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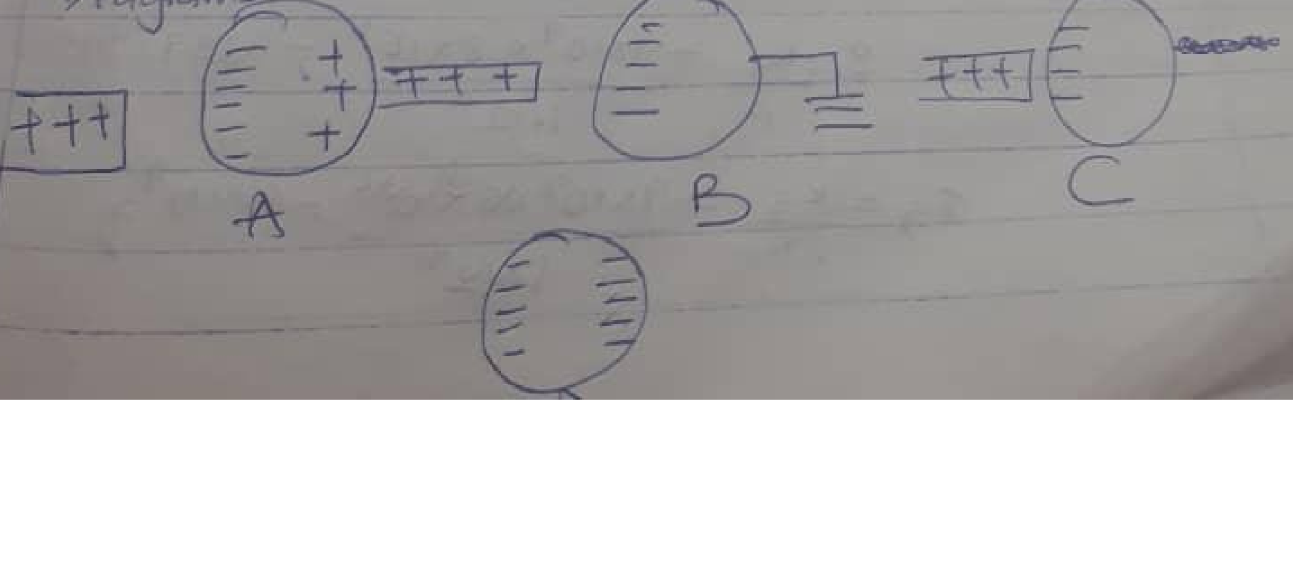
MBBS
19/MHS01/046
PHY 102.

COVID-19 HOLIDAY ASSIGNMENT
Section A

Charging by induction: Electric charges can be obtained on an object without touching it, by a process called electrostatic induction. For instance, a positively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground as shown in the diagram below. The repulsive force between the protons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some protons move to the side of the sphere farthest away from the rod (diagram A). The region of the sphere nearest the positively charged rod has an excess of negative charge because of the migration of protons away from this location. If a grounded conducting wire is then connected to the sphere, as in (diagram B), some of the protons leave the sphere and travel to the earth. If the wire to ground is then removed (diagram C), the conducting sphere is left with an excess of induced negative charge. Finally when the rubber rod is removed from the vicinity of the sphere (diagram D), the induced negative charge remains on the underground sphere and becomes uniformly distributed over the surface of the sphere.

Diagrams



1b. $K = 9\times10^9$

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

$F = 1N$

$d = 2m$

Calculate the charge on each sphere

Recall that

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

$K = 9\times10^9$

$$1 = \frac{(9\times10^9 \times}{2^2}$$

1c $Q_1 = Q_2 = 8\mu C$

$d = 0.5m$

determine Q if electric field at a point P is 0

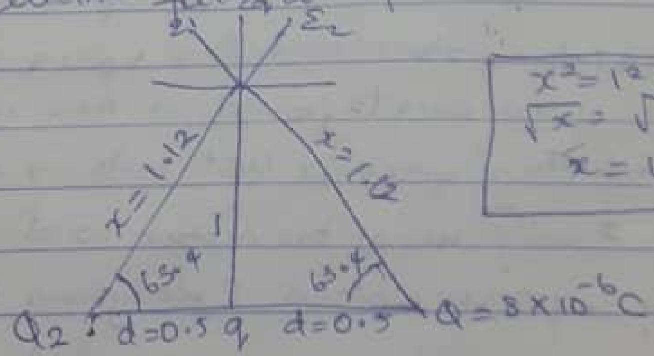
θ

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

$\tan\theta = 1/0.5 = 2$

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

$\theta = 63.4$



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

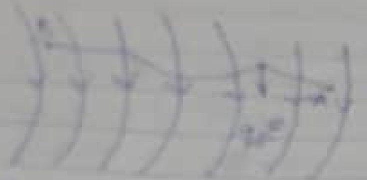
$\sqrt{x} = \sqrt{1.25}$

$x = 1.12$

$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 5739.795918$$

$$E_2 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.12^2} = 5739.795918$$

$$E_q = \frac{kq}{r^2} = \frac{9\times10^9 \cancel{\times 8\times10^{-6}}\, q}{\cancel{1.12^2}} = 9\times10^9 q$$



In the diagram above, the test charge q_0 is moved from point A to point B along an arbitrary path inside an electric field. The electric field $\vec{E}$ exerts a force $F = q_0 E$ on the charge shown in the diagram above. To move the test charge from A to B at constant velocity, an external force of $F = -q_0 E$ must act on the charge. Therefore, the elemental work done dW is given as

$$dW = F \cdot dL \quad — (1)$$

But

$$F = -q_0 E \quad — (2)$$

Substituting equation (2) in (1) yields

$$dW = -q_0 E dL \quad — (3)$$

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

$$W(A \to B)_{Ag} = -q_0 \int_A^B E dL \quad — (4)$$

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

$$V_B - V_A = \frac{W(A \to B)_{Ag}}{q_0} \quad — (5)$$

putting equation (4) in (5) yields

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

SECTION B.

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

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

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

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

cyclotron frequency = angular speed

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

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

$$\omega = 6222.2T^{-1}.$$

4c) In the question we were give parameter like

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

ii) radius of 1.4×10^{-7} m

iii) magnetic field of 3.5×10^{-1} weber

and you are asked to find the cyclotron frequency which is ~~the~~ equal / the same thing as angular speed. It's called cyclotron frequency because it is a frequency of an accelerator called cyclotron

Recall that angular speed $= \omega = v/r = \frac{qB}{m}$

$$= \frac{v}{r} = \frac{qB}{m} = \frac{1.6 \times 10^{-10} \times 3.5 \times 10^{-10}}{9.11 \times 10^{-31}}$$

$$= 6222.22T^{-1}$$

Since cyclotron frequency is equal to angular speed the cyclotron frequency is equal to $= 6.22.22T^{-1}$ as unit as $1/T$ which is equal to the unit of frequency dimensionally

vector	angle	x-comp	y-comp
$\mathcal{E}_1 = 5739.775918$	$63.4°$	$\mathcal{E}_1 \cos\theta$	
	$\mathcal{E}_{1k}$	-2576.045785	
$\mathcal{E}_2 = 5739.775918$	$63.4°$	2576.045785	5132.262839
$\mathcal{E}_q = 9\times10^9 q$	$90°$	$\mathcal{E}_q \cos\theta = 0$	5132.262839
		$\Sigma x = 0$	$9\times10^9 q$
			$\Sigma y = 10264.52568$

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

$\mathcal{E}_q = \sqrt{(0)^2 + (10264.52568)^2}$

since $E = 0$

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

making q subject of formulae

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

$q = 1.140502853\times10^{-6}$

$\simeq q = 1.14\mu C$.

3. volume charge density, $\rho = \dfrac{dQ}{dv} \Rightarrow dQ = \rho dv$

ii) surface charge density, $\sigma = \dfrac{dQ}{dA} \rightarrow dQ = \sigma dA$

Linear charge density, $\lambda = \dfrac{dQ}{dL} \Rightarrow dQ = \lambda dL$

3b. Electric Potential difference

The electric potential difference between two points in an field can be defined as the work done per unit charge electrical forces when a charge is transported from point to the other. It is measured in volt (V) per coulomb (J/C). Electric potential difference is a sc quantity.

... of conductors
... (?) will the
... only
... represented

...lush.

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

using special integrals

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

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

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

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

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

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

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

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

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

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

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

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

5 Biot-savart law states that the magnetic field is directly proportional to the product permeability of free space (μ_0), the current (I), the change in length, the radius and inversely proportional to square of radius (r^2). It can be represented mathematically by

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\,d\vec{l} \times r}{r^2}$$

The unit of $\vec{B}$ is weber/metre square

5a Magnetic field of a straight current carrying conductor
By applying the biot-savart law, we find magnitude of the field $d\vec{B}$

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

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

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

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

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

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

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

Recall $dl = dy$

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

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