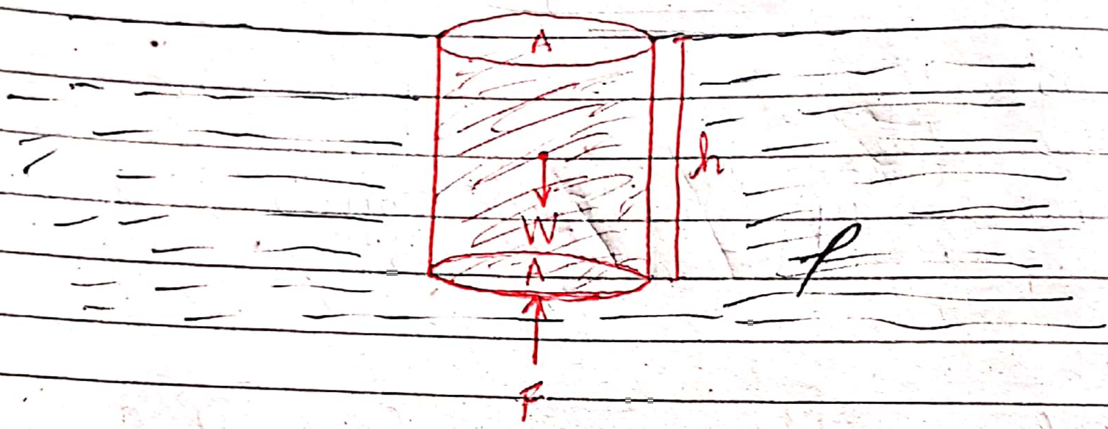
Formula:- $P = h\rho g$

where $h \Rightarrow$ depth of ~~top~~ fluid column
$\rho \Rightarrow$ Density of fluid
$g \Rightarrow$ Gravitational field Strength

Proof of $P = h\rho g$:-



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

$$P = \frac{W}{A} = \frac{mg}{A}$$

$$P = \frac{\rho V g}{A}$$

$$P = \frac{\rho (\cancel{A})(h) g}{\cancel{A}}$$

$$\boxed{P = \rho h g}$$

Upthrust:-

The force exerted by the fluid particles in upward direction due to difference of pressure is called upthrust.

Symbol :- U

Formula :- $U = F_2 - F_1$

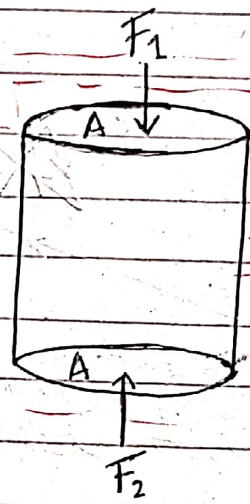
$U = P_2A - P_1A$

$U = A(P_2 - P_1)$

$U = \text{constant}\ (P_2 - P_1)$

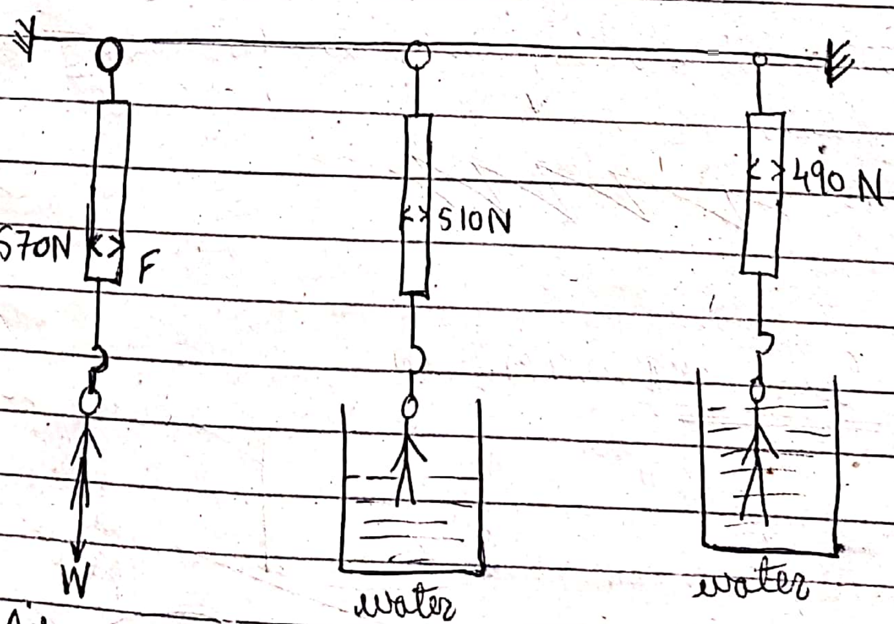
$U \propto (P_2 - P_1)$

i.e. upthrust is caused due ~~to~~ difference of pressure.



Example :-

~~In Air~~



Air

$F = W = 570N$

$W = F + U$

$570 = 510 + U$

$U = 60\ N$

$W = F + U$

$570 = 490 + U$

$U = 80\ N$

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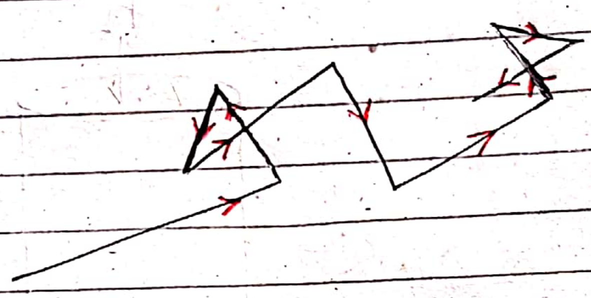
Brownian Motion

def:-
The random motion of particles of fluid is called Brownian motion.

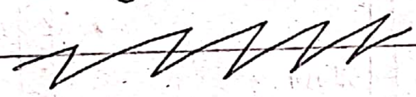
★ Random → independant of space (↓ direction) and time (i.e. direction)

Figure:-

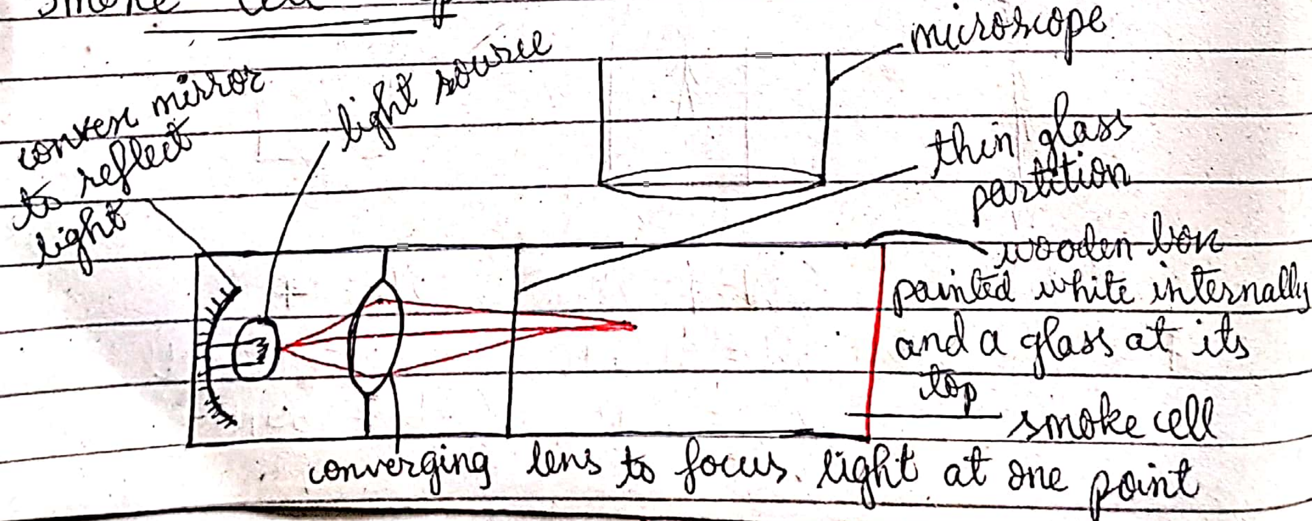


★ Straight lines of different lengths
★ Abrupt (rapid) change of path (shown by sharp corners)
★ At least one line must be cut

★ A pattern like this is also not ~~accel~~ acceptable
↳ there should be no pattern



Smoke Cell experiment



Observation:-

Small specs of light are observed due to reflection of light rays from the smoke particles. The rapid change of path ~~o~~ of smoke particles is due to bombardment of invisible air particles with them. This signifies that air a all gas particles also move randomly.

Note:-

Same observation is obtained when polen grain suspended in water are viewed through a microscope. So this indicates us that all liquid particles ~~move~~ → move randomly throughout the available space

Density + States of Matter ⇒ from handout

Physical Properties of Material

Stress

Def:- force per unit cross-sectional area is called stress

* In case of pressure ⇒ 2 objects are involved
* In stress ⇒ the ~~c~~ cross-sectional area of that object is taken, on which force is applied (i.e. only one object involved, on which force is applied, and the area of which is taken as cross-sectional area).
  ⇒ also in stress that object is deformed on which force is applied
* In pressure ⇒ object deformed, other than on which force is applied

Symbol :- σ (Sigma)

Formula :- $\sigma = F/A$

Unit :- Nm^{-2} or Pascal (Pa)

P.S :- Scalar

Types :-

(i) Tensile stress :-

★ ⇒ extension is produced in the object due to tensile stress

(ii) Compressive stress :-

★ ⇒ Compression is caused ~~ft~~ ~~from~~ due to force /stress

Strain

def :- Change in length per unit original length is called strain.

Symbol :- ϵ (Epsilon)

Formula :- $\frac{\Delta L}{L}$

Unit :- No units due to ratio of similar quantities

S :- Scalar

Types

) Tensile strain :

$\frac{\text{Extension}}{\text{original length}}$

b) compressive strain :- $\dfrac{\text{Compression}}{\text{original length}}$

Hooke's law

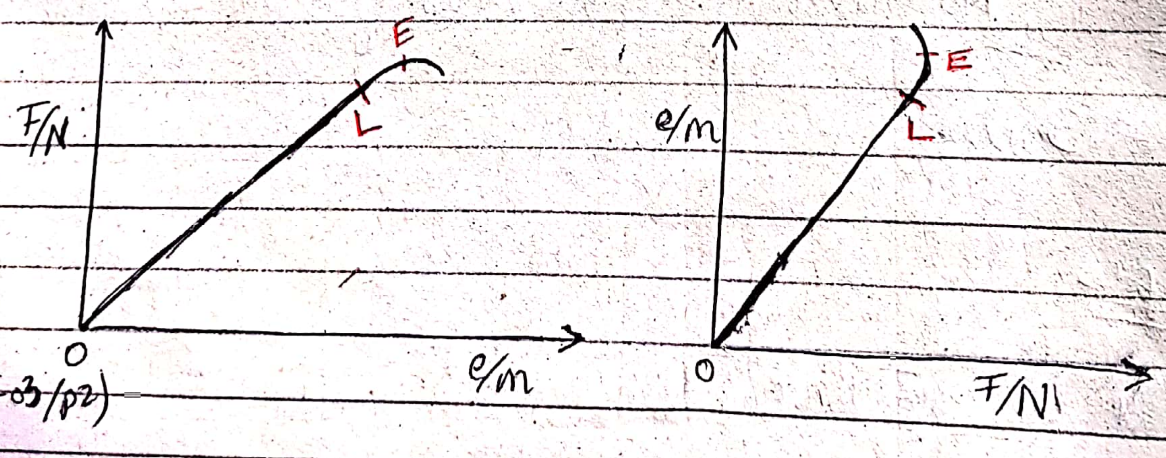
Statement :-
Within the elastic limit, the force applied is directly proportional to the extension produced.

mathematical form :-

$$F \propto e$$
$$F = ke$$

where k is the constant of proportionality and is called spring or Elastic ~~tim~~ constant. Its value depends upon the nature of material.

Graph :-



(J-03/p2)

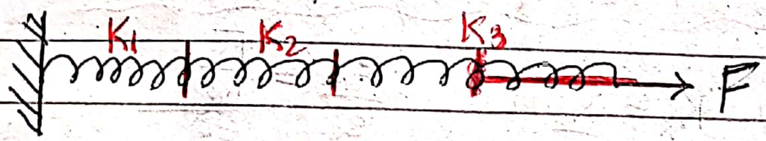
* L ~~is the~~ ⇒ limit of proportionality (End pt. of straight line from origin)
* OL ⇒ Region where Hooke's law is valid

* E ⇒ Elastic limit (End pt. from ~~value~~ where the object return to its original shape and size when ~~g~~ applied force is removed from it.)
* OE ⇒ Elastic region
* Beyond E ⇒ Plastic region (Region in which an object is permanently stretched).

- K → Gradient of F/N against e/m graph
- K ⇒ Reciprocal of gradient of e/m against F/N graph

Combination of Springs

(i) Springs in Series :-



Resultant spring constant (K_R)

$$= \frac{1}{K_R} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3}$$

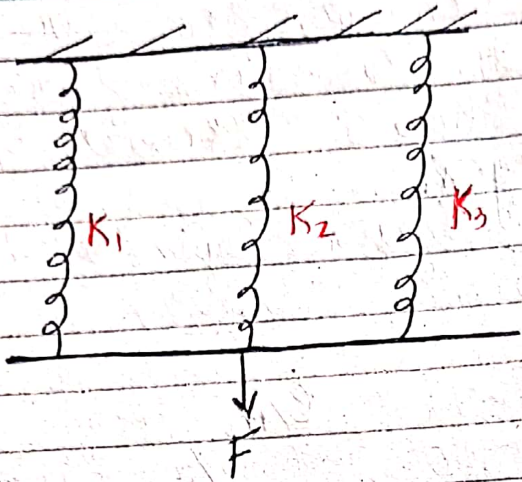
- Identical springs in series

⇒ $K_n = \frac{K}{n}$, K ⇒ spring constant of single spring

n ⇒ no. of identical springs.

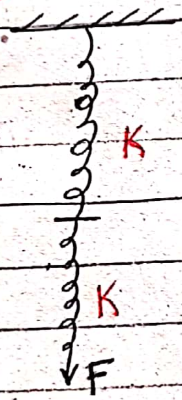
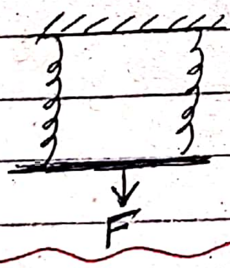
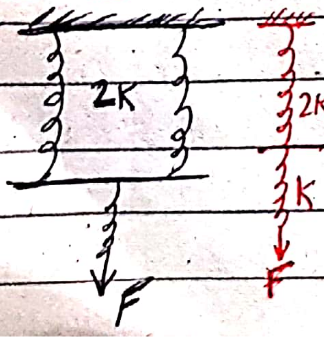
(ii) Springs in Parallel :-

* diagram on next page.



$K_R = K_1 + K_2 + K_3$

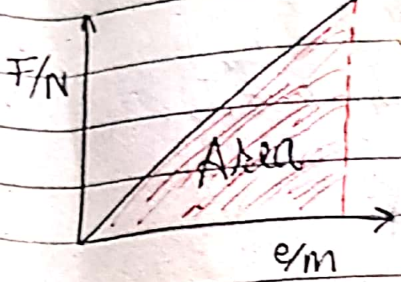
Q) N-09

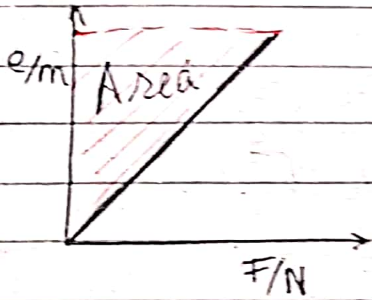
Combination	Resultant K	Resultant extension in terms of e
	$K_R = \frac{K}{2}$	$\frac{e_R}{e} = \frac{\frac{F}{K_R}}{\frac{F}{K}}$; $\frac{e_R}{e} = \left(\frac{F}{K_R}\right)\left(\frac{K}{F}\right)$; $\frac{e_R}{e} = \frac{K}{\frac{K}{2}} \Rightarrow \boxed{e_R = 2e}$
	$K_R = K_1 + K_2$; $K_R = K + K$; $K_R = 2K$	$\frac{e_R}{e} = \frac{K}{K_R}$; $\frac{e_R}{e} = \frac{K}{2K} \Rightarrow \boxed{e_R = \frac{e}{2}}$
	$K_R = \frac{(2K)(K)}{2K+K}$; $= \frac{2K^2}{3K}$; $= \frac{2}{3}K$	$\frac{e_R}{e} = \frac{K}{K_R}$; $\frac{e_R}{e} = \frac{K}{\frac{2}{3}K}$; $\boxed{e_R = \frac{3}{2}e}$

Elastic Potential energy

Already done in work, energy, power

→ E_p = Area of force – extension graph along with extension ~~area~~ axis





$E_p = \frac{1}{2} Fe$

But $F = Ke$

$E_p = \frac{1}{2}(Ke)(e) \Rightarrow \boxed{E_p = \frac{1}{2} Ke^2}$

Young Modulus

→ def:
Stress per unit strain is called young Modulus.

Symbol: E

· Formula: Stress $\propto$ strain

$\sigma \propto \epsilon$ → this proportionality constant is ~~f~~ called Young Modulus

$\sigma = E\,\epsilon$

$\frac{F}{A} = E\left(\frac{\Delta L}{L}\right)$

Scanned by CamScanner

$$E = \frac{FL}{A\Delta L} \quad \text{or} \quad E = \frac{FL}{Ae}$$

Units:- Nm^{-2} or Pascal (Pa)

P.S:- Scalar

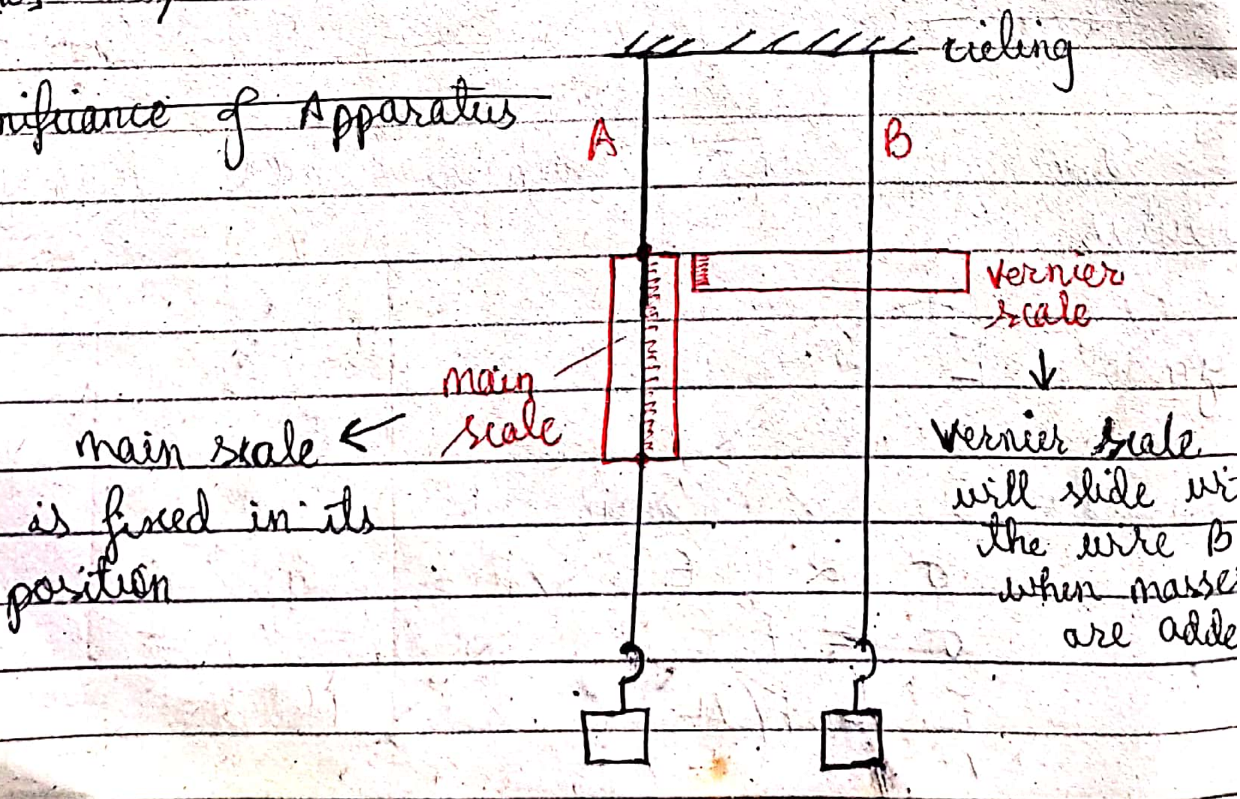
Dependance:-
Nature of solid material i.e its crystal structure (arangement of atoms)

Note:-
(i) Young Modulus is only for solid because one can not ~~perform~~ deform ~~fluids~~ fluids (liquids and gases) in one direction
(ii) It's value for metal $> 10^{10}$ Pa

Example:- Experimental determination of Young Modulus of a metallic wire

(J-2011
Q4 [10] → marks)

~~Significance of Apparatus~~



Significance of Appratus:-

(i) A and B are two metallic wires of same material for fair comparison.

(ii) Mass are attached to the lower ends to wire to keep them taut, so that there must be no kinks in the wires and accurate length can be determined.

(iii) The lengths of wires should be long so that lesser is the ~~pt~~ percentage uncertainity for greater degree of accuracy $\left(\frac{\Delta L}{L} \times 100\right)$.

(iv) Measure diameter of wire 'B' at different positions along its length and get its mean value.

v) Main scale is fixed to wire A and a sliding vernier scale to wire B to measure the ~~increase~~ increase in length.

Procedure:-

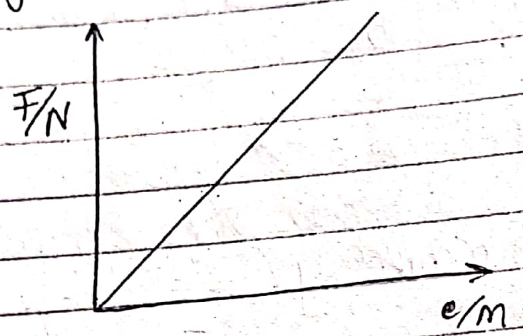
i) Add standard masses to the lower ~~and~~ end of wire ~~of~~ B and keep the mass of wire constant.

ii) Measure the corresponding ~~ext~~ increase extension of wire B using vernier scale.

iii) Also remove masses from wire B after ~~lo~~ loading it one by one ~~to~~ to check that wire ~~doe~~ does not exceed its elastic limit

Analysis:-

Plot the graph of Force/N against extension/m which should be a straight line from origin and finally get its gradient.



$$\text{Gradient} = \frac{F}{e}$$

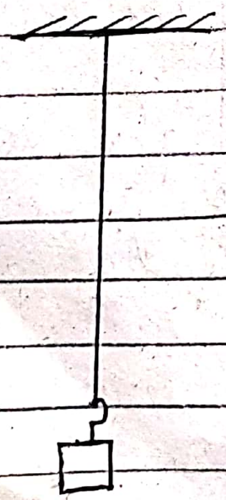
Calculation:-

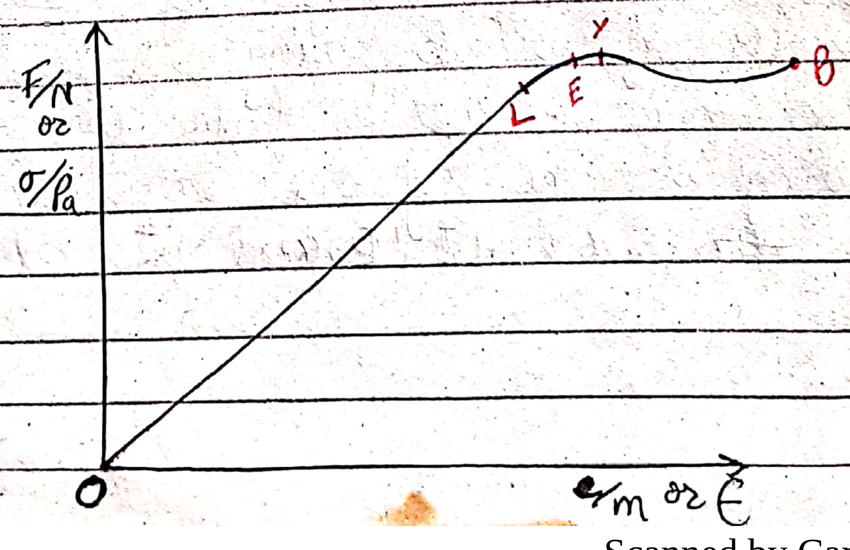
$$E = \left(\frac{F}{e}\right)\left(\frac{L}{A}\right) \cancel{\Rightarrow E =}$$

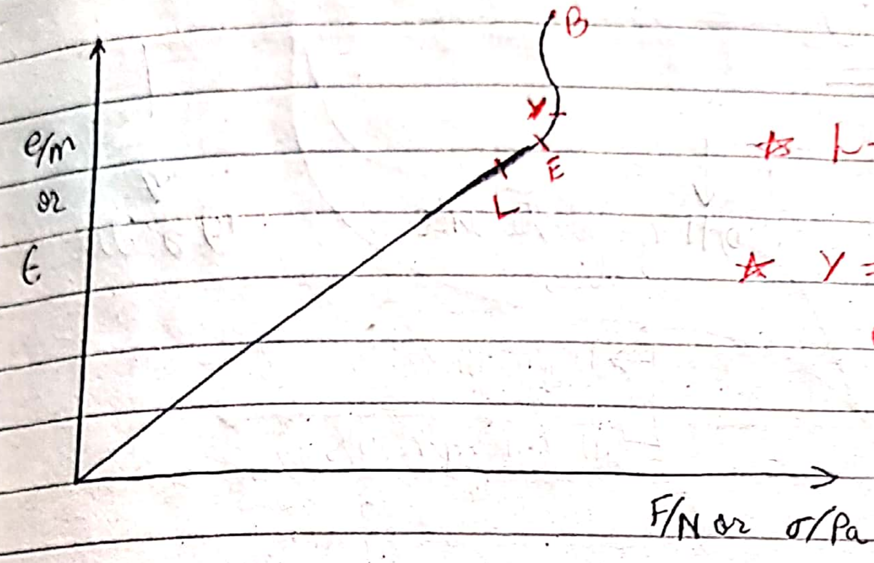
$$\Rightarrow E = (\text{gradient})\left(\frac{L}{A}\right)$$

$$\Rightarrow E = \frac{(\text{gradient})(L)}{\frac{\pi d^2}{4}} = \_\_\_\_\_\_ \text{ Pa}$$

Behavior of a ~~mella~~ metallic wire under stress / tension

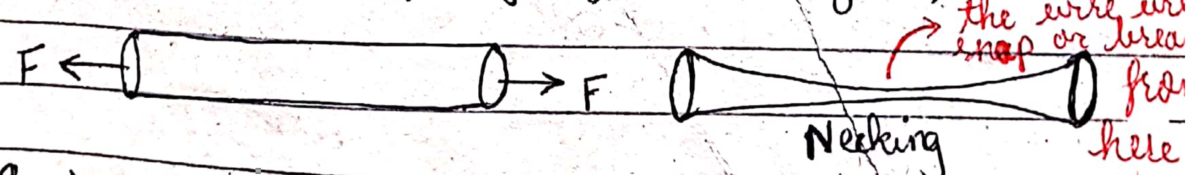






☆ L–E ⇒ curve started
☆ Y ⇒ peak of curve.

* L ⇒ Limit of proportionality (end pt. of straight line from origin)
* OL ⇒ Region where Hooke's law is valid/applicable
* E ⇒ Elastic limit (End point ~~from~~ from where the object return to its original shape and size when applied force is removed from it.
* OE ⇒ Elastic region / Elastic deformation region
* Beyond E ⇒ Plastic region in which an object undergoes permanent deformation and never return to its original shape/size.
* Y ⇒ Yield point (Region from ~~ductile~~ where wire ductile region starts in which a lesser increase ~~in~~ of force causes greater extension i.e necking is the property of this region)



* B ⇒ Ultimate tensile stress / strength pt. of i.e. Breaking pt. of wire

Types of Solids

- a) Crystalline solids
- b) Non-crystalline solids
  - (i) polymers
  - (ii) Amorphous
- (c) Brittle

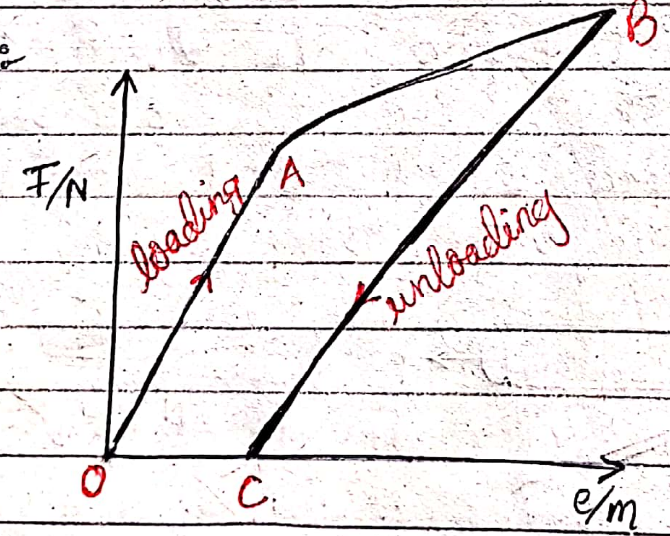
a) Crystalline Solids

* same and uniform pattern throughout structure of solid

Def:-
Solids in which atoms are arranged in a definate geometric pattern ~~throught~~ throughout the lattice structure are called crystalline solids.

Examples:-
All metals and diamond

Graph:-



* Area under OAB ⇒ energy required to stretch a crystalline solid
* Area under BC ⇒ energy recovered from a stretch crystalline solid

* Area of loop OABC ⇒ Energy which can not be recovered and become the internal ~~energy~~ energy of solid.

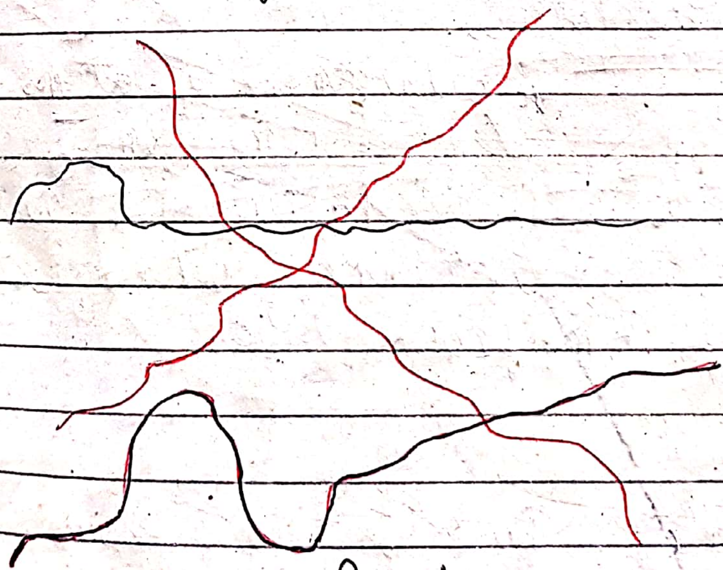
b) (i) Polymers

def:- * particles arranged in tangled format
* in a chain, arragement of atoms regular, same throughout.

Solid in which atoms are arranged in a regu pattern in a long chain, but the arrangemen of atoms in the neighbouring chains is rand

Example:-
nylon, rubber (latex), protein, cellul plastic, pvc, polythene

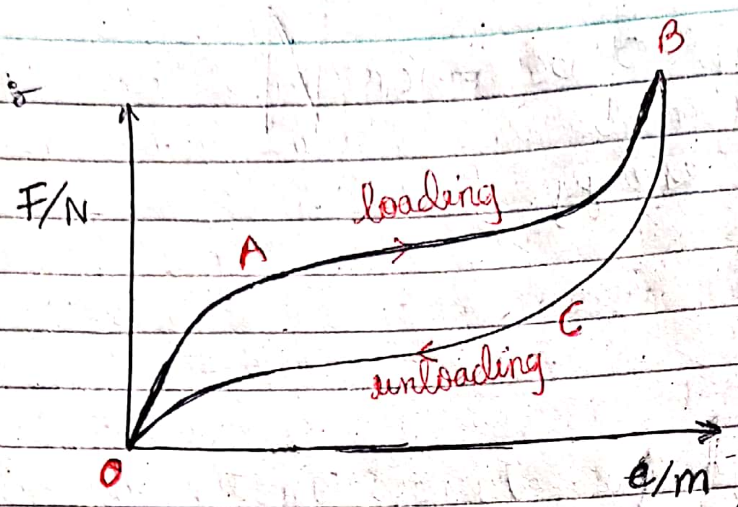
Figure:-



Regular arrangement of atoms in tangled chains of a polymer.

* arrangement of atoms /pattern is uniform in a particular chain, but different chains (neighbouring chains) have different patterns/arrangement of atoms

Graph:-



* Area under OAB => Energy required to stretch a polymer
* Area under BCO => Energy recovered from a stretched polymer
* Area of loop OABC => Energy which can not be recovered and become the internal energy of solid.

b)(ii) Amorphus solids

* arrangement of atoms -> small /short chain format

def:-

~~St~~ Solids in which atoms are arranged in ~~to~~ a tangled manner over short ranges are called Amorphous solids

Examples:-

Talc, Dust particles, flour
(((anything in grinded form)))

* elastic limit ...

→ high compressive strength

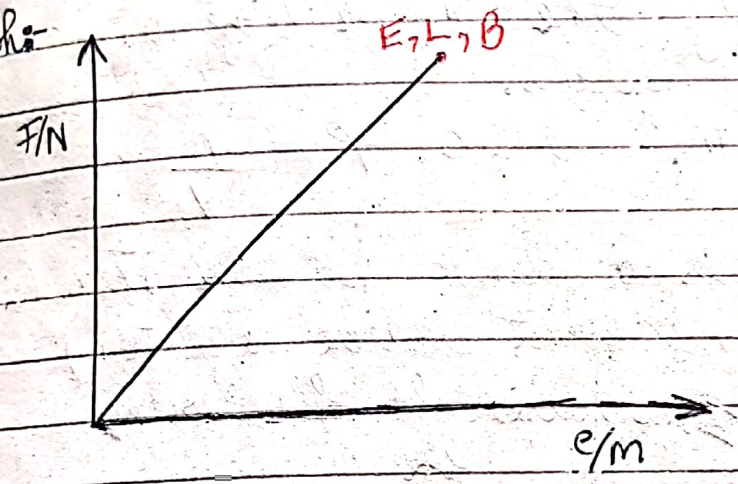
c) Brittle Solids → immediately breaks when their elastic limit exceeds

def:- * a very strong compression

Solids which break ~~tm~~ immediately as its elastic limit is exceeded.

e.g. glass, ~~se~~ ceramics, tile, thigh bone, brick

Graph:-



Note:-

1-) The elastic limit, limit of proportionality & breaking point are nearly at the same point

2-) Brittle solids are very strong under compre... , but break immediately as their elastic li... is exceeded due to small impulsive forc...

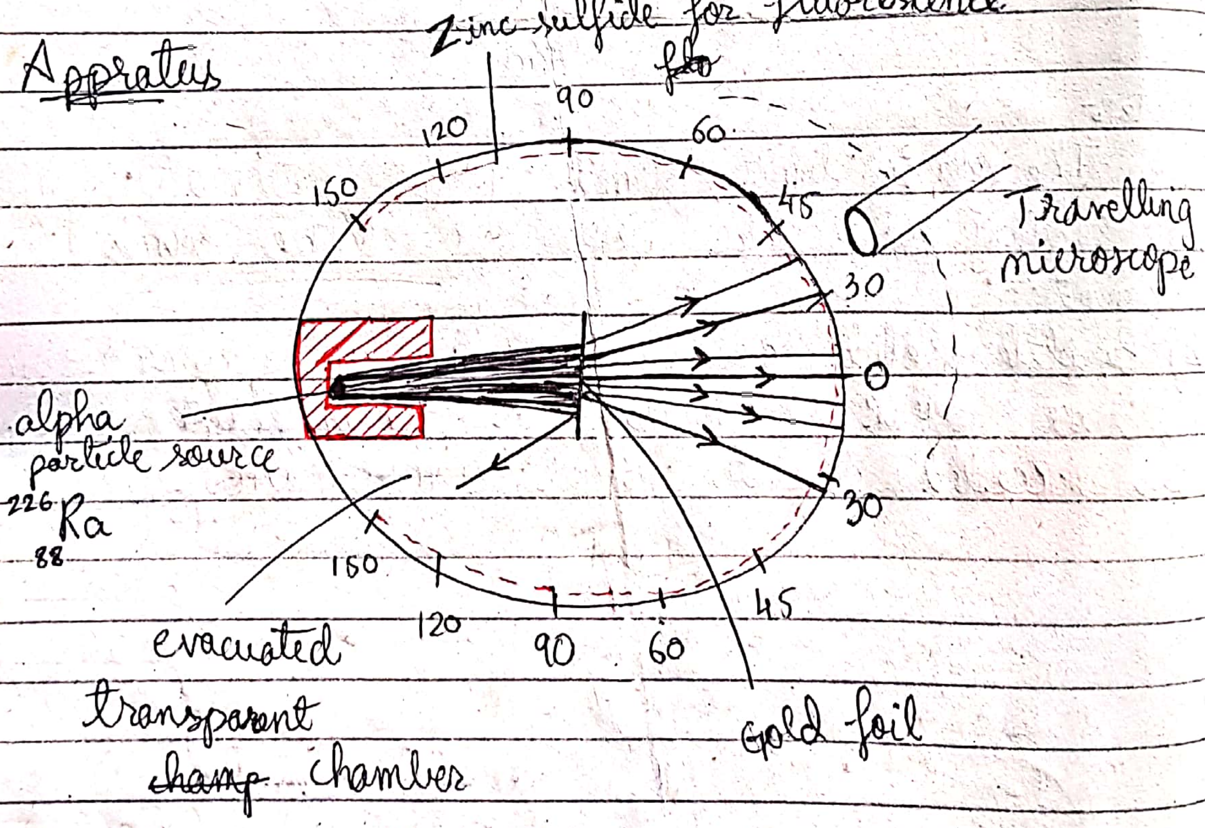
Nuclear Physics

Alpha particle scattering experiment

Significance :-
To study the smaller size and and greater mass of nucleus.
$V\downarrow$ and $m\uparrow$, so $\rho = \frac{m}{V}$

i.e. ~~dense~~ there is a dense ~~nuclear~~ atom (i.e. dense nucleus is present inside an atom)

Appratus



Significance of appratus

(i) α-particle :-

* Alpha particle is a massive particle and does not show any deflection due to orbiting e^- and come closer to gold nucleus (Beta particles shows deflection due to orbiting e^-). ~~and also~~
* Alpha particles have a constant energy, unlike Beta particles. → β has range of E_K
* Gamma rays → have no charge, so simply pass through

(ii) Gold foil is used due to its negligible thickness so that alpha particle can pass through

iii) Lead Block is used so that a ~~colemated~~ collimated beam of alpha particle is directed to the gold foil and absorb random emission of particles

fine beam

) Evacuated chamber :-

An evacuated chamber is taken so that alpha particles do not transfer ~~their en~~ their energy on collision with the gas particles and reach the gold foil with same kinetic energy

(v) Fluorescent wall of Chamber :-

Fluorescence (a small spot of light) occurs ~~at~~ when alpha particles hit on it whose deflection from the gold foil is studied by the angles marked in degrees.

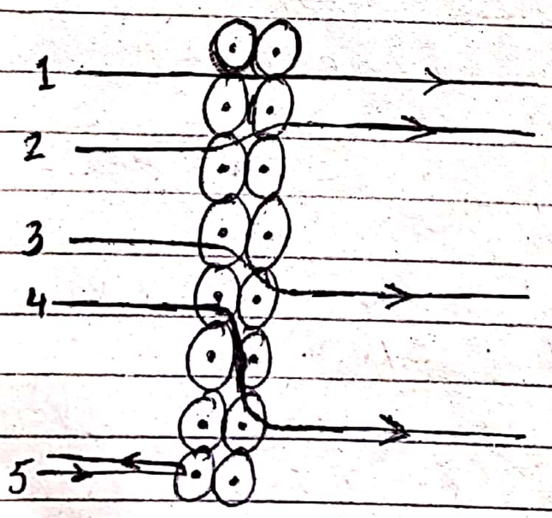
Observation

* most pass with very little deviation.

Most of the alpha particles pass through the foil with very ~~ttl~~ little ~~defection~~ deflection and very few of them are deflected at large angles.

One out of 8000 is deflected at ~~at~~ an angle greater than 90°.

Microscopic View



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

Reasons:-

Reason of deflection is due to similar charges on a nucleus and α - particles. Th angle of ~~deflection~~ deflection is dependant upon the distance of α-particles from Gold nucleus $\left(F \propto \frac{1}{r^2}\right)$

Path 1:-
Resultant force = 0 due to same distance from the nuclei of neighbouring atom

Path 2, 3, 4 :
Greater deflection as $F \propto \frac{1}{r^2}$, F (↑), r (↓)

Path 5:-
α-particle does not carry sufficient energy to ~~cover~~ overcome the electric potential energy and is bounced back.

Result:-

⇒ Smaller size of nucleus :-

★ size of nucleus small → hence α-particle deviates otherwise, it would bounce back

★ Most of the α-particles pass through the foil ~~A~~ with very little ~~deviation~~ deviation, indicate that size of nucleus ~~is~~ is very small, as compared to an atom.

⇒ massive nucleus :-

the concept of applied ~~force~~ here is ~~applied~~

★ light body colliding with massive body

The bouncing back of α-particle indicate that mass ~~of n~~ of nucleus ~~of~~ of gold atom is greater than that of alpha particles.

~~Co~~ ⇒ small and a massive nucleus present inside an atom → conclusion.

Charge no :- It is the no. of protons in the nucleus of an atom.

Symbol :- Z

Mass no. / nucleon no. :-

It is the no. of protons and neutrons in the nucleus of an atom.

Symbol :- A

Formula :- $A = Z + N$ where N ⇒ no. of neutrons

Isotope :-

Nucleids having same charge no. but different mass no. is called isotope.

* only no. of neutrons are different → hence different mass no.

e.g. Hydrogen

	no. of ~~atoms~~ protons	no. of neutron
$^{1}_{1}H$	1	0
$^{2}_{1}H$	1	1
$^{3}_{1}H$	1	2

Nuclide:
An element which is identified by its mass no. and charge no. is called nuclide.

Notation: $^{\text{mass no.}}_{\text{charge no.}}\text{Symbol}$ i.e. $^{12}_{6}C$

Note:-

1-) mass of α - particle $= 4u$
$= 4(1.66 \times 10^{-27}) =$ ______ k

2-) Mass of β-particle $= 9.11 \times 10^{-31}$ kg

-) Electron Volt (eV) is the unit of energy
$1eV = 1.60 \times 10^{-19}$ J $\left(V = \frac{W}{Q} \Rightarrow W = VQ \right.$
$1.6 \times 10^{-19} = (1V)(1e^{-})$

1-) There is no change in the mass no., charge no., mass and energy in any nuclear reaction i.e. all are conserved in a nuclear decay.

Nuclear Reaction

Alpha decay (α, ${}_{2}^{4}He$) :-

→ helium nucleus

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

$${}_{88}^{226}Ra \longrightarrow {}_{86}^{222}Rn + \alpha$$

In alpha decay, the mass and charge no. of daughter nuclide is decreased by 4 and 2 respectively.

Beta decay (${}_{-1}^{0}\beta$ or ${}_{-1}^{0}e$) :-

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

$${}_{38}^{90}St \longrightarrow {}_{39}^{90}Y + {}_{-1}^{0}e$$

In β- decay, the charge of daughter nuclide is increased by 1, but there no change in its mass no.

Gamma decay (γ) :-

$${}_{Z}^{A}X \longrightarrow {}_{Z}^{A}Y + \gamma$$

$${}_{30}^{60}Co \longrightarrow {}_{30}^{60}Co + \gamma$$

(gain energy)

* neutrons excite ↑ to emit γ-rays

In γ-decay, there is no change in the mass no. and charge no. of daughter nuclide.

Radioactivity

def:- The spontaneous and random disintegration of charged particles and rays from the nucleus of ~~unstable~~ unstable nuclide is called ~~radioactive~~ radioactivity.

Explanation:-

→ no effect on decay, if any of these factors are altered.

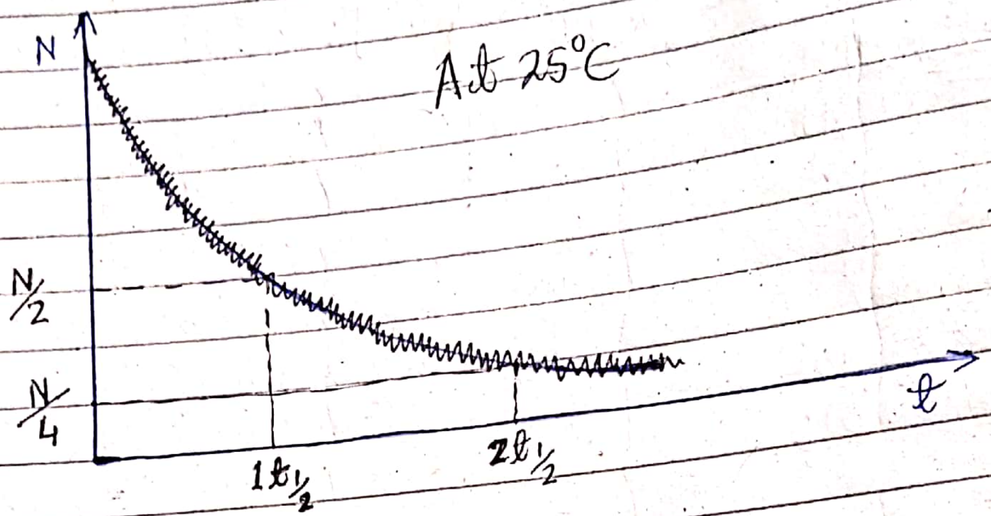
i) Spontaneous:- Independant of any physical condition i.e. temperature, pressure, humidity factor, electric or magnetic field, etc. i.e. decay is independant of above factors.

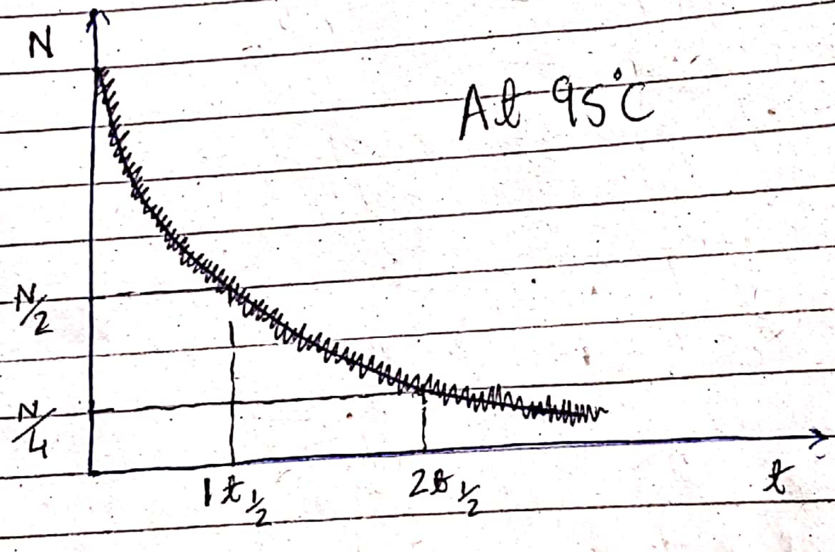
(ii) Random:- Constant probability of decay of a nucleus and is specified by the fluctuations in the decay graph.

iii) Unstable nuclide:- nuclide have lesser binding energy per nucleon are ~~stable~~ unstable.

iv) Radioactive nuclide:- Unstable nuclide which ~~can~~ emit α, β or γ rays is called radioactive nuclide.

* α, β and γ are not radioactive, the source which ~~can~~ emit these is radioactive.



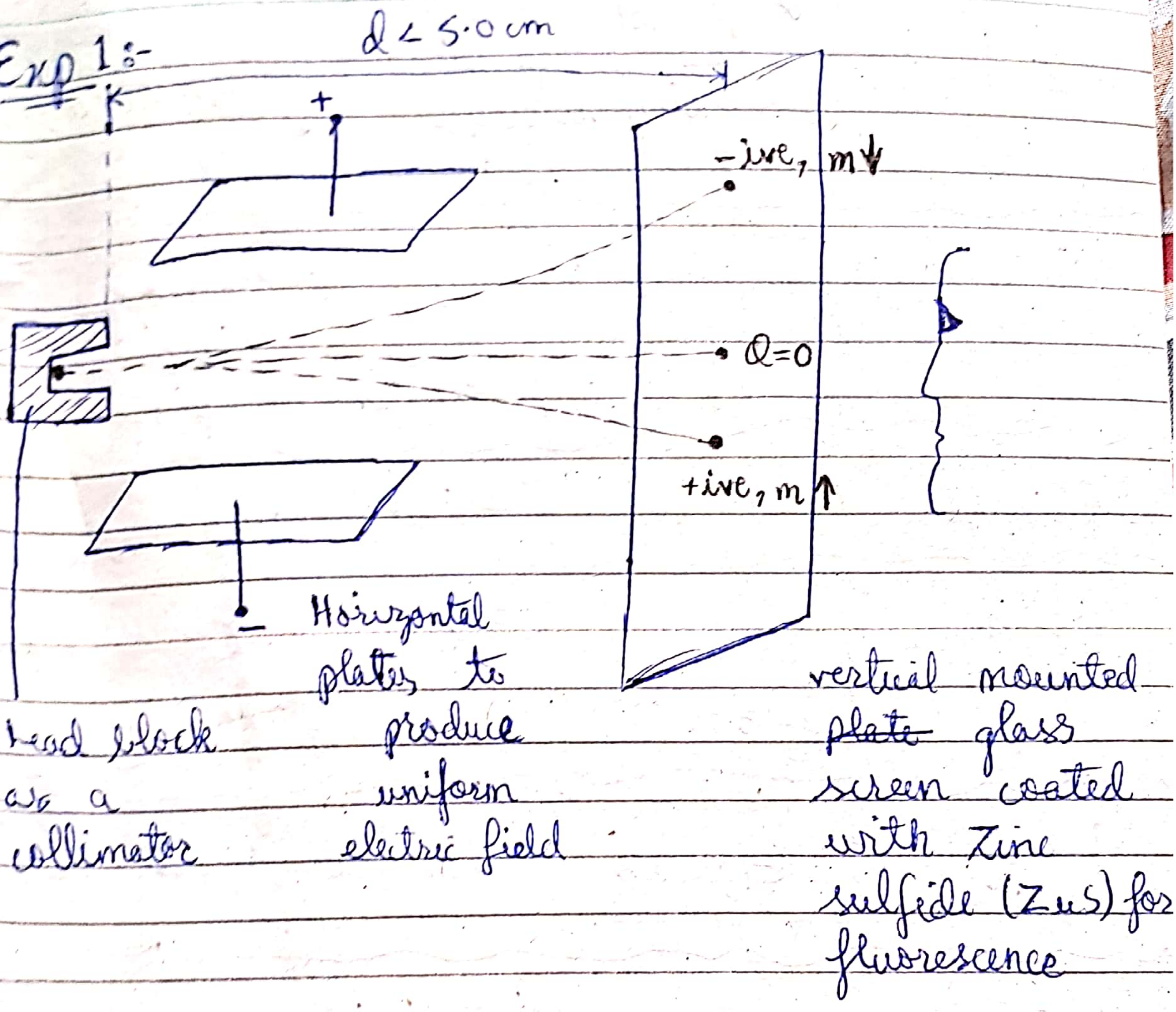


Note:-

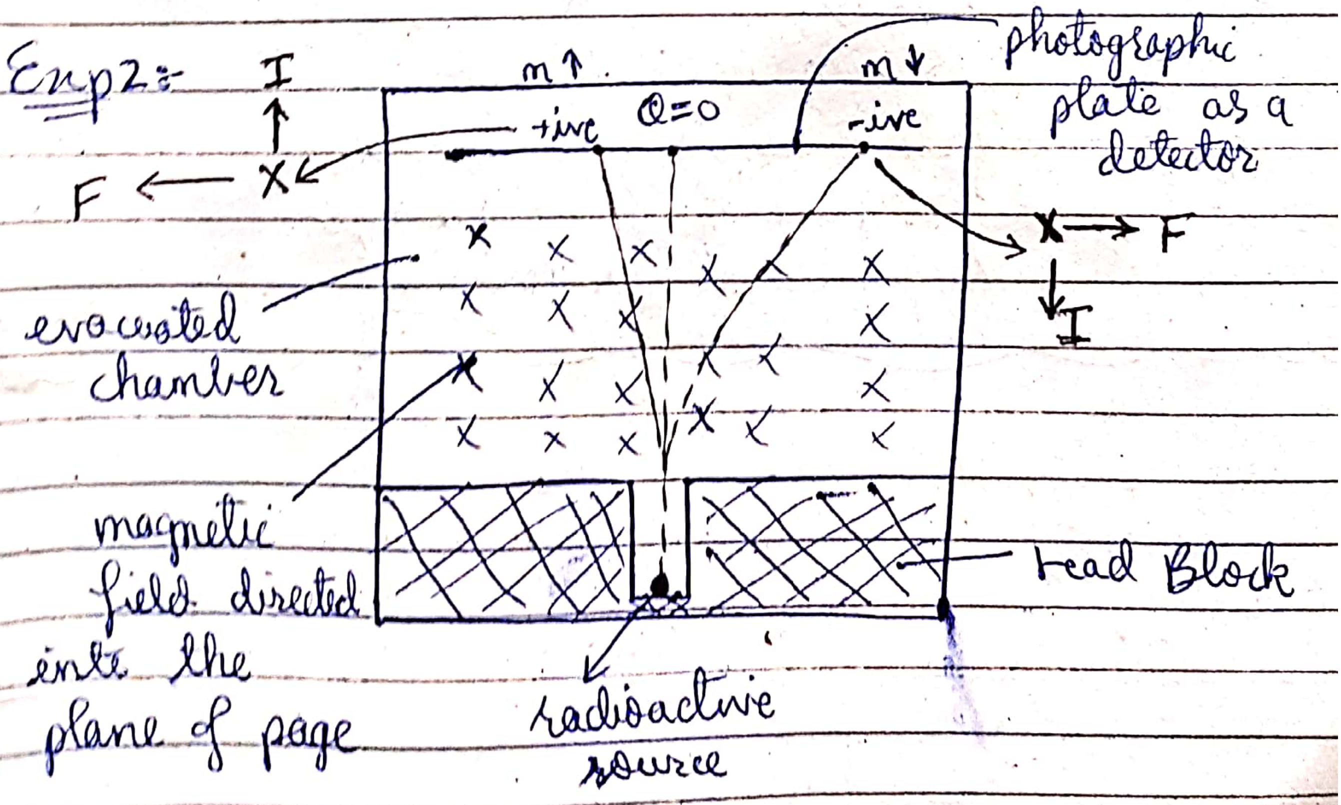
* ~~→ some~~ ⇒ same shape / trend / count rate of graph at different temperatures shows spontaneous nature.

⇒ Fluctuations in decay ~~curve~~ graph curve indicate random nature.

Exp 1:-


d < 5.0 cm
+
-ive, m↓
Q=0
+ive, m↑
-
Lead block as a collimator
Horizontal plates to produce uniform electric field
vertical mounted ~~plate~~ glass screen coated with Zinc sulfide (ZnS) for fluorescence

Exp2:-


I
F ← X
m↑
m↓
+ive
Q=0
-ive
photographic plate as a detector
X → F
I
evacuated chamber
magnetic field directed into the plane of page
Lead Block
radioactive source

Its helium nucleus and not helium atom, since atom is neutral and α is +ive charged. The mass ratio (or simply mass of α-particle and helium nucleus is same thats why we reffer to it as helium nucleus.

Properties:-

Property	α	β	γ
Nature	Helium nucleus	fast moving electron	e.m ray of highest frequency
Charge	+ive	-ive	no charge
Speed	$\frac{1}{10}c$ $\frac{1}{10}(3.0\times10^{8})ms^{-1}$	$\frac{9}{10}c$ $\frac{9}{10}(3.0\times10^{8})ms^{-1}$	c $3.0\times10^{8}ms^{-1}$
Ionising ability	Greatest	Intermediate	Least
Penetration Power	Least 5.0 cm in air blocked by a piece of paper	Intermediate 40.0 cm in air blocked by 1mm Aluminium	Greatest