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MATRIC NO: A/MHS01/370

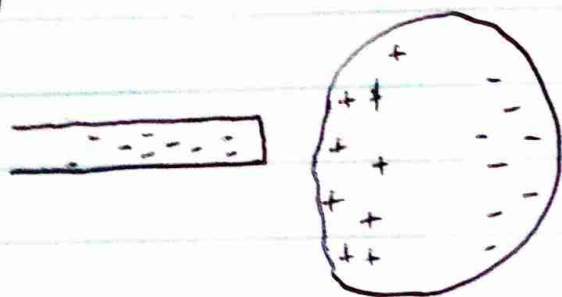
DEPT: MBBS

COURSE: PHY102

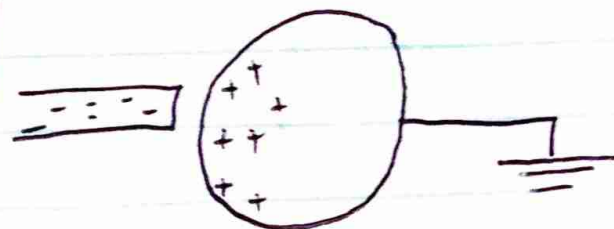
1a Charging by induction

Electric charges can be obtained on an object without contact by the process of Electrostatic induction. If a positively charged rubber rod is brought near an uncharged ^{conducting} sphere that is insulated, the repulsive force between the electrons in the rod and the sphere causes a redistribution of charges. The electrons move to the side furthest from the rod while the side closer to it has an excess of positive charges. If a grounding wire is then connected to the sphere, the electrons will flow to the earth leaving the sphere with induced positive charges. Finally when the rod is removed, the induced charges ~~become~~ become, uniformly distributed around the sphere.

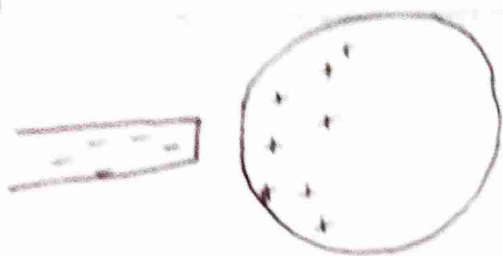
(a)



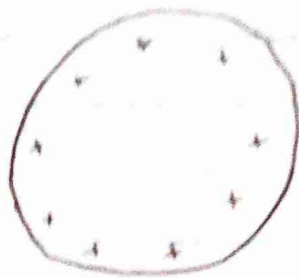
(b)



(c)



(d)



b

$$k = 9 \times 10^9$$

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

$$F = 1 \text{ N}$$

$$d = 2 \text{ m}$$

$$F = \frac{k q_1 q_2}{d^2}$$

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

$$4 = 9 \times 10^9 \times (5 \times 10^{-5} - q_2) \times q_2$$

$$4 = 4.5 \times 10^{-5} q_2 - 9 \times 10^9 q_2^2$$

$$0 = -9 \times 10^9 q_2^2 + 4.5 \times 10^{-5} q_2 - 4$$

Using the quadratic formula

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

$$9 \times 10^9 q_2^2 - 4.5 \times 10^{-5} q_2 + 4 = 0$$

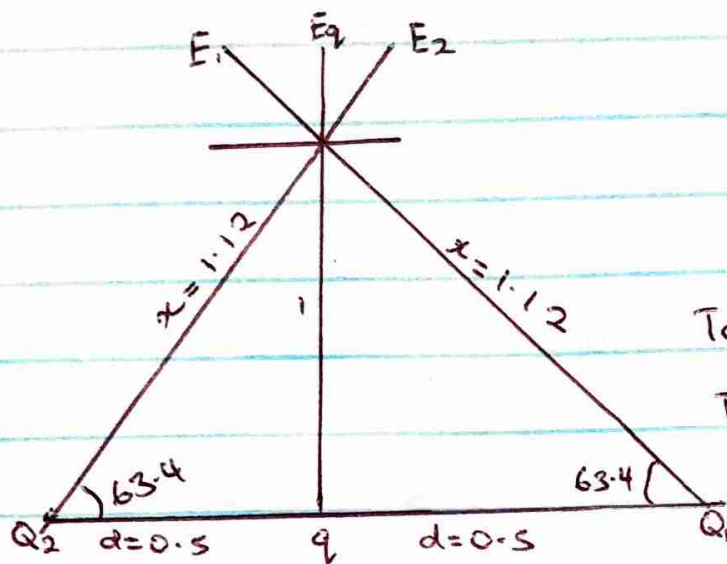
$$q_1 = 0.0000111 \text{ C} = 1.11 \times 10^{-5} \text{ C}$$

$$q_2 = 0.0000388 \text{ C} = 3.8 \times 10^{-5} \text{ C}$$

1c $Q_1 = Q_2 = 84 \text{ C}$

$d = 0.5 \text{ m}$

Q1 if electric field is at point P is zero



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

$$x^2 = 1.25^2$$

$$x = \sqrt{1.25}$$

$$x = 1.12$$

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

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

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

$$\theta = 63.4$$

$$E_1 = \frac{kq_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^8}{(1.12)^2}$$

$$= 57397.9598$$

$$E_2 = \frac{kq_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^8}{(1.12)^2} = 57397.95918$$

$$E_q = \frac{kq}{r^2} = \frac{9 \times 10^9 \times q}{1} = 9 \times 10^9 q$$

Vector	Angle	x-component	y-component
$E_1 = 57397.95918$	63.4	$E \cos \theta = -2570.05$	$E \sin \theta$ $= 5132.26$
$E_2 = 57397.95918$	63.4	2570.05 257	$= 5132.26$
$E_q = 9 \times 10^9 q$	90°	0 $E_x = 0$	$9 \times 10^9 q$ $E_y =$ 10264.52

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

$$E_q = \sqrt{0^2 + (10264 \cdot 52)^2}$$

$$\text{Since } E_q = 0$$

$$0 = 9 \times 10^9 q + 10264 \cdot 52$$

$$q = \frac{10264 \cdot 52}{9 \times 10^9}$$

$$q = 1.140502863 \times 10^{-16}$$

$$q = 11.4 \mu\text{C}$$

3a) Volume charge density $\rho = \frac{dQ}{dV}$ in $dQ = \rho dV$

ii) Surface charge density $\sigma = \frac{dQ}{dA}$ in $dQ = \sigma dA$

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

b) Electric potential difference

Electric potential difference is the work done per unit charge against electrical forces when a charge is transported from one point to another. It is measured in volts (V) or Joules per coulomb (J/C). It is a scalar quantity.

$$dW = F \cdot dl \quad \dots (1)$$

$$\text{But } F = -q_0 E \quad \dots (2)$$

$$\therefore dW = -q_0 E \cdot dl \quad \dots (3)$$

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

$$W(A \rightarrow B)_{Aq} = -q_0 \int_A^B E dl \dots (4)$$

From the definition of electric p.d., it follows that:

$$V_B - V_A = \frac{W(A \rightarrow B)_{Aq}}$$

$$\therefore V_B - V_A = \frac{-q_0 \int_A^B E dl}{q_0}$$

$$V_B - V_A = - \int_A^B E dl$$

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

It is represented by the symbol Φ . Mathematically,

$$\Phi = B \cdot dA$$

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

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

$$B = 3.5 \times 10^{-1} \text{ weber (meter}^2)$$

cyclotron frequency = angular speed

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

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

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

4 c Mass of electron = $9.11 \times 10^{-31} \text{ kg}$

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

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

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

$$= \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$

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

The unit of cyclotron frequency is equal to unit of frequency dimensionally.

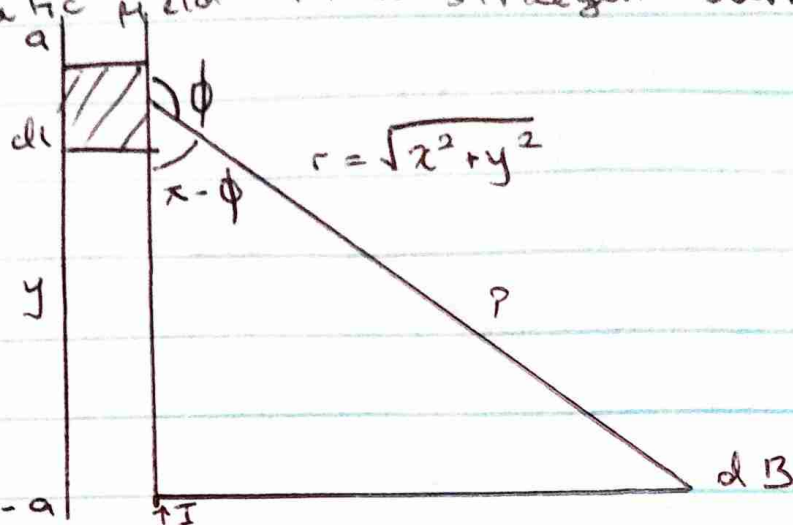
5 Biot-Savart law states that the magnetic field is directly proportional to the product of permeability of free space (μ_0), the current (I), the change in length and inversely proportional to the square of radius.

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

Where μ_0 is a constant called permeability of free space.

The unit of B is weber/metre².

56 Magnetic field in a straight current carrying conductor



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

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

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

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

From the diagram above $r^2 = x^2 + y^2$

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

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

substituting (2) into (1)

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

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

Recall $dl = dy$

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

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

Using special integrals.

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

Eqn (3) becomes: $B = \frac{\mu_0 I x}{4\pi} \left[\frac{y}{x^2 \cdot (x^2 + y^2)^{1/2}} \right]_{-a}^a$

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

When the length $2a$ of the conductor is very great in comparison to its distance x from the 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 $a \rightarrow \infty$

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

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

$$B = \frac{\mu_0 I}{2\pi r} \quad \dots \text{(magnitude of the magnetic field of flux density } B \text{ near}$$

~~Magnetic field~~

a long straight current carrying conductor).