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19/MHS07/003
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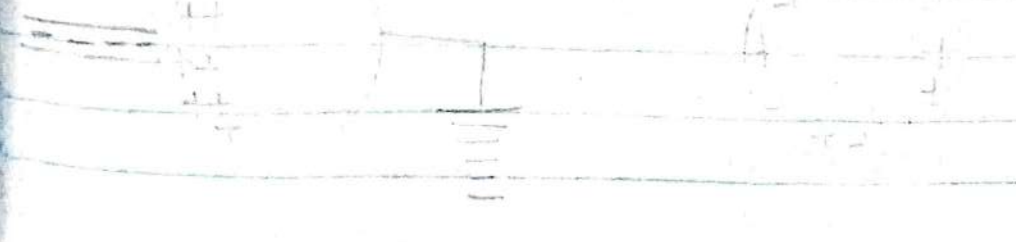
Phy 102 Assignment

Section A

1. Explain with the aid of diagrams, how you can produce a negative charged sphere by method of Induction.

Electric charges can be obtained on an object without touching it by a process called Electrostatic Induction. A negatively charged rubber rod brought near a neutral <Uncharged> conducting sphere that is Insulated so that there is no conducting path to ground as shown below. 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, as in, 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 ~~xxx~~ vicinity of the sphere, the Induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.



1b. $K = 9\times10^{9}\ Nm^2/C^2$

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

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

From columb's Law

$$F = \frac{Kq_1q_2}{r^2}$$

$$1.0 = \frac{9\times10^{9}(5\times10^{-5} - q_2)q_2}{(2)^2}$$

$$1.0 = \frac{4.5\times10^{5}q_2 - 9\times10^{9}q_2^{2}}{4}$$

$4.5\times10^{5}q_2 - 9\times10^{9}q_2^{2} = 4.0$

$\cancel{4.5\times10^{5}q^{2} \pm 4}$ $\quad 9\times10^{9}q^{2} - 4.5\times10^{5}q^{2} + 4$

$$q = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

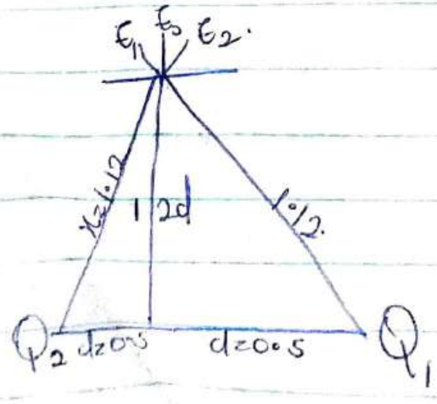
$$q = \frac{-(-4.5\times10^{5}) \pm \sqrt{(4.5\times10^{5})^2 - 4(9\times10^{9})\times +4}}{2(9\times10^{9})}$$

$$q = \frac{4.5\times10^{5} \pm \sqrt{5.85\times10^{10}}}{1.8\times10^{10}} = \frac{4.5\times10^{5} \pm 2.41\times10^{5}}{1.8\times10^{10}}$$

$$q_1 = \frac{4.5\times10^{5} + 2.41\times10^{5}}{1.8\times10^{10}} \qquad q_2 = 1.1\times10^{-5}\,C$$

$q_1 = 3.8\times10^{-5}\,C$

1c.



$x^2 = 1^2 + 0.5$

$x^2 = 1.25$

$x = \sqrt{1.25}$

$x = 1.12$

$$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^{9}\times8\times10^{-6}}{(1.12)^6}$$

$= 57397.959$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2}$

$= 51397.959$

$E_q = \frac{kq}{r^2}$

Vector	Angle	x-Component	y-Component
$E_1 = 51397.959$	63.4	$E_1 \cos\theta$ $= 25700.45$	$E_1 y \sin\theta$ $= 51322.62$
$E_2 = 51397.959$	63.4	$E_2 \cos\theta$ $= 25700.45$	$E_2 \sin\theta$ $= 51322.62$
$E_q = 9\times10^9 q$	90°	$E_{q}\cos\theta$ $= 0$	$E_{q}\sin\theta$ $= -10264.5268$

Magnitude

$= \sqrt{(E_x)^2 + (E_y)^2}$

$E_q = \sqrt{(0)^2 + (10264.5268)^2}$

$q = \frac{10264.5268}{9\times10^9}$

$q = 1.140[illegible]\times10^{[illegible]}$

$q = 114[illegible]$

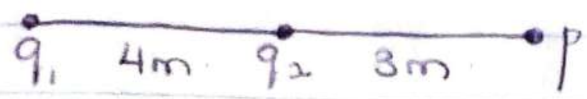
(2) Distinguish between the term of Electric Field and [illegible] Field Intensity:

Electric Field is a region of space in which an Electric charge will Experience an Electric force while Electric Field Intensity can be defined as the force per unit charge

Mathematically $E = \frac{F(N)}{q_0(C)}$ N/C

~~The direction of Electric~~

2b.



$E = E_1 + E_2$

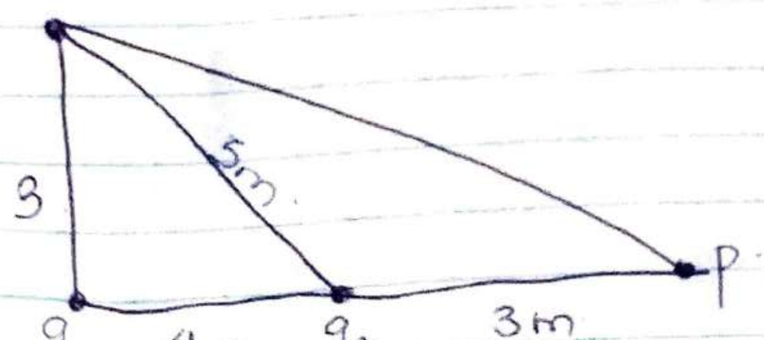
$E_1 = \frac{Kq_1}{r_1} = \frac{9\times10^9 \times 8\times10^{-9}}{(4+3)^2} = 1.469$ N/C

$E_2 = \frac{Kq_2}{r_2} = \frac{9\times10^9 \times 12\times10^{-9}}{(3)^2} = 12.0$ N/C

$E = 1.469 + 12$

$= 13.5$ N/C

ii



$Hyp^2 = Adj^2 + opp^2$

$= 4^2 + 3^2$

$= 16 + 9$

$\sqrt{25} = 5$

$E = E_1 + E_2$.

$E_1 = \frac{Kq_1}{r} = \frac{9\times10^9 \times 8\times10^{-9}}{(3)^2}$

$= 8.0\ N/C$.

$E_2 = \frac{Kq_2}{r} = \frac{9\times10^9 \times 12\times10^{-9}}{(5)^2}$

$= 4.32\ N/C$.

Vector	Angle.	X Component	Y-Component.
8.0	90°	$8.0 \cos 90$ $= 0$	$8.0 \sin 90$ $= 8.0$
4.32	36.9°	$4.32 \cos 36.9$ $= 3.45$	$4.32 \sin 36.9$ $= 2.59$

$E_x = 0 + \cancel{3K}\ 3.45$

$E_x = 3.45$.

$E_y = 8 + 2.59$

$= 10.59$

$E = \sqrt{(E_x)^2 + (E_y)^2}$

$E = \sqrt{(3.45)^2 + (10.59)^2}$

$E = 11.2\ N/C$.

Section B.

4. A Magnetic Flux is defined as the strength of magnetic Field represented by lines of force - It is usually represented by the symbol ϕ

mathematically: $\phi = \vec{B} \cdot d\vec{A}$

$$\phi = \int \vec{B} \cdot d\vec{A}$$

$$\phi_B = \int \vec{B} \cdot d\vec{A}$$

$$\cancel{BA\cos\phi} \quad BA\cos\theta$$

4b. An Electron with rest of mass = 9.11×10^{-31} kg

Radius = 1.4×10^{-7}

$B = \cancel{1.14 \times 10^{-7}}\ 3.5 \times 10^{-1} / m^2$.

Cyclotron Frequency = ~~A~~ngular Speed.

$$W = \frac{qB}{m} = \frac{1.60 \times 10^{-11} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$

$$= 6.15 \times 10^{10}\ T. \text{ or } 6.2\ T^{-1}$$

4c. Discuss your answer in 4b above.

There we go to find the cyclotron frequency which is also equal or the same thing as angular speed. It is called cyclotron frequency because It is a frequency of an accelerator called Cyclotron

Angular Speed $W = \frac{v}{r} = \frac{qB}{m}$.

5a. State the Biot – Savart Law

Biot – Savart law states that "the magnetic field is directly proportional to the product permeability of free space (μ), the Current (I), the radius and Inversely proportional to square of radius (r

It can be represented mathematically by

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

Where μ_0 is a constant called permeability of free space

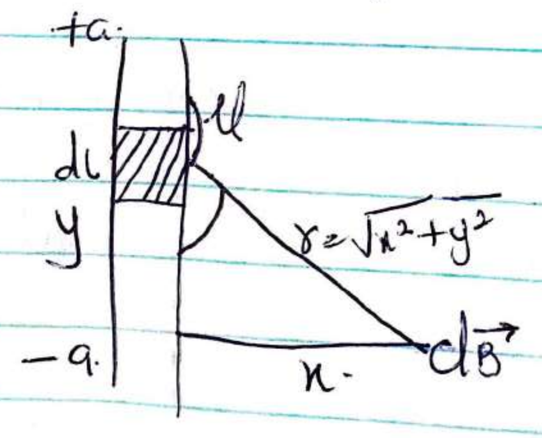
$$\mu_0 = 4\pi \times 10^{-7} \, T.m/A$$

The Unit of B is weber/meter square.

5b. Using the Biot – Savart Law, show that the magnitude of the magnetic field of a straight current – Conductor is given as:

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

Magnetic Field of a straight Current Carrying Conductor.



Applying the Biot – Savart Law

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

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

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

$r^2 = x^2 + y^2.$

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

But $\sin(\pi - \mu) = \dfrac{x}{\sqrt{x^2+y^2}} = \dfrac{x}{(x^2+y^2)^{1/2}}.$

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

Recall $d\mu = dy$

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

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 A 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 its infidently long.

$$(x^2+a^2)^{1/2} = a$$

$$as\ a \rightarrow \infty$$

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

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

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

Equation C defines the magnitude of the magnetic field of flux density near a long straight current carrying conductor.