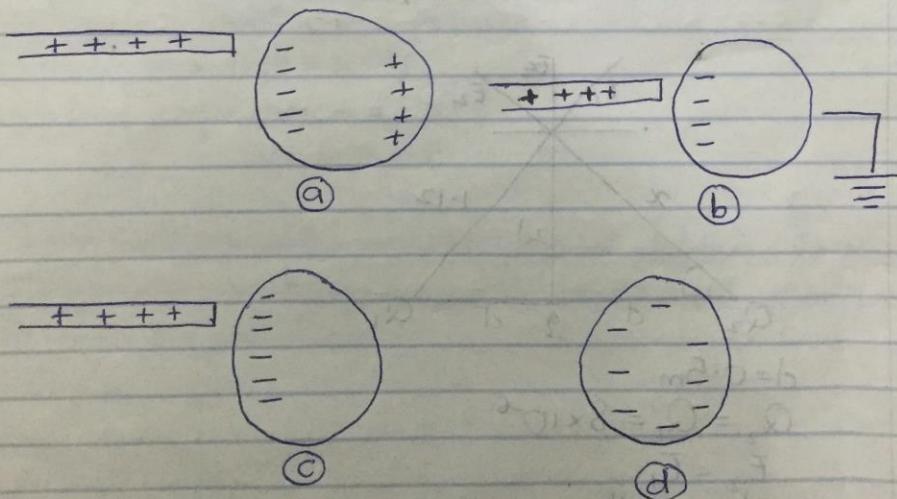


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COURSE CODE: PHY 102 ASSIGNMENT

PHY104 Assignment

- 1a Consider a positively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to the ground. The repulsive force between the positive charges in the rod and those in the sphere causes a redistribution of charges on the sphere so that some of the positive charges move to the side of the sphere farthest away from the rod. The region of the sphere nearest the positively charged rod has an excess of negative charges because of the migration of positive charges away from this location. If a grounded conducting wire is then connected to the sphere, some of the positive charges leave the sphere and travel to the ground. If the wire is then removed, the conducting sphere is left with 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 surfaces of the sphere.



1b $K = 9 \times 10^9 \text{ Nm}^2/\text{C}^2$

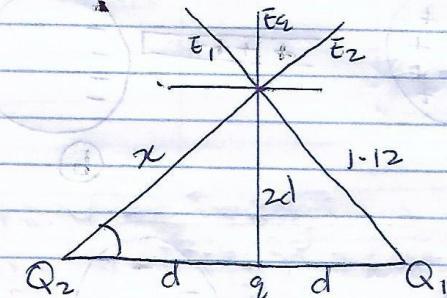
$$q_1 + q_2 = 5 \times 10^{-5} \text{ C}$$

$$F = 1.0 \text{ N}$$

$$d = 2.0 \text{ m}$$

- Institutional Physics
- Recall that $F = kq_1 q_2 / r^2$ (Newton's law of gravitation)
 - $F = kq_1 q_2 / r^2$ is Coulomb's law of electrostatics (Coulomb)
 - $F = kq_1 q_2 / r^2$ is the force of attraction between two charges.
 - $F = kq_1 q_2 / r^2$ is the force of repulsion between two charges.
 - $kq_1 q_2 / r^2 = 1 \times 2^2 = 4.444 \times 10^{-10}$
 - $q_1 + q_2 = 5.0 \times 10^{-5}$
 - $q_2 = 5.0 \times 10^{-5} - q_1$
 - Recall $q_1 q_2 = 4.444 \times 10^{-10}$
 - $q_1 (5.0 \times 10^{-5} - q_1) = 4.444 \times 10^{-10}$
 - $q_1^2 - (5.0 \times 10^{-5}) q_1 + 4.444 \times 10^{-10} = 0$
 - Using general formula
- $$5.0 \times 10^{-5} + \sqrt{(5.0 \times 10^{-5})^2 - 4(4.444 \times 10^{-10})}$$
- $$q_1 = 3.84 \times 10^{-5} C$$
- $$q_2 = 5.0 \times 10^{-5} - 3.84 \times 10^{-5}$$
- $$q_2 = 1.16 \times 10^{-5} C$$
- $$\therefore q_1 = 3.84 \times 10^{-5} C ; q_2 = 1.16 \times 10^{-5} C$$

1c



$$d = 0.5m$$

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

$$E_2 = E_1$$

Using Pythagoras theorem

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

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

$$x = 1.12$$

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

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

$$\theta = 63.43^\circ$$

$$E_2 = \frac{kq_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1-12)^2} = 57397.95918$$

$$E_1 = E_2 = 57397.95918$$

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

Vector	Angle	X-comp	Y-comp
$E_1 = 57397.95918$	63.4	25700.45785	51322.62839
$E_2 = 57397.95918$	63.4	-25700.45785	51322.62839

$$\sum E_x = 0 \quad \sum E_y = 102645 - 2568$$

$$E_q = \sqrt{\sum E_x^2 + \sum E_y^2}$$

$$E_q = \sqrt{(0)^2 + (102645 - 2568)^2}$$

$$E_q = 0 + 102645 - 2568$$

$$q = \frac{E_q}{9 \times 10^9} = \frac{102645 - 2568}{9 \times 10^9}$$

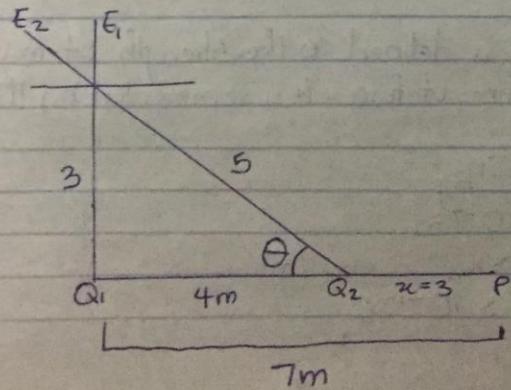
$$q = 1.14 \times 10^{-5} C$$

$$q = 1.14 \times 10^{-6} C$$

$$q = 1.14 \mu C$$

2a Electric field is a region of space in which an electric charge will experience an electric force while electric field intensity is the force per unit charge.

2b



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

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

$$\theta = 36.9^\circ$$

$$E_{\text{net}} = E_1 + E_2$$

$$E_1 = \frac{kq_1}{r^2} = \frac{9 \times 10^9 \times 3 \times 10^{-9}}{7^2} = 1.469 \text{ N/C}$$

$$E_2 = \frac{kq_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{3^2} = 12 \text{ N/C}$$

$$E_{\text{net}} = 12 + 1.469$$

$$\text{i. } E_{\text{net}} = 13.469 \text{ N/C}$$

$$E_{\text{net}} \approx 13.5 \text{ N/C}$$

$$\text{ii. } E_1 = \frac{kq_1}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = 4.32 \text{ N/C}$$

Vector	Angle	X-comp	Y-comp
$E_1 = 8 \text{ N/C}$	90°	0	8
$E_2 = 4.32 \text{ N/C}$	36.9°	-3.45	2.59
		$\Sigma x = -3.45$	$\Sigma y = 10.59$

$$E_{\text{net}} = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$$

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

$$E_{\text{net}} = 11.14 \text{ N/C}$$

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

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

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

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

$$q = -1.6 \times 10^{-19} \text{ C}$$

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

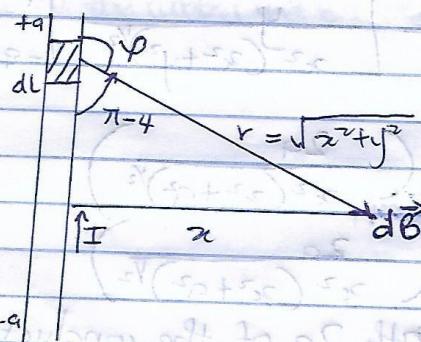
The answer is negative because we are dealing with an electron but the electron is moving at a cyclotron frequency of 6.15×10^{16} rad/s.

5g Biot-Savart law

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

where μ_0 is a constant called Permeability of free space

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



Applying the Biot-Savart law, we find the magnitude of the field $d\mathbf{B}$

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

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

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

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

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^a dL \sin(\pi - \phi) \quad \dots \quad (1)$$

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

$$\text{Substituting } x \text{ and } y \text{ into the equation, we get:}$$

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

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

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:

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

Eqn (3) therefore becomes

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

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

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

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 ,

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

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

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

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

This equation defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor.