PYQ - 2023

1) a) $A = (2, 2, -1)$

$B = (6, 3, -2)$

$A \cdot B = |A||B| \cos\theta$

$\cos\theta = \dfrac{12 + 6 + 2}{\sqrt{4+4+1} \cdot \sqrt{36+9+4}} = \dfrac{20}{21}$

$\theta = \cos^{-1}\left(\dfrac{20}{21}\right)$

b) ~~$A \cdot B = |A| \cdot |B| \cos\theta$~~ to be cos. mutually ⊥r

$$A \times B = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 4 & 3 \\ 4 & 2 & -4 \end{vmatrix} = \hat{i}(-16-6) - \hat{j}(-4-12) + \hat{k}(2-16)$$

$= -22\hat{i} + 16\hat{j} - 14\hat{k}$

$= \sqrt{484 + 196 + 256}$

$= \sqrt{936}$

$|A| = \sqrt{16+9+1} = \sqrt{26}$

$|B| = \sqrt{16+4+16} = \sqrt{36} = 6$

$A \times B = |A||B| \sin\theta$

$\sin\theta = \dfrac{\sqrt{26} \times \sqrt{36}}{\sqrt{36} \times \sqrt{26}} = 1$

$\theta = \dfrac{\pi}{2}$ mutually ⊥r

(c) $W = F \cdot dr = (5, 2, 3)(10, 0, 3)$

$= 50 + 9 = 59$ J

484
196
256
936
468
234
117
39
13

36
26
6

(d) $A = 3\hat{i} + 2\hat{j}$, $B = 2\hat{j} - 4\hat{k}$

$$|A \times B| = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 2 & 0 \\ 0 & 2 & -4 \end{vmatrix} = \hat{i}(-8) - \hat{j}(-12) + \hat{k}(6)$$

$$= -8\hat{i} + 12\hat{j} + 6\hat{k}$$

$$|A \times B| = \sqrt{64 + 36 + 144} = \sqrt{344}$$

$$= 2\sqrt{86} \text{ sq. unit.}$$

2	344
2	172
2	86
	43

(e) $|P| = 10$, $|Q| = 1$

$\bar{P} \cdot \bar{Q} = 6 = |P||Q| \cos\theta$ $\quad \cos\theta = \frac{3}{5}$, $\theta = \cos^{-1}\left(\frac{3}{5}\right)$

$\bar{P} \times \bar{Q} = |P||Q| \sin\theta$ $\quad \sin\theta = \sqrt{1 - \frac{9}{25}}$

$= 10 \times 1 \times \frac{4}{5} = 8$ $\quad = \frac{4}{5}$

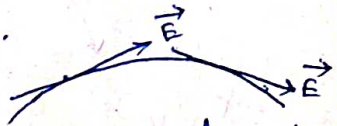
2) (a): **Coulomb's law**:- the force of attraⁿ or repⁿ b/w two charged bodies directly proportional to the product of their charges and inversely proportional to the square of the distance between them.

$F = K\frac{q_1 q_2}{qr}$ $\quad \{F \propto q_1 q_2,\ F \propto \frac{1}{qr}\}$

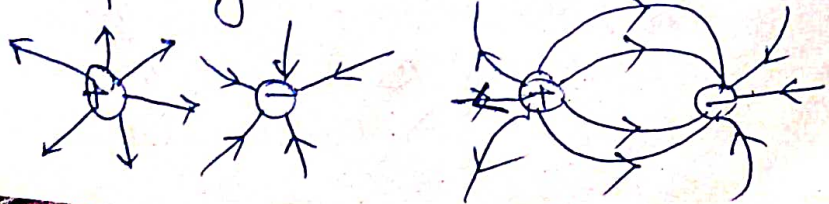
field

(b) properties of electric lines of force :-

An Electric field line is curve drawn in such a way that the tangent to it at each pt is in the direction of the net field at that pt.



(1) $\vec{E}$ lines are continious curves, they start from a +vely charged body and end at a -vely charged body. If there is a single charge then the field lines may start or end at infinity.



(2) $\vec{E}$ lines do not formed continious closed loops. (as they exist inside a charged body)

(3) tangent at any pt gives $\vec{E}$ Intensity direcⁿ of at that pt.

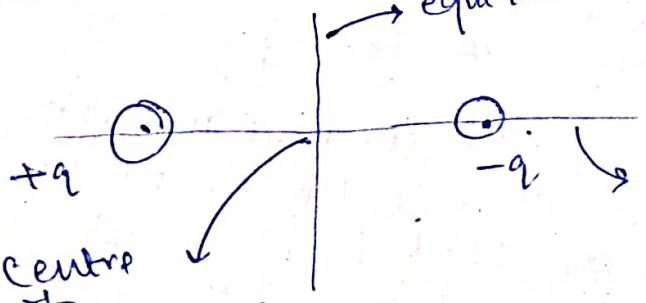
(4) No two $\vec{E}$ lines can Intersect each other.

(c) Gauss law :- the total Electric flux passing over a closed surface in vacuum is $\frac{1}{\varepsilon_0}$ times of the total charge inside the surface.

$$\phi_{net} = \oint \vec{E} \cdot d\vec{s} = \frac{q_{in}}{\varepsilon_0}$$

$$\varepsilon_0 = 8.85 \times 10^{-12} \ C^2/Nm^2$$

(d) Electric dipole :- It is a system of two pt charges which are equal in magnitude but have opp. nature and are separated by a small distance.

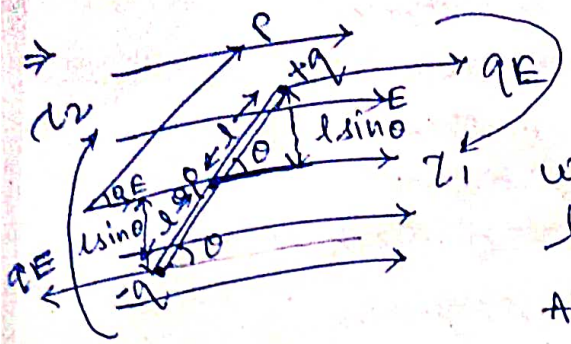


The total flux passing through a closed surface in vacuum is $\frac{1}{\varepsilon_0}$ times the total charge inside the surface

$$\oint \vec{E} \cdot d\vec{s} = \frac{q}{\varepsilon_0}$$

(e) Torque on an Electric dipole placed in a uniform $\vec{E}$.

$F_{net} = 0$ Always | Translational eqm



two equal and opp. forces which do not have same line of action ⇒ Rotate About COM.

Torque = F × ⊥d (b/w F and axis of rotation)

$\vec{\tau} = \vec{\tau_1} + \vec{\tau_2}$

$= F \times \perp d + F \times \perp d$

$= qE\, l\sin\theta + qE\, l\sin\theta$

(clockwise) clockwise

$= 2qE\, l\sin\theta = q(2l)E\sin\theta$

$\vec{\tau}_{net} = p E \sin\theta$ | $\theta \rightarrow$ angle b/w dipole moment and $\vec{E}$.

↓ dipole moment

$= \vec{p} \times \vec{E}$ as same as the direction of torque.

(clockwise)

3(a) Central force :- If a force acting on particle such a way that it is always directed towards or away from a fixed pt and its magnitude depends only on distance ($\vec{r}$) from the fixed pt, then it is said to be central force.

e.g. {Centripital force / centrifugal} {Gravitational / Electrostatic / spring force}

characteristics of central force:-

(1) Radial direcⁿ:- the force acts along the line joining the center and the object, which is also known as radial direcⁿ. this means the force either attracts or repels the object toward or away from the center.

(2) magnitude depends on distance:- mag of the ~~center and~~ central force depends solely on the distance b/w the obj and center of force.

(3) conservative force :- central forces are typically conservative, means the work done by the force in moving an obj ~~b/w and center of force. mathematically it is often expressed as~~ ∈ b/w two pts is independent of the path taken. the total mech. energy (PE + KE) of the system is conserved.

* Areal velocity the rate of change of Area wrt time is known as areal velocity, $v_a = \frac{dA}{dt}$, (m^2/s) unit.

* physical significance of the cross product :-

Magnitude of cross product of two vectors is equal to the area of the llogram whose two adjacent sides are represented by these two vectors.

(4) · Stoke's law :- $F = 6\pi\eta a v$

The viscous force on a moving obj inside a fluid depends upon -

(i) shape and size of obj
(ii) speed of obj
(iii) viscosity of fluid

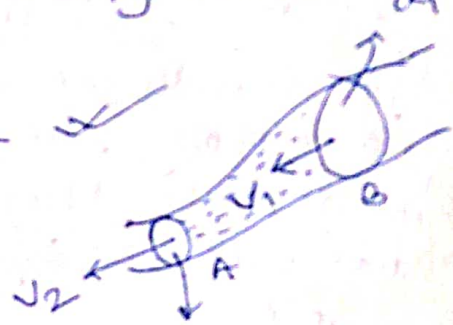
* diff b/w streamline flow / laminar flow

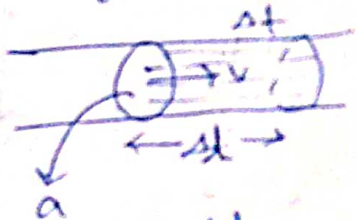
Streamline flow	Laminar flow
2) Layers are streamlined	1) Laminar flows are regular 2) Layers are parallel
3) R_n < 1000 or 2000	3) R_n < 2000
	4) viscosity plays Imp role
5) the flow is steady (less than critical velocity)	5) velocity slow

* Equation of continuity :-

the rate of flow from A and B will be same irrespective of their area

$$a_1 v_1 = a_2 v_2$$





rate of flow $= \frac{a\Delta l}{\Delta t} = aV$

Reynold number :- Ratio of initial force and viscous force -

→ used to determine the type of floco pattern while flowing through a pipe.

laminar : $R_n < 2000$

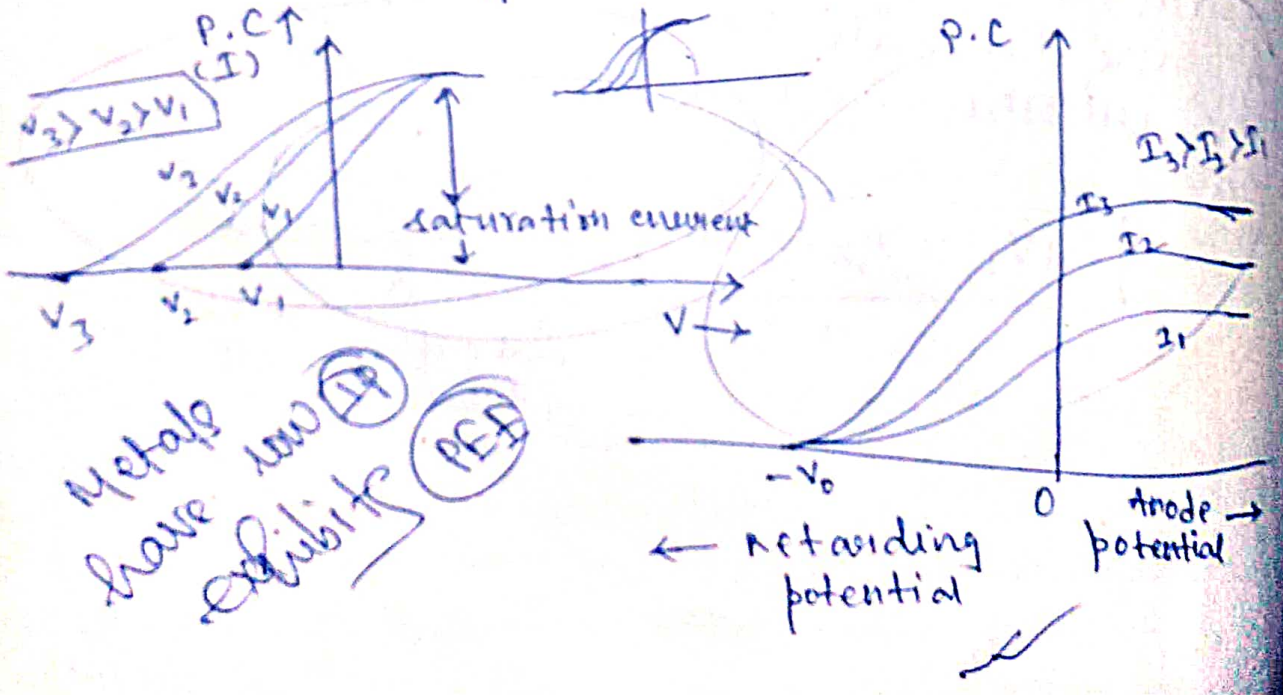
turbulant : $R_n > 2000$

Bernouli's theorem :- For a perfect incompressible liq., flowing in a continious stream, the total energy of a particle remains the same, while the particle moves from one part to another.

applications :- 1) venturi meter
2) pitot tube
3) orifice meter

$\frac{v^2}{2g} + \frac{p}{\rho g} + z = \text{const.}$

5) (a) photo electric effect :- when light of sufficiently small wavelength is incident on a metal surface, electrons ejected from the metal, this phenomenon is called photo electric effect.



metals have low ionization potential exhibits photo electric effect.

* Heiseberg's uncertainity principle :-

It is Impossible to calculate momentum and position of particle like $\bar{e}$ simultaneously, and accurately.

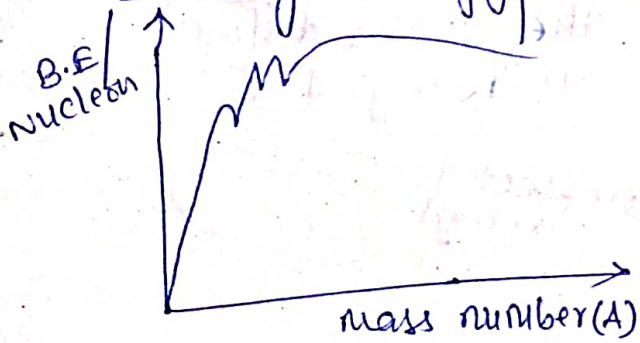
$$\Delta x \times \Delta p \geq \frac{h}{4\pi}$$

* significance of ψ in schrodinger's wave eqn

ψ represents amplitude of the wave -

6) Binding energy of a nucleus :- the nucleons are bound together in a nucleus and energy must be supplied to the nucleus to separate the constituent nucleons to large distances, the amnt of energy needed to do this is called binding energy of nucleus.

* Binding energy/ nucleon: Binding energy divided by the mass number



$$R = R_0 A^{\frac{1}{3}}$$

↳ Relⁿ b/w mass no. and radius of nucleus

*. what is nuclear reactor?

⇒ Device used to initiate and control a fission or fusion rxns. are used to generate electricity in nuclear power plants.

^{60}Co : Radiation therapy to prevent cancer

^{24}Na : study blood circulation

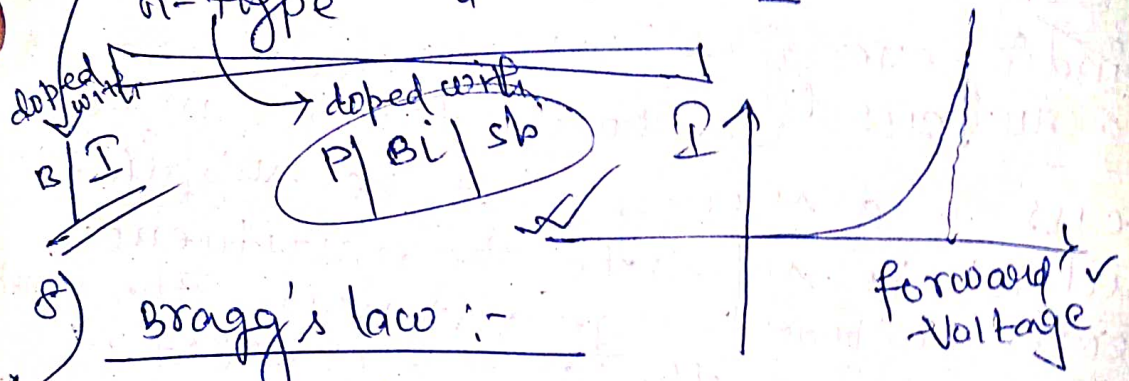
^{3}H : diagnosis used for water content of the human body.

7) Doping done in semiconductor :-

to control the conductivity of the semiconductor and to change the number of charge carriers.

p-type semiconductor —

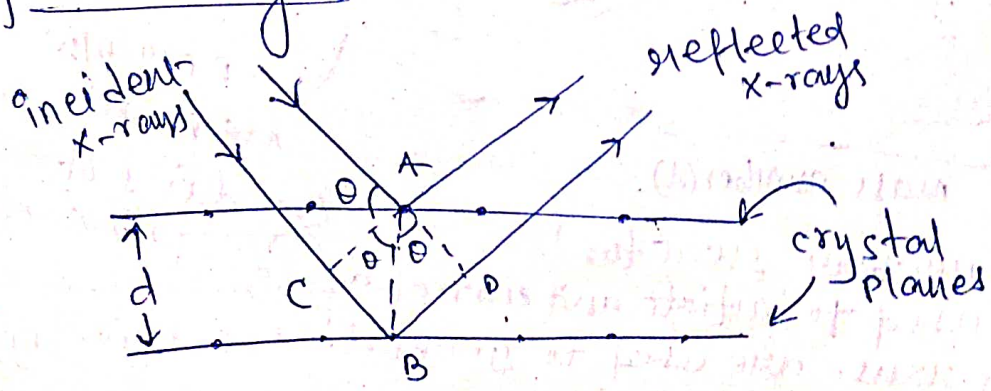
n-type " —



8) Bragg's law :-

* the x-ray diffracted from atoms in crystal planes obey the laws of reflection

* the two rays reflected by successive planes will be in phase if the extra distance travelled by the IInd ray is an integral no. of wavelengths.



$CB + BD = n\lambda$ — (1)

$CA = BD$

in $\triangle ABD$, $\sin\theta = \frac{AB}{BD}$

$CA = BD = AB \sin\theta$

$n\lambda = 2AB \sin\theta \Rightarrow 2d \sin\theta = n\lambda$

* $\lambda = 100 \text{ Å} = 100 \times 10^{-10} = 10^{-8}$ m

$\theta = 90°$

$n = 1$

$2 \times d \times 1 = 1 \times 10^{-8}$

$d = \frac{10^{-8}}{2}$ m

* mathematically, moseley's law

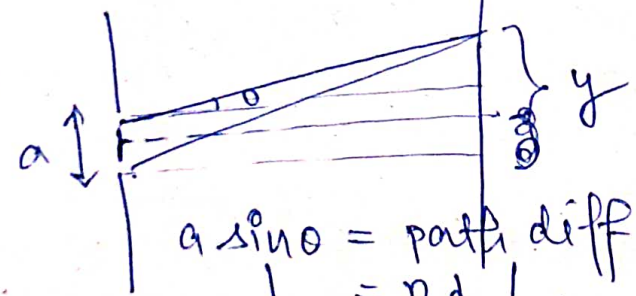
$\sqrt{\nu} = a(Z - b)$; Z: Atomic no. of target

a, b const. ν: freq. of characteristic spectrum

proportionality const. screening const.

* | Diamagnetism | Paramagnetism | Ferromag.

Q)

a) 

$a \sin\theta$ = path diff $= n\lambda$

$\Rightarrow a\theta = n\lambda$

$\Rightarrow \theta = \frac{n\lambda}{a}$

$\frac{y}{D} = \tan\theta = \theta$

$y = D\theta = \frac{n\lambda D}{d}$

↓ posn of maxima

If $d \uparrow$ ed $\omega \downarrow$ ed thinner fringes

fring width (diff b/w maxima) $= \frac{\lambda D}{d} = \omega$

FET :- when one diffracted wave is matched to the Bragg condition in a wedge-shaped crystalline specimen with a const. orientation, both the bright filed Image and dark filed Image of this specimen exhibit periodic fringes depending on the change of the thickness, this pattern is termed FET

e.g. Necoton's Rings.

* yes, knife edge diffrac^{n} occurs without Interference

* In case of thin film interf. the pheno, of Interf. happens without diffrac^{n}

** out of syll.

16)

Central force (Rakiba mam)

$f = (2xy + z^3)\hat{x} + x^2\hat{y} + 3xz^2\hat{z}$ is a conservative force field, find the potential.

$$\Rightarrow \quad \nabla \times f = \begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 2xy+z^3 & x^2 & 3xz^2 \end{vmatrix} = 0 \quad -(1)$$

Since it represent conservative force field, therefore

$$f = ((2xy+z^3), x^2, 3xz^2) = -\nabla V$$

$$= -\left(\hat{x}\frac{\partial V}{\partial x} + \hat{y}\frac{\partial V}{\partial y} + \hat{z}\frac{\partial V}{\partial z}\right)$$

$$\frac{\partial V}{\partial x} = 2xy + z^3 \quad (2) \qquad -\frac{\partial V}{\partial y} = x^2 \quad (3) \qquad -\frac{\partial V}{\partial z} = 3xz^2 \quad (4)$$

from (2) Integrating wrt 'x', $y, z \to$ const.

$$-V = x^2y + z^3x + g(y,z) \quad -(5)$$

clearly $g(y,z)$ can't be func^n of x, now,

$$-\frac{\partial V}{\partial y} = x^2 + \frac{\partial g}{\partial y}(y,z) \quad -(6)$$

comparing (6) and (3) $\quad \frac{\partial g}{\partial y}(y,z) = 0$

therefore 'g' is not a func^n of y, hence from eq (5)

$$-V = x^2y + z^3x + g(z) \quad -(7)$$

which gives $\quad -\frac{\partial V}{\partial z} = 3z^2x + \frac{dg}{dz} \quad -(8)$

comparing (8) with (4) $\frac{dg}{dz} = 0$, therefor g is const.

$$\boxed{V = -x^2y - xz^3 + c}$$

$c = -g$ is const.

P.T $F = r^3 r$ is conservative.

$$F = \hat{r}\, r^3 + \hat{\theta}(0) + \hat{\varphi}(0)$$

$$\nabla \times F = \frac{1}{r^2 \sin\theta} \begin{vmatrix} \hat{r} & r\hat{\theta} & r\sin\theta\,\hat{\varphi} \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \varphi} \\ r^3 & 0 & 0 \end{vmatrix} = 0$$

$\therefore$ F is a conservative force field

$$F = r^3 \hat{r} = -\nabla V = -\left[\hat{r}\frac{\partial V}{\partial r} + \hat{\theta}\frac{\partial V}{r\partial \theta} + \hat{\varphi}\frac{1}{r\sin\theta}\frac{\partial V}{\partial \varphi}\right]$$

$$-\frac{\partial V}{\partial r} = r^3$$

$-V = \frac{1}{4} r^4 + c_4$, therefore the corresponding scalar potential is

$$V = -\frac{1}{4} r^4 - c_4 \quad | \quad c_4 \rightarrow \text{arbitrary constant}$$

Any force is called central force when it is always directed towards or away from a fixed pt and whose magnitude depends only on the distance b/w the center and particle $f(\vec{r}) = f(r)\hat{r}$ ✓

classical Mechanics - Physics

central force :- Any force is called central force when it's always directed towards or away from a fixed point.

* The magnitude of force depends upon the distance from centre of force to the particle.

* mathematical expression :-

$$\vec{f}(\vec{r}) = f(r) \cdot (\pm \hat{r})$$

"jahan vi 'r' ki terms rahegi wo central force hogi"

$\hat{r}$ = unit vector along position vector

$+\hat{r}$ = central force will be repulsive force

$-\hat{r}$ = " " " " attractive ($\vec{G}$)

the motion of particle under central force is always in a plane - (show that)

$$\Rightarrow \quad \vec{F}(\vec{r}) = f(r)\,\hat{r}$$

vector multiplication of $\vec{r}$ on both side

$$\vec{r} \times \vec{F}(\vec{r}) = \vec{r} \times f(\vec{r})\hat{r} \quad \text{--(i)}$$

$\hat{r} = \frac{\vec{r}}{|r|}$

$\vec{r} = \hat{r}|r|$

we know, $\hat{r} = \frac{\vec{r}}{|r|} \Rightarrow \vec{r} = |r|\hat{r}$ --(ii)

from eqn (i) and (ii)

$$\vec{r} \times \vec{F}(\vec{r}) = |r|\,\hat{r} \times f(r)\,\hat{r}$$

$$\vec{r} \times \vec{F}(\vec{r}) = |r|\,f(r)\,[\hat{r} \times \hat{r}] \quad \text{and} \quad [\hat{r} \times \hat{r}] = 0$$

$$\Rightarrow \boxed{\vec{r} \times \vec{F}(\vec{r}) = 0} \quad \text{--(iii)}$$

If mass of particle is define by 'm' then by IInd law of Newton, $\vec{F} = m\vec{a}$

$$= m\frac{d^2(\vec{r})}{dt^2} \quad \text{--(iv)}$$

Put the value of $\bar{F}$ from (iv) in (iii)

$$\bar{r} \times m \frac{d^2 r}{dt^2} = 0$$

$$m\left[\bar{r} \times \frac{d^2 \bar{r}}{dt^2}\right] = 0 \quad ; \text{ we know, } m \neq 0$$

$$\boxed{\bar{r} \times \frac{d^2 \vec{r}}{dt^2} = 0} \quad \text{—(v)}$$

$$\boxed{\left[\bar{r} \times \frac{d^2 r}{dt^2}\right] = \frac{d}{dt}\left[\bar{r} \times \frac{d\bar{r}}{dt}\right]} \quad \text{—(vi)}$$

as $\frac{d}{dt}\left[\bar{r} \times \frac{d\bar{r}}{dt}\right] = \frac{d\bar{r}}{dt} \times \frac{d\bar{r}}{dt} + \bar{r} \times \frac{d^2 \bar{r}}{dt^2}$

$$= \left(\bar{r} \times \vec{\bar{r}}^{\,0}\right) + \vec{r} \times \frac{d^2 r}{dt^2}$$

$$= \bar{r} \times \frac{d^2 r}{dt^2}$$

from (i), (vi) $\quad \frac{d}{dt}\left(\bar{r} \times \frac{d\bar{r}}{dt}\right) = 0$

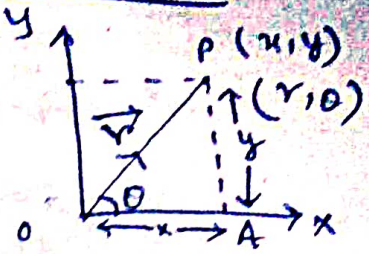
as diff is 0, so $\left(\bar{r} \times \frac{d\bar{r}}{dt}\right) = \text{const} = \vec{c}$

this is time Independent.

↓ const. vector which is $\perp^r$ to the plane made by $\bar{r}$ and $\frac{d\bar{r}}{dt}$.

So motion of particle under central force is always in a plane.

Eqn of motion under central force -



xy-plane

(r,θ)
(r,θ,φ)

→ by ΔOAP ; $\cos\theta = \frac{x}{r}$

$$x = r\cos\theta \quad \text{——(i)}$$

similarly, $y = r\sin\theta$ ——(ii)

$\bar{a} = a_x\hat{i} + a_y\hat{j}$ —(iii) [acceleration, in r-direction and θ-direction]

$\bar{a} = a_r\hat{r} + a_\theta\hat{\theta}$ —(iv)

$a_x = \frac{d^2x}{dt^2}$, $a_y = \frac{d^2y}{dt^2}$

⇒ diff. wrt time eq (i) and (ii)

$$\frac{dx}{dt} = \frac{dr}{dt}\cos\theta + r(-\sin\theta)\frac{d\theta}{dt}$$

similarly, $\frac{dy}{dt} = \frac{dr}{dt}\sin\theta + r\cos\theta\frac{d\theta}{dt}$

Now, $a_x = \frac{d^2x}{dt^2} = \frac{d^2r}{dt^2}\cos\theta + \frac{dr}{dt}(-\sin\theta)\frac{d\theta}{dt} - \frac{dr}{dt}\sin\theta\frac{d\theta}{dt}$

$$- r\cos\theta\left(\frac{d\theta}{dt}\right)\left(\frac{d\theta}{dt}\right)$$

$$a_x = \frac{d^2r}{dt^2}\cos\theta - r\sin\theta\frac{d^2\theta}{dt^2}$$

$$- 2\sin\theta\left(\frac{dr}{d\theta}\right)\left(\frac{d\theta}{dt}\right) - r\cos\theta\left(\frac{d\theta}{dt}\right)^2 - r\sin\theta\frac{d^2\theta}{dt^2}$$

$$a_y = \frac{d^2y}{dt^2} = \frac{d^2r}{dt^2}\sin\theta + \frac{dr}{dt}\cos\theta\frac{d\theta}{dt} + \frac{dr}{dt}\cos\theta\frac{d\theta}{dt}$$

$$- \sin\theta\left(\frac{d\theta}{dt}\right)^2 r + r\cos\theta\frac{d^2\theta}{dt^2}$$

$$= \frac{d^2r}{dt^2}\sin\theta + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\cos\theta - r\sin\theta\left(\frac{d\theta}{dt}\right)^2 + r\cos\theta\frac{d^2\theta}{dt^2}$$

put a_x, a_y in (iii)

$$\vec{a} = \frac{d^r r}{dt^r}\{\cos\theta\left[\frac{d^r r}{dt^r} - r\left(\frac{d\theta}{dt}\right)^r\right] - \left[r\frac{d^r\theta}{dt^r} + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right]\sin\theta\}\hat{i} + \sin\theta\left[\frac{d^r r}{dt^r} - r\left(\frac{d\theta}{dt}\right)^r\right] + \cos\theta\left[r\frac{d^r\theta}{dt^r} + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right]\hat{j}$$

$$\bar{a} = (\cos\theta\hat{i} + \sin\theta\hat{j})\left(\frac{d^r r}{dt^r} - r\left(\frac{d\theta}{dt}\right)^r\right) + (\cos\theta\hat{j} - \sin\theta\hat{i})\left[r\frac{d^r\theta}{dt^r} + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right] \quad \text{(vi)}$$

$$\vec{a} = a_r\hat{r} + a_\theta\hat{\theta} \quad \text{(iv)}$$

comparison (iv) and (vi)

$$a_r = \left[\frac{d^r r}{dt^r} - r\left(\frac{d\theta}{dt}\right)^r\right]$$

$$a_\theta = \left[r\frac{d^r\theta}{dt^r} + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right]$$

$\hat{r} = \cos\theta\hat{i} + \sin\theta\hat{j}$

$\hat{\theta} = -\sin\theta\hat{i} + \cos\theta\hat{j}$

mass of particle 'm', by IInd law $f = ma$

$$\Rightarrow \vec{f} = m\vec{a}.$$

$$\Rightarrow f(r)\hat{r} = m\left[a_r\hat{r} + a_\theta\hat{\theta}\right]$$

by comparing

$ma_r = f(r)$

$ma_\theta = 0$

Eqn of motion :-

$$m\left[\frac{d^r r}{dt^r} - r\left(\frac{d\theta}{dt}\right)^r\right] = f(r)$$

$$m\left(r\frac{d^r\theta}{dt^r} + 2\left(\frac{dr}{dt}\right)\left(\frac{d\theta}{dt}\right)\right] = 0$$

both are eqn of motion

Physics (sugg)

1) $\bar{A} = (4, a, 1)$ if $\perp^r$ to each other
$\bar{B} = (2, -1, -1)$ $\quad \bar{A} \cdot \bar{B} = 0$

$8 - a - 1 = 0 \Rightarrow \boxed{a = 7}$ ✓

if $\parallel$ to each other $\quad \bar{A} \cdot \bar{B} = 1$

$8 - a - 1 = 1$

$\boxed{a = 6}$

2) $\bar{a} \times \bar{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & -2 & 1 \\ 1 & -3 & 5 \end{vmatrix} = \hat{i}(-10+3) - \hat{j}(14) + \hat{k}(-9+2)$

$= -7\hat{i} - 14\hat{j} - 7\hat{k} = \bar{c}$

$\hat{c} = \dfrac{\bar{c}}{|c|} = \dfrac{-7(\hat{i} + \hat{j} + \hat{k})}{\sqrt{3}}$ ✓

$= \dfrac{\hat{i} + \hat{j} + \hat{k}}{\left(\frac{\sqrt{3}}{7}\right)}$ ✓

projection of $\bar{A}$ on $\bar{B}$

$= \bar{A} \cdot \hat{B}$

$= \dfrac{\bar{A} \cdot \bar{B}}{|B|}$

3) $F = (1, 3, -1)$; $\bar{r}_1 = (3, 0, 2)$, $\bar{r}_2 = (1, 1, 1)$

$\tau = \bar{r} \times F$ $\qquad \bar{r}_1 \times \bar{r}_2$

$= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ -2 & -1 & 3 \\ 1 & 3 & -1 \end{vmatrix}$ $= \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 0 & 2 \\ 1 & 1 & 1 \end{vmatrix}$ $= \dfrac{3+6+5}{\sqrt{25+9+1}}$

$= \hat{i}(1-9) - \hat{j}(2-3) + \hat{k}(6+1)$ $= \hat{i}(-2) - \hat{j}(1) + \hat{k}(3)$ $= \dfrac{14}{\sqrt{35}}$

$= (-2, -1, 3)$

$= -7\hat{i} + \hat{j} + 7\hat{k}$; $|\bar{\tau}| = \sqrt{49 + 49 + 1} = \sqrt{99}$ ✓

W = f · distance

$= (1,3,-1)(-2,-1,3)$

$= -2-3-3 = -8$ J

* $\bar{r}_1 \times \bar{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 3 & 0 & 2 \\ 1 & 3 & -1 \end{vmatrix} = \hat{i}(-6) - \hat{j}(-5) + \hat{k}(9)$

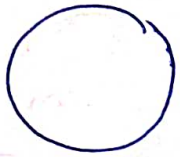
$= (-6, 5, 9)$

$\bar{r}_2 \times \bar{F} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 1 & 1 & 1 \\ 1 & 3 & -1 \end{vmatrix} = \hat{i}(-1-3) - \hat{j}(-1-1) + \hat{k}(3-1)$

$= (-4, 2, 2)$

net $\tau = \sqrt{36+25+81} + \sqrt{16+4+4}$

4)



$m = 25$ kg

$R = 0.2$ m

$\omega = 240$ rpm

$= \frac{240 \times 2\pi}{60}$

$= 8\pi$ rad/s

$\omega_f = \omega_i - \alpha t$

$0 = 8\pi - \alpha \times 20$

$\alpha = \frac{8\pi}{20}$ rad/s^2

20s (given)

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

$T = \frac{2\pi}{\omega} = \frac{1}{4}$

$\tau = I \times \alpha$

$= MR^2 \times \alpha$

$= \frac{25 \times 4}{100} \times \frac{8\pi}{20}$

$= \frac{8\pi}{20}$ N-m

$r \times F = \frac{8\pi}{20}$

$F = \frac{8\pi}{20 \times R} = \frac{8\pi \times 5}{20 \times 1} = 2\pi$ N

$\omega = 240$ rpm $= \frac{240 \times 2\pi}{60} = 8\pi$ rad/s

Energy = Force × distance

$= \tau \times \omega$

$= \frac{28\pi}{20} \times 8\pi = \frac{16\pi^2}{5}$ J

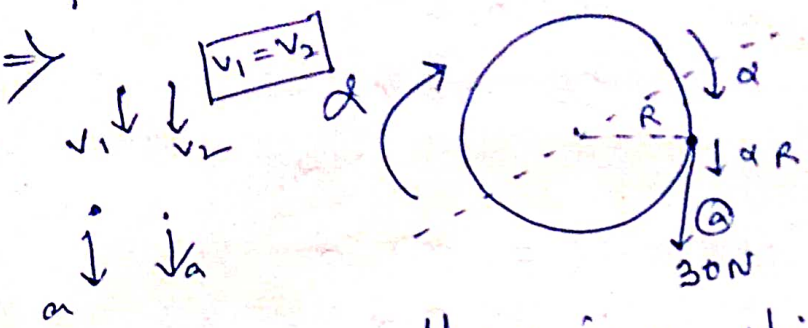
MI

$= MR^2$

$= \frac{2}{5} \times 25 \times 0.2 \times 0.2$

$= 4$ kg m^2

5) A rope of negligible mass is wound around a hollow cylinder of mass 3 kg. and R = 40 cm what is angular acc^n of cylinder if rope is pulled with a force of 30N? linear acc^n of the rope?



$|\vec{\tau}| = r_\perp F$

$|\vec{\tau}| = 30R = I\alpha$

there is no slipping so $\alpha R = a$

$$\alpha = \frac{30R}{I} = \frac{30R}{MR^2} = \frac{30}{MR} = \frac{100}{4} = 25 \text{ rad/s}^2$$

$$a = \alpha R = 25 \times 0.4 = 10 \text{ m/s}^2$$

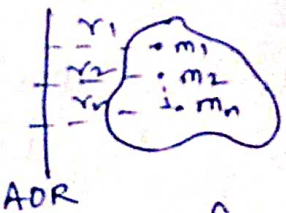
6) **Torque** (τ) is a tendency of a force to rotate the object about some axis. $\vec{\tau} = F \times \perp_d$

Angular momentum O is called Angular momentum. Moment of linear momentum $\vec{L} = rp = mvr$

MOI MOI about a given axis of rotation is the sum of product of mass of its particles and sq. of their distances from the axis of rotation.

$$I = m_1 r_1^2 + m_2 r_2^2 - - - m_n r_n^2$$

$$= \sum_{i=1}^{n} m_i r_i^2$$



Radius of gyration of body about an axis of rotation is the root mean square distance of its particle from the same axis of rotation, $I = MK^2$

ROG $\leftarrow K = \sqrt{\frac{I}{m}}$

$L = I\omega$

we know,

$L = MVr$

$= Mr\omega r$

$= Mr^2\omega$

$= I\omega$

as $mr^2 = I$ (MoI)



$\tau = I\alpha$

we know

$\tau = F \times r$

we know

$F = ma$

By putting

$\tau = mar$

and $a = r\alpha$

so $\tau = mr^2\alpha$

$= I\alpha$

as $I = MoI = Mr^2$ for spherical obj



Stokes law derivation

the viscous force acting on sphere is directly prop to following factors -

i) co-eff. of viscosity $\eta \rightarrow F \propto \eta^a$

ii) Radius of sphere $r \rightarrow F \propto r^b$

iii) velocity of the obj $v \rightarrow F \propto v^c$

combining these —

$F \propto \eta^a r^b v^c$

$F = K \eta^a r^b v^c$

Equating dimensions -

$[MLT^{-2}] = [ML^{-1}T^{-1}]^a [L^b] [LT^{-1}]^c$

$= [M]^a [L]^{-a+b+c} [T]^{-a-c}$

comparing both sides, $a = 1, c = 1, b = 1$

for any spherical body $K = 6\pi$

so $F = 6\pi\eta r v$ (proved)

Photo electric effect: The phenomenon in which electrons are emitted from the metal surface (e.g. Na, K, Cs etc) under the action of light (photon) is called photo electric effect.

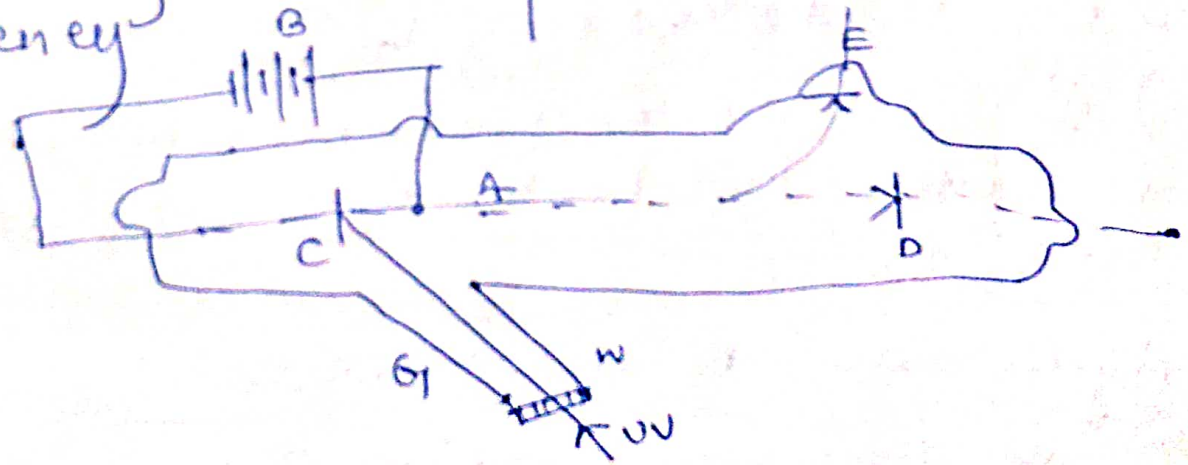
the metals that exhibit photo electric effect are called photosensitive materials and the emitted e^-s are called photo electrons

summarizations of Lenard's experiment:-

1) If the Intensity of UV is ↑ed, it will cost no e^-s to reach A, but if C is made -ve with respect to A, then on ↑ing the intensity of UV, the current ↑es.

2) For constant ~~incident~~ Intensity if the frequency of the incident radiation ↑ed then stopping potential ↑es

3) the photo current is Independent of ~~Intensity~~ frequency but depends on Intensity



Characteristics of photoelectric effect:-

1) there is a certain minimum freq (ν_0) of incident radiation below which there is no emission of photoes, this freq is called threshold freq. which depend on the material and the nature of the emitting surface.

2) for a given freq (ν) ($\nu > \nu_0$) the no. of photoes emitted is for a const. accelarating potential is directly prop to the intensity of the incident radia

3) for freq $\nu > \nu_0$, the velocities of the emitted photoes vary b/w zero and a definite maximum (v_m). the max kinetic energy determined in terms of stopping pot. the stopping potential is independent of incident light.

4) the max vel v_m depends on freq but not on Intensity, v_m ↑es when ν ↑es

5) the emission of photoes is instantaneous no matter how feeble the incident light may be.

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physics by syll checking

1) Definitions/what is?
2) Derivation from all chapters (- all derivation)
3) 2023 PYQ
4) sugg
5) HCV Question/soln
6) Notes + given sugg (in grp)

Physics preparation

1) what is a physical quantity?

⇒ All the quantities which can be measured directly or indirectly in terms of which the laws of physics are described are called physical quantities e.g. scalar | vector

2) Negetive vector and reciprocal vector :-

A vector whose magnitude is same but direction is changed in opposite direc^n

A vector whose direc^n is same but magnitude is changed (Reciprocal)

3) divergent of $\vec{A}$, if $\vec{A} = (3x^2y\hat{i} + 2y\hat{j} + 3yz^2\hat{k})$

$$\Rightarrow \vec{\nabla}\cdot\vec{A} = \frac{\partial}{\partial x}(3x^2y) + \frac{\partial}{\partial y}(2y) + \frac{\partial}{\partial z}(3yz^2)$$

$$= 6xy + 2 + 6yz$$

if $(x,y,z) \equiv (0,1,2)$ then, divergent = 14

4) curl of a vector, $\vec{A} = 3x\hat{i} + 2y\hat{j} + 5z\hat{k}$

$$\vec{\nabla}\times\vec{A} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ 3x & 2y & 5z \end{vmatrix} = \hat{i}\left(\frac{\partial}{\partial y}(5z) - \frac{\partial}{\partial z}(2y)\right)$$

$$-\hat{j}\left(\frac{\partial}{\partial x}5z - \frac{\partial}{\partial z}3x\right) + \hat{k}\left(\frac{\partial}{\partial x}2y - \frac{\partial}{\partial y}3x\right)$$

$$= 0$$

Then $\vec{A}$ is conservative in nature

* if you need to check a vector / force to conservative in nature or not the $(\vec{\nabla}\times\vec{A})$ checking, if it becomes '0' then $\vec{A}$ will be conservative.

5) properties of VDO : vector differential operator

I) $\bar{\nabla} \cdot (\bar{\nabla} \times \bar{A}) = 0$

$\bar{\nabla} \times (\bar{\nabla} \phi) = 0$

$\bar{\nabla} \times (\bar{\nabla} \times \bar{A}) = [\bar{\nabla}(\bar{\nabla} \cdot \bar{A} - \bar{\nabla}\bar{A}]$

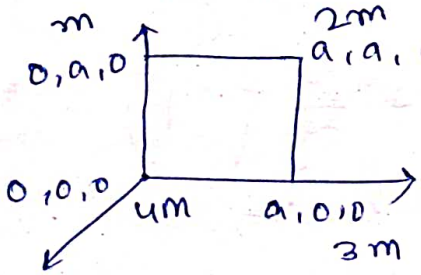
$= \bar{A}(\nabla\nabla - \nabla^2)$

6) COM A pt of a rigid body where whole mass is assumed to be concentrated.

pos^n vector of com $\vec{R} = \frac{\sum m_i r_i}{M}$, as $\sum m_i = M$

$\sum_{i=1}^{r} m_i r_i = \frac{m_1 r_1 + m_2 r_2 + m_3 r_3 \cdots}{M}$

e.g.



COM determining process

$M = m + 2m + 3m + 4m = 10m$

$(X) = \frac{\sum_{i=1}^{4} m_i x_i}{M} = \frac{m_1 x_1 + m_2 x_2 + m_3 x_3 + m_4 x_4}{10m}$

$= \frac{m \times 0 + 2m \times a + 3m \times a + 4m \times 0}{10m}$

$= \frac{a}{2}$

$(Y) = \frac{\sum_{i=1}^{4} m_i y_i}{M} = \frac{m_1 y_1 + m_2 y_2 + m_3 y_3 + m_4 y_4}{10m}$

$= \frac{m \times a + 2m \times a + 3m \times a + 4m \times 0}{10m}$

$= \frac{3}{10} a$

$Z = \frac{\sum_{i=1}^{4} m_i z_i}{M} = \frac{m_1 z_1 + m_2 z_2 + m_3 z_3 + m_4 z_4}{10m}$

$= \frac{m \times 0 + 2m \times 0 + 3m \times 0 + 4m \times 0}{10m} = 0$

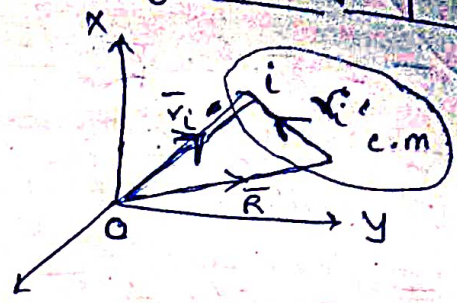
$\bar{R} = \frac{a}{2}\hat{i} + \frac{3a}{10}\hat{j}$, $|\bar{R}| = \sqrt{\frac{a^2}{4} + \frac{9a^2}{100}} = \frac{a\sqrt{34}}{10}$

7) Derive [illegible] of system of particle

$\bar{r}_i = \bar{R} + \bar{r}_i'$

$\frac{d}{dt}(\bar{r}_i) = \frac{d}{dt}(\bar{R} + \bar{r}_i')$

$\vec{v_i} = \vec{v} + \vec{v_i'}$



$\bar{U}_i$ ⇒ velocity wrt origin

$\bar{v}$ = vel wrt COM

$\bar{v}_i'$ = vel of i^{th} particle

$\sum M_i \bar{V}_i = \sum M_i V + \sum M_i v_i' \neq 0$

as $\sum M_i v_i' = 0$, as $\bar{r}_i = \bar{R} + \bar{r}_i'$

$\Rightarrow \bar{r}_i' = \bar{r}_i - \bar{R} \Rightarrow \sum M_i r_i' = \sum M_i r_i - \sum M_i \bar{R}$

$= M\bar{R} - M\bar{R} = 0$

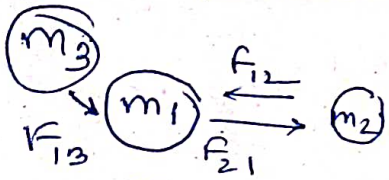
$\sum M_i v_i = \sum M_i \bar{V} = M\bar{V}$

$\boxed{\sum \bar{P}_i = M\bar{V}}$

$\boxed{\bar{P} = m\bar{V}}$

8) $f_{1e} \longrightarrow m_1, m_2 \xrightarrow{f_{2e}} \cdots m_N$

$\bar{r}_1, \bar{r}_2, \cdots \bar{r}_N$



$j \neq i$

Motion of COM

$\bar{f}_{1e} + \sum \vec{f}_{ij} = m_1 \vec{a} = m_1 \frac{d^r}{dt^r}(\bar{r}_1)$

$\bar{f}_{2e} + \sum \bar{f}_{2j} = \frac{m_2 \, d^r(\bar{r})}{dt^r}$

$\bar{f}_{3e} + \sum_{j=1}^{N} f_{ij} = \sum_{i=1}^{N} m_i \frac{d^r}{dt^r}(\bar{r}_i)$

$\sum_{i=1}^{N} \bar{f}_{ie} = \sum m_i \frac{d^r}{dt^r}(\vec{r}_i)$

$\sum_{i=1}^{N} \vec{f}_{ie} = \sum m_i \cdot \frac{d^r r_i}{dt^r}$

$f_e = \frac{d}{dt}(P)$

$f_e = 0$

$\frac{d(P)}{dt} = 0$

P → constant.

$f_e = \sum m_i \frac{d^r r_i}{dt^r}$

$r_i = \frac{d^r}{dt^r} \sum (m_i - \bar{r}_i)$

$= \frac{d^r}{dt^r}\left(\frac{\sum m_i \bar{r}_i}{\sum m_i}\right)$

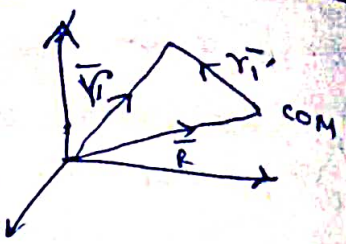
$= \sum M_i \frac{d^r}{dt^r}(\vec{R})$

$= M \frac{d^r}{dt^r} \bar{R} = \frac{M d\bar{v}}{dt}$

$= \frac{d}{dt}(MV) = \frac{d}{dt}(\bar{P})$

9) Angular momentum of system of particles

$$\bar{r}_i = \bar{r}_i' + \bar{R} \quad \text{---(1)}$$



$$\frac{d}{dt}\vec{r}_i = \frac{d}{dt}r_i' + \frac{d}{dt}R$$

$$\bar{v}_i = \bar{v}_i' + \bar{V} \quad \text{---(2)}$$

Ang mom - $\bar{L} = \Sigma (\bar{r}_i \times \bar{p}_i)$

$$\Rightarrow \bar{L} = \sum_i \left(\bar{r}_i' + \bar{R}\right) \times \left(m_i \bar{v}_i\right)$$

$$\Rightarrow \bar{L} = \Sigma \left(\vec{r}_i + \vec{R}\right) \times m_i \left(\vec{v}_i' + \vec{V}\right)$$

$$L = \Sigma \left(\bar{R} \times m_i \bar{V}\right) + \Sigma \left(\bar{R} \times m_i \bar{v}_i\right) + \Sigma \bar{r}_i' * \left(m_i \vec{V}\right) + \Sigma \left(\bar{r}_i' \times m_i \vec{v}_i\right)$$

we know that,

$$\Sigma m_i r_i' = 0$$

$$\Sigma \bar{R} \times m_i \vec{v}_i = R \times \frac{d}{dt} \Sigma m_i \vec{r}_i' = 0$$

and $\Sigma \left(\vec{r}_i' \times m_i \vec{V}\right) = \Sigma m_i \bar{r}_i \times \bar{V} = 0$

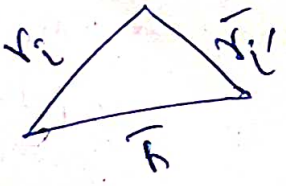
so, we can write,

$$\bar{L} = \Sigma \left(\bar{R} \times m_i \bar{V}\right) + \Sigma \left(\vec{r}_i' \times m_i \vec{v}_i\right)$$

$$= \left(\bar{R} \times m \bar{V}\right) + \Sigma \bar{r}_i \times \vec{p}_i'$$

AM of CM about origin

AM of system of particle about CM



10) Kinetic Energy of system of particles

Let m_i be the mass of the particle.

$\bar{r_i}$ = posⁿ vector of the particle

$\bar{v_i}'$ = velocity of i^{th} particle

$\bar{v_i} = \bar{v_i}' + \bar{v}$

$\bar{r_i} = \bar{r_i}' + \bar{R}$

$dr_i = \frac{dr_i'}{dt} + \frac{d\bar{R}}{dt} \Rightarrow \bar{v_i} = \bar{v_i}' + \bar{v}$

Kinetic energy of system: $KE = \sum_i \frac{1}{2} m_i v_i^2$

$KE = \sum_i \frac{1}{2} m_i (v_i \cdot v_i) = \frac{1}{2} m_i (\bar{v_i}' + \bar{v})(\bar{v_i}' + \bar{v})$

$= \frac{1}{2} \sum_i m_i (v_i'^2 + v^2 + 2 v_i' \bar{v})$

$= \frac{1}{2} \sum_i m_i v_i'^2 + \frac{1}{2} \sum m_i v^2 + \frac{2}{2} \sum m_i (v_i' \cdot \bar{v})$

$= \frac{1}{2} \sum m_i v_i'^2 + \frac{1}{2} \sum m_i v^2 + \bar{v} \frac{d}{dt} (\sum m_i r_i')$

$\sum m_i r_i' = 0$ | $KE = \frac{1}{2} \sum m_i v_i'^2 + \frac{1}{2} \sum m_i v^2$

$= \frac{1}{2} \sum m_i v_i'^2 + \frac{1}{2} M v^2$ ✓

11) What is central force :- If a force acts on a particle such a way that it always directed towards or away from a fixed pt and its magnitude depends only on distance from the fixed pt then it is said to be central force.

e.g. gravitational force e.g. spring force

e.g. electrostatic force

12) properties of central force :-

1) radial direction :- the force acts along the line joining the center and the object which is also known as radial direction. this means the force either attracts or repel the object, towards or away from the center.

2) magnitude depends on distance :- magnitude of the central force depends solely on the distance b/w the object and center of force.

3) conservative force : central forces are typically conservative, means work done by the force in moving an object between two pts is independent of the path taken. The total mechanical energy (PE + KE) of the system is conserved.

$$\boxed{\nabla \times \vec{F} = 0}$$

13) $\vec{F} = (2xy + z^3)\hat{i} + x^2\hat{j} + 3xz^2\hat{k}$

we have to find V ?

$A = (A_x, A_y, A_z)$

$\Rightarrow \vec{F} = -\vec{\nabla} V$

$$(\hat{i}F_x + \hat{j}F_y + \hat{k}F_z) = -\left(\hat{i}\frac{\partial V}{\partial x} + \hat{j}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$$

comparing LHS = RHS

$$F_x = -\frac{\partial V}{\partial x}, \quad F_y = -\frac{\partial V}{\partial y}, \quad F_z = -\frac{\partial V}{\partial z}$$

$F_x = 2xy + z^3$ — (i)

$F_y = x^2$ — (ii)

$F_z = 3xz^2$ — (iii)

Integrating (I)

$$\int -dV = \int (2xy + z^3)\,dx$$

$$-V = \frac{2x^2}{2} y + z^3 x + c(y,z)$$

$$\Rightarrow -V = x^2 y + z^3 x + c(y,z) \quad \text{—(IV)}$$

from (II) $-\frac{\partial V}{\partial y} = x^2$

$$-V = x^2 y + c(x,z) \quad \text{—(V)}$$

from (III)

$$-\frac{\partial V}{\partial z} = 3xz^2 \Rightarrow -V = 3x\frac{z^3}{3} + c(x,y)$$

$$\Rightarrow -V = xz^3 + c(x,y) \quad \text{—(VI)}$$

diff (IV) wrt y

$$-\frac{\partial V}{\partial y} = x^2 + 0 + \frac{\partial}{\partial y}(c(y,z))$$

$$= x^2 + \frac{\partial}{\partial y}(c(y,z))$$

and $-\frac{\partial V}{\partial y} = x^2 + 0$ $\quad \frac{\partial}{\partial y}(c(y,z)) = 0$

wrt z $\quad -\frac{\partial V}{\partial z} = 3z^2 x + \frac{\partial}{\partial z}\{c(y,z)\}$

$$\Rightarrow \frac{\partial}{\partial z}(c(y,z)) = 0$$

$c(y,z) = c$ any const.

$$\boxed{V = x^2 y + z^3 x + c}$$

14) Find out work done -

$W = \int F \cdot dr$

$F = (F_x, F_y, F_z)$

$dr = (dx, dy, dz)$

PT

$\bar{F} \cdot r^2 \hat{n}$ is a conservative force

$$\nabla \times F = \frac{1}{r^2 \sin^2\theta} \begin{vmatrix} \hat{r} & r\hat{\theta} & r\sin\theta\, d\hat{\phi} \\ \frac{\partial}{\partial r} & \frac{\partial}{\partial \theta} & \frac{\partial}{\partial \phi} \\ F_r & rF_\theta & r\sin\theta F_\phi \end{vmatrix}$$

conservative proof $= 0$

---

15) General wave equation :-

$$\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2}, \quad y(x,t) = y(x \pm vt)$$

⇓ prove it !

16)

$y(x,t) = A \sin[k(x \pm vt)]$

$\frac{dy}{dx} = A \frac{d}{dx}[\sin k(x \pm vt)]$

$= A \cos[k(x \pm vt)] \frac{d}{dx}(kx \pm vt)$

$= Ak \cos(kx \pm kvt)$

$\frac{d^2y}{dx^2} = -Ak^2 \sin(kx \pm kvt)$

$= -k^2 y$ — (i)

$\frac{dy}{dt} = A \frac{d}{dt}(\sin(kx \pm kvt))$

$= A \cos(kx \pm kvt) \frac{d}{dt}(k(x \pm vt))$

$= \pm kvA \cos(kx \pm kvt)$

$\frac{d^2y}{dt^2} = -k^2 v^2 A \sin k(x \pm vt)$

$= -k^2 v^2 y$ — (ii)

$$\frac{\frac{d^2y}{dx^2}}{\frac{d^2y}{dt^2}} = \boxed{\frac{d^2y}{dx^2} = \frac{1}{v^2}\frac{d^2y}{dt^2}}$$ Proved

light travelling in any medium or ether

State huygen's principle :-

I) Light travels in the form of wave in an imaginary medium, called ether.

II) Secondary wavelet theory :-

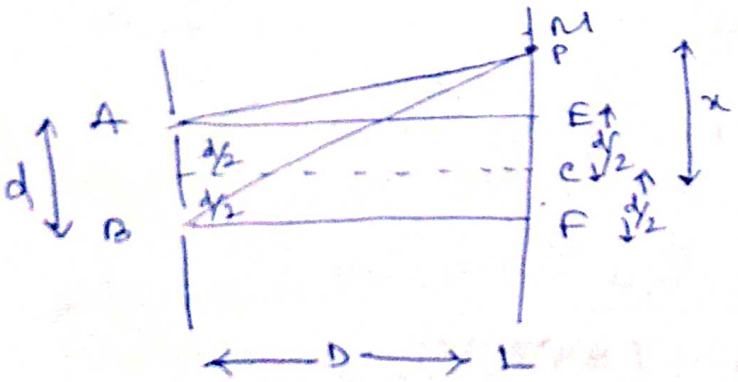
a) When a disturbance is produced, particles of medium starts vibrating.

b) surface in a medium on which particles vibrate in same phase is called wavefront.

c) Every pt on given wavefront may be regarded as fresh source of disturbance and produces its own wavelets called secondary wavelet.

d) when medium is homogeneous then secondary wavelets spread with same speed in all direction.

e) Explain YDSE :- (expression for fringe width in YDSE)



A, B two coherent sources at distance 'd' let us choose any pt P at height 'x'

Path diff = BP − AP —(1)

In ΔBPF

$$BP^2 = BF^2 + PF^2$$

$$BP = \sqrt{BF^2 + PF^2}$$

$$= \sqrt{D^2 + (PC + CF)^2}$$

$$= \sqrt{D^2 + \left(x + \frac{d}{2}\right)^2}$$

$$= \left(D^2 + \left(x + \frac{d}{2}\right)^2\right)^{1/2}$$

$$= \left[D^2\left(1 + \frac{\left(x + \frac{d}{2}\right)^2}{D^2}\right)\right]^{\frac{1}{2}} = D\left[1 + \left(\frac{x + \frac{d}{2}}{D}\right)^2\right]^{\frac{1}{2}}$$

$$\Rightarrow \left[1 + \left(\frac{x + d/2}{D}\right)^2\right]^{\frac{1}{2}}$$ is a Binomial

Now, expanding Binomial as $(1+x)^n = 1 + nx$

$$BP = D\left[1 + \frac{1}{2}\left(\frac{x + d/2}{D}\right)^2\right] \quad \text{— (III)}$$

Now, In ΔAPE, $AP^2 = AE^2 + PE^2$

$$\Rightarrow AP = \sqrt{AE^2 + PE^2}$$

$$AP = \sqrt{D^2 + (PC - EC)^2} = \sqrt{D^2 + \left(x - \frac{d}{2}\right)^2}$$

$$= \left[D^2 + \left(x - d/2\right)^2\right]^{\frac{1}{2}} = \left[D^2\left(1 + \left(\frac{x - d/2}{D}\right)^2\right)\right]^{\frac{1}{2}}$$

$$= D\left(1 + \frac{1}{2}\left(\frac{x - d/2}{D}\right)^2\right) \quad \text{— (IV)}$$

Putting II and III in I

$$\text{Path diff} = D\left[1 + \frac{1}{2}\left(\frac{x + d/2}{D}\right)^2\right] - D\left[1 + \frac{1}{2}\left(\frac{x - d/2}{D}\right)^2\right]$$

$= D\left[\sqrt{x + \frac{1}{2}\left(\frac{x+d/2}{D}\right)^2} - x - \frac{1}{2}\left(\frac{x-d/2}{D}\right)^2\right]$

$= D\left[\frac{1}{2D^2}\left\{(x+d/2)^2 - (x-d/2)^2\right\}\right]$

$= \frac{1}{2D}\left\{x^2 + d^2/4 + x\cdot d - x^2 - d^2/4 + x\cdot d\right\}$

$= \frac{1}{2D} \times 2xd = \frac{xd}{D}$ = path diff.

for maxima ; path diff $= n\lambda$, $n = 0, 1, 2, 3$

$\Rightarrow \frac{xd}{D} = n\lambda \Rightarrow x_n = \frac{nD\lambda}{d}$ ✓

for, $n=0$, $x_0 = 0$ at 'c' | central maximum or central bright fringe

$n=1$, $x_1 = \frac{D\lambda}{d}$ | 1st bright fringe

$n=2$, $x_2 = \frac{2D\lambda}{d}$

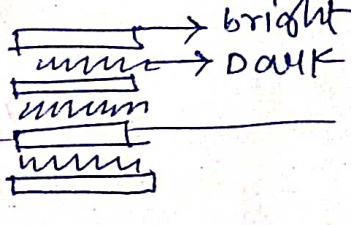
$n=3$, $x_3 = \frac{3D\lambda}{d}$ .....

for minima, path diff $= \frac{(2n-1)\lambda}{2}$, $n = 1, 2, 3 \cdots$

$\frac{xd}{D} = \left(\frac{2n-1}{2}\right)\lambda \Rightarrow x_n = (2n-1)\frac{D\lambda}{2d}$

for $n=1$, $x_1 = \frac{D\lambda}{2d}$, 1st dark fringe

$n=2$, $x_2 = \frac{3D\lambda}{2d}$



Fringe width :- the distance b/w two consecutive bright or dark fringes is called fringe width

for bright fringe (constructive) or maxima

β = diff b/w two dark fringe ($x_n - x_{n-1}$)

$= \frac{3D\lambda}{2d} - \frac{D\lambda}{2d} = \frac{D\lambda}{d}$

For dark fringe (destructive) / Minima

$$\beta = x_n - x_{n-1}$$
$$= x_2 - x_1$$
$$= \frac{2\lambda D}{d} - \frac{\lambda D}{d} = \frac{\lambda D}{d}$$

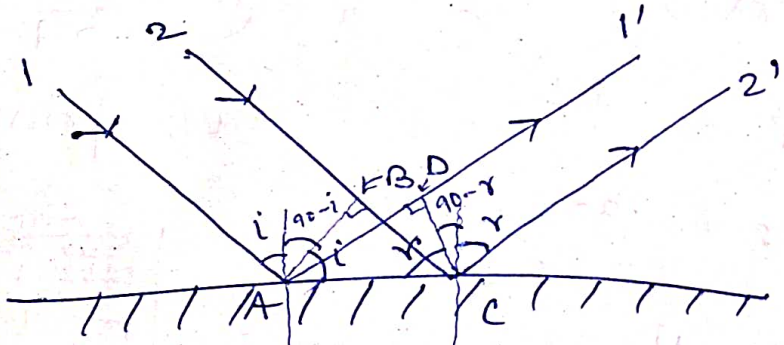
19) **wavefront** is grp of all the pts of wav which have same phase

A line ⊥r to a wavefront is called a ray

20) types of ~~spherical~~ wavefronts → spherical wavefront (wh wa is pt
→ cylindrical (linear light sources)
→ plane (source at large distance)

21) Reflection on the basis of wave theory:

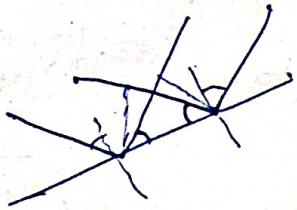
let 1 and 2 are Incident rays and 1', and 2' are reflected rays. If v is the velocity of light, t is the time taken from B to C or A to D



$$t = \frac{\text{distance}}{\text{speed}} = \frac{BC}{v} \quad \text{—— (I)}$$

$$t = \frac{AD}{v} \quad \text{—— (II)} \quad ; \text{ equate (I) and (II)}$$

$$\Rightarrow \frac{BC}{v} = \frac{AD}{v} \Rightarrow BC = AD$$



on Δ ADC, $\sin r = \frac{AD}{AC} \Rightarrow AC \sin r = AD$

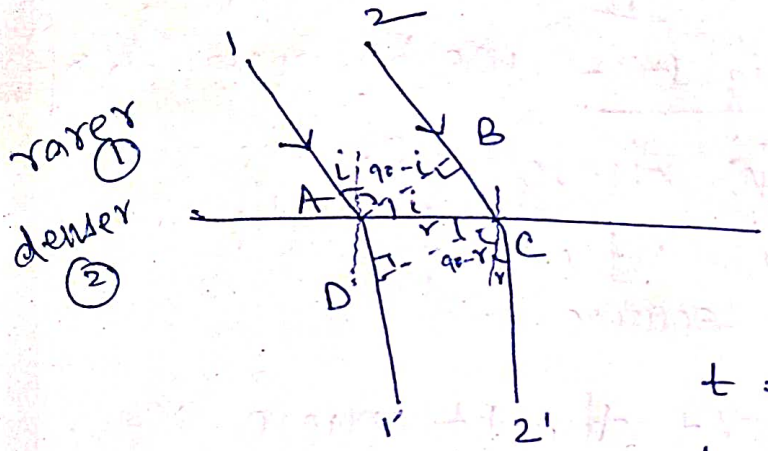
$\Rightarrow \sin i = \sin r$ (proved)

$\Rightarrow \boxed{i = r}$ laws of reflection

(22) Refraction on the basis of wave theory:

---- v_1 is vel in medium 1 (μ_1)

— v_2 " " " 2 (μ_2)



if $\mu_1 < \mu_2$
then $v_1 > v_2$

$\mu_1 : 1$
$\mu_2 : 2$

$$t = \frac{BC}{v_1} \quad \text{—①}$$

$$t = \frac{AD}{v_2} \quad \text{—②}$$

$\Rightarrow$ equating ① and ②

$\Rightarrow \frac{BC}{AD} = \frac{v_1}{v_2}$ —③

on Δ ABC
$\sin i = \frac{BC}{AC}$
$BC = AC \sin i$

on Δ ADC
$\sin r = \frac{AD}{AC}$
$AD = AC \sin r$

From ③

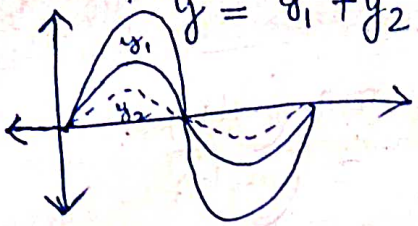
$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\mu_2}{\mu_1}$$

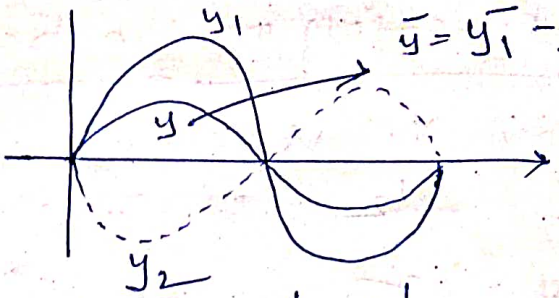
as $\boxed{v \propto \frac{1}{\mu}}$

$\boxed{\frac{\sin i}{\sin r} = \mu}$ snell's law |proved|



(23) superposition prineiple :- when two or more waves travelling through a medium, super gnpose on each other, then a new wave is formed in which resultant displacement is equal to vector sum of displacement due to gndividual waves.





(24) gnterference of light :- The phenomenon of redistribution of light energy in a medium on account of superposition of light wave from two co-herent source.

a) constructive gnterference :- At the pt where Tresultant is max ✓

b) destructive :- at the pt where Tresultant is min ✓

25) coherent source :- two source of light having same I, same and are in constant phase difference ✓ ✓

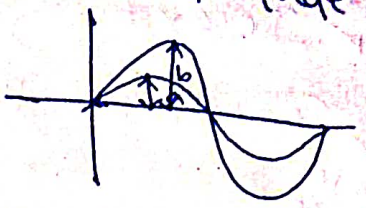
* condition for obtaining co-herent sources :-

1) coherent source (cs) obtained from same source by some device
2) the cs's should give monochromatic light
3) the path diff b/w the light waves from two sources should be small.

26) condition for constructive and destructive interference :-

let us consider light waves from two sources

a, b : amplitude



$\Rightarrow y_1 = a\sin\omega t$

$y_2 = b\sin(\omega t + \phi)$

by superposition principle

$y = y_1 + y_2$

$= a\sin\omega t + b\sin(\omega t + \phi)$

$= a\sin\omega t + b[\sin\omega t\cos\phi + \cos\omega t \sin\phi]$

$= \sin\omega t[a + b\cos\phi] + b\cos\omega t\sin\phi$

let $a + b\cos\phi = R\cos\theta$ — (I)

$b\sin\phi = R\sin\theta$ — (II) ✓

$y = \sin\omega t(R\cos\theta) + \cos\omega t(R\sin\theta)$

$= R(\sin\omega t\cos\theta + \cos\omega t\sin\theta)$

$= R[\sin(\omega t + \theta)]$; R is Resultant Amplitude

Amplitude resultant —

$\Rightarrow$ Adding (I) and (II) and squaring

$(a + b\cos\phi)^2 + (b\sin\phi)^2 = (R\cos\theta)^2 + (R\sin\theta)^2$

$a^2 + b^2\cos^2\phi + 2ab\cos\phi + b^2\sin^2\phi = R^2(\cos^2\theta + \sin^2\theta)$

$\Rightarrow R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$

for R_{max} ; $\cos\phi = 1$, $\phi = 0, 2\pi, 4\pi$

$= 2n\pi$, $n = 0, 1, 2, 3$

$R = a + b$

for R_{min} ; $\cos\phi = -1$, $\phi = \pi, 3\pi, 5\pi$ - - -

$= (2n-1)\pi$; where $n = 1, 2, 3$ - - -

$R = a - b$

calculate path diff $(x) = \frac{\lambda}{2\pi}\phi$. for max $x = n\lambda$

for min $x = \left(\frac{2n-1}{2}\right)\lambda$

Ratio of Intensity at max and min

$I \propto (\text{Amplitude})^2$

$I = K(\text{Amplitude})^2$

constructive $I_{max} = K(a+b)^2$

destructive $I_{min} = K(a-b)^2$

$$\frac{I_{max}}{I_{min}} = \frac{(a+b)^2}{(a-b)^2}$$

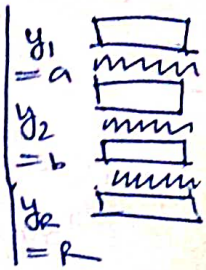
Intensity of fringes :-

$I \propto (\text{Amp})^2$

$I_1 \propto a^2$, $I_1 = Ka^2$, $a = \sqrt{\frac{I_1}{K}}$

$I_2 \propto b^2$, $I_2 = Kb^2$, $b = \sqrt{\frac{I_2}{K}}$

$I_R \propto R^2$, $I_R = KR^2$



$$I_R = K[a^2 + b^2 + 2ab\cos\phi]$$

$$= \frac{K}{K}[I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi]$$

Bright fringes :- $\cos\phi = 1$, at YDSE, $I_1 = I_2 = I$

$I_{max} = 4I$

$\cos\phi = -1$, $I_{min} = 0$

(27) **Diffraction of light :-** the phenomenon of bending of light around the sharp corners and the spreading of light with in the geometrical shadow of opaque obstacles is called diffraction.

(28) Difference between interference and diffraction :-

Interference	Diffraction
1) In Interference Intensity of maximas are same	1) In diffran Intensity of maximas goes on decreasing
2) Path diff for maxima $= n\lambda$ $min = (2n-1)\frac{\lambda}{2}$	2) Path diff $max = (2n+1)\lambda/2$ $min = n\lambda$
3) due to superposition of light wave from two source	3) due to superposition of secondary wavelets from one source
4) co-herent source are req.	4) not necessary.

(29) Polarization of light :- the phenomenon of restricting the vibration of light on a particular direction ⊥r to the propagation of light wave is called polarization of light.

Bragg's law

$2d \sin\theta = n\lambda$

1) the x-ray diffracted from a atoms in crystal planes, obey the laws of diffraction
2) the two rays reflected by successive planes will be in same phase if the IInd ray travelled the extra distance is Integral no. of wavelengths

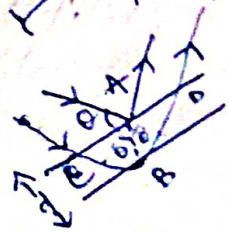
Brewsters law

$\mu = \tan i$

~~Natus law~~ Mosley law

$\sqrt{\nu} = a(Z-b)$

a: propo. const.
b: screening const.
Z: ato nic no of targ
ν: freq.



(30) Mass defect :-

$$\Delta m = (N m_n + Z m_n) - m\left(\tfrac{A}{Z}X\right)$$

From einstein's mass energy equivalence

$$B.E = \Delta m c^2$$

(31) Bethe-weizaekar formula -

$$R \propto A^{\frac{1}{3}}$$

$$R = R_0 A^{\frac{1}{3}}, \quad R_0 = 1.2 \text{ fm}$$

a) volume effect :- $B \propto A$

$$B = a_v A$$

b) surface effect :- $B \propto -A^{\frac{2}{3}}$

$$B = -a_s A^{\frac{2}{3}}$$

c) coulomb's effect :-

$$B \propto -\frac{Z^2}{A^{\frac{1}{3}}} \Rightarrow B = -a_c \frac{Z^2}{A^{\frac{1}{3}}}$$

$$B = a_v A - a_s A^{\frac{2}{3}} - a_c \frac{Z^2}{A^{\frac{1}{3}}}$$

(32) Law of Radioactive decay :-

* Radioactive decay is a random process.
* A particular nucleus can decay at any time b/w $t = 0$ to ∞
* "when there is large no. of nuclei, the rate of decay/disintegration $\propto$ number of nuclei in sample"

Rutherford and Soddy's law / Law of Radioactive decay

let in time dt, dN nuclei decays

'N' nuclei

dN is -ve

undecayed

$$\text{Rate of Decay} = \frac{\text{no. of nuclei decays}}{\text{time}} = -\frac{dN}{dt}$$

$$-\frac{dN}{dt} \propto N \Rightarrow -\frac{dN}{dt} = \lambda N$$

λ : Decay const. / Disint. const. / Radioactive const.

⇒ Now,

$$\int_{N_0}^{N} \frac{dN}{N} = -\int_{0}^{t} \lambda\, dt$$

let $t = 0, N_0$; $t = t, N$

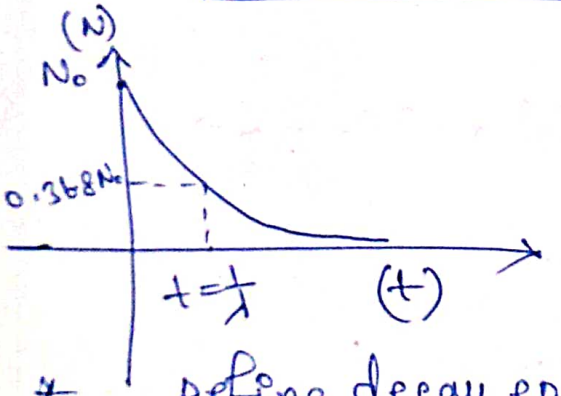
$$\left[\log N\right]_{N_0}^{N} = -\lambda(t) \Rightarrow \boxed{\log \frac{N}{N_0} = -\lambda t}$$

$$\Rightarrow \boxed{N = N_0 e^{-\lambda t}}$$

N : no. of nuclei left undecayed at 't'

N_0 : Initial no. of nuclei

t : time



* Define decay const. (λ) if $t = \frac{1}{\lambda}$

$$N = N_0 e^{-1} = 0.368\, N_0$$

⇒ λ is the reciprocal of time in which the no. of nuclei left undecayed are 36.8% of initial number of nuclei.

⇒ λ is the ---- in which 63.2% nuclei decays.

* **Half life of decay :-** the time in which half of nuclei decays and half remain undecayed.

$\Rightarrow t = t_{1/2} \quad N = \frac{N_0}{2} \; ; \; \log_e\left(\frac{N}{N_0}\right) = -\lambda t$

$\Rightarrow \log\left(\frac{1}{2}\right) = -\lambda t_{1/2}$

$\Rightarrow -\log 2 = -\lambda t_{1/2} \Rightarrow \boxed{t_{1/2} = \frac{0.693}{\lambda}}$

$\boxed{N = \frac{N_0}{2^n}}$ No. of nuclei left after n half lives.

* Activity :- Rate of decay / disintegration

(Bq) (Ci)

$R = -\frac{dN}{dt} \Rightarrow \boxed{R = \lambda N}$

$\boxed{R = \lambda N_0 e^{-\lambda t}}$

at $t=0$, $R = \lambda N_0$ = initial activity $= R_0$

$R = R_0 e^{-\lambda t}$ ✓

rutherford, / curie / Bequrel ✓

Experiments show Vol of nucleus $\propto$ mass number

$V \propto A$

$\Rightarrow \frac{4}{3}\pi R^3 \propto A \Rightarrow R^3 \propto A$ (A → mass number)

$R = R_0 A^{\frac{1}{3}}$

R_0 → radius of nucleus; const for all nuclei 1.2×10^{-15} m $= 1.2$ fm

nuclear density $\Rightarrow \sim 2 \times 10^{17}$ kg/m^3

α-decay: $^{A}_{Z}X \longrightarrow {}^{4}_{2}He + {}^{A-4}_{Z_2}Y$

parent — daughter

mass deft $\Delta M = [M_x - (M_\alpha + M_y)]$

Energy due to $\Delta M = \Delta Mc^2 = [M_x - (M_\alpha + M_y)]c^2$

$Q = [M_x - (M_\alpha + M_y)]c^2$

$= [M_x - (M_\alpha + M_y)] \times 931.5 \text{ meV}$

* Kinetic energy of emitted α-particle

$KE_\alpha = \frac{Q M_y}{M_\alpha + M_y}$ $\quad KE_y = \frac{Q M_\alpha}{M_\alpha + M_y}$

$KE = \frac{p^2}{2m}$; $K = \frac{1}{2} mv^2$

* β- decay: $\boxed{\beta\ominus}$ $^{A}_{Z}X \longrightarrow {}^{0}_{-1}e + {}^{A}_{Z+1}y + \bar{\nu}$ anti-neutrino

$Q = [m_n - (m_p + m_e)] \times 931.5 \text{ meV}$

$\bar{e}$ capture $\boxed{\beta\oplus}$ $^{A}_{Z}X \longrightarrow {}^{0}_{+1}e + {}^{A}_{Z-1}y + \nu$ Nutrino

* Mass Energy equivalence:- If Energy of a body is ↑ed by amt $\boxed{E}$; it's mass ↑es by 'm'. where, $m = \frac{E}{c^2} \simeq 4.7 \times 10^{-14}$ kg

$E = 4.2 \times 10^{3}$ J

* what is mass defect:-

the mass of nucleus is less than the sum of mass of all nucleons making it.
(some mass disappears during formation of nucleons)
the mass i.e. disappeared is termed as mass defect.

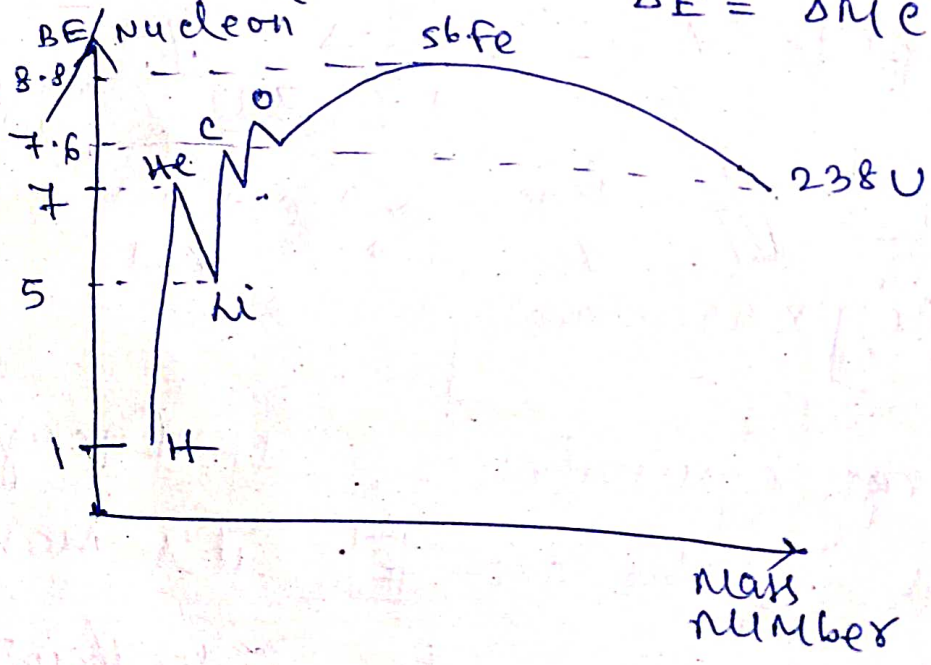
$$\Delta M = (Z M_H + (A-Z) M_n - M_x)$$

Z → no. of protons → M_p

$$\Delta E = [Z M_p + (A-Z) m_n - M_x] c^2$$

ΔE (Binding energy) Amt of energy required to separate all nucleons from the nucleus.

$$\Delta E = \Delta M c^2$$



$I = \frac{I_0 \sin^2(\pi/2)}{(\pi a/2)^2}$

$\Rightarrow$

for minima :- $\frac{dI}{d\alpha} = 0$ [where $\alpha = \pi a/2$

$$\frac{d^2 I}{d\alpha^2} > 0$$

$$\frac{d}{d\alpha}\left\{\frac{\sin^2\alpha}{\alpha^2}\right\} = 0 \Rightarrow \frac{2\sin\alpha\cos\alpha}{\alpha^2} - \frac{2\sin^2\alpha}{\alpha^3} = 0$$

$$\Rightarrow \frac{2\sin\alpha}{\alpha^3}(\alpha\cos\alpha - \sin\alpha) = 0$$

$$\sin\alpha(\alpha\cos\alpha - \sin\alpha) = 0$$

$\sin\alpha = 0$ or $\alpha\cos\alpha - \sin\alpha = 0$

at $\alpha = 0$, $\frac{d^2 I}{d\alpha^2} > 0$.

$\alpha = n\pi$

$\pi a = 2n\pi \Rightarrow \left(\frac{2\pi}{\lambda}\sin\theta\right) a = 2\pi n$

$\Rightarrow$ $\boxed{a\sin\theta = n\lambda}$ $\Rightarrow$ $\boxed{\theta \approx n\lambda/a}$

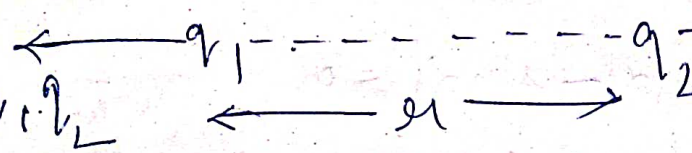
at $\alpha = \tan\alpha$ $\frac{d^2 I}{d\alpha^2} < 0$

$\alpha = (n + 1/2)\pi$, $n = 1, 2$ $\Rightarrow \frac{2\pi}{\lambda}\sin\theta\, a = n + 1/2$

$\Rightarrow$ $a\sin\theta = (n + 1/2)\lambda/2$

Diffraction :

1) coulomb's law :- the magnitude of electrostatic force b/w two pt objects is directly proportional to the product of the two charges and inversely proportional to the square of the distance b/w them and acts along the line joining their centres.



$$\left\{ F = \frac{1}{4\pi\varepsilon_0} \frac{q_1 q_2}{r^2} \right\}$$

* ε_r : ratio of permittivity at medium to the " at free space

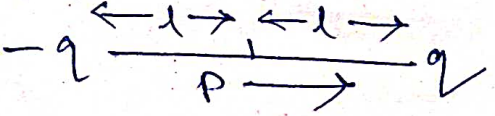
$\varepsilon_r = \frac{\varepsilon_m}{\varepsilon_0}$, also known as dielectric constant

ε : It is the property of a material due to which it opposes the external $\vec{E}$ passing through it ; due to electrical polarization.

ε_0 : 8.85×10^{-12} cr/NMr

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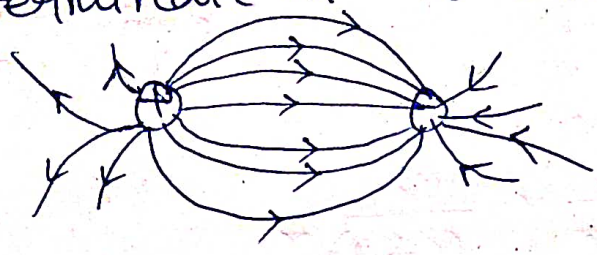
3) Electric dipole :- the arrangement of 2 equal and opposite charges kept at some finite distance

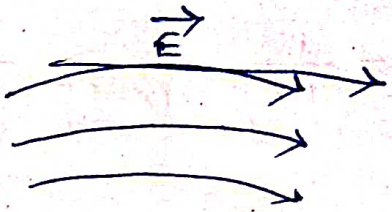


$P = q(2l)$

2) Properties of electric field lines

I) Field lines originate at +ve charge and terminate at -ve charge





II) two $\vec{E}$ lines can never intersect each other (This is because at point two tangents can be drawn and $\vec{E}$ have two directions, not possible)

III) Greater is the density of field lines, greater is the strength of $\vec{E}$ at that region



IV) Electric field lines do not form closed loops because of the conservative nature of $\vec{E}$ (i.e, work done by $\vec{E}$ depends on final and initial position and not the path followed)

V) $\vec{E}$ lines are continious in nature.

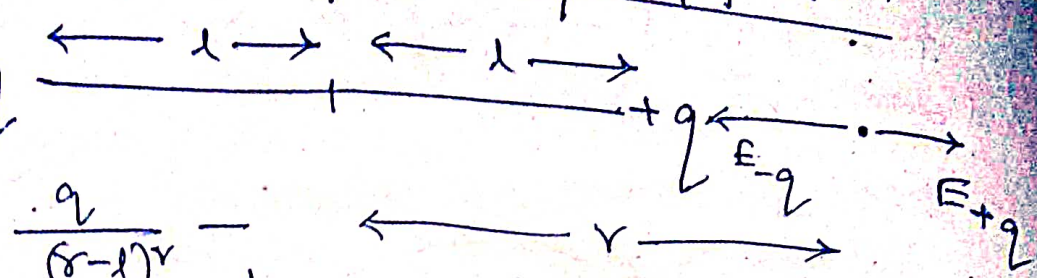
Gauss law:

Torque $\quad \vec{P} \times \vec{E}$

The total flux enclosed by a closed surface is $\frac{1}{\varepsilon_0}$ times of the total charge enclosed by the surface.

$$\oint \vec{E} \cdot d\vec{S} = \phi = \frac{q}{\varepsilon_0}$$

4) P at axial position / end position



$$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{(r-l)^2} - \frac{1}{4\pi\varepsilon_0}\times\frac{q}{(r+l)^2}$$

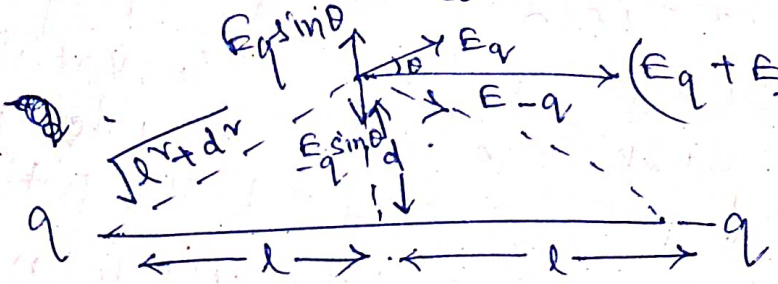
$$= \frac{q}{4\pi\varepsilon_0}\times\left(\frac{(r+l)^2-(r-l)^2}{((r+l)(r-l))^2}\right)$$

$$= \frac{q}{4\pi\varepsilon_0}\frac{4rql}{(r-l)^2(r+l)^2}$$

$$= \frac{1}{4\pi\varepsilon_0}\frac{2\times(2ql)\,r}{(r+l)^2(r-l)^2} = \frac{1}{4\pi\varepsilon_0}\frac{2pr}{(r-l)^2(r+l)^2}$$

for $r \gg l$ $\quad \vec{E} = \frac{1}{4\pi\varepsilon_0}\times\frac{2\vec{p}}{r^3}$

5) Equitorial pt



a) Field along x-axis

$$E_x = 2\times\frac{1}{4\pi\varepsilon_0}\times\frac{q}{l^2+d^2}\cos\theta$$

$\rightarrow 2E_q\cos\theta$

$$E = 2\times\frac{kq}{(l^2+d^2)}\times\frac{d}{(l^2+d^2)^{1/2}}$$

$$= 2kql\,\frac{1}{(l^2+d^2)^{3/2}} = \frac{kp}{r^3} \text{ for } r \gg 2a$$

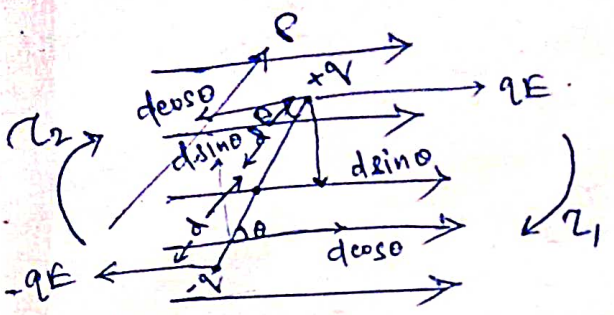
b) Field along y-axis

as $E_{+q} = E_{-q} = \frac{kq}{(r^2+d^2)}$

b) y direction $= 0$

** definition of torque :- Torque (τ) is a tendency of force to rotate the body (rigid) about some axis, τ = force x $\perp^r$ distance b/w two objects/particle

⇒ Torque on a uniform $\vec{E}$



Torque = force x $\perp^r$ distance

$\tau = f \times d$

$\tau = \tau_1 + \tau_2$

τ_1 due to $+q$

τ_2 due to $-q$

Now, $\tau = qE\,d\sin\theta - (-qE)\,d\sin\theta$ as $\perp^r$ distance $= d\sin\theta$

$= 2qE\,d\sin\theta$

$= (2d).q.E\sin\theta$ as dipole (P) $= q \times 2d$

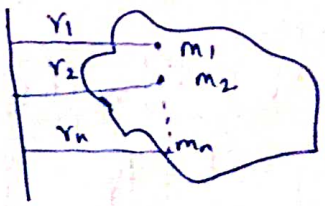
$= pE\sin\theta$

$= p \times E$ (∵ direction of $\vec{p} \times \vec{E}$ is same as direction of τ) (clockwise)

** define angular momentum :-

⇒ Moment of linear momentum is called angular momentum. $\vec{L} = r\vec{p} = mvr$

** Define Moment of Inertia :- MoI about a given axis of rotation is the sum of product of mass and square of their distances ~~abc~~ from axis of rotation.



$MoI = m_1 r_1^r + m_2 r_2^r + \cdots m_n r_n^r$

$= \sum_{i=1}^{n} M_i r_i^r$

* **Define Radius of gyration:-** Radius of gyration of a body about an axis of rotation is the root mean square distance of its particle from the axis of rotation.

$$\begin{cases} I = MK^2 \\ K = \sqrt{\frac{I}{M}} \end{cases}$$

same

$L = I\omega$ | $\tau = I\alpha$

$L = p r$
$= mvr$
$= mr^2\omega$
$= I\omega$

$\frac{mr^2 \cdot v}{r}$

$\tau = Fr$
$= mar$
$= \frac{mr^2 \cdot a}{r}$
$= I\alpha$

* **Stokes law:-** the viscous force acting on a sphere is directly proportional to the following-

1) co-efficient of viscosity (η)
2) Radius of sphere (r)
3) velocity of the object (v)

From dimensional method, if we consider viscous force as 'F', then $F \propto \eta^a$, $F \propto r^b$, $F \propto v^c$, now,

$F \propto \eta^a r^b v^c$

$F = K \eta^a r^b v^c$

and we know, dimension of F (force) $= [MLT^{-2}]$

$r = [L]$, $v = [LT^{-1}]$

$\eta = [ML^{-1}T^{-1}]$

Now,

$[MLT^{-2}] = [ML^{-1}T^{-1}]^a [L]^b [LT^{-1}]^c$

$[MLT^{-2}] = [M^a L^{-a+b+c} T^{-a-c}]$

$a = 1$, $-a+b+c = 1$

$-a-c = -2$ $\quad -1+b+1 = 1$

$a+c = 2$ $\quad b = 1$

$c = 1$

$F = K\eta r v$

K: for sphere, 6π

$F = 6\pi\eta r v$

Go Green

Q) Define central force:- If a force is acting on a particle such a way that it's always acted towards or away from a fixed pt. and its magnitude always depends on the distance ($\bar{r}$) from that fixed pt. then it's said to be central force.

e.g. $F(\bar{r}) = F(r)(\hat{r})$

e.g. gravitational force

e.g. Electrical force

* characteristics of central force:-

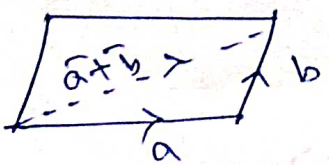
1) radial direction:- the central force always acts along the line joining the center and the object, which is also known as radial direction. this means the force will be either attractive or repulsive.

2) magnitude depends on distance; ✓

3) conservative force:- --- work done by the force in moving a object b/w two pts is always path independent. TE = KE + PE conserved.

Q) Areal velocity $\left(\frac{dA}{dt}\right)$ (m^2/s) the rate of change of Area wrt time

Q) physical significance of cross product:-



$\bar{a}$, $\bar{b}$ (if) are two vectors denoted by two adjacent sides of a ||ogram then diag of ||ogram $\bar{a}+\bar{b}$

and Area of ||ogram = $|\bar{a} \times \bar{b}|$

P↑ central force is a conservative force

⇒ $\vec{F}$(central force) $= f(r)\,\hat{r}$

$= f(r)\,\dfrac{\bar{r}}{|\bar{r}|}$

$= \dfrac{f(r)}{|\bar{r}|}\,\bar{r}$

$= g(r)\,\bar{r}$

Now,

curl of $\bar{F}$

$= \bar{\nabla} \times \bar{F} = \bar{\nabla} \times \{ g(r)\,\bar{r} \}$

$= \bar{\nabla}(g(r)) \times \bar{r} + g(r)(\bar{\nabla} \times \bar{r})$

$= \bar{\nabla}(g(r)) \times \bar{r}$ as $\bar{\nabla} \times \bar{r} = 0$

$= \dfrac{d\,g(r)}{dr}\,\hat{r} \times \bar{r}$ as direc^{n} of $\bar{r}$ and $\hat{r}$ is same

$= 0$

so the curl is '0', so $\bar{f}$(central force) is conservative.

$\bar{\nabla} \times \bar{r} = 0$ as $\bar{r} = r_1\,\hat{i} + r_2\,\hat{j} + r_3\,\hat{k}$

now,

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ r_1 & r_2 & r_3 \end{vmatrix} = \hat{i}\left(\frac{\partial}{\partial y} r_3 - \frac{\partial}{\partial z} r_2\right) - \hat{j}\left(\frac{\partial}{\partial x} r_3 - \frac{\partial}{\partial z} r_1\right) + \hat{k}\left(\frac{\partial}{\partial x} r_3 - \frac{\partial}{\partial y} r_1\right)$$

$= 0$

as r_1, r_2, r_3 = const.

Streamline flow

layers are streamlined

$r_n < 1000$

the flow is steady

Laminar flow

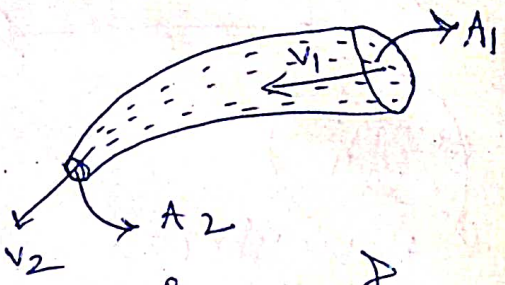
layers are parallel

$r_n < 2000$

the flow is slow

* Equation of continuity :- the rate of flow of fluid from any cross sectional area will be same irrespective of their area.

$$A_1 V_1 = A_2 V_2$$



* Reynold's number
  Ratio of Initial force and viscous force
  use to determine type of flow
  (laminar, turbulant)

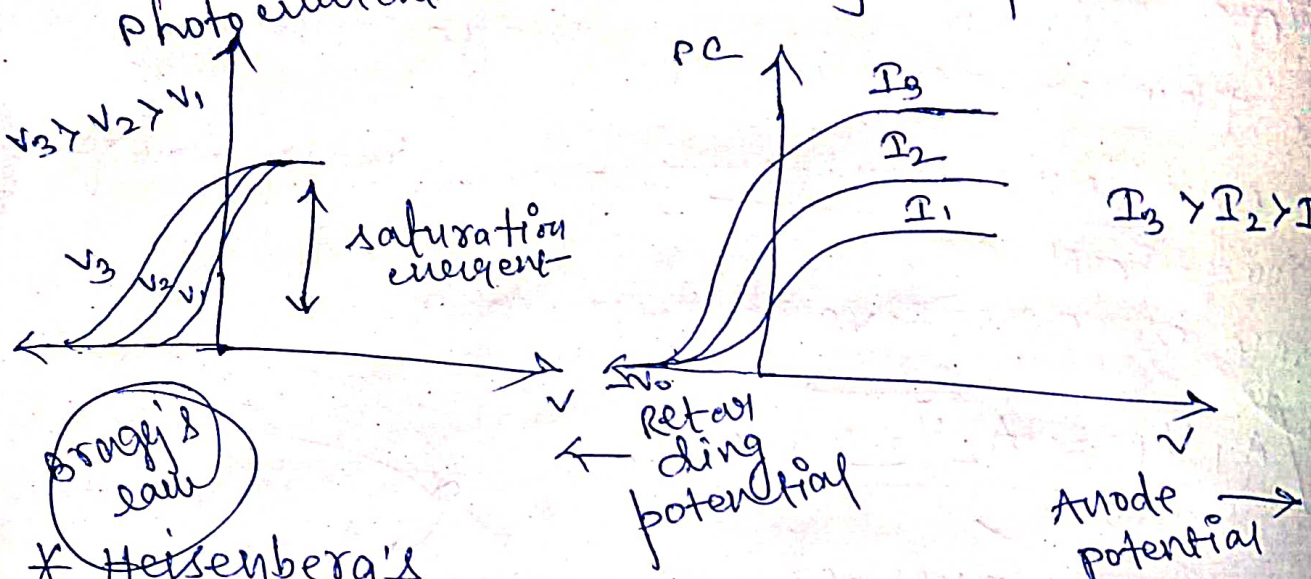
* Bernoulli's th :- For a perfect incompressible liquid flowing in a continious stream, the total energy of a particle remains same, while the particle moves from one part to another.

Application : { venturi meter, pitot tube, orifice meter }

$$\frac{1}{2} P V^2 + \rho g h + p = \text{const}$$

for a perfect incompressible liquid - the total energy for a particle remains const. while the particle moves from one part to another

* Photo electric effect :- photo electric effect the phenomenon in which, small wavelength light incident on a metal surface and es from that surface ejected —



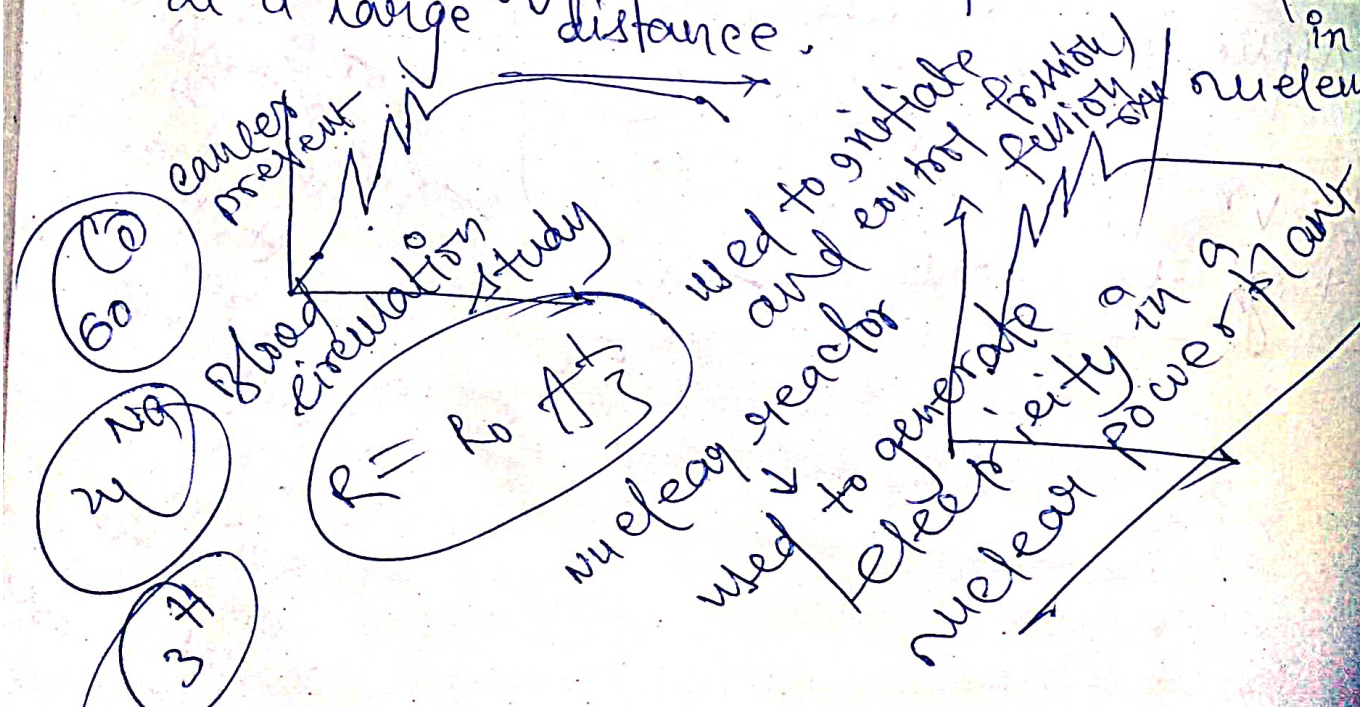
Broglie's law

* Heisenberg's uncertainity principle :-

It is impossible to calculate accurately and simultaneously, position and momentum of a particle, like e.

$$\Delta x \cdot \Delta p \geq \frac{h}{4\pi}$$

BE the energy req. to separate nucleons at a large distance.



differences b/w dia, para, ferro

	Dia	Para	Ferro
1)	They are feebly repelled by a magnet	They are feebly attracted by the magnet	They are strongly attracted a magnet
2)	when subjected to a magnetising field, they are feebly magnetised in opposite direction to the magnetising field	they are magnetised feebly in the direction of mag. field	they are magnetised strongly in the direction magnetising field
3)	$\mu_r < 1$ (relative permeability)	$\mu_r > 1$	$\mu_r > 1$
4)	Intensity of magnetisation is small and -ve	I: small and +ve	I: large and +ve
5)	χ_m: susceptibility small and -ve (χ_m independent of Temp)	small and +ve (dependent on Temp)	large and +ve (dependent on Temp)
6)	Does not obey curie's law	obey curie's law	Does not obey curie law but above Curie, they turned in para mag
7)	Due to orbital motion of $\bar{e}$	Due to spin motion of $\bar{e}$s	Due to formation of domains

Motion of particle under central force is always in a plane

$$f(\bar{r}) = f(r)\,\hat{r}$$

$$\bar{r} \times f(\bar{r}) = \bar{r} \times f(r)\hat{r} = |\bar{r}|\,F(r)\,|\hat{r}\times\hat{r}| = 0$$

$$\bar{r} \times f|\bar{r}| = 0$$

$$\bar{r} \times m\left(\frac{d^2 r}{dt^2}\right) = 0$$

$$\bar{r} \times \frac{d^2 r}{dt^2} = 0$$

$$\bar{r} \times \frac{d}{dt}\left(\bar{r} \times \left(\frac{dr}{dt}\right)\right) = 0$$

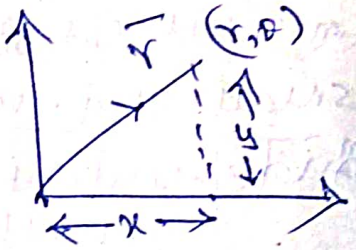
$\bar{r} \times \left(\frac{dr}{dt}\right) = \text{constant}$ ↓ ⊥r vector

---

Equation of motion under central force

$x = r\cos\theta$

$y = r\sin\theta$



$\frac{dx}{dt}$ | $\frac{dy}{dt}$

$\bar{a} = a_r\hat{r} + a_\theta\hat{\theta}$

$\bar{a} = a_x\hat{i} + a_y\hat{j}$

$240\ \text{rpm} = 240 \times \frac{2\pi}{60} =$ 8 rad/s

MOI = MR²

Energy = τ × ω | $\omega_f = \omega_i - \alpha t$

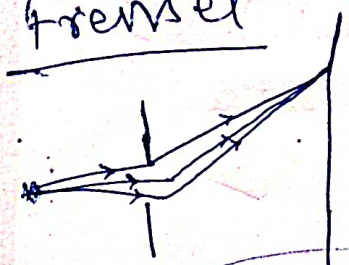
$\tau = I\alpha$

$\tau = rF$

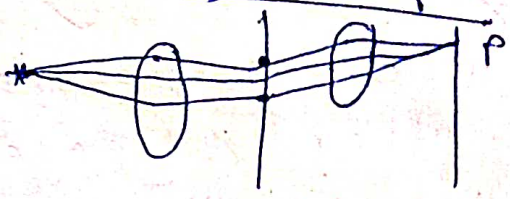
radius of ... the distance of the obj from axis

* difference b/w fresnel diffraction and fraunhofer diffraction

Fresnel



Fraunhofer



1) the distance b/w source and obstaekle and sereen and obstaekle is finite

2) No lenses are req. to study Fresnel diff

3) the wavefront gneident on the aparture is either cylindrical or spherical

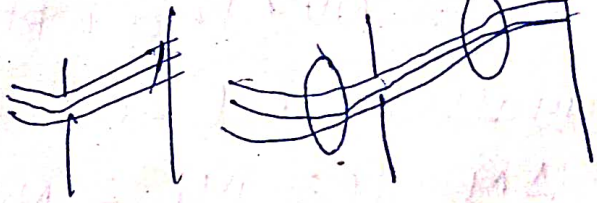
4) the diffracted wavefront is cylindrical/ spherical

1) the distance b/w source and obstaekle and sereen and obstaekle is effective infinite

2) Two convex lenses are req to study fraunhofer diff.

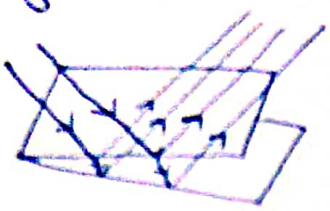
3) the wavefront gneident on the aparture is plane.

4) the diffracted wavefront is plane



* Fringes for equal thickness (Fizeau fringes)

Newton's rings



thickness of the film varies

wedge shaped film

11 beams are made to fall on the upper surface of the films

* optical path diff = $2\mu t \cdot \cos r$ — $r, \mu \rightarrow$ const

so due to variation of t OPD varies and acc to the condition of

$OPD = n\lambda$ and $OPD = (n + 1/2)\lambda$

bright and dark fringes are obtained.

* Haidinger's fringes :-

thickness of the film const. | Every fringe corresponds to a particular angle of incidence

central fringe corresponds to normal incidence

* Michelson interferometer

suggestions

Nuclear physics

1) Mass defect and Binding energy

$\Delta M = \{(ZM_p + NM_n) - M_x\}$ 931.1 MeV

$= \Delta M c^2$

2) Bethe weizsäckers formula (effect)
3) Nuclear force property
4) Radioactivity $N = N_0 e^{-\lambda t}$, $t_{1/2} = \frac{0.693}{\lambda}$ — vol, sol, colons
5) Isotope

* Polarization :-

polarisation of light as property of light- for which the phenomenon of restricting the vibration of light on a particular direction ⊥ to the propagan of light.

Diffraction :-

the phenomenon of bending of light around the sharp corners and the spreading of light within geometrical shadow of opaque obstacles is called so

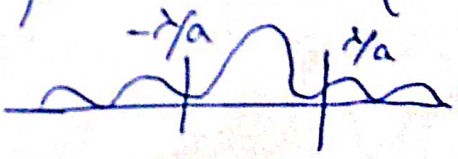
suggestions

electrodynamics

1) coulomb's law
2) Gauss law: (prove) → a) solid sphere
   b) hollow "
3) Definition of ε_0 :
4) electric field lines
5) electric dipole (axial | equitorial)

wave optics

1) YDSE (derivation of fringe width)
2) Interference
3) $I = \frac{I_0 \sin^2\alpha}{\alpha^2}$, $\frac{dI}{d\alpha} = 0$) minima - proof



4) $\Delta = \frac{2d}{a}$ (numerical)
5) $\beta = \frac{dD}{d}$ (numerical)

* 1) Coulomb's law :- the force of attraction or repulsion b/w two charged particles is directly proportional to the product of their charges and Inversely proportional to the square of the distance b/w them

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

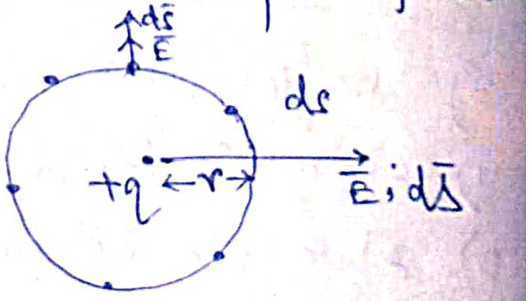
$F \leftarrow q_1 \cdots\cdots q_2 \rightarrow F$, $\leftarrow r \rightarrow$

$$F = K \frac{q_1 q_2}{r^2}$$, K: coulomb's const.

$\varepsilon_0 : 8.85 \times 10^{-12} C^2/N m^2$ $\quad K = \frac{1}{4\pi\varepsilon_0}$

2) Gauss law :- the total electric flux passing through a closed surface is equal to ~~the~~ $\frac{1}{\varepsilon_0}$ times the total charge enclosed by the closed surface

$$\phi = \oint \bar{E} \cdot d\bar{s} = \frac{q}{\varepsilon_0}$$



proof : $\phi = \oint \bar{E} \cdot d\bar{s}$

$= \oint E \, ds \cos\theta$

$= \oint E \, ds \cos 0^\circ = \oint E \, ds$

$= \oint \frac{Kq}{r^2} ds = \frac{Kq}{r^2} \oint ds = \frac{Kq}{r^2} 4\pi r^2$

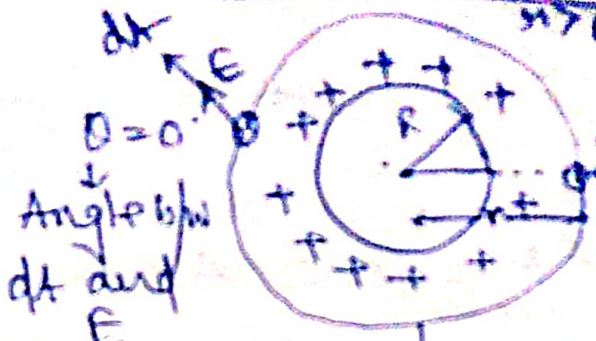
$= Kq \times 4\pi = \frac{1}{4\pi\varepsilon_0} \times q \times 4\pi = \frac{q}{\varepsilon_0}$

a) E

i) Inside the sphere

E = 0
as Inside the Sphere there are no charge.

ii) outside sphere:-



r : charge

Flux = $\phi = \oint \vec{E} \cdot d\vec{A}$

$= \oint E \cdot dA \cos 0°$

$= \oint E \, dA$

$\frac{q_{in}}{\varepsilon_0} = E \oint dA = E \times 4\pi r^2$

$E = \frac{q}{4\pi r^2 \varepsilon_0}$ $\left[E = \frac{1}{4\pi\varepsilon_0}\right]$

q_{inside} : and $\sigma = \frac{q_{in}}{4\pi R^2}$

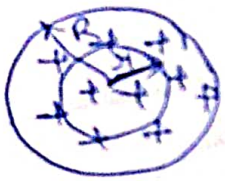
$q_{in} = \sigma 4\pi R^2$

now, $\frac{\sigma 4\pi R^2}{\varepsilon_0} = E \, 4\pi r^2$

$E = \frac{\sigma R^2}{\varepsilon_0 r^2}$

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

(b)



$\phi = \oint E \cdot dS$

$= E \cdot 4\pi r^2$

$\rho = \frac{q_{in}}{\frac{4}{3}\pi R^3}$

$q_{in} = 4\pi R^2 \rho$

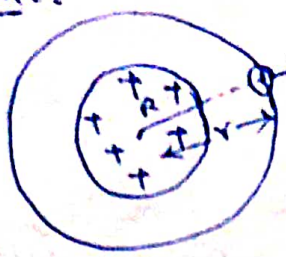
$E \cdot 4\pi r^2 = \frac{4\pi R^3 \rho}{3\varepsilon_0}$

$E = \frac{R^3 \rho}{3\varepsilon_0 r^2}$ $\left(= \frac{r\rho}{3\varepsilon_0}\right)$

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

b) $\vec{E}$ due to solid sphere :-

i) outside :-



φ : charge/volume ; $\varphi = \frac{q_{in}}{\frac{4}{3}\pi R^3}$

$$\phi = \frac{Q_{inside}}{\varepsilon_0} = \frac{\varphi \frac{4}{3}\pi R^3}{\varepsilon_0}$$

$$\phi = \oint E \cdot dA = \oint E \cdot dA \cos\theta = \oint E\, dA \quad \text{as } \theta = 0$$

$$= E \oint dA = E\, 4\pi r^2$$

$$\frac{\varphi \frac{4}{3}\pi R^3}{\varepsilon_0} = E\, 4\pi r^2 \; ; \; E = \frac{\varphi R^3}{3\varepsilon_0 r^2}$$

or $E = \frac{1}{4\pi\varepsilon_0} \frac{Q_{in}}{r^2}$ $\quad E \propto \frac{1}{r^2}$

3) ε_0 : permittivity of free space :-

⇒ It is representation of capability of a vaccum to permit $\vec{E}$.

$\varepsilon_0 \mu_0 = \frac{1}{c^2}$

8.85×10^{-12} c^2/Nm^2

μ_0 : $4\pi \times 10^{-7}$ H/m

* $\varepsilon_r = \frac{\varepsilon_m}{\varepsilon_0}$; (dielectric constant)

4) Electric field lines :-

Field lines are the graphical visualisation of $\vec{E}$, it can use to detect strength of $\vec{E}$

properties :- I) Field lines can never Intersect each other

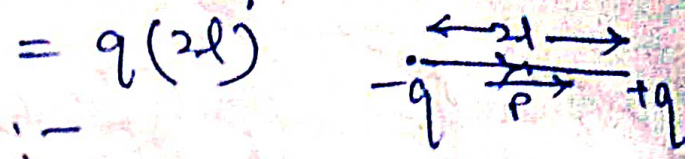
II) they can never make closed loops

III) tangent at electric field lines gives direction of $\vec{E}$ Intensity

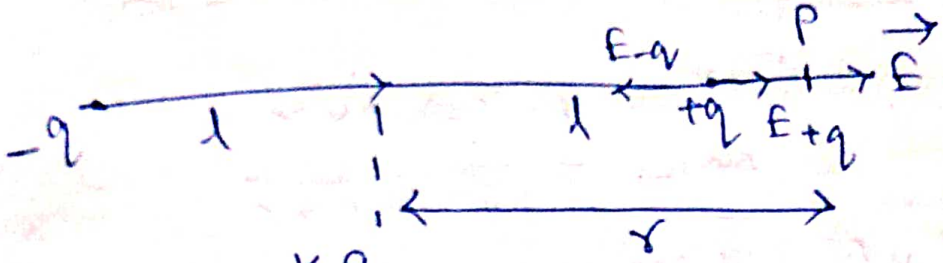
IV) they starts from a +ve charge and end on a -ve charge.

5) Electric dipole :- The arrangement of two equal and opposite charges in $\vec{E}$.

the value of dipole $(\vec{p}) = q(2l)$



a) $\vec{r}$ at axial position :-

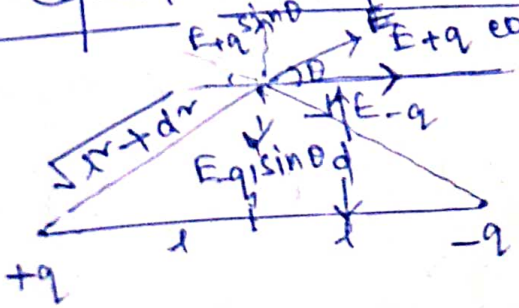


$$E = \frac{Kq}{(r-l)^2} - \frac{Kq}{(r+l)^2}$$

$$= \frac{q}{4\pi\varepsilon_0}\left(\frac{4rl}{((r-l)(r+l))^2}\right) = \frac{2r}{4\pi\varepsilon_0}\frac{(2l\times q)}{(r-l)^2(r+l)^2}$$

when $r >>> l$ $\quad \vec{E} = \frac{2p\cancel{r}}{4\pi\varepsilon_0 \cancel{r^4} r^3} = \frac{2K\vec{p}}{r^3}$

b) $\vec{p}$ at equitorial position :-

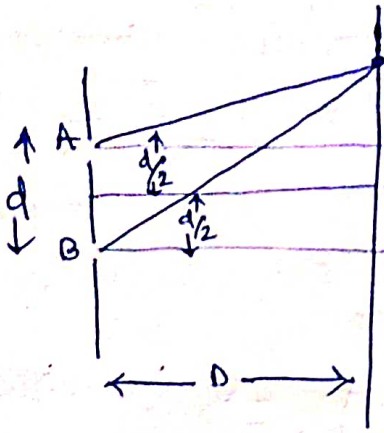


a) Field along x-axis :- $E_x = 2 \times \frac{1}{4\pi\varepsilon_0}\frac{q}{(\sqrt{l^2+d^2})^2}\cos\theta$

$\Rightarrow E_x = 2 \times \frac{1}{4\pi\varepsilon_0}\frac{q}{(l^2+d^2)} \times \frac{l}{\sqrt{l^2+d^2}} = \frac{(2l)q}{4\pi\varepsilon_0(l^2+d^2)^{3/2}}$

$= \frac{Kp}{l^3}$ as $l >>> d$

6) Derivation of fringe width



at 'O' central maxima
'P' at any pt.
here, Path difference = BP − AP

In Δ APX; $AP^2 = AX^2 + PX^2$

$AP = \sqrt{AX^2 + PX^2} = \sqrt{AX^2 + (PO - XO)^2}$

$AP = \sqrt{D^2 + \left(x - \frac{d}{2}\right)^2} = \sqrt{D^2\left(1 + \left(\frac{x - d/2}{D}\right)^2\right)}$

$= D\left\{1 + \left(\frac{x - d/2}{D}\right)^2\right\}^{\frac{1}{2}}$, by Binomial theorem

$= D\left(1 + \frac{1}{2}\left(\frac{x - d/2}{D}\right)^2\right)$

and In Δ BPY; $BP^2 = BY^2 + PY^2$

$\Rightarrow BP = \sqrt{BY^2 + PY^2} = \sqrt{BY^2 + (PO + OY)^2}$

$BP = \sqrt{D^2 + \left(x + \frac{d}{2}\right)^2} = \left\{\sqrt{D^2\left(1 + \left(\frac{x + d/2}{D}\right)^2\right)}\right\}$

$= D\left(1 + \left(\frac{x + d/2}{D}\right)^2\right)^{\frac{1}{2}}$, By Binomial theorem

$= D\left(1 + \frac{1}{2}\left(\frac{x + d/2}{D}\right)^2\right)$

NOW, Path diff (BP − AP) $= D\left(1 + \frac{1}{2}\left(\frac{x + d/2}{D}\right)\right) - D\left(1 + \frac{1}{2}\left(\frac{x - d/2}{D}\right)\right)$

$BP - AP = \Delta x = D\left\{1 + \frac{(x + d/2)^2}{2D^2} - 1 - \frac{(x - d/2)^2}{2D^2}\right\}$

$\Delta x = \frac{D \cdot x \cdot d}{D^2} = \frac{xd}{D}$

Path diff for maxima in Interference $= n\lambda = \frac{xd}{D} \Rightarrow x = \frac{nD\lambda}{d}$, $n = 0, 1, 2, 3, 4$

at $n=0$, $x=0$ (central maxima)

$n=1$, $x = \frac{D\lambda}{d}$ (1st Bright fringe)

$n=2$, $x = \frac{2D\lambda}{d}$ (IInd " ")

Path diff for minima in Interference $= \left(\frac{2n-1}{2}\right)\lambda$

$\left(\frac{2n-1}{2}\right)\lambda = \frac{dx}{D} \Rightarrow x = \frac{(2n-1)D\lambda}{2d}$, $n = 1, 2, 3, \ldots$

at $n=1$, $x = \frac{D\lambda}{2d}$ (1st bright fringe)

at $n=2$, $x = \frac{3D\lambda}{2d}$ (IInd " ")

Now, fringe width $\Rightarrow$ Distance b/w two successive bright / dark fringe

$= \frac{2D\lambda}{d} - \frac{D\lambda}{d} = \frac{D\lambda}{d} = \omega$ ✓

7) Inter-ference

8) $I = I_0 \frac{\sin^2\alpha}{\alpha^2}$, for minima, $\left(\alpha = \frac{\pi a}{\lambda}\right)$

$\frac{dI}{d\alpha} = 0 = I_0\left\{\frac{2\sin\alpha\cos\alpha}{\alpha^2} - \frac{2\sin^2\alpha}{\alpha^3}\right\}$

$\Rightarrow \frac{2\sin\alpha}{\alpha^3}\{\alpha\cos\alpha - \sin\alpha\} = 0$

$\Rightarrow \sin\alpha = 0$ or $\tan\alpha = \alpha$

$\alpha = 0, \pi, 2\pi, \ldots$

$= n\pi$

$\frac{\pi a}{\lambda} = n\pi$

$\pi a = 2n\pi$

$\frac{2\pi}{\lambda}\sin\theta \times a = 2\pi n$

$a\sin\theta = n\lambda$

Bragg's law

$d\sin\theta = n\lambda$

$\frac{d^2I}{d\alpha^2} > 0$

$\frac{d^2I}{d\alpha^2} < 0$

$\alpha = \left(n + \frac{1}{2}\right)\pi$, $n = 1, 2, \ldots$

$\frac{2\pi}{\lambda}\sin\theta\, a = \left(n + \frac{1}{2}\right)$

$a\sin\theta = \left(n + \frac{1}{2}\right)\frac{\lambda}{2}$

9) **Numericals formula :-**

fringe width $(\omega) = \frac{D\lambda}{d}$ | $N = N_0 e^{-\lambda t}$

$R = R_0 A^{\frac{1}{3}}$

(B.E) $\Delta E = \{(ZM_p + NM_n) - M_x\} 931.1$ MeV

$= \Delta M c^2$

Bethe weizsäcker formula $R = R_0 A^{\frac{1}{3}}$

10) **Effects of Bethe weizsäcker formula :-**

$R = R_0 A^{\frac{1}{3}}$; $R_0 = 1.2$ f

$= 1.2 \times$

I) **Volume effect :-** $B \propto A$

$B = a_v A$ | $B : \rightarrow B.E$

$A : \rightarrow A.N$

II) **surface effect :-** $B \propto A^{-\frac{2}{3}}$

III) **coulomb's effect :-** $B = B \cdot a_s A^{\frac{2}{3}}$

$B \propto -\frac{Z^2}{A^{\frac{1}{3}}}$; $B = a_c \left(-\frac{Z^2}{A^{\frac{1}{3}}}\right)$

So, $BE = a_v A - a_s A^{-\frac{2}{3}} - a_c \frac{Z^2}{A^{\frac{1}{3}}}$

11) $N = N_0 e^{-\lambda t}$ and $t_{1/2} = \frac{\ln 2}{\lambda}$

⇒  → N Nuclei

let dN Nucleis decays at dt time

Rate of decay $= -\frac{dN}{dt}$ N : undecay no. of Nuclei

and $-\frac{dN}{dt} \propto N$ ⇒ $-\frac{dN}{dt} = N\lambda$

⇒ $\int_{N_0}^{N} \frac{dN}{N} = -\lambda \int_0^t dt$ ⇒ $\ln\left(\frac{N}{N_0}\right) = -\lambda t$

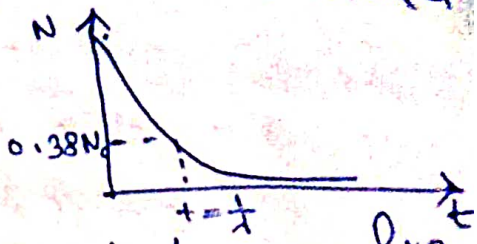
⇒ $N = N_0 e^{-\lambda t}$ (proved)

$N = N_0 e^{-\lambda t}$; If $t = \left(\frac{1}{\lambda}\right)$ then

$= N_0 \left(\frac{1}{e}\right) = 0.368\, N_0$

λ: (define decay const.) → the reciprocal of time in which 36.8% of Initial nuclei decayed.

at $t_{1/2}$ (half life) $N = \frac{N_0}{2}$,



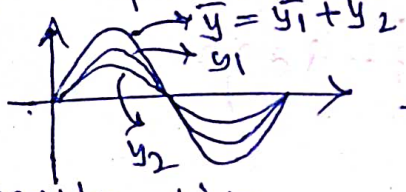
now, $\ln\left(\frac{N_0}{2N_0}\right) = -\lambda t_{1/2} \Rightarrow t_{1/2} = +\frac{\ln 2}{\lambda}$

$\Rightarrow t_{1/2} = \frac{0.693}{\lambda}$ (proved)

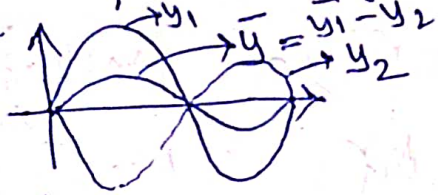
(7) constructive and destructive Interference

when I_{Max} when I_{min}

Interference:- phenomenon of ~~light~~ redistribution of light Energy in a Medium on account of superposition of two light waves.



constructive superposition of y_1 and y_2



destructive superposition of y_1 and y_2

for Interference

let,

$y_1 = A \sin \omega t$

$y_2 = B \sin(\omega t + \phi$

By superposition principle

$y = y_1 + y_2 = A \sin \omega t + B(\sin \omega t \cos\phi + \cos \omega t \sin$

$= \sin \omega t (A + B\cos\phi) + B \cos \omega t \sin\phi$

let, $A + B\cos\phi = R\cos\theta$ - ① $B\sin\phi = R\sin\theta$ - ②

$y = R(\sin(\omega t + \theta))$; R is resultant Amplitude

squaring and adding ① and ②

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

$= A^2 + B^2 + 2AB\cos\phi$

R : resultant Amplitude

when constructive Int. R_{max} ; $\cos\phi = 1$

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

when destructive Int. $R_{min} = A-B$, as $\cos\phi = -1$

we know, Intensity $\propto$ (Amplitude)^2

$$\Rightarrow I = K A_M^2 \quad ; \quad A_M : \uparrow$$

$$I_{max} \left(\begin{matrix}\text{constructive} \\ \text{Interference}\end{matrix}\right) = K(A+B)^2$$

$$I_{min} \left(\text{destructive}\right) = K(A-B)^2$$

$$\Rightarrow \frac{I_{max}}{I_{min}} = \left(\frac{A+B}{A-B}\right)^2$$

Intensity for fringes, let, $I_1 \propto A^2$ $I_2 \propto B^2$

$I_R = KR^2$ | $I_1 = KA^2$ | $A = \sqrt{\frac{I_1}{K}}$

$R = \sqrt{\frac{I_R}{K}}$ | $I_2 = KB^2$ | $B = \sqrt{\frac{I_2}{K}}$

then $I_R \propto R^2$

A, B, R are Amplitudes and we know, $R^2 = A^2 + B^2 + 2AB\cos\phi$

Now,

$$\left(\sqrt{\frac{I_R}{K}}\right)^2 = \left(\sqrt{\frac{I_1}{K}}\right)^2 + \left(\sqrt{\frac{I_2}{K}}\right)^2 + 2\sqrt{\frac{I_1 I_2}{K^2}}\cos\phi$$

$$I_R = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$$

$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2$ | $I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2$

$\hookrightarrow \cos\phi = 1$ | $\hookrightarrow \cos\phi = -1$

for Interference (YDSE) $I_1 = I_2 = I$

so $I_{Max} = 4I$

$I_{min} = 0$