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MATRIC NO: 19/MHS01/145

DEPT: MBBS

COLLEGE: MHS

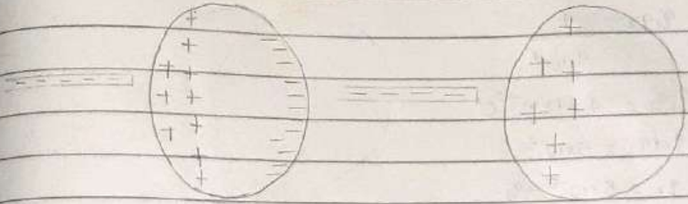
Assignment:

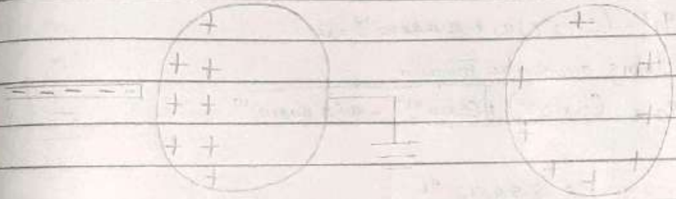
Section A

1a. Charging By Induction

Electric charges can be obtained on an object without touching it, by a process called electrostatic induction. Consider a positively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod. The region of the sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducting wire is then connected to the sphere, some of the electrons leave the sphere and travel to the earth. If the wire to ground is then removed, the conducting sphere is left with an excess of induced positive charge.

Finally, when the rubber rod is removed from the vicinity of the sphere, the induced positive charge remains on the ~~undergrounded~~ ungrounded sphere and becomes uniformly distributed over the surface of the sphere.





16. $K = 9\times10^9$

$F = 1N.$

$r = 2$

$q_1 + q_2 = 5\times10^{-5} C$

$$F = \frac{k q_1 q_2}{r^2}$$

$$q_1 q_2 = F\left(\frac{r^2}{k}\right)$$

$$\cancel{q_1 q_2 = 1\left(\frac{2^2}{9\times10^{10}}\right)}$$

$$q_1 q_2 = 1\left(\frac{2^2}{9\times10^9}\right)$$

$$q_1 q_2 = \frac{4}{9\times10^9}$$

$q_1 q_2 = 4.44\times10^{-10} C^2$

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

$q_2 = 5\times10^{-5} - q_1$

$q_1(5\times10^{-5} - q_1) = 4.44\times10^{-10}$

$5\times10^{-5} q_1 - q_1^2 = 4.44\times10^{-10}$

$q_1^2 - (5\times10^{-5}C)q_1 + 4.44\times10^{-10} = 0$

Using quadratic Formula

$$q_1 q_2 = \frac{(5\times10^{-5}) + \sqrt{(5\times10^{-5})^2 - 4(4.44\times10^{-10}}}{2}$$

$$= 3.84\times10^{-5}C$$

$$\frac{(5\times10^{-5}) - \sqrt{(5\times10^{-5})^2 - 4(4.44\times10^{-10}}}{2}$$

$$= 1.16\times10^{-5}C$$

$q_1 = 3.84\times10^{-5}C$, $q_2 = 1.16\times10^{-5}C$ vicelloso

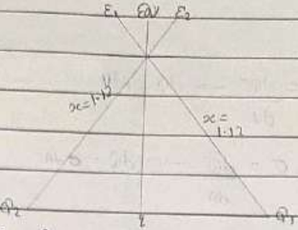
$q_1 + q_2 = 5.0\times10^{-5}$

$3.84\times10^{-5} + 1.16\times10^{-5} = 5.0\times10^{-5}C$

1c. $Q_1 = Q_2 = 8uC$

$d = 0.5m$

determine Q if electric field at a point P is zero



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

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

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

Vector	Angle	x-component	y-component
$E_1 = 5739.795918$	63.4	$E_1 x \cos\theta$	
		-2570.045785	5132.262839
$E_2 = 5739.795918$	63.4	2570.045785	5132.262839
$Eq = 9\times10^9 q$	90	$Eq \cos\theta = 0$	$9\times10^9 q$
		$Ex = 0$	$Ey = 10264.52568$

$$\text{Magnitude} = \sqrt{(Ex)^2 + (Ey)^2}$$

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

Since $E = 0$

$0 = 9\times10^9 q + 10264.52568$ (making q subject of formulae)

$$q = -\frac{10264.52568}{9\times10^9} \quad \therefore q = 1.140502853\times10^{-6}$$

$$\simeq q = 11.4\mu C$$

3a.

(i) Volume charge density, $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$

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

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

3b. $dW = F dL \quad \cdots \text{ eqn } (1)$

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

Substituting equation (2) in (1) yields

$dW = -q_0 E dL \quad \cdots \text{ eqn } (3)$

The total workdone in moving the test charge from A to B is:

$$W(A \rightarrow B)_{AB} = -q_0 \int_A^B E dL \quad \cdots (4)$$

From the definition of electric potential difference, it follows that:

$$V_B - V_A = \frac{W(A \rightarrow B)_{AB}}{q_0} \quad \cdots (5)$$

Putting equation 4 into 5 yields

$$V_B - V_A = -\int_A^B E dL \quad \cdots (6)$$

SECTION B

4. A 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 $\Phi = B \cdot dA$.

4b. $m = 9 \times 10^{-31} kg$

$r = 1.4 \times 10^{-7} m$

$B = 3.5 \times 10^{-1}$ weber/meter^2

Cyclotron Fequency = angular speed

$$\omega = \frac{v}{r} = \frac{qB}{m}$$

$$\omega = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$$

$$\omega = 62222222222.22222 \; T^{-1}$$

4c. In the question we were given Paramitors such as

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

ii. A radius of $1.4 \times 10^{-7} m$

iii. magnetic field of 3.5×10^{-1} weber/meter square and you are asked to find the cyclotron frequency which is equal or the same thing as angular speed. It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron. Recall that angular speed is given as $\omega = \frac{v}{r} = \frac{qB}{m}$

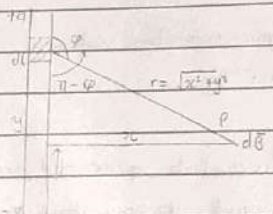
Substituting we have $\omega = \frac{v}{r} = \frac{qB}{m} = \frac{1.6\times10^{-10} \times 3.5\times10^{-10}}{9.11\times10^{-31}}$

$\frac{qB}{m} = 62222222222.22222\,T^{-1}$

So since cyclotron frequency is equal to angular speed the cyclotron frequency is equal to $= 62222222222.22222T^{-1}$, have a unit as $\frac{1}{T}$ which is equal to the unit of frequency dimensionally.

5a. The 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). It can be represented mathematically by $dB = \frac{\mu_0 I dl \times r}{4\pi r^2}$

5b.



Applying the Biot- Savart Law we find the magnitude of the field $d\vec{B}$

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

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

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

From the diagram, $r^2 = x^2 + y^2$ (pythagoras theorem)

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

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

Substituting equation 2 into 1, we have

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

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} dl \frac{x}{(x^2+y^2)^{5/2}}$$

Recall $dl = dy$

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

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

Using special integrals:

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

Equation 3 therefore becomes

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

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

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

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 larger 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 the y axis. Thus, at all points in a circle of radius r, around the conductor, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r} \quad --- \text{(II)}$$

Equation (II) defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor.