PHYSICS 102

NAME: HARRISON DAVIDA EBERECHI

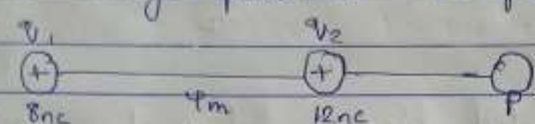
DEPARTMENT: MEDICINE AND SURGERY

MATRIC NO: 19/MH301/181

2a) Electric field is a region around a charge in which it exerts electrostatic force on another charge.

Mathematical formular: $E = \frac{F}{q}$

While the strength of electric field at ~~extensity~~ any point in space is called electric field intensity. It is a vector quantity. It is also the force experienced by a unit positive charge placed at that point.

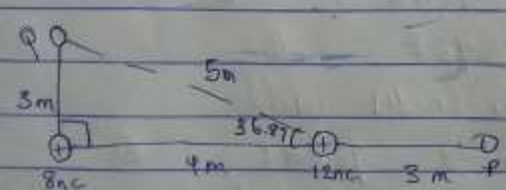
b) 

$$E_{1p} = \frac{Kq_{1p}}{r^2} = \frac{9\times10^9 \times (8\times10^{-9})}{7^2} = 1.469 N/c$$

$$E_{2p} = \frac{Kq_{2p}}{r^2} = \frac{9\times10^9 \times (12\times10^{-9})}{3^2} = 12 N/c$$

$$E_{net} = 12 + 1.469$$

$$= 13.469 N/c$$

ii 

$$E_{1q} = \frac{Kq}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8 N/c$$

$$E_{2q} = \frac{Kq}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/c$$

Charge	Angle	X component	Y component
$E_1 = 8$ N/C	90°	$E_1 \times \cos 90^\circ = 0$	$E_1 = 8 \sin 90 = 8$
$E_2 = 4.32$ N/C	36.87°	$E_2 \cos 36.87^\circ = 3.46$	$E_2 \sin 36.87 = 2.59$
		$\sum E_x = 3.46$	$\sum E_y = 10.59$

$$E_{net} = \sqrt{8.46^2 + 10.59^2}$$
$$= 11.14 \text{ N/C}$$

3a 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 electrical potential difference between two points in an electric field can be defined as the workdone per unit charge against electrical forces when a charge is transported from one point to the other. It is measured in volts or joules per coulomb (J/C). It is a scalar quantity.

Therefore the elemental workdone dW is given as

$$dW = F \cdot dL \quad \text{--- (1)}$$

But $$F = -q_0 E \quad \text{--- (2)}$$

Substituting equation (2) in (1) yields

$$dW = -q_0 E dL \quad \text{--- (3)}$$

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

$$W(A \rightarrow B)_{ag} = -q_0 \int_A^B E dL \quad \text{--- (4)}$$

From the definition of electrical difference, it follows that

$$V_B - V_A = \frac{W(A \rightarrow B)_{ag}}{q_0} \quad \text{--- 5}$$

Putting (4) in (3) yields

$$V_B - V_A = -\int_A^B E\,dl \quad \ldots (6)$$

3c $V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$ recall $\frac{1}{4\pi\varepsilon_0} = 9\times10^9 = K$

$$V_P = 9\times10^9 \times \left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right]$$

Where $V_P = 0$

$$0 = 9\times10^9 \times \left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right]$$

$$0 = \frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4+x} = \frac{2\times10^{-6}}{x}$$

$$10\times10^{-6}x = 8\times10^{-6} + 2\times10^{-6}x$$

$$8\times10^{-6} = 10\times10^{-6}x - 2\times10^{-6}x$$

$$8\times10^{-6} = 8\times10^{-6}x$$

$$x = 1$$

$\therefore$ position along the x-axis is 1m

Where $V = 0$

$$V = K\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

$$0 = \left[\frac{10\times10^{-6}}{4-x} + \frac{-2\times10^{-6}}{x}\right]$$

$$\frac{2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4-x}$$

$$8\times10^{-6} = 10\times10^{-6}x + 2\times10^{-6}x$$

$$8\times10^{-6} = 12\times10^{-6}x$$

$$x = \frac{8\times10^{-6}}{12\times10^{-6}x}$$

$$x = 0.67m$$

Position of $V = 0$ is 0.67m

a) Magnetic flux is the strength of magnetic field represented by lines of force. Represented by ϕ: $\phi = B \cdot dA$.

b) $m = 9.11 \times 10^{-31}$

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

Mag field $= 3.5 \times 10^{-1}$ web

Finding the cyclotron frequency [Angular Speed]

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

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

$$W = 6.14 \times 10^{10} s^{-1}$$

c) The mass given was mass of electron so we would also use charge of electron to solve which is 1.6×10^{-19}. We were ~~forced~~ asked to find the cyclotron frequency which is also angular speed, so we solved using the formula

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

5a Biot - Savart law is an equation describing the magnetic field generated by a constant electric current. It is fundamental to magnetostatics.

b Magnetic Field of a straight Current Carrying Conductor

Applying the 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 diagram, $r^2 = x^2 + y^2$ (pythagoras theorem)

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

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

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 $dl = dy$

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

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

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,

$$(x^2+a^2)^{1/2} \simeq a, \text{ as } a \to \infty$$

$$\therefore \quad B = \frac{\mu_0 I}{2\pi x}$$

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

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