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Dept: MBBS

Course Code: Phy102

Matric no: 19/m#501/261

2a) Distinguish between the terms 'electric field' and 'electric field intensity'.

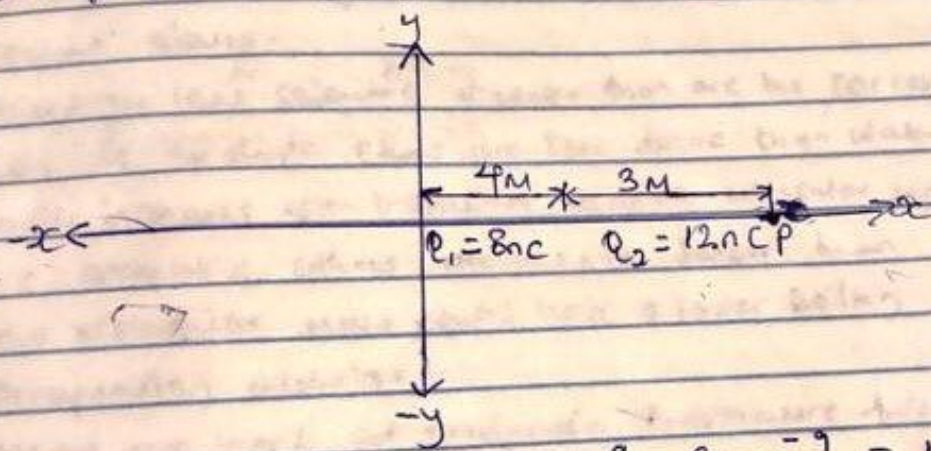
An electric field is a region of space in which an electric charge will experience an electric force.

Electric field intensity E , can be defined as the force per unit charge.

2b) A positive charge $Q_1 = 8 \text{ nC}$ is at the origin, and a second positive charge $Q_2 = 12 \text{ nC}$ is on the x -axis at $x = 7 \text{ m}$. And

i) The net electric field at a point P on the x -axis at $x = 7 \text{ m}$.

ii) The electric field at a point Q on the y -axis at $y = 3 \text{ m}$ due to the charges.



$$E_1 = \frac{kQ_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = \underline{1.4694 \text{ N/C}}$$

$$E_2 = \frac{kQ_2}{r_2^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{3^2} = \underline{12 \text{ N/C}}$$

Vector	Angle	x-comp	y-comp
$E_1 = 1.4694 \text{ N/C}$	0	$1.4694 \cos 0$ $= 1.4694$	0
$E_2 = 12 \text{ N/C}$	0	$12 \cos 0 = 12$	0

$$E = \sqrt{E_x^2 + E_y^2}$$

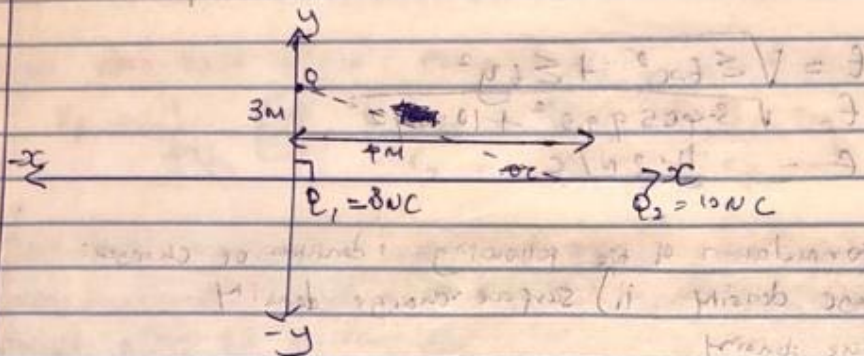
$$E = \sqrt{E_x^2}$$

$$E = \sqrt{13.4694^2}$$

$$E = 13.4694$$

$$E = 13.5 \text{ N/C}$$

11)



To find the distance between electric field at point P and Q_2 use

Pythagoras theorem

$$AB^2 = AC^2 + BC^2$$

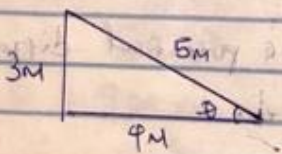
$$x^2 = 3^2 + 4^2$$

$$x^2 = 9 + 16$$

$$\sqrt{x^2} = \sqrt{25}$$

$$x = 5 \text{ m}$$

To find the angle between the horizontal and E_2 , distance



$$\sin \theta = \frac{3}{5}$$

$$\theta = \sin^{-1} \frac{3}{5}$$

$$\theta = 36.87^\circ$$

$$E_1 = \frac{kq_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{3^2} = 8 \text{ N/C}$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = 4.32 \text{ N/C}$$

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Vector	Angle	X-component	Y-component
$E_1 = 8 \text{ N/C}$	90°	$8 \cos 90 = 0$	$8 \sin 90 = 8$
$E_2 = 4.32 \text{ N/C}$	36.87°	$4.32 \cos 36.87 = 3.455995$	$4.32 \sin 36.87 = 2.592$
		3.455995	10.592

$$E = \sqrt{E_x^2 + E_y^2}$$

$$E = \sqrt{3.455995^2 + 10.592^2}$$

$$E = 11.2 \text{ N/C}$$

- State the formulation of the following densities of charges:
- Volume charge density
 - Surface charge density
 - Linear charge density

Solution: i) Volume charge density, $\rho = \frac{dq}{dv} \rightarrow dq = \rho dv$

ii) Surface charge density, $\sigma = \frac{dq}{dA} \rightarrow dq = \sigma dA$

iii) Linear charge density, $\lambda = \frac{dq}{dL} \rightarrow dq = \lambda dL$

- Explain with appropriate equations, the electric potential difference. Electric potential difference between two points in an electric field can be defined as the work done per unit charge against forces when a charge is transported from one point to another.

We have different formulas for electric potential difference depending on how the case may be.

- i) We have electric potential in a uniform electric field which is

$$V_B - V_A = W/q \rightarrow B = Aq$$

$$q \cdot 1 \text{ V} = 1 \text{ C} \times 8 \text{ N/C} \times 1 \text{ m} = 8 \text{ J} = 8 \text{ C} \cdot \text{V}$$

- ii) We can also define potential difference as the potential energy for unit charge.

Hence, The angular speed $\omega = \frac{qB}{m_p}$

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

$$= +6.147 \times 10^{10} \text{ rad/s}$$

4) We were told to find the cyclotron frequency in the angular speed. The formula was provided above and the values were slotted into the formula.

5) Biot-Savart law

1) The vector $d\vec{B}$ is perpendicular both to $d\vec{l}$ (which points in the direction of the current) and to the unit vector \hat{r} directed from $d\vec{l}$ to P .

2) The magnitude of $d\vec{B}$ is inversely proportional to $\frac{1}{r^2}$ where r is the distance from $d\vec{l}$ to P .

3) The magnitude of $d\vec{B}$ is proportional to the current I and to the magnitude of the length element $d\vec{l}$.

4) The magnitude of $d\vec{B}$ is proportional to $\sin\theta$, where θ is the angle between I and $d\vec{l}$.

Therefore

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I d\vec{l} \times \hat{r}}{r^2}$$

$$B = \frac{\mu_0 I}{4\pi} \int_a^a \frac{1}{(x^2 + r^2)^{3/2}} dx$$

using special integrals

$$\int \frac{dx}{(x^2 + r^2)^{3/2}} = \frac{x}{r^2 \sqrt{x^2 + r^2}}$$

Equation (x x x) therefore becomes

$$B = \frac{\mu_0 I}{4\pi} \left[\frac{x}{r^2 \sqrt{x^2 + r^2}} \right]_a^a$$

$$0 \geq 90000x - 18000(4+x)$$

$$0 \geq 90000x - 72000 - 18000x$$

$$72000 = 90000 - 18000x$$

$$72000 = 72000x$$

$$x = 1$$

$$x = 1$$

$$4+x = 4+1 = 5m$$

so, the position along the x-axis lie $V=0$ is 5m

1) What is magnetic flux?

The magnetic flux is defined as the strength of magnetic field represented by lines of force. It is usually represented by the symbol ϕ .

2) An electron with a rest mass of 9.11×10^{-31} kg moves on a circular orbit of radius 1.4×10^{-7} m in a uniform magnetic field of 3.5×10^{-1} weber/meter square, perpendicular to the speed with which electron moves. Find the cyclotron frequency of the moving electron.

$$W = \frac{qB}{m}$$

$$F_s = qvB \sin \theta$$

$$F_B = qvB$$

$$F_c = qvB = \frac{mv^2}{r}$$

$$v = \frac{qBr}{m}$$

$$v = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$$

$$v = 8.605934 \text{ m/s}$$

$$V_B - V_A = \frac{Q}{4\pi\epsilon_0} \left(\frac{1}{r_B} - \frac{1}{r_A} \right)$$

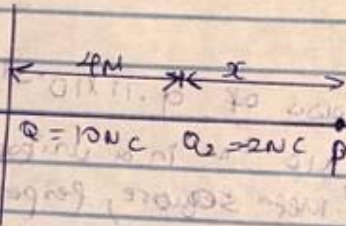
i) We also have electric potential due to single point charge

$$V_B - V_A = \frac{Q}{4\pi\epsilon_0} \left[\frac{1}{r_B} - \frac{1}{r_A} \right]$$

ii) We also have electric potential due to several point charges

$$V_p = \frac{1}{4\pi\epsilon_0} \left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3} + \frac{Q_4}{r_4} \right]$$

3c) Two point charges $Q_1 = 10\text{ nC}$ and $Q_2 = -2\text{ nC}$ are arranged along the x-axis at $x = 0$ and $x = 4\text{ m}$ respectively. Find the position along the x-axis where $V = 0$.



$$V_p = \frac{1}{4\pi\epsilon_0} \left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} \right]$$

$$\text{Let } V_p = 0$$

$$0 = 9 \times 10^9 \left[\frac{10 \times 10^{-9}}{4+x} + \frac{-2 \times 10^{-9}}{x} \right]$$

$$0 = 9 \times 10^9 \left[\frac{10 \times 10^{-9}}{4+x} - \frac{2 \times 10^{-9}}{x} \right]$$

$$0 = \frac{90000}{4+x} - \frac{18000}{x}$$

$$4+x(x) = \frac{90000}{x} \times (4+x)(x) - \frac{18000}{x} (4+x)(x)$$

Substitution (x, y) into (r) we have:

$$B = \frac{N_0 I}{4\pi} \int_{-a}^a dl \frac{zC}{(x+y^2)(x^2+y^2)^{3/2}}$$

$$B = \frac{N_0 I}{4\pi} \int_{-a}^a dl \frac{x}{(x+y^2)^{3/2}} \frac{zC}{(x^2+y^2)^{3/2}}$$

Recall $dl = dz$

$$B = \frac{N_0 I}{4\pi} \int_{-a}^a \frac{dx}{(x^2+y^2)^{3/2}} \frac{z}{(x^2+y^2)^{3/2}} dz$$

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

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

When the length $2a$ of the conductor is very great in comparison to the distance x from point P , we consider it infinitely long that is, when a is much greater 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 a rod symmetric about the y -axis. This, at all points in a circle of radius r , around the conductor, the magnitude of B is

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

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

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

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

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

$$B = \frac{\mu_0 I}{4\pi} \int_{-a}^a \frac{d \sin(\pi - \theta)}{x^2 + y^2}$$

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