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Civil Engineering
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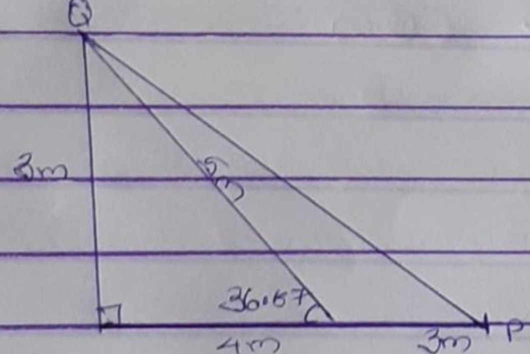
Phy 102

Section A

2a Electric field refers to the region of space in which an electric ~~field intensity~~ charge will experience an electric force.
Electric field intensity refers to the force per unit charge at a point

2b 

$q_1 = 8nC \qquad q_2 = 12nC$

ii $E_1 = \frac{kq_1}{r^2} = \frac{(9\times10^{9})\times(8\times10^{-9})}{7^2} \Rightarrow 1.47N/C$

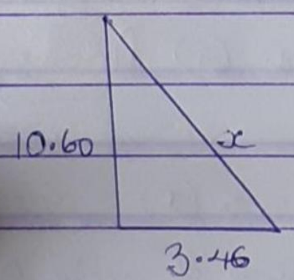
$E_2 = \frac{kq_2}{r^2} = \frac{(9\times10^{9})\times(12\times10^{-9})}{7^2} \Rightarrow 2.20N/C$

∴ The net electric field at a point $P \Rightarrow 3.67 N/C$

iii $E_1 = \frac{(9\times10^{9})\times(8\times10^{-9})}{3^2} \Rightarrow 8.0$

$E_2 = \frac{(9\times10^{9})\times(12\times10^{-9})}{5^2} \Rightarrow 4.32$

x	y
$8 \times \cos(90)$	$8 \times \sin 90$
$= 0$	$= 8$
$4.32 \times \cos(36.87)$	$4.32 \times \sin(36.87)$
$= 3.46$	2.60
3.46	10.60



$$x = \sqrt{(10.60)^2 + (3.46)^2}$$

3a i) Volume charge density

$$\rho = \frac{dQ}{dA} \longrightarrow dQ = \rho\, dV$$

ii) Surface ~~velocity~~ charge density

$$\sigma = \frac{dQ}{dA} \longrightarrow dQ = \sigma\, dA$$

iii) Linear charge density

$$\lambda = \frac{dQ}{dl} \longrightarrow dQ = \lambda\, dl$$

3b $dW = F \cdot dL$ ... (1)

$F = -q_0 E$ --- (2)

Substituting equation (2) in (1)

$dW = -q_0 E dL$ --- (3)

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

$W(A \to B)_{Ag} = -q_0 \int_A^B E dL$ --- (4)

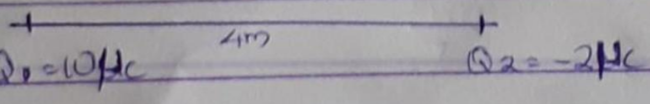
From the definition of electric potential difference it follows that

$V_B - V_A = \frac{W(A \longrightarrow B)_{Ag}}{q_0}$ --- (5)

Putting eqation (4) in (5)

$V_B - V_A = -\int_A^B E dL$ --- (6)

c



$Q_1 = 10\mu c \quad Q_2 = -2\mu c$

$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} \times \frac{Q_2}{r_2}\right]$

$\frac{0}{9\times10^{9}} = \frac{10\times10^{-6}}{r_1} - \frac{2\times10^{-6}}{r_2}$

$2r = 10r_2 \; ; \; r_1 = 5r_2$

4a Magnetic flux refers to the strength of a magnetic field represented by lines of force. It is usually represented by the symbol Φ

4b Given: $q = 1.6 \times 10^{-19}$ C, $r = 1.4 \times 10^{-7}$ m, $B = 3.5 \times 10^{-1}$ weber/m²
$m = 9.11 \times 10^{-31}$ kg

Cyclotron frequency = Angular speed (ω)

$$\omega = \frac{qB}{m_p} = \frac{1.60 \times 10^{-19} C \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31} kg}$$

$$= 6.14 \times 10^{10} \text{ rad/s}$$

$\therefore$ The cyclotron frequency is 6.14×10^{10} rad/s

4c $F_B = qvB\sin\theta$ where $\theta = 90°$

$$\therefore F_B = qvB$$

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

Since the proton moves in a circular orbit, therefore

$$m_p v = qBr$$

$$v = \frac{qBr}{m_p} = \frac{1.6 \times 10^{-19} \times (3.5 \times 10^{-1}) \times (1.4 \times 10^{-7} m)}{9.11 \times 10^{-31}}$$

$$\therefore v = 8.6 \times 10^{3} \text{ m/s}$$

From $v = \frac{qBr}{m_p}$, we have that

$$\frac{v}{r} = \frac{qB}{m_p}$$

Since $v/r = \omega$ (Angular Speed)

$$\omega = \frac{qB}{mp} \Rightarrow \frac{1.60 \times 10^{-19} \times (3.5 \times 10^{-1})}{9.11 \times 10^{-31}}$$

$$\therefore \omega = 6.14 \times 10^{10} \text{ rad/s}$$

Hence Angular Speed = cyclotron frequency

5a Biot-Savart law states that the magnetic intensity dH at a point A due to current (I) flowing through a small element dl is

i) Directly proportional to current (I)

ii) Directly proportional to the sine of angle θ between the direction of current and the line joining the element dl from A

iii) Directly proportional to the length of the element (dl)

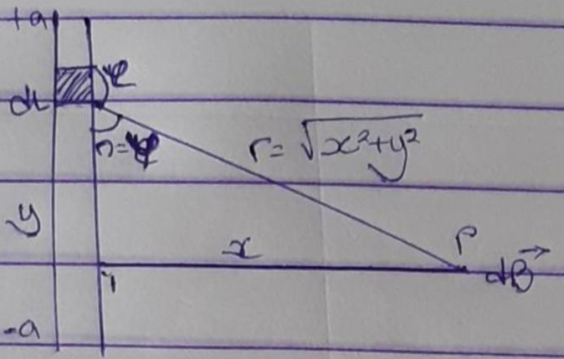
iv) ~~Inversely~~ proportional to the square of the distance x of point A from the element dl.

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

Where μ_0 is a constant called permeability of free space

$\hat{r}$ is the unit vector directed from dl towards A

5b



Applying the Biot-Savart law

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

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

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

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

Then using special integrals

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

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

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

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

$\therefore B=\frac{\mu_0 I}{2\pi x}$ Since $(x^2+a^2)^{1/2}\equiv a$, as $a\to\infty$

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