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19/MHS01/093
MEDICINE & SURGERY. PHY102

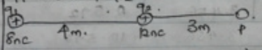
SECTION A.

2. Distinguish between Electric field & Electric field Intensity

Electric field is a region of space in which an electric charge will experience an electric force.
Electric field Intensity is the force per unit charge, which is given by

$$E = \frac{F \text{ (Newton)}}{q_0 \text{ (Coulomb)}}$$

b) $Q_1 = 8nC$, $Q_2 = 12nC$.

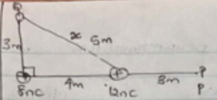


$$E_{1P} = \frac{kq_{1P}}{r^2} = \frac{9\times10^9 \times (8\times10^{-9})}{7^2} = 1.469 \text{ N/C}$$

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

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

(11)



$\cos\theta = \frac{4}{5} = 36.87°$

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

$x = \sqrt{9+16}$

$= \sqrt{25}$

$= 5m$

$E_{1P} = \frac{Kq_{1P}}{r^2} = \frac{9\times10^9 \times (8\times10^{-9})}{8^2} = 8\ N/C$

$E_{2P} = \frac{Kq_{2P}}{r_2} = \frac{9\times10^9 \times (12\times10^{-9})}{5^2} = 4.32\ N/C$

Vector	Angle	X component	Y-component
E_{1P} (8N/C)	90°	0	8
E_{2P} (4.32N/C)	36.87°	3.456	2.592
		3.456	10.592

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

$= 11.14\ N/C$

3 Volume Charge density, $\rho = \frac{dQ}{dV}$

i.e. $dQ = \rho \, dV$

Surface Charge density, $\sigma = \frac{dQ}{dA}$

i.e. $dQ = \sigma \, dA$

Linear charge density, $\lambda = \frac{dQ}{dL}$

i.e. $dQ = \lambda \, dL$.

6. Electric potential difference.

Electric potential difference between 2 points in an electric field is the workdone per unit charge against electrical forces when a charge is moved from one point to another. It is measured in Volts or J/C.

If a test charge, q_0, moves from point A to B inside an Electric field, E

The force exerted, $F = -q_0 E$

Since $dW = F \cdot dL$

$$dW = -q_0 \varepsilon \, dL..$$

Workdone in moving a test charge from A to B

$$W(A \to B)_{Ag} = -q_0 \int_A^B \varepsilon \, dL.$$

from

$$W = qV$$

$$V = \frac{W}{q}$$

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

$$V_B - V_A = \frac{-\cancel{q_0} \int_A^B \varepsilon \, dL}{\cancel{q_0}}$$

$$V_B - V_A = -\int_A^B \varepsilon \, dL.$$

(c) To the left of q_1

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

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

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

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

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

$10\mu C(4+x) = 2\mu c\, x$

$40\mu c + 10x\mu c = 2\mu c\, x$

$40 = 2x - 10x$

$40 = -8x$

$x = \frac{40}{-8} = -5m.$

In between.

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

$V = \frac{k(-2)}{4-x}$

$0 = 40 - x - 2x$

$0 = 40 - 3x$

$x = \frac{40}{3}$ (This value is not between the points)

To the right

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

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

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

$$10(x-4) = 2x$$

$$10x - 40 = 2x$$

$$10x - 2x = 40$$

$$8x = 40$$

$$x = 5m$$

SECTION B

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

(b) $m_e = 9.11 \times 10^{-31}$ kg.

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

$B = 3.5 \times 10^{-7}$ W/m^2.

find ω, the cyclon frequency of the electron

$$\omega = \frac{qB}{m_e}$$

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

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

$$\omega = \frac{qB}{m_e}$$

$$= \frac{1.60 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31} Kg}$$

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

(c) The angular speed, also referred to as cyclon frequency with which a particle, an electron in this case, travels round a circular orbit is 6.147×10^{10} radian per second.

(5) The Biot - Savart Law states that:

1) The vector $d\vec{B}$ is perpendicular both to $d\hat{l}$ and to the unit vector $\hat{r}$ directed from $d\hat{l}$ towards P.
2) The magnitude of $d\vec{B}$ is inversely proportional to r^2, where r is the distance from dl 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 $\hat{r}$ and dl.

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

5b) Applying the Biot-Savart Law:

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

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

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

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

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

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

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

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

$$B = \frac{\mu_0 I r}{4\pi}\int_{-a}^{a} \frac{1}{(r^2+y^2)^{3/2}}\, dy \quad \cdots \text{ using integral}$$

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

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

$$B = \mu_0 I \left[\frac{2a}{r^2+a^2)^{1/2}}\right).$$

$$(r^2+a^2)^{1/2} = a, \text{ as } a \to \infty.$$

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