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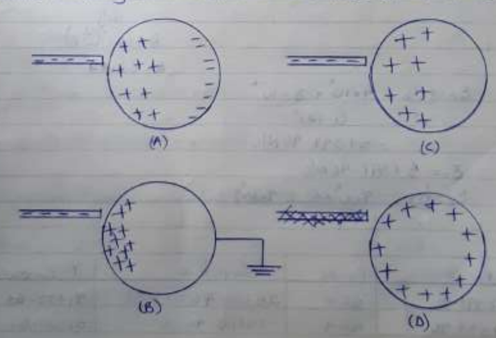
MATRIC NO: 19/MHS01/411

PIY 102

ASSIGNMENT

1a. Charging by Induction:

Electric charges can be obtained on an object without touching it by a process called electrostatic 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 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 the electrons away from this location. If a grounded conducting wire is then connected to the sphere, as in the figure below, 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 vicinity of the sphere, the induced positive charge remains on the underground sphere and becomes uniformly distributed over the surface of the sphere.



b. $q_1 + q_2 = 5.0 \times 10^{-5} C$ 　　　 $F = 1N$

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

$k = 9 \times 10^9$

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

$q_1 q_2 = \frac{1 \times 2^2}{9 \times 10^9} = 4.444 \times 10^{-10}$

$q_1 + q_2 = 5.0 \times 10^{-5}$

$q_2 = 5.0 \times 10^{-5} - q_1$

$q_1 (5.0 \times 10^{-5} - q_1) = 4.444 \times 10^{-10}$

$q_1^2 - 5.0 \times 10^{-5} q_1 + 4.444 \times 10^{-10} = 0$

$q_1 = 3.84 \times 10^{-5} C$ or $1.16 \times 10^{-5} C$

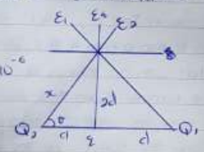
$q_2 = 5.0 \times 10^{-5} - 3.84 \times 10^{-5}$ or 5.0×10^{-5} or 1.16×10^{-5}

$q_2 = 1.16 \times 10^{-5} C$ or $3.84 \times 10^{-5} C$

c. $d = 0.5$

$Q_2 = Q_1 = 8 \times 10^{-6}$

$E_2 = E_1$



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

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

$x = 1.12$

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

$\theta = \tan^{-1}\left(\frac{1}{0.5}\right)$

$\theta = 63.45°$

$E_2 = \frac{k q_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2}$

$= 57397.96 N/C$

$E_1 = 57397.96 N/C$

$E_4 = \frac{k q}{r^2} = \frac{9 \times 10^9 \times 4}{1} = 9 \times 10^9 q$

Vector	Angle	X-Component	Y-Component
$E_1 = 57397.96$	63.4	25700.46	51322.63
$E_2 = 57397.96$	63.4	-25700.46	51322.63
		$E_x = 0$	$E_y = 102645.26$

$E_t = \sqrt{0^2 + 102645.26^2}$

$E_q = 102645.26$

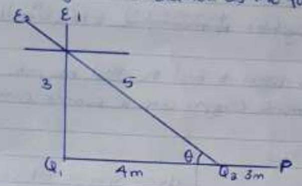
$q = \frac{E_2}{9\times10^9} = \frac{102645.2565}{9\times10^9}$

$= 114\times10^{-5}C$

2a. Electric field - Is a region of space in which an electric charge will experience an electric field.

Electric field Intensity - Can be defined as the force per unit charge.

b.



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

$\theta = \tan^{-1}(\frac{3}{4})$

$\theta = 36.9$

$E_{net} = E_1 + E_2$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469\ N/C$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12N/C$

$E_{net} = 12 + 1.469$

$= 13.469\ N/C$

ii. $E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$

$E_2 = \frac{kQ_2}{r^2} = 9\times10^9 \times 12\times10^{-9} = 4.32N/C$

Vector	Angle	X-Component	Y-Component
$E_1 = 8N/C$	$90°$	0	8
$E_2 = 4.32N/C$	$36.9°$	-3.45	2.59
		$\Sigma_x = -3.45$	$\Sigma_y = 10.59$

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

$= 11.14\ N/C$

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

b. $m = 9.11 \times 10^{-31}$ kg $r = 1.4 \times 10^{-7}$ m $B = 3.5 \times 10^{-1}$ Wb/m^2 $q = -1.6 \times 10^{-19}$

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

$$\omega = -6.15 \times 10^{10} \text{ rad/s}$$

c. The answer is negative because we are dealing with an electron but the electron is moving at a cyclotron frequency of ~~is moving at~~ 6.15×10^{10} rad/s.

5a. The Biot-Savart law is used to find the total magnetic field created at some point on a current carrying wire or current consisting of charges flowing through space.

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

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

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

From diagram, $r^2 = x^2 + y^2$ (Pythagoras rule)

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

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

Substituting (**) in (*) we have

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

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

Recall $dl = dy$

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

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

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,

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

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

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: $\boxed{B = \frac{\mu_0 I}{2\pi r}}$ ... (*)