Ashwani kr. Chaudhary
ACE 077 BCT 020.

Q.1) Soln.

width (b) = 2 cm = 2×10^{-2} m

Thickness (t) = 2 mm = 2×10^{-3} m.

$B = 1.5T$

$I = 100A$

Hall voltage (V_H) = ?

hall mobility (μ_H) = ?

we have,

$$\text{Hall coefficient } (R_H) = \frac{E_H}{J, B}$$

$$\frac{1}{ne} = \frac{\frac{V_H}{b}}{\frac{I}{bt}\cdot B}$$

$$V_H = \frac{BI}{net}$$

$$= \frac{1.5\times100}{8.4\times10^{28}\times1.6\times10^{-19}\times2\times10^{-3}}$$

$$= 5.58\times10^{-6}\ V.$$

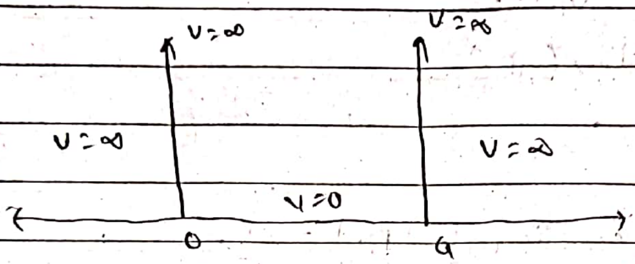
$$\text{Hall mobility } (\mu_H) = \frac{R_H}{\rho} = \frac{1}{ne\rho}$$

$$= \frac{1}{8.4\times10^{28}\times1.6\times10^{-19}\times1.72\times10^{-8}}$$

$$= 231.2\ m^2V^{-1}s^{-1}$$

Q.4) Ans

An electron is confined in a one dimension infinite potential well of width a, the potential energy is $V=0$ for $0 \le x \le a$ & $V=\infty$ for $x \le 0$ & $x \ge a$ find the Eigen function $\psi_n(x) = A \sin\left(\frac{n\pi x}{a}\right)$ & energy Eigen value $E_n = \frac{n^2\pi^2\hbar^2}{2ma^2}$.



Let us consider a particle restricted to move along $x \ge 0$ & $x=a$. The potential energy (V) of the point is zero within the limit & infinity on the outside

ie.

$$V=0 \text{ for } 0 \le x \le a$$

$$\& \quad V=\infty \text{ for } x \ge a \;\&\; x \le 0$$

The schrodinger wave equation for the particle within the box is

$$\frac{d^2\psi}{dx^2} + \frac{2m(E-V)}{\hbar^2}\psi = 0 \quad \text{---(1)}$$

$$\frac{d^2\psi}{dx^2} + \frac{2mE}{\hbar^2}\psi = 0 \quad \text{---(2)}$$

$$\text{Let } k^2 = \frac{2mE}{\hbar^2} \text{ then} \quad \text{---(3)}$$

$$\frac{d^2\psi}{dx^2} + k^2\psi = 0 \quad \text{---(4)}$$

Then,

sol^n of above sol^n is

$$\psi(x) = A\sin kx + B\cos kx \quad -(5)$$

where A & B are constant to be determined using Boundary. As particle doesn't exist outside the basic the box. $\psi = 0$ outside the box & on the walls.

ie.

$x = 0$ & $x = a$

for $x = 0$

$\psi(x) = 0$

$0 = 0 + B$

$B = 0$

simillarly,

$x = a$

$\psi(a) = 0$.

$0 = A\sin ka + 0$

$\sin ka = 0$

$\sin ka = \sin n\pi$

$ka = n\pi$

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

Then,

$$k^2 = \frac{2mE}{\hbar}$$

or $\frac{n^2\pi^2}{a^2} = \frac{2mE}{\hbar}$

or $E_n = \frac{n^2\pi^2\hbar^2}{2ma^2}$ which is Eigen Energy.

Now,

Substituting

$B = 0$ & $k = \frac{n\pi}{a}$ in eq (5)

$$\psi_n(x) = A\sin \frac{n\pi x}{a} + 0$$

$$\psi_n(x) = A\sin \frac{n\pi x}{a}$$

Q.N. 2)

⇒ The phenomom of generation of induced emf is in a coil due to change in magnetic flux is called electromagnetic induction.

We know that. A toroid is a solenoid bent in-to the shape of hollow dought neught ~~magnet~~
consider a torid having rectangle cross section area. carrying current I. a & b be the internal & external radi of a toroid & h be the width of cross section of torid.

let us take small strip of length 'dr' at across term from the centre ~~stinct~~ 'h' be the width of the strip there force its area is h.dr

The magnetic flux through taroid is

$$\phi_B = \int \vec{B}\cdot d\vec{A} = \int_a^b B\, h\, dr$$

The magnetic field due to torid $B = \frac{\mu_0 N I}{2\pi r}$ where N is the total no. of turn in toriud

$$\phi_B = \frac{\mu_0 N I h}{2\pi} \int_a^b \frac{dr}{r}$$

$$= \frac{\mu_0 N I h}{2\pi} \ln \frac{b}{a}.$$

Inductane of torid

$$(L) = \frac{N\phi_B}{I}$$

$$= \frac{\mu_0 N^2 h}{2\pi} \ln \frac{b}{a}$$

Q.N. 3)

In non-conducting medium,
charging density 's' & current density J both zero. If medium have permicibility then π_0

According to Maxwells equation

$$\nabla \cdot \vec{E} = 0 \quad \text{—(i)}$$

$$\nabla \cdot \vec{B} = 0 \quad \text{—(ii)}$$

$$\nabla \cdot \vec{E} = -\frac{d\vec{B}}{dt} \quad \text{—(iii)}$$

taking curl on eq^n (iii).

$$\nabla \cdot \nabla \cdot \vec{E} = -\frac{d(\vec{\nabla} \times \vec{B})}{dt}$$

$$\bar{\nabla}(\bar{\nabla} \cdot \vec{E}) - \vec{E}(\bar{\nabla} \cdot \vec{\nabla}) = -\frac{d}{dt}\left(\pi \cdot \varepsilon \cdot \frac{d\vec{E}}{dt}\right)$$

$$-\bar{\nabla}^2 \cdot \vec{E} = -\pi \varepsilon \frac{d^2\vec{E}}{dt^2}$$

$$\bar{\nabla}^2 \cdot \vec{E} = \pi \varepsilon \frac{d^2\vec{E}}{dt^2} \quad \text{—(iv)}$$

Again, taking curl on eq^n (v)

$$\bar{\nabla} \times \bar{\nabla} \times \vec{B} = \pi \varepsilon \frac{d(\bar{\nabla} \times \vec{E})}{dt}$$

$$\bar{\nabla}(\bar{\nabla} \cdot \vec{B}) - \vec{B}(\bar{\nabla} \cdot \bar{\nabla}) = \pi \varepsilon \frac{d\left(-d\vec{B}/dt\right)}{dt}$$

$$0 - \bar{\nabla}^2 \vec{B} = -\pi \varepsilon \frac{d^2\vec{B}}{dt^2}$$

$$\nabla^2 \vec{B} = \pi \varepsilon \cdot \frac{d^2\vec{B}}{dt^2} \quad \text{—(vi)}$$

Scanned with CamScanner

Equation (v) & (vi) are eqⁿ of electromagnetic wave.
Now, comparing eqⁿ with general wave eqⁿ.

$$\nabla^2 \vec{y} = \frac{1}{v^2} \frac{d^2 \vec{y}}{dt^2}$$

$$v = \frac{1}{\sqrt{\mu \varepsilon}}$$

which is reqd. relation for velocity of wave in non-conducting medium.

Q.N.6)

The electric field for cylindrical capacitor is,

$$E = \frac{q}{2\pi\varepsilon_0 l r} \quad \text{--- (i)}$$

where, $l \rightarrow$ length
$r \rightarrow$ radius

~~(Energy (unit volume)~~

Energy density is

$$u = \frac{1}{2}\varepsilon_0 E^2 = \frac{q^2}{8\pi^2\varepsilon_0 l^2 r^2} \quad \text{--- (2)}$$

by putting value from eq^n (i) we get (2)

ans,

The energy stored betn the co-axial cylinder of the length l & Radius r & a is

$$U = \int u \, dv = \int_a^r u (2\pi r l) \, dr \quad \text{--- (3)}$$

where, $dv = (2\pi r dr) l$ is the volume element

from (2) & (3)

$$U = \frac{q^2}{4\pi\varepsilon_0 l} \int_a^r \frac{dr}{r} = \frac{q^2}{4\pi\varepsilon_0 l} \ln \frac{r}{a}$$

similarly the energy stored betn co-axial cylinder b & a is

$$u_0 = \frac{q^2}{4\pi\varepsilon_0 l} \ln b/a$$

$$\therefore \frac{u}{u_0} = \frac{\ln(r/a)}{\ln(b/a)}$$

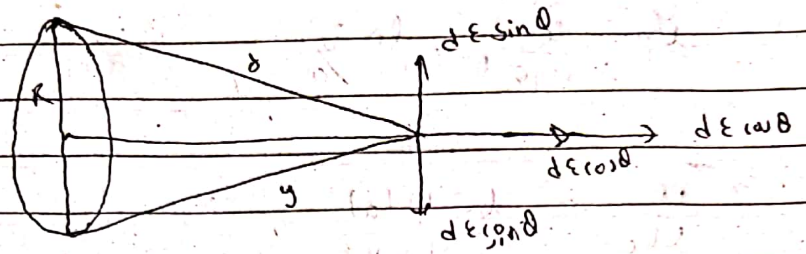
also $\frac{u}{u_0} = \frac{1}{2}$

or $\frac{\ln(r/a)}{\ln(b/a)} = \frac{1}{2} \Rightarrow \ln b/a = 2\ln r/a \Rightarrow \ln \frac{r^2}{a^2}$

or $\frac{b}{a} = \frac{r^2}{a^2}$

or $r = \sqrt{ab}$ proved

Q.N.5)



Here let a ring of radius 'R' & at distance y from the centre of the ring.

Now,

lets divide the ring small elemental segment (dl) then

$$dq = \lambda dl$$

Now small electric field at a distance r.

$$dE = \frac{dq}{4\pi\varepsilon_0 r^2} = \frac{\lambda dl}{4\pi\varepsilon_0 (y^2+R^2)}$$

Now

since as it is symmetric we found out that the component of dE the dE cos θ & dE sin θ. ~~di~~ dE sine cancel out & cort dE cos θ is functional so, we can get resultant field by integrating it

so,

$$E = \int dE \cos\theta$$

$$E = \int_0^{2\pi R} \frac{\lambda y \, dl}{4\pi\varepsilon_0 (y^2+R^2)^{3/2}} \qquad \left(\because \cos\theta = \frac{y}{\sqrt{R^2+y^2}} \right)$$

$$F = \frac{\lambda y \cdot 2\pi R}{4\pi\varepsilon_0 (y^2+R^2)^{3/2}}$$

$$= \frac{e y}{4\pi\varepsilon_0 (y^2+R^2)^{3/2}}$$

Now let ~~g~~ a electron is present at the axial line of that ring then, force experienced by the ring then,

force experienced by the ring is,

$$F = -\frac{e}{2} \times F$$

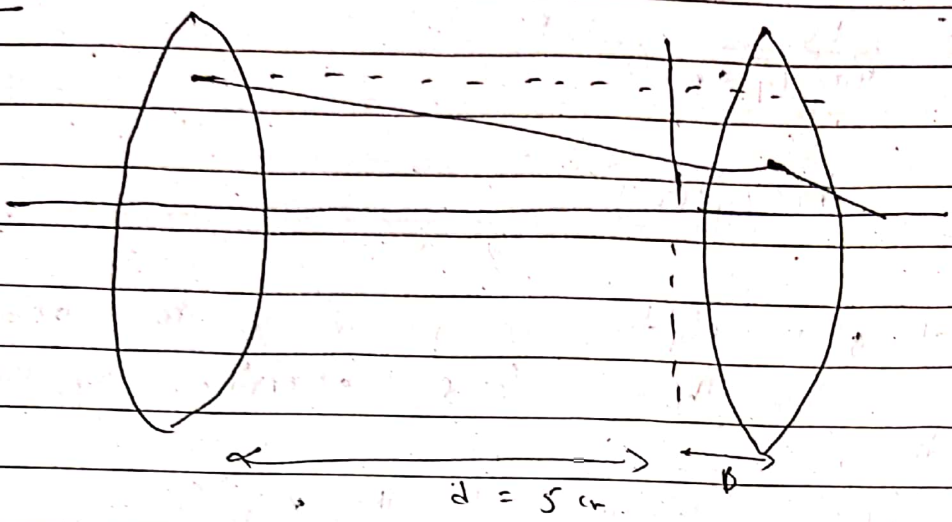
$$F = -\frac{e}{2} \times \frac{e \times y}{4\pi\varepsilon_0 (y^2+R^2)^{3/2}}$$

$$F = \left(\frac{-e_2 \cdot e}{4\pi\varepsilon_0 R^3} \right) \times y \quad [\text{when} \because R >>> y]$$

which is $F = -kx$ [SHM eqn]

so, the motion of electron will be SHM.

Q.N. 8)



given,

$d = 5\ cm$

$f_1 = 10\ cm$

$f_2 = 4\ cm$

$F = ?$

we know,

by the formula of combination of lens separated by a small distance

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} - \frac{d}{f_1 f_2}$$

$$= \frac{1}{10} + \frac{1}{4} - \frac{5}{10 \times 4}$$

$$= \frac{1}{10} + \frac{1}{4} - \frac{1}{8}$$

$$= \frac{4+10-5}{40}$$

$$\frac{1}{F} = \frac{9}{40}$$

$$f = 40/9$$

$f = 4.44$ cm

Also,

To determine the position of principle poin.

which α & β ar Then,

Then

$$\alpha = \frac{fd}{f_2}$$

$$\alpha = \frac{4.44 \times 5}{4}$$

$$\alpha = 5.55 \text{ cm}$$

& lastly,

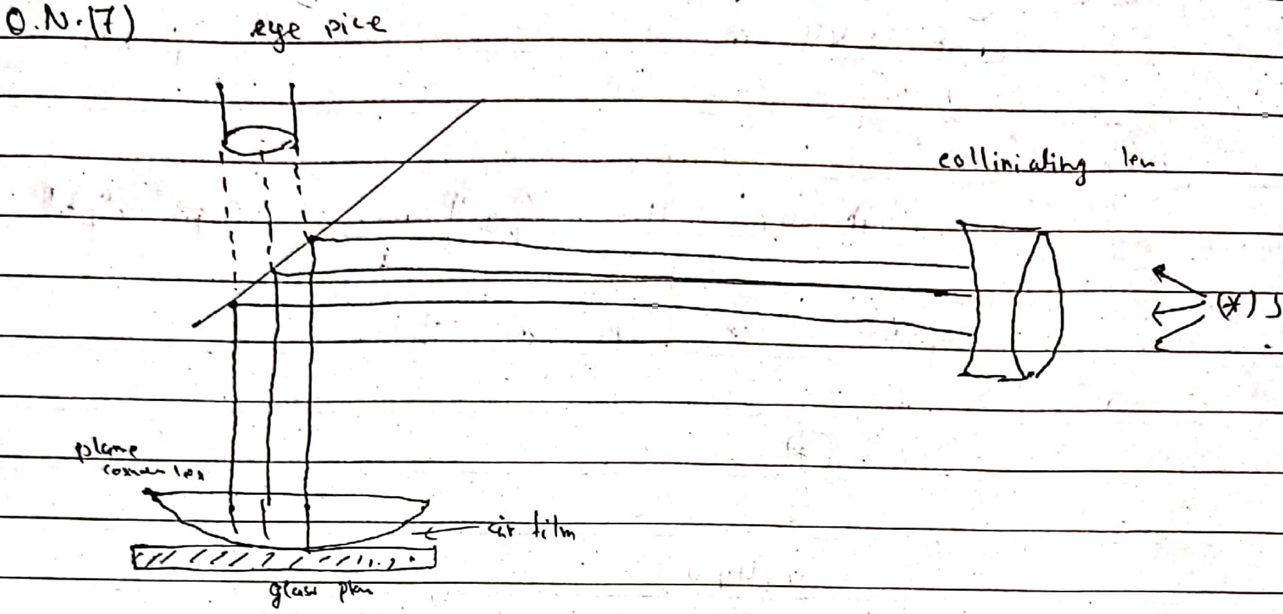
$$\beta = -\frac{fd}{f_1}$$

$$\beta = -\frac{4.44 \times 5}{10}$$

$$\beta = -2.22 \text{ cm}$$

//

Q.N.(7)



let S be source of light A parallel beam of light from lens system is reflected by a glass plate P which is inclined at angle 45' with the horizontal A plano convex lens of length focal length is exposed to reflected light from glass plate P which enclose an air film as in the figure

let the diameter of nth dark ring be D_n which is related with the wavelength of light & radius of curvature of plano convex lens i

$$D_n^2 = 4n\lambda R \quad \text{—(i)}$$

Simillarly for $(n+m)^{th}$ dark fring

$$D_{n+m}^2 = 4(n+m)\lambda R \quad \text{—(ii)}$$

lly.

$$D_{n+m}^2 - D_n^2 = 4m\lambda R \quad \text{—(iii)}$$

$$\lambda = \frac{D^2_{n+m} - D_n^2}{4mR} \quad \text{---(v)}$$

To determine the refractive index of given transparent liquid, gently pour the liquid into the air film space without disturbing the entire arrangement.

let D_n & D_{n+m} be diameter of n^{th} & $(n+m)^{th}$ Newton ring.

Then we can re write eq^n (iii) as

$$D'^2_{n+m} - D'^2_n = \frac{4m\lambda R}{\mu} \quad \text{---(v)}$$

$$\frac{D'^2_{n+m} - D'^2_n}{4mR} = \frac{\lambda}{\mu} \quad \text{---(vi)}$$

Dividing eq^n (v) by (vi)

$$\frac{\cancel{\lambda}}{\frac{\cancel{\lambda}}{\mu}} = \frac{D^2_{n+m} - D_n^2}{4mR} \times \frac{4mR}{D'^2_{n+m} - D'^2_n}$$

$$\mu = \frac{D^2_{n+m} - D_n^2}{D'^2_{n+m} - D'^2_n}$$