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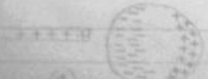
COURSE: PHYS 102
MATRIC NO: 19/Eng02/011

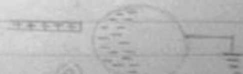
ASSIGNMENT

1a) Explain with the aid of a diagram how you can produce a negatively charged sphere by method of induction.

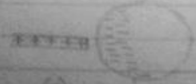
Consider a ~~neg~~ positively charged rubber rod brought near a neutral (uncharged) conducting sphere that ~~is insett~~ is insulated so that there is no conducting path to ground as shown below. The ~~repult~~ ~~repulsive force~~ attractive force between the positively charged rod and the electrons in the sphere causes the electrons to migrate towards the rod thereby, giving that region an excess of negative charge. If a grounded conducting wire is then connected to the sphere at the region concentrated with positive charges, then some of the electrons from the ground flows through the conducting wire and into the sphere. If the wire to the ground is then removed, 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, the induced negative charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere as shown in (4) below.



(1)



(2)



(3)

(4)

16, $K = 9 \times 10^9$

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

$F = 1N$

$d = 2m$

Charge on each sphere = ?

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

$$1 = \frac{9 \times 10^9 \times (q_1 q_2 5 \times 10^{-5})}{2^2}$$

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

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

Quadratic equation

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

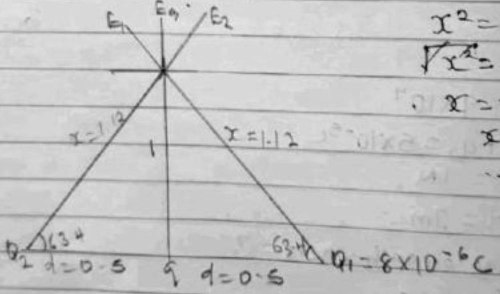
$q_1 = 0.0000111C \simeq 1.11\times10^{-5}C$

$q_2 = 0.000038C \simeq 3.8\times10^{-5}C$

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

$d = 0.5m$

if Electric field at a point P is zero.



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

$\sqrt{x^2} = \sqrt{1.25}$

$x = \sqrt{1.25}$

$x = 1.12$

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

$\tan\theta = \frac{1}{0.5}$

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

$\theta = 63.4$

$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.9598$

$E_2 = \frac{Kq_2}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} = 57397.95918$

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

Vector	Angle	X-component	Y-component
$E_1 = 57397.95918$	63.4°	$E_1\cos\theta =$	$E_1\sin\theta =$
		2570.045785	5132.262839
$E_2 = 57397.95918$	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 $Eq = 0$

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

Making q subject of formula

$q = \frac{10264.52568}{9\times10^9}$

$q = 1.140502853\times10^{-16}$

$q = 11.4\mu C$

3a i, Volume charge density, $\rho = \frac{dQ}{dV}$ 'n $dQ = \rho dV$

ii, Surface charge density, $\sigma = \frac{dQ}{dA}$ 'n $dQ = \sigma dA$

iii, Linear charge density, $\lambda = \frac{dQ}{dL}$ in $dQ = \lambda dL$

3b, Electric potential difference

The Electric potential difference between two points in an electric field can be defined as the workdone per unit charge against electrical forces when a charge is transported from one point to another. It is measured in Volt (V) or Joules per coulomb (J/C). It is a scaler quantity.

Elemental works done dW is given as:

$$dW = F \cdot dL \quad -- ①$$

But $\quad F = -q_0 E \quad -- ②$

Substituting equation ② in ① $= dW = -q_0 E dL \quad -- ③$

Total works done in moving the test charge from A to B is:

$$W(A \text{ 'n } B)_{ag} = -q_0 \int_A^B E dL \quad -- ④$$

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

$$V_B - V_A = \frac{-W(A' \cap B)Ag}{q_0} \quad \text{--- (5)}$$

putting equation (4) in (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 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 frequency = angular speed

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

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

$$\omega = 6.22 \times 10^{10}\ T^{-1}$$

4c mass of electron $= 9.11 \times 10^{-31}$ Kg radius $= 4.4 \times 10^{-7}m$

magnetic field $= 3.5 \times 10^{-1}$ weber/meter^2.

cyclotron frequency can be called Angular speed

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

substituting we have, $\omega = \frac{v}{r} = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$

$= 6.22 \times 10^{10} T^{-1}$

So cyclotron frequency $= 6.22 \times 10^{10} T^{-1}$, the unit is equal to unit of frequency dimensionally.

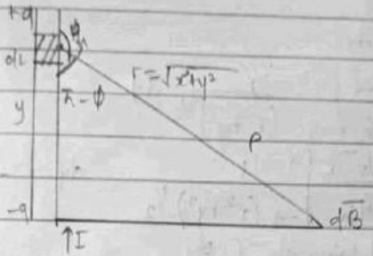
5. Biot-Savart law states that the magnetic field is directly proportional to the product permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to the square of radius (r^2). It can be represented mathematically by:

$$dB = \frac{\mu_0 I dl \times r}{4\pi r^2}$$ where μ_0 is a constance called Permeability of free space

$\mu = 4\pi \times 10^{-7} T.\frac{m}{A}$

unit of B is weber/metre square.

5b, Magnetic Field of a straight current carrying conductor



A section of a straight current carrying conductor

Applying the Biot-savart law, we find the magnitude of the field dB

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

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

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

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

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

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

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

Equation (3) 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, $(x^2+a^2)^{1/2} \simeq a$, 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: $B = \frac{\mu_0 I}{2\pi r}$ -- # (magnitude of the magnetic field of flux density B near a long, straight current carrying conductor)