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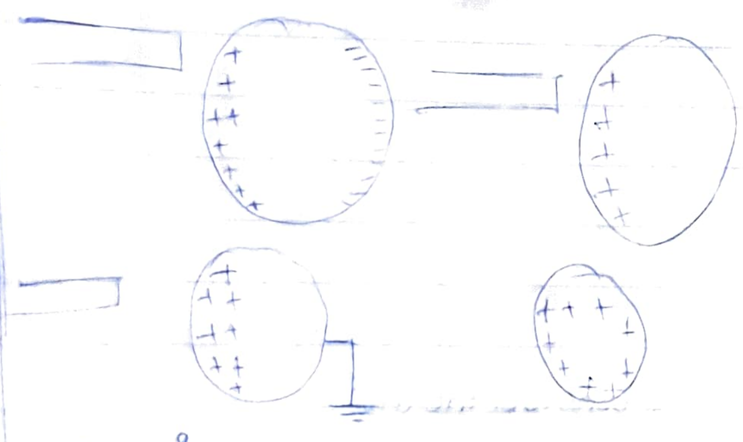
19/MHS01/023
MEDICINE AND SURGERY
PHY 102: ASSIGNMENT

1a.

CHARGING BY INDUCTION: Electric charges can be obtained on an object without touching by a process called electronic induction.
Consider 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 distribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod (Diagram B) 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 connected to the sphere and travel to the earth. If the wire to ground is then removed (diagram c), the conductor sphere is left with an excess of induced positive charge. Finally, when the rubber rod is removed from the vicinity of the sphere (diagram d), the induced positive charge remains on the underground sphere and becomes uniformly distributed over the surface of the sphere.



b. $k = 9 \times 10^{9}$

$q_1 + q_2 = 5 \times 10^{-5}C$

$F = 1N$

$d = 2m$

Charge on each spere = ?

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

$= 9\times10^9 \times C$

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

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

Quadratic equation

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

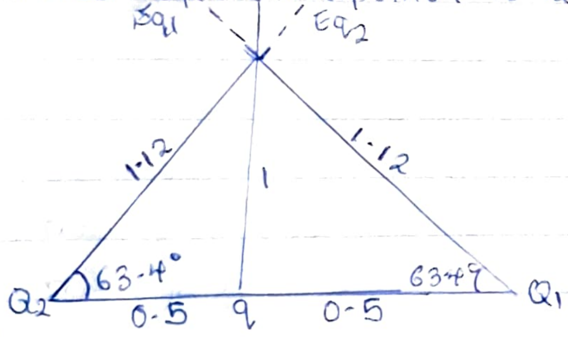
$q_1 = 0.0000111C \simeq 1.11\times10^{-5}C$

$q_2 = 0.00038C \simeq 3.8\times10^{-5}C$

1c. $Q_1 = Q_2 = 8NC$

$d = 0.5m$

If electric field at a point P is zero



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

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

$x = 1.12$

$\text{Tan}\,\theta = \frac{\text{opp}}{\text{adj}}$

$\text{Tan}\,\theta = 1/0.5$

$\text{Tan}\,\theta = 2$

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

$\theta = 63.4$

$E_{q_1} = \frac{Kq_1}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2}$

$E_{q_1} = E_{q_2} = 57397.95918$

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

3ai. Volume charge density $(\rho) = \frac{dt'nda}{dv} = \rho dv$

ii. Surface charge density $(\sigma) = \frac{dq'nda}{dA} - \sigma dA$

iii. Linear charge density $(\lambda) = \frac{dq'nda}{dl} = \lambda dl$

3b. Electric potential difference between two points in an electric field can be defined as the work done per unit charge against electrical force when a charge is transported from one point to the other. It is measured in Joules per coulomb (J/C) or in volts. It is a scalar quantity.

c.

4a. Magnetic flux is defined as the strength of magnetic field represented by lines of force. Magnetic flux is usually represented by the symbol

b. $m = 9.11 \times 10^{-31}$ kg

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

$B = 3.5 \times 10^{-1}$

Cyclotron frequency is ω

$$\omega = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.1 \times 10^{-31}}$$

$\omega = 6.147 \times 10^{10}$ rad/s

c. The angular speed, ω is often referred to as the cycloton frequency because the charge particle circulates at this angular frequency or angular speed in the a type of frequency of an accelerator called cyclotron.

5. Biot-Savart law is an equation describing 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 the square of radius (r^2). It can be represented mathematically by

$$dB = kIdl\sin\theta / r^2$$

The unit is weber/metre square.

5b. $$B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl\sin l}{r^2}$$

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

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

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

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

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

Substituting (xx) into (x), we have

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

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

Recall $dl = dy$

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

Using special integrals

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

Equation (3) becomes

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

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

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

When the length 2a of the conductor is very great in comparison to

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

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

It's distance x from point P, we consider it infinitely long.