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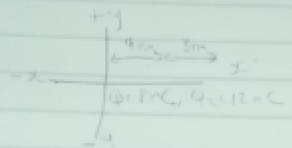
MBBS
PHY 102

Assignment

a. An electric field is a region of space in which an electric charge will experience an electric force while electric field intensity can be defined as force per unit electric.

$Q_1 = 8nC$, $Q_2 = 12nC$ are on the x-axis of $x = 4cm$. Find the net ~~static~~ electric field at point P on the x-axis $x = 7cm$



$$E_1 = kq/r_1 = \frac{9\times10^9 \times 8 \times 10^{-9}}{7^2} = 1.4694\ N/C$$

$$E_2 = kq/r_2^2 = \frac{9\times10^9 \times 12\times10^{-9}}{9} = 12N/C$$

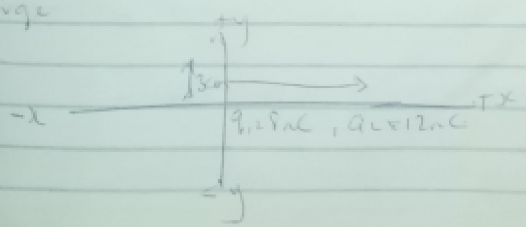
Vector	Angle	X-component	Y-component
$E_1 = 1.4694 N/C$	0	$1.4694\cos\theta = 1.4694$	0
	θ	$12\cos\theta = 12$	0
		13.4694	

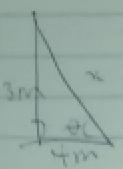
$$E = \sqrt{E_x^2 + E_y^2}$$

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

$E = 13.4694$.

The electric field at point q on the y-axis at y = 3m due to the charge





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

$x^2 = 9 + 16$

$x = 5m$

$\sin\theta = 3/5$

$\theta = \sin^{-1}(3/5)$ $\quad \therefore \theta = 36.87°$

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

$E_2 = kQ_2/r^2 = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/C$

Vector	Angle	x-component	y-component
$E_1 = 8 N/C$	$90°$	$8\cos 90° = 0$	$8\sin 90 = 8$
$E_2 = 4.32 N/C$	$36.87°$	$4.32\cos 36.87 = 3.45575$	$4.32\sin 36.87 = 2.59$
		3.45575	10.592

$E = \sqrt{\Sigma E_x^2 + \Sigma E_y^2} = \sqrt{3.456^2 + 10.592^2}$

$E = 11.2 N/C$

3 Formulation of the following identities of charges

(i) volume charge density $= \rho = dq/dv \Rightarrow dq = \rho dv$

(ii) surface charge density $= \sigma = dq/dA \Rightarrow dq = \sigma dA$

(iii) linear charge density $\lambda = dq/dl \Rightarrow dq = \lambda dl$

(4) Electric potential difference between two points in an electric field can be defined as the workdone per unit charge against forces when a charge is transported from one point to another.

a. When the electric potential is in a uniform electric field.

$V_B - V_A = W(A \to B)/m$

b. Electric potential difference is also the potential energy per unit charge

$V_B - V_A = \Delta U/q_0$

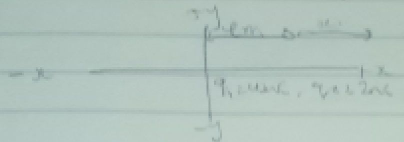
c. We also have electric potential due to a single point charge

$V_B - V_A = Q/4\pi\varepsilon_0 \left(\frac{1}{r_B} - \frac{1}{r_A}\right)$.

d. We also have electric potential due to several point charge

$$V = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} + \frac{q_4}{r_4} + \dots \frac{q_n}{r_n}\right)$$

c. $q_1 = 10nC$ and $q_2 = 2nC$ are along the x-axis at $x = 0$ and $x = 4m$ respectively. Find the position along the x-axis where $V = 0$



$$V_P = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$$

let $V_P = 0$

$$0 = 9\times10^9\left[\frac{10\times10^{-9}}{4+x} + \frac{(-2\times10^{-9})}{x}\right]$$

$$0 = \frac{90000}{4+x} - \frac{1800}{x}$$

Multiply all through by $(4+x)(x)$

$$(4+x)(x)0 = \frac{9000}{4+x}(4+x)(x) - \frac{1800}{x}(4+x)(x)$$

$$0 = 90000x - 1800(4+x)$$

$$72000 = 90{,}000 - 18000x$$

$$72000 = 72000x$$

$$x = 1$$

$$\therefore 4 + x = 4 + 1 = 5$$

So the position along the x-axis where $V = 0$ is $5m$

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

b. $M_e = 9.11\times10^{-31}kg$, $r = 1.4\times10^{-7}m$, $B = 3.5\times10^{-1}\ wb/m^2$, $\theta = 90°$

$F_B = qvB\sin\theta$, where $\theta = 90°$

$$F_B = qvB$$

$$F_B = mv^2/r$$

$$v = \frac{qBr}{m_e} \quad \therefore v = \frac{1.6\times10^{-19}\times3.5\times10^{-1}\times1.4\times10^{-7}}{9.11\times10^{-31}}$$

$$v = 8.605 \times 93m/s$$

Hence angular speed : $\omega = \frac{qB}{m_p} = \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}} = 6.147\times10^{10}$

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

5. Biot Savt - Savart Law

6. (i) The vector $\vec{dB}$ is perpendicular to dl (which points in the direction of the current) and to unit vector $\hat{r}$ directed from dl toward P.

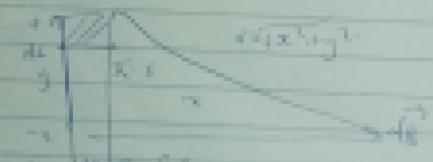
(ii) The magnitude of $\vec{dB}$ is inversely proportional to r^2

(iii) The magnitude of $\vec{dB}$ is proportional to the current I and to the magnitude of the length element dl

(iv) The magnitude of dB is proportional to $\sin\theta$, where θ is the angle between $\hat{r}$ and $\vec{dl}$

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

(b)



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

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

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

From diagram, $r^2 = x^2 + y^2$

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

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

Substituting (2) into (1)

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

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

Recall $dl = dy$.

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

$$B = \frac{\mu_0 I x}{4\pi} \int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}} \, dy \quad \text{—— } (5)$$

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

Equation 5

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

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

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

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

In a physical condition, we have axial symmetry about the y-axis. Thus, at all point in a circle of radius r, around the conductor the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r} \quad \text{—— } (4)$$