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Assignment Section A

1a) Charging By Induction

Electrical charges can be obtained on an object withouth touching it, by a process called electrostatic induction. Consider a positively charged rubber rod brought near a neutral (uncharged) conducting ~~a positively charged rubber rod~~ sphere that is insulated so that there is no conducting path group. 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 as 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 rob is removed from the vicinity of the sphere the induced positive charge remains on the unlegrounded sphere and becomes uniformly distributed ~~and~~ over the surface of the sphere.

1b) 9×10^9

$f = 1N$

$r = 2$

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

$$f = \frac{kq_1q}{r^2}$$

$$q_1q_2 = f\left(\frac{r^2}{k}\right)$$

$$q_1q_2 = 1\left(\frac{2^2}{9\times10^9}\right)$$

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

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

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

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

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

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

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

Using Almighty formula

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

$= 1.6\times10^{-6}\ C$

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

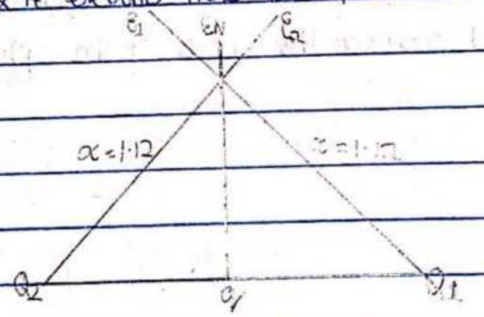
$q_1 + q_2 = 5.0\times10^{-5}$

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

10) $Q_1 = Q_2 = 8uC$

$d = 0.5m$

determine Q if electric field at a point P is zero



$$\mathcal{E}_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} = 57397.95918$$

$$\mathcal{E}_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} = 57397.95918$$

$$\mathcal{E}_4 = \frac{kq}{r^2} = \frac{9\times10^4\times9}{1} = 9\times10^9 q$$

Vector	Angle	x-component	Y-component
ε_1	63.4	$\varepsilon_1 x \cos\theta$	
		-2570.045785	5132.262839
ε_3	63.4	2570.045785	5132.262839
ε_4	98	$\varepsilon_4 \cos\theta = 0$	$9\times10^9 q$
		$\varepsilon x = 0$	$\varepsilon y = 10264.52568$

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

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

Since $\varepsilon = 0$

$0 = 9\times10^9 q + 10264.5258$ (making a subject of formula)

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

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

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) $dw = F dL$ . . . . equ(1)

$F = -q_0 E$ . . . . equ(2)

Substituting equation (2) In (1) yields

$dW = -q_0 E dL$ . . . . equ(3)

Total workdone in moving the test charge from a to B is

$W(A \to B)Ag = -q_0 \int_A^B E dL$ . . . (4)

From the ~~...~~ defintion of electric potential Difference It follows that

$V_B - V_A = \frac{W(A \to B)AS}{q_0}$ . . . (5)

Putting equation 4 into 5 yields

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

Section B

4) A magnetic ~~...~~ flux is defined as the strength of the magnetic field which can be represent by the lines of the forces. It is represented by the Symbol ϕ. Mathematically given as $\phi \cdot B \cdot CLA$

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

$\omega = \frac{V}{r} = \frac{\alpha B}{m}$

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

$\omega = 6.2222222222.22222 T^{-1}$

4c: In the question we were given parameters such as

i) mass of Electron

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

iii) magnetic field of 3.5×10^{-1} weber/metre square and you are asked to find the cycloton frequency and it is the same as angular speed is given as

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

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

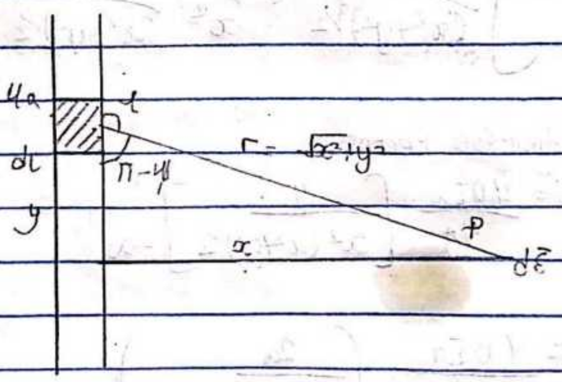
$$\frac{qB}{m} = 62222222222.22222T^{-1}$$

So since cycloton frequence is equal to angular speed the cycloton frequency is equal to $= 62222222222.22222T^{-1}$, have a unit w/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 ~~probability~~ Product premeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to the square of radius (r^2). It can be represented mathematically by ~~dB = ...~~ r

$$dB = \frac{\mu_0 I dl \times r}{4\pi r^2}$$

5b)



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

$$B = \frac{\mu_0 I}{4\pi}\int_{0a}^{4a} \frac{dl \sin\theta}{r^2}$$

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

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

from the diagram, $r^2 = x^2 + y^2$ (Pythagoras theorem)

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

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

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

$$B = \frac{\mu_0 I x}{4\pi} \left(\frac{2a}{x^3 (x^2+a^2)^{1/2}} \right)$$

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

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

$$(x^2 + a^2)^{\frac{1}{2}} \doteq a, \text{ as } a \rightarrow \infty$$

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

In a physical situation, we have axial symmetry about the y-axis, Thus and 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 conductor.