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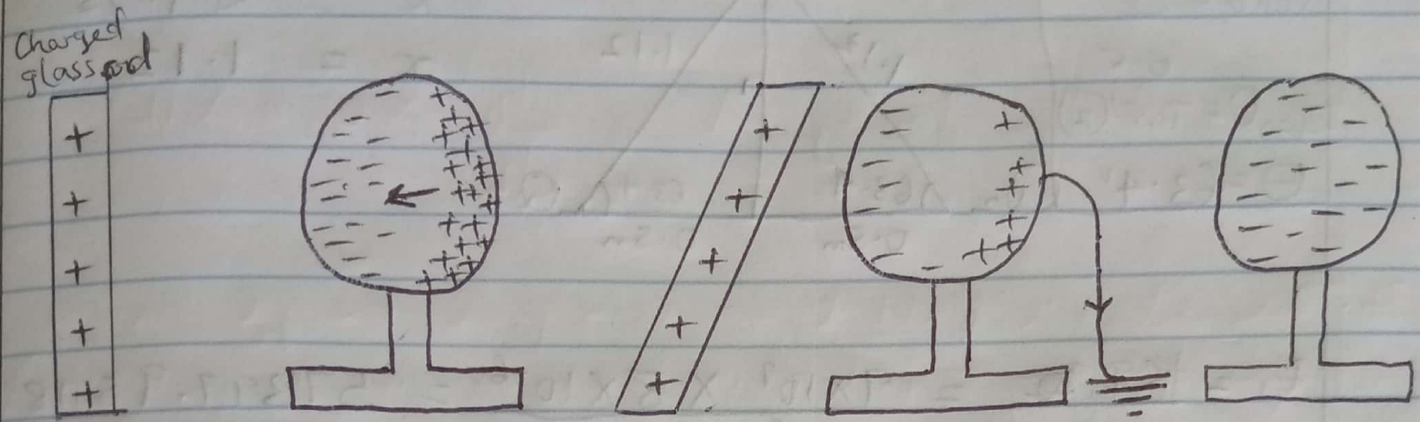
DEPT: PETROLEUM ENGINEERING
COURSE CODE: PHY 102 - Assignment.

1a.



We bring the positive charged glass rod near the sphere positive side and touch the negative end with the fingers thus earthing the conductor. The positively charged electrons leak away to the earth through the human body, leaving only the negative charges on the conductor. These negative charges remain on the conductor as long as the inducing charge remains. If the finger is now removed, then the glass rod is removed, the sphere will be left with a net negative charge.

b. $F = 1N \quad r = 2.0m \quad k = 9\times10^9 Nm^2/C^2 \quad q_1 + q_2 = 5\times10^{-5}C$

$$F = \frac{kq_1q_2}{r^2}$$

$$1 = \frac{9\times10^9 \times (q_1 + q_2)\, 5\times10^{-5}}{2^2}$$

$$4 = 9\times10^9 \times q_1 5\times10^{-5} + 9\times10^9 q_2$$

$$4 = 4.5\times10^5 q_1 + 9\times10^9 q_2$$

It is a quadratic equation.

$$9\times10^9 q_2 - 4.5\times10^5 q_1 + 4 = 0$$

$q_1 = 0.0000111C$

$q_2 = 0.000038C$

$\therefore q_1 = 1.11\times10^{-5}C \quad , \quad q_2 = 3.8\times10^{-5}C$

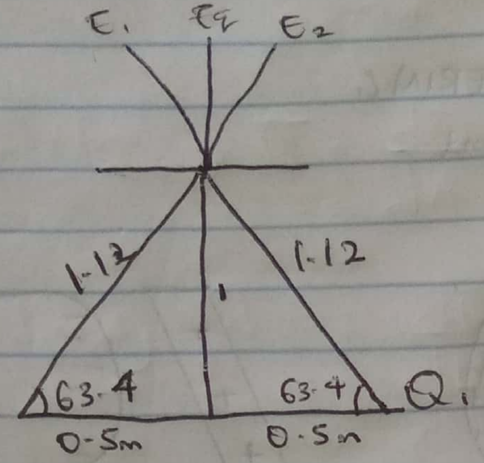
c. $Q_1 = Q_2 = 8\,\mu C \qquad d = 0.5m$

$\tan\theta = \frac{opp}{Adj}$

$\tan\theta = \frac{1}{0.5}$

$\tan\theta = \tan^{-1}(2)$

$\theta = 63.4°$



$x^2 = 1^2 + 0.5^2$

$x^2 = 1 + 0.25$

$x = \sqrt{1.25}$

$x = 1.12$

$E_1 = \frac{Kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.95918$

$E_2 = \frac{Kq_2}{r_2^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.95918$

$E_q = \frac{Kq}{r^2} = \frac{9\times10^9 \times q}{1} = 9\times10^9 q$

Vector	θ	x-Comp.	y-Comp.
$E_1 = 57397.95918$	$63.4°$	$E_1\cos 63.4° = 25700.45785$	$E_1\sin 63.4° = 51322.62839$
$E_2 = 57397.95918$	$63.4°$	25700.45785	51322.62839
$E_q = 9\times10^9 q$	$90°$	$E_q\cos 0 = 0$	$9\times10^9 q\sin(90°)$ 10264.52568

Magnitude $= \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$

$E_q = \sqrt{(0)^2 + (10264.52568)^2}$

Since $E = 0$

$0 = 9\times10^9 q + 10264.52568$

Making q the sub. of formular

$q = -\frac{10264.52568}{9\times10^9}$

$q = -1.141\times10^{-6} \quad \therefore q = -1\,\mu C$

2a. Electric field is a region around a charged body where the effect of an electric force is felt

While,

Electric field intensity can be defined as the force per unit charge.

3a. Volume charge density, $P = \frac{dQ}{dv} \xrightarrow{dQ} pdv$

Surface charge density, $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$

Linear charge density, $\lambda = \frac{dQ}{dL} \rightarrow dQ = \lambda dL$

3b. The electric field E exerts a force $F = q_0 E$, an external force of $F = -q_0 E$ must act on the charge. The elemental work done dW is given as:

$$dW = F \cdot dl \quad \text{----} (1)$$

But ;

$$F = -q_0 E \quad \text{-----} (2)$$

Substituting equ (2) in (1) yields

$$dw = -q_0 E dl \quad \text{---} (3)$$

Then total work done in moving the test charge from A to B is

$$W_{(A-B)Ag} = -q_0 \int_A^B E dl \quad \text{...} (4)$$

from the definition of electric potential difference, it follow

$$V_B - V_A = \frac{W_{(A-B)Ag}}{q_0} \quad \text{---} (5)$$

putting equ (4) in (5) yields:

$$V_B - V_A = -\int_A^B E dl$$

4a Magnetic flux is defined as the strength of the magnetic field which can be represented by line of forces. It is represented by the symbol Φ, mathematically, given as $\Phi = B \cdot dA$

b. $W = v/r = qB/m$

$m = 9.11 \times 10^{-31}$ kg, $r = 1.4 \times 10^{-7}$ m, $B = 3.5 \times 10^{-1}$ tesla

$W = qB/m_e$ $q_e = 1.6 \times 10^{-19}$ C

where M_e = Mass of ~~electron~~ $= 1.6 \times 10^{-19}$ kg

$$W = \frac{(1.6 \times 10^{-19}) \times (3.5 \times 10^{-1})}{(9.11 \times 10^{-31})}$$

$W = 6.15 \times 10^{10}$ rad/s

c. In the question we were given parameters such as:

i. Mass of the electron $= 9.11 \times 10^{-31}$ kg

ii. A radius of 1.4×10^{-7} m

iii. magnetic field of 3.5×10^{-1} weber/meter square and was asked to find the cyclotron frequency because it is a frequency of an accelerator called cyclotron.

Recall that angular speed is given as $w = \frac{v}{r} = \frac{qB}{m}$

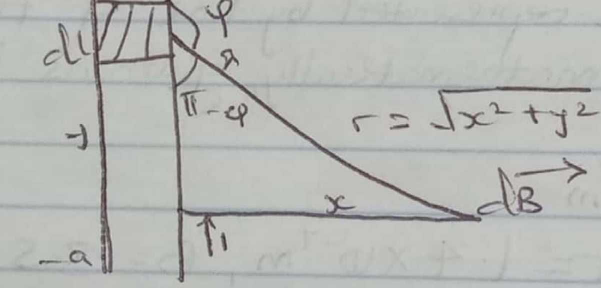
Substituting the values we have, $\frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-10}}{9.11 \times 10^{-31}}$

$= 6.15 \times 10^{10}$ rad/s

Since cyclotron frequency is equal to angular speed the cyclotron frequency is equal to 6.15×10^{10} rad/s, having a unit as $1/T$ which is equal to the unit of frequency dimensionally.

5a. Biot-Savart law states that the magnetic field is directly proportional to the product permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to square of radius (r^2).

b. Magnetic Field of a Straight Current Carrying Conductor



Applying the Biot-Savart law, we find the magnitude of the field $\vec{dB}$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin\varphi}{r^2}$$

$$\sin(\pi - \varphi) = \sin\theta$$

$$\therefore B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin(\pi - \varphi)}{r^2}$$

from diagram, $r^2 = x^2 + y^2$

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl \sin(\pi - \varphi)}{x^2 + y^2} \quad \text{----- } (*)$$

But $\sin(\pi - \varphi) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}}$ ----- $(**)$

Substituting (* *) into (*), we have

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} dl \frac{x}{(x^2+y^2)(x^2+y^2)^{1/2}}$$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} dl \frac{x}{(x^2+y^2)^{3/2}}$$

Recall $dl = dy$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{x}{(x^2+y^2)^{3/2}} dy$$

$$B = \frac{\mu_0 I x}{4\pi}\int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}} dy \quad \ldots\ldots (* * *)$$

Using special integrals:

$$\int \frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2}\frac{y}{(x^2+y^2)^{1/2}}$$

Equ (* * *) becomes

$$B = \frac{\mu_0 I x}{4\pi}\left[\frac{y}{x^2(x^2+y^2)^{1/2}}\right]_{-a}^{a}$$

$$B = \frac{\mu_0 I x}{4\pi}\left(\frac{2a}{x^2(x^2+a^2)^{1/2}}\right) = \frac{\mu_0 I}{4\pi x}\left(\frac{2a}{(x^2+a^2)^{1/2}}\right)$$

When the length $2a$ of the conductor is very great in comparison to its distance x from point P, we consider it infinitely long. That is when a is much longer than x,

$$(x^2+a^2)^{1/2} \cong a, \text{ as } a \to \infty$$

$$\therefore B = \frac{\mu_0 I}{2\pi x}$$

In a physical situation, we have axial symmetry about y-axis. Thus at all points in a circle of radius r, around the conductor, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r}$$