PHY 102 ASSIGNMENT

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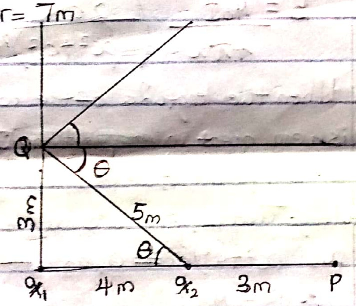
SECTION A

2a) An electric field is a region of space in which an electric charge will experience an electric force which electric field intensity, E, can be defined as the force per unit charge.

b) $Q_1 = 8\mu C$, $Q_2 = 12\mu C$, $x = 4m$.

i) $r = 7m$



$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-4}}{7^2} = 1.5 NC^{-1}$

$E_2 = \frac{9\times10^9 \times 12\times10^{-4}}{3^2} = 12 NC^{-1}$

$E_{net} = 12 + 1.5 = 13.5 NC^{-1}$

iii) $Q/E_1 = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8 NC^{-1}$

θ	x cosθ	y sinθ
90°	0	+8

$E_2 = \frac{9\times10^9 \times 12\times10^{-9}}{25} = 4.32 NC^{-1}$

$E_x = -3.46 NC^{-1}$ $E_y = 10.59 NC^{-1}$

$|E| = \sqrt{(-3.46)^2 + (10.59)^2}$

$|E| = 11.14 NC^{-1}$

3a) 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, $\lambda = \frac{dq}{dL} \rightarrow dq = \lambda dL$.

b) The electric potential difference between two points in an electric field can be defined as the work done per unit charge against electrical forces when a charge is transported from one point to the other.

$dW = F \cdot dL$

But $F = -q_0 E$

$\therefore dW = -q_0 E dL$

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

$V_B - V_A = \frac{W(A \rightarrow B)_{Ag}}{q_0} = -\int_A^B E \, dL$

c) $Q_1 = 10\mu C$, $Q_2 = -2\mu C$, $x_1 = 0$, $x_2 = 4m$

$V = 0$, Electrical intensity/Force $= \frac{q}{4\pi\varepsilon_0 r^2}$

$\Rightarrow \frac{2\times10^{-9}C}{4\pi\varepsilon_0 (d)^2}, \frac{10\times10^{-9}C}{4\pi\varepsilon_0 (4+d)^2} = 0$

$2(4+d)^2 = 10d^2$

$2(16+8d+d^2) = 10d^2$; $32+16d+2d^2 = 10d^2$

$32+16d-8d^2 = 0$, $8d^2-16-32 = 0$

$d^2-2d-4 = 0$, Using $x = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$d = \frac{-(-2) \pm \sqrt{(-2)^2 - 4(1)(-4)}}{2(1)}$

$d = 1 \pm 4.4721$

$d = 5.4721$ or -3.4721

$\therefore$ Based on x-axis where $V = 0$, the point is at 5.4721 or -3.4721.

SECTION B.

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

b) $B = 3.5 \times 10^{-1}$ Weber$/m^2$

$M = 9.11 \times 10^{-31}$ kg

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

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

$\omega = ?$

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

$\omega = 6.147 \times 10^{10}$ rad/s.

5a) Biot-Savart Law is an equation that describes the magnetic field created by a current wire and allows you to calculate its strength at various points.

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

b) Using Biot-Savart Law, we find the magnitude of the field $d\vec{B}$:

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

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

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

From Pythagoras's theorem:

$$r^2 = x^2 + y^2$$

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

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

Substituting (**) into (*), 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, $(x^2+a^2)^{1/2} \cong a$, 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 the magnetic field of a straight current-carrying conductor is given as:

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