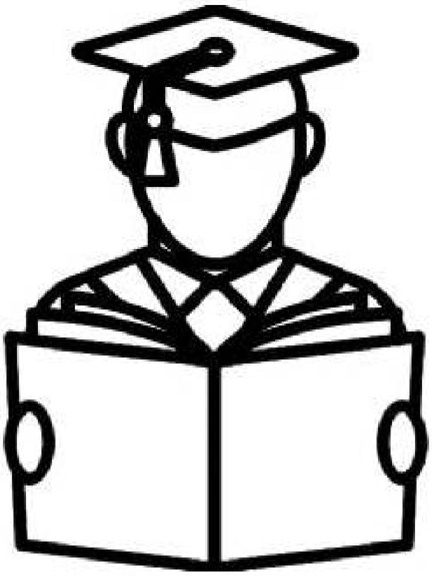
चौधरी PHOTOSTAT

"I don't love studying. I hate studying. I like learning. Learning is beautiful."



"An investment in knowledge pays the best interest."

Hi, My Name is

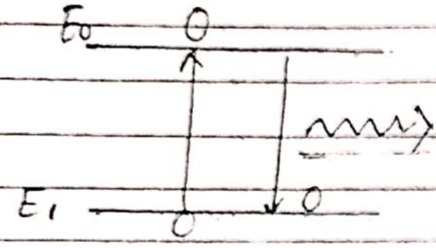
Physics (PH)
for JAM
(Career Endeavour)

Date 30/5/2018

OPTICS

★ Optics :- It is branch of science which study behavior of light

Light :



$\Delta E = \frac{hc}{\lambda}$

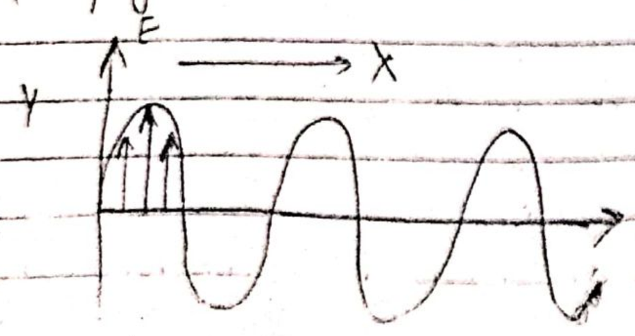
When atoms or molecules deexcite, it's emits radiation

Light

Particle	Wave
Photon	Electromag. Wave
$\Delta E = h\nu$	$E_{av} = \frac{1}{2} \varepsilon_0 E_0^2$
	where $E_0 \rightarrow$ amplitude

★ Light cannot behave simultaneously as wave & Particle

★ EM Waves – It is transverse wave in which $\vec{E}$ or $\vec{B}$ oscillate perpendicular to the dirn of propagation.



* Ashok Sam (HIR)

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Wave: All wave satisfy wave eqⁿ.

$$\boxed{\frac{1}{c^2}\frac{\partial^2 \psi(r,t)}{\partial t^2} = \nabla^2 \psi(r,t)}$$

Speed:

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}} = 3 \times 10^8 \, m/s \text{ in free space}$$

Speed of light in medium

$$\boxed{V_m = \frac{c}{n}} \quad n \rightarrow \text{refractive index}$$

$n \rightarrow$ Refractive index of medium.

→ When light changes medium, its frequency remain same.

→ As ν is characteristic of Source ($\Delta E = h\nu$)

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

or

$$\boxed{\nu = \frac{v}{\lambda} = \frac{v_1}{\lambda_1} = \text{constant}}$$

$$\boxed{\lambda_m = \frac{\lambda_{air}}{n}}$$

* Expression of wave :-

Plane wave : $\vec{E}(z,t) = E_0 \sin(\omega t - kz + \phi)\hat{x}$

ω → Angular frequency; k → Angular wave no.; z → dir^n of propagation

Amplitude : Max Displacement

Amp ∝ Energy Intensity

Angular frequency : $\omega = \frac{2\pi}{T}$; rad/sec

$\Rightarrow \omega = 2\pi\nu$

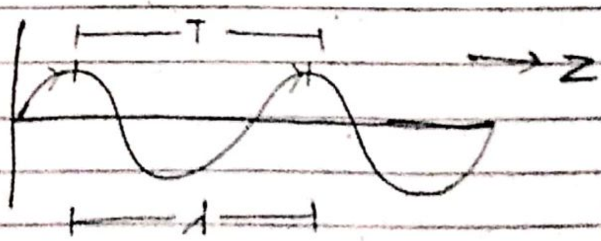
Now, $\boxed{\nu = \frac{1}{T}}$; sec^{-1}

Angular wave Number. $K = \frac{2\pi}{\lambda}$ rad/m

wave Number $k = \frac{1}{\lambda}$; m^{-1}

* Also, $\boxed{K_m = nK_0}$ $\left[\because \lambda_m = \frac{\lambda_0}{n}\right]$

* Phase :-



Argument of sine & cosine fn is called **phase**

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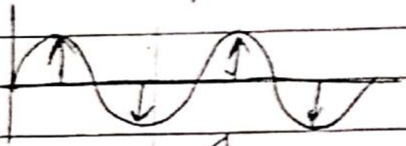
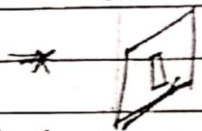
★ Spherical Wave :

Plane Wave : All the vibration takes place in single plane therefore it is called plane wave.

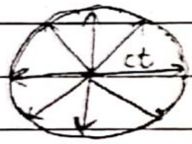
⇒ A extended source (e.g. Linear Source produces plane wave)

$$E(z,t) = E_0 \sin(\omega t - kz)$$





⇒ Point Source creates spherical wave



Eqn :-

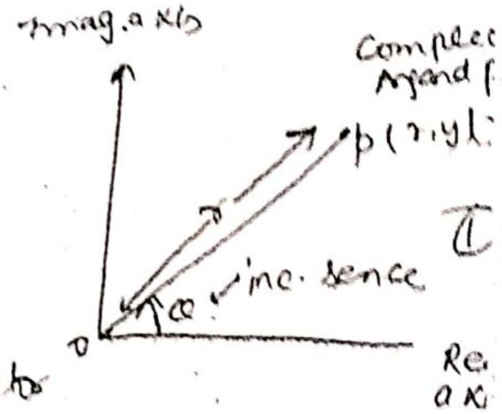
$$E(r,t) = \frac{E_0}{r} \sin(\omega t - \vec{k}\cdot\vec{r})$$

$$E(r,t) = E(r) \sin(\omega t - kz)$$ k is a scalar but we use it as a vector

where $\boxed{E(r) = \frac{E_0}{r}}$

i.e Amplitude is inversely propor. to distance

* Complex analysis



Basic preview of complex variables.

$z = x+iy$ (Cartesian form)

$z = re^{i\alpha}$ (polar form)

$r = |z|$ and $\alpha = \arg z$ (Amplitude)

$|\vec{OP}|$: Magnitude / length of the radius vector

$r = |z| = \sqrt{x^2+y^2}$

$= \sqrt{(R.P)^2 + (I.P)^2}$.

where α is the angle OP makes with +ve x-axis α is arg z

$\tan^{-1} \frac{y}{x}$

$\alpha = \tan^{-1} \frac{y}{x}$

$$\boxed{\alpha = \tan^{-1} \frac{I.P}{R.P}}$$ ✓

* $|z_1+z_2| \leq |z_1| + |z_2|$ ✓

* $|z_1 - z_2| \geq |z_1| - |z_2|$

* $|z_1 z_2| = |z_1|\,|z_2|$

* $\left|\frac{z_1}{z_2}\right| = \frac{|z_1|}{|z_2|}$

* $\arg(z_1 . z_2) = \arg(z_1) + \arg(z_1)$

* $\arg\left(\frac{z_1}{z_2}\right) = \arg(z_1) - \arg(z_2)$

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De MOIVRE'S THEOREM -

$(\cos\theta + i\sin\theta)^n = \cos n\theta + i\sin n\theta$

EULER'S FORMULA

$e^{i\theta} = \cos\theta + i\sin\theta$ $\qquad\qquad i = e^{i(4n+1)\frac{\pi}{2}}$

$1 = e^{i(2n)\pi}$ $\qquad\qquad -i = e^{i(4n+3)\frac{\pi}{2}}$

$-1 = e^{i(2n+1)\pi}$

Complex cube root of unity

$x^3 = 1$

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

$x = \left[e^{i(2n)\pi}\right]^{1/3}$

where $n = 0, 1, 2$

$n = 3, 4, 5$

$n = 6, 7, 8$

$n=0 \quad x = e^{i0} = 1$ $\qquad$ 1, ω, ω

$n=3 \quad x = e^{i(2\pi)} = 1$

$n=6 \quad x = e^{i(4\pi)} = 1$

$n=0 \quad x = 1$

$n=1 \quad x = -\frac{1}{2} + i\frac{\sqrt{3}}{2} = \omega$

$n=2 \quad x = -\frac{1}{2} - i\frac{\sqrt{3}}{2} = \omega^2$

$1, \omega, \omega^2$ → complex cube roots of unity

Basically.

$1+\omega+\omega^2 = 0$

$\omega^3 = 1$ (2)

$ax^3 + bx^2 + cx + d = 0$

$\Downarrow$

α, β, γ

since $\alpha+\beta+\gamma = -\frac{b}{a}$

$\alpha\beta + \beta\gamma + \gamma\alpha = +\frac{c}{a}$

$\alpha\beta\gamma = -\frac{d}{a}$

ex → $x^3 - 1 = 0$ $\quad x^3 - 0x^2 - 0x - 1 = 0$

$a = 1 \quad b = c = 0 \quad d = -1$

$\alpha+\beta+\gamma = -\frac{b}{a} = 0$

$\alpha.\beta.\gamma = -\frac{d}{a} = +1$

Q If $|z_1+z_2| = |z_1-z_2|$ then phase diff. b/w z_1 and z_2 is

(a) 30°

(b) 45°

(c) 60°

(d) 90°

P.D $(z_1, z_2) = \arg(z_1) - \arg(z_2)$

Alternate Vizalization. → These type of eq^n is likes as Impedence in Resistance and Inductor in our electronics which have a phase of 90° B/w them.

$|z_1+z_2| = |z_1-z_2|$

$z_1 = r_1 e^{i\theta_1}$

$z_2 = r_2 e^{i\theta_2}$

$|r_1 e^{i\theta_1} + r_2 e^{i\theta_2}| = |r_1 e^{i\theta_1} - r_2 e^{i\theta_2}|$

$\sqrt{(r_1\cos\theta_1 + r_2\cos\theta_2)^2 + (r_1\sin\theta_1 + r_2\sin\theta_2)^2}$

$\sqrt{(r_1\cos\theta_1 - r_2\cos\theta_2)^2 + (r_1\sin\theta_1 - r_2\sin\theta_2)^2}$

$r_1^2 + r_2^2 + 2r_1r_2\cos(\theta_1-\theta_2) = \sqrt{r_1^2 + r_2^2 - 2r_1r_2\cos(\theta_1-\theta_2)}$

taking Sq both sides

$4r_1r_2\cos(\theta_1-\theta_2) = 0$

$\cos(\theta_1-\theta_2) = 0$

$\theta_1-\theta_2 = \pi/2$

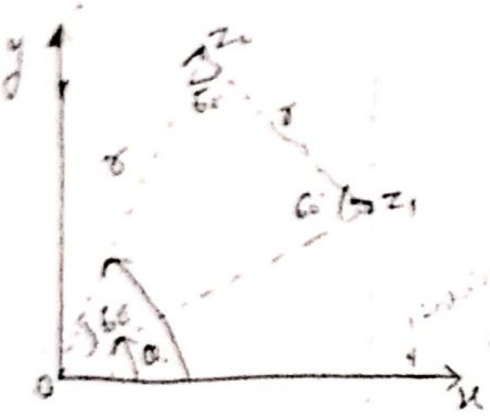
Q If z_1, z_2 and origin form a equilateral Δ then which of the following is True?

a) $z_1^2 + z_2^2 + z_1z_2 = 0$

b) $z_1^2 + z_2^2 - z_1z_2 = 0$

c) $z_1^2 + z_2^2 = 0$

d) $z_1^2 + z_2^2 - 2z_1z_2 = 0$



$z_1 = re^{i\theta}$

$z_2 = re^{i(\theta+\frac{\pi}{3})}$

$\frac{z_1}{z_2} = e^{i\frac{\pi}{3}}$

$\frac{z_2}{z_1} = e^{i\frac{\pi}{3}}$

$\frac{z_1}{z_2} + \frac{z_2}{z_1} = 2\cos\frac{\pi}{3}$

$z_1^2 + z_2^2 - z_1z_2 = 0$

Electricity & Magnetism   C. M. T

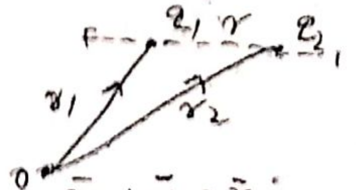
Coulomb's law → for two point charges force of attraction or repulsion is given as — Basically they are stationary. (1)

$F = \frac{K q_1 q_2}{r^2}$ $K = \frac{1}{4\pi\epsilon_0}$ in vaccum.

vector form of coulomb's law

force 1 due to 2

$\vec{f}_{12} = \frac{K q_1 q_2 (\vec{r}_1 - \vec{r}_2)}{|\vec{r}_2 - \vec{r}_1|^3}$



$\vec{r}_1 + \vec{r} = \vec{r}_2$

$\vec{r} = \vec{r}_2 - \vec{r}_1$

Force on 2 due to 1

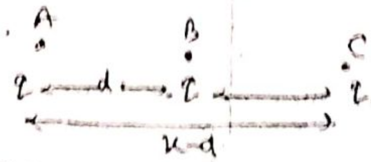
$\vec{F}_{21} = \frac{K q_1 q_2 (\vec{r}_2 - \vec{r}_1)}{|\vec{r}_2 - \vec{r}_1|^3}$ use −ve sign if charge is −ve

$\vec{f}_{12} = f(-\hat{r}) = F\left(-\frac{\vec{r}}{r}\right)$

$K \frac{q_1 q_2}{r^2}\left(-\frac{\vec{r}}{r}\right)$

if there is extended object then first cal. force due to element and then integrate.

Q



what is net force on charge at C

$F = \frac{3Kq^2}{4d^2}(-i)$

well know distance

$K\frac{q q}{d^2} + K\frac{q q}{(u-d)^2} = 0$

$\frac{1}{d^2} = \frac{-1}{(u-d)^2}$

$\frac{1}{d} = \frac{-1}{u-d}$

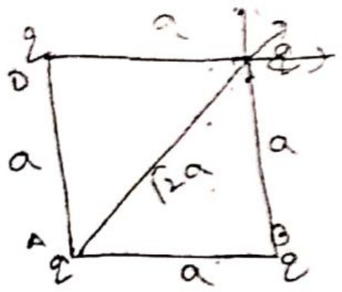
$u - d = -d$

$u = 2d$

$d = \frac{u}{2}$

putting in (i) we gets

Q.



$= \sqrt{(F_{AB})^2 + (F_{BC})^2 + F_{AB}F_{BC}\cos\theta}$

$F_{AB} = \dfrac{kq^2}{a^2}$

$F_{BC} = \dfrac{kq^2}{a^2}$

$F_{AC} = \dfrac{kq^2}{(\sqrt{2}a)^2} = \dfrac{kq^2}{2a^2}$

$= \sqrt{\left(\dfrac{kq^2}{a^2}\right)^2 + \left(\dfrac{kq^2}{a^2}\right)^2 + 2 \times \dfrac{kq^2}{a^2} \times \dfrac{kq^2}{a^2} \cdot \dfrac{1}{\sqrt{2}}}$

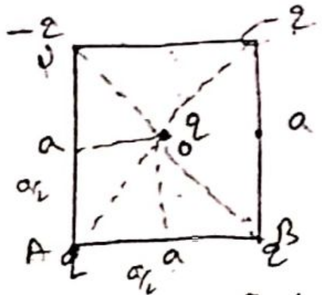
$= \sqrt{\left(\dfrac{kq^2}{a^2}\right)^2 + \left(\dfrac{kq^2}{a^2}\right)^2 + \sqrt{2}\left(\dfrac{kq^2}{a^2}\right)\left(\dfrac{kq^2}{a^2}\right)}$

$= \dfrac{kq^2}{a^2}\sqrt{1+1+\sqrt{2}}$

$\dfrac{kq^2}{a^2}\sqrt{2+\sqrt{2}} + \dfrac{kq^2}{2a^2}$

$= \dfrac{kq^2}{a^2}\left[\sqrt{2+\sqrt{2}} + \dfrac{1}{2}\right]$

Q



A point charge q is placed at the distance $\left(\dfrac{a}{\sqrt{2}}\right)$ above the centre of the square. Calc force on this point charge

dista $\sqrt{\left(\dfrac{\sqrt{2}a}{2}\right)^2 + \left(\dfrac{a}{\sqrt{2}}\right)^2} = \sqrt{\dfrac{a^2}{\sqrt{2}} + \dfrac{a^2}{\sqrt{2}}} = \sqrt{\dfrac{2a^2}{\sqrt{2}}} = \sqrt{2}a$

$f_{OA} = \sqrt{\dfrac{kq^2}{(\sqrt{2}a)^2} + \dfrac{kq^2}{(\sqrt{2}a)^2}} = 4\dfrac{kq^2}{(\sqrt{2}a)^2}\cos 45$

$4\dfrac{kq^2}{2a^2}\dfrac{1}{\sqrt{2}}$

$\dfrac{2}{\sqrt{2}}\dfrac{kq^2}{a^2} = \sqrt{2}\dfrac{kq^2}{a^2}\,f$

$\sqrt{\dfrac{kq^2}{(\sqrt{2}a)^2}}\sqrt{1+1+\dfrac{1}{\sqrt{2}}}$

$\dfrac{kq^2}{(\sqrt{2}a)^2}\sqrt{2+\dfrac{1}{\sqrt{2}}}$

$\dfrac{kq^2}{(\sqrt{2}a)^2}\,2(\sqrt{2}-1)$

$\dfrac{kq^2}{a^2}\dfrac{2}{2}$

$\dfrac{kq^2}{a^2}(\sqrt{2}-\tfrac{1}{2})$

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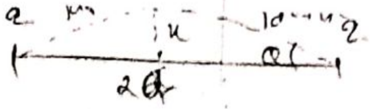
(6).



$F = 2\frac{KQ^2}{a^2+x^2}\cos\theta.$

$F = \frac{2KQ^2}{a^2+x^2} \times \frac{x}{\sqrt{a^2+x^2}}$

$F = 2KQ^2 \frac{x}{(a^2+x^2)^{3/2}}$

$\frac{\partial F}{\partial x} = 2KQ^2 \frac{(a^2+x^2)^{3/2}\frac{\partial}{\partial x}x - \frac{d}{dx}(a^2+x^2)^{3/2}(x)}{(a^2+x^2)^3}$

$\frac{\partial F}{\partial x} = 2KQ^2 \frac{(a^2+x^2)^{3/2} - x\cdot\frac{3}{2}(a^2+x^2)^{1/2}\,2x}{(a^2+x^2)^3}$

$\frac{\partial F}{\partial x} = 0$

$2KQ^2\left[(a^2+x^2)^{3/2} - 3x^2(a^2+x^2)^{1/2}\right] = 0$

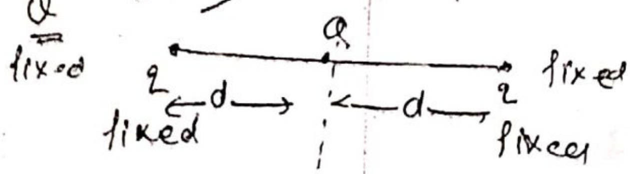
$(a^2+x^2)^{1/2}\left[a^2+x^2-3x^2\right] = 0$

$a^2 - 2x^2 = 0$

$a^2 = 2x^2$

$\boxed{x = \frac{a}{\sqrt{2}}}$

JEST 2015



If particle of charge Q is slightly displaced along dotted line then which of the following are correct

(b) Speed continuously increases

(ii) acc. first inc. and then dec.

Q5 $q + \lambda q = c$

$q(1+\lambda) = c$

$q = \frac{c}{1+\lambda}$

$F = \frac{Kq\lambda q}{(\lambda a - a)^2} = \frac{Kq^2\lambda}{a^2(1-\lambda)^2}$

$F = \frac{Kc^2\lambda}{a^2(1-\lambda)^2(1+\lambda)^2}$

$\frac{\partial F}{\partial \lambda} = 0 \quad = 1$ ...

Electric field [E]

It is introduced to explain action at a distance without contact.

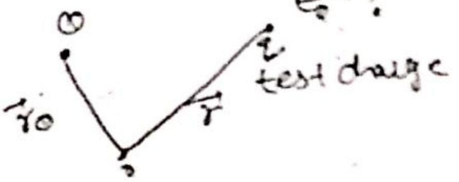
$\vec{E} = \frac{\vec{F}}{q_0}$ $\frac{N}{C}$ volt/meter

$\vec{F} = q\vec{E} \rightarrow$ where q is the charge in which force is to be find and the E is due to some other agency.

used for point charges as well as extended charges

field due to point charge..

$\vec{E}_q = ?$



$\vec{E}_Q(r) = \frac{\vec{F}_{qQ}}{q} = k\frac{qQ(\vec{r}-\vec{r}_Q)}{q|\vec{r}-\vec{r}_Q|^3}$

$$\boxed{\vec{E}_Q(\vec{r}) = \frac{kQ(\vec{r}-\vec{r}_Q)}{|\vec{r}-\vec{r}_Q|^3}}$$

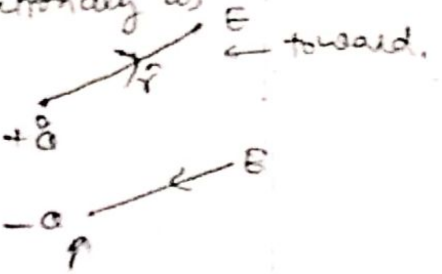
This formula can be valid for both stationary as well as moving charge particles

If charge is at origin

if $r_Q = 0$

$\vec{E}_Q(\vec{r}) = \frac{kQ\vec{r}}{r^3}$

$$\boxed{E_Q(r) = \frac{kQ}{r^2}\hat{r}}$$



* field is away from the +ve charge

field due to extended charge :-

$\vec{E}(r) = \int \frac{k\,dQ\,(\vec{r}-\vec{r}_Q)}{|\vec{r}-\vec{r}_Q|^3}$ → origin, where we find net $\vec{E}$

Applies in all the cases of electrostatics

$I_B = ?$ $\qquad I_C = \gamma I_B \quad , \quad I_E = 101 \cdot I_B$.

$-0.7 + 12 = 156 I_B \quad \Rightarrow I_B = \dfrac{11.3}{156}$

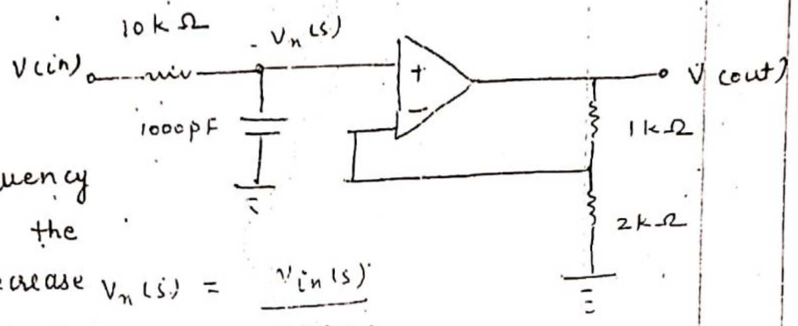
$I_E = I_B + I_C$

$I_C = I_E - I_B$

$= \dfrac{101(11.3)}{156} - \dfrac{11.3}{156}$

$= \dfrac{100 \times 11.3}{156}$

Q. 16, 55



(a) The frequency above which the gain will decrease by 20dB per decade is

(b) At 1.2 KHz the close loop gain is

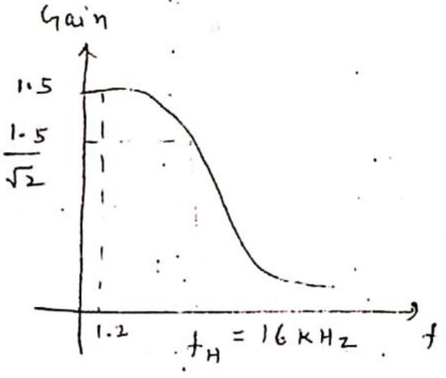
$V_n(s) = \dfrac{V_{in}(s)}{1+RCS}$

$V_o(s) = V_n(s)\left[1 + \frac{1}{2}\right]$

$T(s) = \dfrac{V_o(s)}{V_i(s)} = \dfrac{1.5}{\underbrace{1+RCS}_{\Rightarrow LPF}} = \dfrac{Gain}{1+j\frac{f}{f_H}}$

$f_H = \dfrac{1}{2\pi RC} \approx 16$ KHz

↳ upper 3-dB freq. LPF



$T(jf) = \dfrac{1.5}{1+j2\pi fRC}$

$|T(jf)| = \dfrac{1.5}{\sqrt{1+(2\pi fRC)^2}}$

$f = 1.2$ KHz

$|T(jf)| \approx 1.5$

19th century

$c \gg v$

Newtonian Mechanics
To study the dynamics
of particles

Maxwell theory of
Electromagnetic
To study Radiation

Relativistic Domain :-

$v \approx c$ (Newtonian Mechanics fail.)
↓ (Relativistic Mechanics) ✓

Microscopic Domain :-

Black body Radiation
Photoelectric Effect
Compton Effect
} Sol^n Quantum Mecha-

* Atomic stability
Atomic spectroscopy
} Atomic Physics.

Quantum Theory of light
OR
Photon theory of light

Light is collection of photons
$\underbrace{\text{photons}}$ Particle nature of light.

$$\boxed{\begin{aligned} E_{ph} &= h\nu = \frac{hc}{\lambda} \\ P_{ph} &= \frac{E_{ph}}{c} = \frac{h\nu}{c} = \frac{h}{\lambda} \end{aligned}}$$

$$E = n_{ph} h\nu$$

number of photons

I (intensity) = Energy / time / area

$I = (n_{ph} h\nu) / \text{time} / \text{area}$

$I \uparrow \Rightarrow n_{ph} \uparrow$ (ν will remain same)
frequency

$I \downarrow \Rightarrow n_{ph} \downarrow$ (")

Neglecting all losses due to collision —

$$\boxed{(E_{K.E})_{max} = h\nu - W_0 = h\nu - h\nu_0}$$

↳ Photoelectric equation

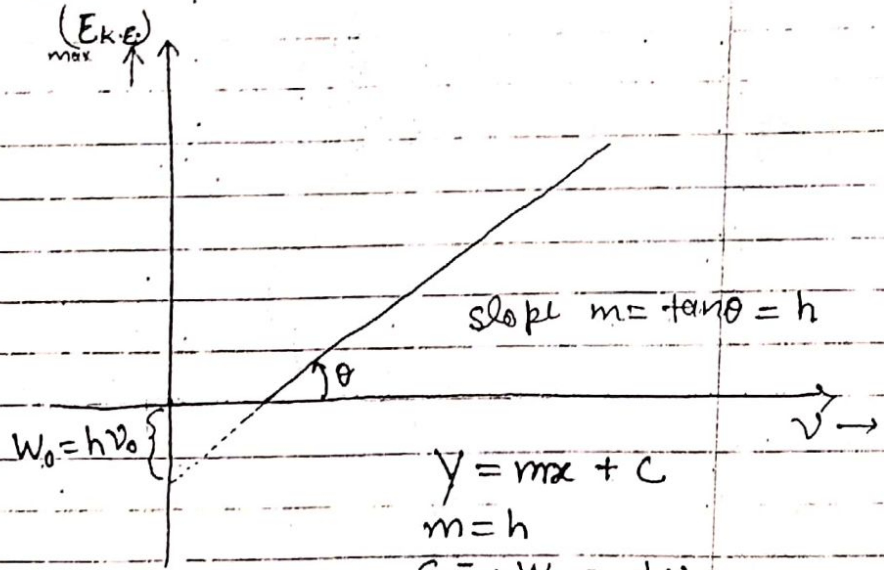
$\nu_0 \rightarrow$ Threshold Frequency.

$$\boxed{(E_{K.E})_{min.} = 0}$$

if $\nu < \nu_0 \Rightarrow E_{K.E} < 0$ ✗

↓

No emission of photo e^-s

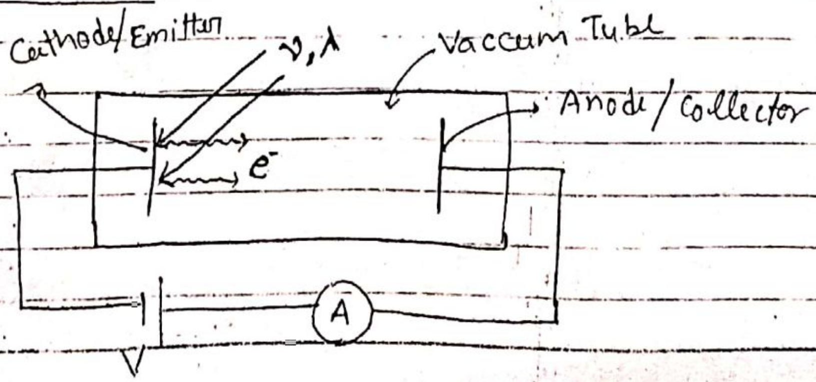


$y = mx + c$

$m = h$

$c = -W_0 = -h\nu_0$

Experimental set-up



Photoelectric Effect :-

When a light of sufficiently of high frequency incident on a metal surface then e^- are emmited from the metal surface. This phenomena is known as photo electric Effect, and the emmited electrons are known as photo electrons.

The minimum energy required for the electron to come out of the metal surface is said to be the "work function" of the metal.

Let assume *two collision e^- have to come out of the metal surface —

$$h\nu \xrightarrow[\Delta E_{loss} = 0.1h\nu]{1^{st}\ \text{collision}} = 0.9h\nu$$

$$0.9h\nu \xrightarrow[\Delta E_{loss} = 0.09h\nu]{2^{nd}\ \text{collision}} = \overset{**}{0.81h\nu}$$

*The collision can be more than 2.

$$0.81\,h\nu \geq W_0$$

$\downarrow$

e^- will come out of the metal surface

**0.81hν energy should be greater than or equal to work func.

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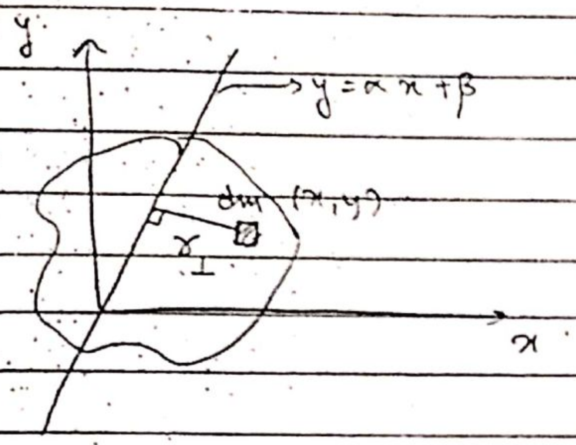
Moment of inertia & product of Inertia



$$r_\perp = \frac{|y - \alpha x - \beta|}{\sqrt{1 + \alpha^2}}$$

Product of Inertia:

$$I_{yx} \text{ or } I_{xy} = -\int dm\, xy$$

$$I_{xz} \text{ or } I_{zx} \Rightarrow -\int dm\, xz$$

$$I_{yz} \text{ or } I_{zy} \Rightarrow -\int dm\, yz.$$

$$= -\sum m_i y_i z_i$$

discrete.

Inertia tensor:

It is a 3×3 matrix formed by moment of inertia & P.I.

Kinetic (THERMODYNAMICS)

postulates of kinetic theory →
Let us we have a container with volume V and having n identical mol. each of mass 'm'

(i) The molecules behaves as point particles whose vol. is small compared to the vol. of the container & with respect and also small enough with respect to the intermol. distance.

2) The mol. are in constant motion each mol. occasionally collide with another mol. with the walls of the mol. These collisions are perfectly elastic.

3) The walls are perfectly rigid and infinitely massive.

4). The mol. does obey newton's laws of motion.

5) The time of collision is much small as compared to the average time B/w two collision.

* Notations

N = no. of molecules

η = no. of moles

N_A = Avagadro 6.023×10^{23}

How does pressure originate in the container having some amount of gas?

→ when the gas collide with the walls of the container they introduce pressure.

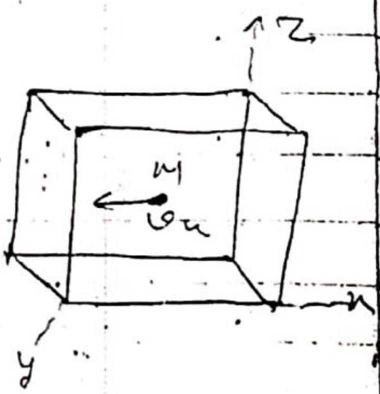
Derivation → Assuming that all the mol. having same magnitude of velocity $|v_x|$

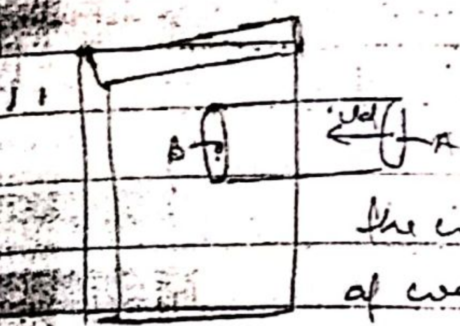
for each collision the change in momentum

$\Delta p = |\Delta f - \Delta i|$ (change in p)

$m|v_x| - m(-v_x|$

$= 2m v_x$





If this mol. has to collide with the wall in time 'dt' then the length of wall of the cylinder would be

$|v_x| dt$

vol. of the cylinder $A|v_x| dt$ each

mol. in the cylinder will contribute change of momentum $2m|v_x|$

Assuming that the mol. are uniformly distributed in the container