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Dept: MBBS

Subject: PHYSICS COVID-19 ASSIGNMENT

SECTION A

1a Charging by Induction

Electric charges can be obtained on an object without touching it, by a process called electrostatic induction.

Consider a positively charged rubber rod brought near a neutral (uncharged) conducting sphere that is no conducting path to ground as shown below. The repulsive force between the protons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some protons move to the side of the sphere farthest away from the rod (fig 1.3a). The region of the sphere nearest the positively charged rod has an excess of negative charge because of the migration of protons away from this location. If a grounded conducting wire is then connected to the sphere as (1.3b), some of the protons leave the sphere and travel to the earth. If the wire to ground is then removed (fig 1.3c), 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 (fig 1.3d), the induced negatively charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

Diagram:-

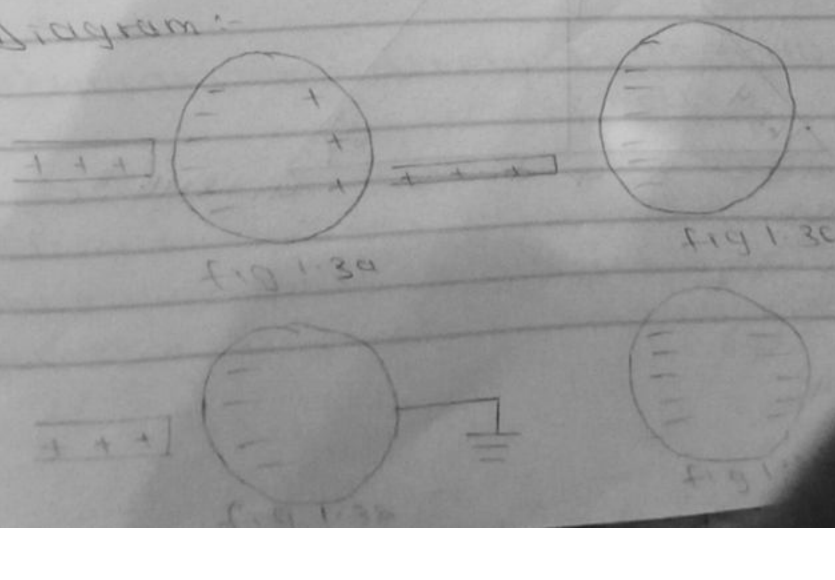


fig 1.3a fig 1.3c fig 1.3b fig 1

$K = 9\times10^9$

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

$F = 1N$

$d = 2m$

Calculate the charge on each sphere!

Recall that

$K = 9\times10^9$

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

$1 = \frac{9\times10^9\times(q_1q_2 5\times10^{-5})}{2^2}$

$4 = 9\times10^9\times5\times10^{-5}q_1 + 9\times10^9 q_2$

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

It is a quadratic equation

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

$q_1 = 0.0000111C$

$q_2 = 0.0000038C$

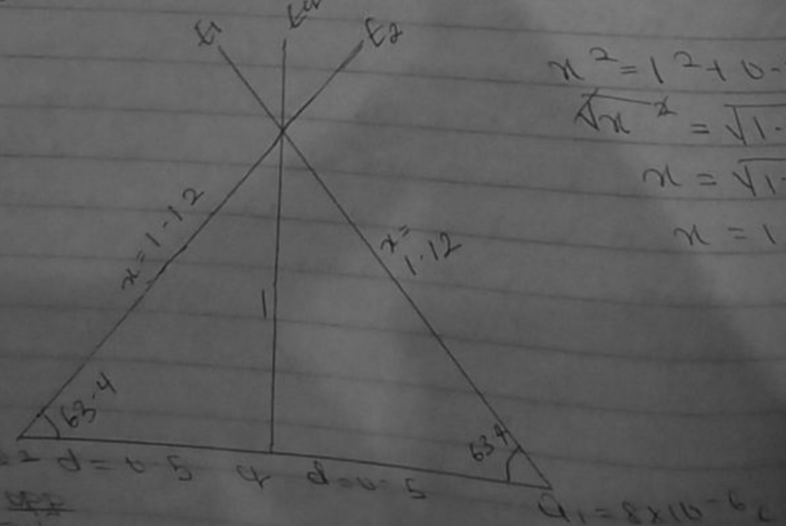
$\simeq q_1 = 1.11\times10^{-5}C$

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

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

$d = 0.5m$

determine Q if electric field at a point P is zero



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

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

$x = \sqrt{1.25}$

$x = 1.12$

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

$\tan\theta = \frac{1}{0.5} = 2$

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

$\theta = 63.4$

$$f_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 5739.795918$$

$$f_2 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{1.12^2} = 5739.795918$$

$$f_q = \frac{kq}{r^2} = \frac{9\times10^9 \times q}{1} = 9\times10^9 q$$

Vector	angle	x-component	y-component
$f_1 = 5739.795918$	63.4°	$f_1 \times \cos\theta$ -2570.045785	5132.262839
$f_2 = 5739.795918$	63.4°	2570.045785	5132.262839
$f_q = 9\times10^9 q$	90°	$f_q \cos\theta = 0$ $\Sigma x = 0$	$9\times10^9 q$ $f_y = 10264.52568$

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

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

Since $\Sigma q = 0$

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

Making q subject of formula

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

$$q = 1.140502853\times10^{-6}$$

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

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

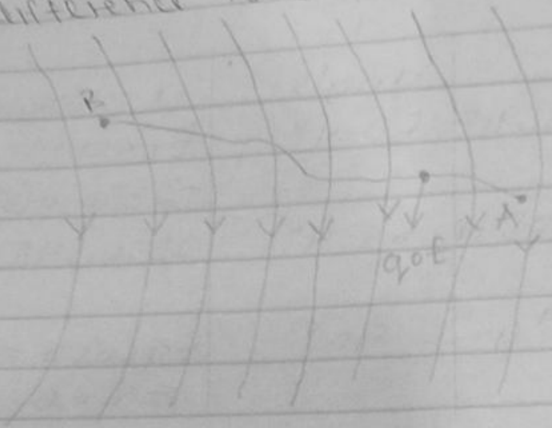
ii) Surface charge density, $\sigma = \frac{dQ}{dA}$ $\therefore$ $dQ = \sigma dA$

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

3b) Electric Potential difference:

The electric potential difference between t[illegible]
points in an electric field can be [illegible]

as the work done per unit charge against electrical forces when a charge is transported from one point to the other. It is measured in volt (V) or joules per coulomb (J/C). Electric potential difference is a scaler quantity.



Consider the diagram above, suppose a test charge q_0 is moved from point A to point B along an arbitrary path inside an electric field E. The electric field E exerts a force $F = q_0E$ on the charge as shown in fig 3.1. To move the test charge from A to B at constant velocity an external force of $F = -q_0E$ must act on the charge.

Therefore the elemental workdone dW is given as

$$dW = F \cdot dl \quad \text{- - - (1)}$$

But $\quad F = -q_0E \quad$ - - (2)

Substituting equation (2) in (1) yields

$$dW = -q_0E\,dl \quad \text{- - - (3)}$$

Then total workdone in moving the test charge from A to B is

$$W(A \to B)_{Ag} = -q_0\int_A^B E\,dl \quad \text{- - - (4)}$$

from the definition of electric potential difference it follows that:

$$V_B - V_A = \underline{W(A \to B)_{Ag}} \quad \text{- - - (5)}$$

Putting equation(4) in (5) yields
$$V_B - V_A = -\int_A^B E \cdot dl \quad (6)$$

Section B

4a) Magnetic flux is defined as the strength of the magnetic field which can be represented by lines of forces. It is represented by the symbol Φ mathematically given as $\Phi = B \cdot dA$

4b) $m = 9.11 \times 10^{-31}$ kg

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

$B = 3.5 \times 10^{-1}$ weber/meter^2

Cyclotron frequency = angular speed

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

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

$$w = 6222222222222.22222 T^{-1}$$

4c) i) mass of the electron $= 9.11 \times 10^{-31}$ kg

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

iii) magnetic field $= 3.5 \times 10^{-1}$ weber/meter square

cyclotron frequency = angular speed

It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.

Recall that angular speed is given as

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

Substituting for $w = \frac{v}{r} = \frac{qB}{m}$

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

$$= 6222222222222.22222$$

cyclotron frequency is equal to

So since the cyclotron frequency is equal angular speed the cyclotron frequency is equal to 622222222222.22222 T^{-1}, having a unit as of the frequency of unit of frequency

if it is equal to the ...

dimensionally

5a) 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 square of radius (r^2). It can be represented mathematically by

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

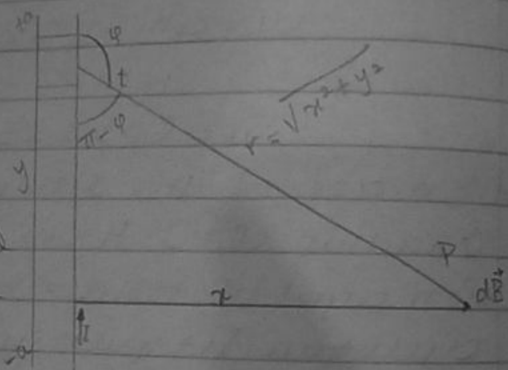
where μ is a constant called Permeability of free space

$$\mu_0 = 4\pi \times 10^{-7}\ T \cdot \frac{m}{A}$$

The unit of B is weber/metre square.

5b) Magnetic field of a straight current carrying conductor

fig 1: A section of a straight carrying conductor Applying the Biot-Savart law, we find magnitude of the field dB



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

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

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

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

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

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

Substituting (**) into (*), we have

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

$B = \frac{\mu_0 I}{4\pi} \int$

Recall $dl = dy$

$B =$

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Using equa

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Equation (***)

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

Recall $dl = dy$

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

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

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 (***) therefore becomes

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

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

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

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,

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

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

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

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

Equation (#) defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor.