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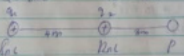
MEDICINE AND SURGERY
19/MHS01/323
PHY 102 ASSIGNMENT

SECTION A

2) a) 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 the force per unit charge. Mathematically, the magnitude of the field is given by: $E = \frac{F(N)}{q_0(C)}$. It is measured in (N/C)

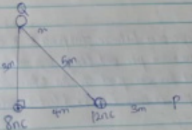
b) $Q = 8nC$ $\quad Q_2 = 12nC$



$E_{1p} = \frac{kq_{1p}}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469N/C$

$E_{2p} = \frac{kq_{2p}}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12N/C$

$E_{net} = (12 + 1.469)N/C$
$= 13.469N/C$



$x^2 = 3^2 + 4^2$
$x = \sqrt{9 + 16}$

$r = \sqrt{25}$

$r = 5m$

$E_1Q = \frac{kq_p}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8N/C$

$E_2Q = \frac{kq_{2p}}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32N/C$

Vector	Angle	X component	Y-component
E_1Q 8N/C	90°	0	8
E_2Q 4.32N/C	36.87°	3.456	2.592
		3.456	10.592

$E_{net} = \sqrt{3.456^2 + 10.592^2}$

$= 11.14N/C$

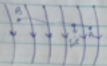
3) a) Volume charge density, $\rho = \frac{dQ}{dv} \Longrightarrow dQ = \rho dv$

b) Surface charge density $\sigma = \frac{dQ}{dA} \longrightarrow dQ = \sigma dA$

c) Linear charge density, $\lambda = \frac{dQ}{dl} \Longrightarrow dQ = \lambda dl$

4) Electric potential Difference

The electric potential difference between two points in an electric field can be defined as the workdone per unit charge against electrical force when a charge is transported from one point to the other. It is measured in volt (V) or joules per coulomb (J/C). Electric potential difference is a scalar quantity.



From the diagram above assuming a test charge q_0 is moved from point A to point B along an arbitrary path inside an electric field E. The electric field exerts a force $F = q_0E$ on the charge. To move the test charge from A to B at constant velocity, an external force of $F = -q_0E$ must act on the charge.

$$\therefore \quad dW = F \cdot dl$$

$$\text{But } F = -q_0E$$

$$dW = -q_0 E\, dl$$

Total workdone in moving the test charge from A to B

$$W(A \to B)_{ag} = -q_0 \int_A^B E\, dl$$

$$V_B - V_A = \frac{W(A \to B)_{ag}}{q_0}$$

$$V_B - V_A = -\int_A^B E\, dl$$

b) For point charge Q_1 to the left

$$V = \frac{Kq}{r}$$

$$V_1 = \frac{K \times (10\mu C)}{x}$$

$$V_2 = \frac{K \times (-2\mu C)}{4 + x}$$

$$\frac{(10\mu)K}{x} = \frac{(2\mu)K}{4 + x}$$

$$\frac{10\mu C}{x} = \frac{2\mu C}{4 + x}$$

$$\frac{10}{x} = \frac{2}{4 + x}$$

$10(4+x) = 2x$

$40 + 10x = 2x$

$40 = 2x - 10x$

$40 = -8x$

$x = -5m.$

In between

$V_1 = \frac{K10}{x}$

$V_2 = \frac{K(-2)}{4-x}$

Where $V = 0$

$0 = 40 - x - 2x$

$0 = 40 - 3x$

$x = \frac{40}{3}$. Here, value is not between the points.

To the right

$V_1 = \frac{10K}{x}$

$V_2 = \frac{2K}{x-4}$

$\frac{10K}{x} = \frac{2K}{x-4}$

$10(x-4) = 2x$

$10x - 40 = 2x$

$10x - 2x = 40$

$8x = 40$

$x = 5m.$

SECTION B

4a) Magnetic flux is the number of magnetic lines of forces set up in a magnetic circuit

b) Mass of electron = 9.11×10^{-31} kg

radius of orbit = 1.4×10^{-2} m

Mag. field (B) = 3.5×10^{-7} wb/m^2

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

$$W = \frac{1.60 \times 10^{-19} \times 3.5 \times 10^{-7}}{9.11 \times 10^{-31}}$$

$$W = 6.147 \times 10^{4} \text{ rad/s}$$

c) The angular speed is often regarded to as the cyclotron frequency because the charge particle (electron) travels round a circular path with an angular speed of 6.147×10^{4} radian per second.

5) a) Biot - Savart Law

- The vector $\vec{dB}$ is perpendicular both to $\vec{dl}$ (which points in the direction of the current) and to the unit vector $\hat{r}$ directed from $\vec{dl}$ toward P.
- The magnitude of $\vec{dB}$ is inversely proportional to r^2, where r is the distance from $\vec{dl}$ to P.
- The magnitude of $\vec{dB}$ is proportional to the current I and to the magnitude of the length element $\vec{dl}$.
- The magnitude of $\vec{dB}$ is proportional to $\sin\theta$, where θ is the angle between $\hat{r}$ and dl.

Mathematically, Biot - Savart Law is expressed as

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

Where μ_0 is a constant called permeability of free space.

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

b) Using Biot-Savart Law

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

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

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

From the above diagram

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

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

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

Substituting (ii) into (i) we have

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

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

Recall $dl = dy$

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

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

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

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

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

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

$(x^2+b^2)^{1/2} = b$, as $b \to \infty$

$$\therefore B = \frac{\mu_0 I}{2\pi x} \quad \text{in a circle} \quad B = \frac{\mu_0 I}{2\pi r}$$