NAME: UDECHUKWU CHINONSO IFENNA
DEPT: COMPUTER ENGINEERING
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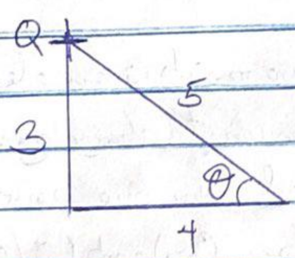
COVID 19 HOLIDAY ASSIGNMENT

2 a) Electric field is the space around an electric charge in which its influence can be felt. The electric field is a vector quantity while Electric field intensity at a point is the force experienced by a unit positive charge placed at that point. Electric field intensity is a vector quantity. The electric field due to a positive charge is always directed away from the charge and the intensity due to a negative charge is always directed towards the charge. The formula for electric field is F/q while Electric field Intensity $(E) = \dfrac{q}{4\pi\varepsilon d^2}$

b) $Q_1 = 8nC$ at the origin
$Q_2 = 12nC$ at $x = 4m$



(i) $E_1 = \dfrac{kq_1}{r_1^2}$

$= \dfrac{9\times10^9 \times 8\times10^{-9}}{7^2}$

$= 1.47 N/C$

$E = E_1 + E_2$
$= 1.47 + 12$
$= 13.5 N/C$

(ii) $r^2 = 3^2 + 4^2$
$r = \sqrt{9+16}$
$r = 5m$
$\theta = \sin^{-1}(3/5)$
$\theta = 36.87°$

$E_1 = \dfrac{kq_1}{r_1^2} = \dfrac{9\times10^9 \times 8\times10^{-9}}{3^2}$
$= 8 N/C$

$E_2 = kq_2 = 9\times10^9 \times 12\times10^{-9}$

Vector	Angle	X component	Y component
$\mathcal{E}_1 = 8 N/C$	$90°$	$\mathcal{E}_{1x} = 8\cos 90°$	$\mathcal{E}_{1y} = 8\sin 90°$
		$= 0 N/C$	$= 8 N/C$
$\mathcal{E}_2 = 4.32 N/C$	$36.87°$	$\mathcal{E}_{2x} = 4.32\cos 36.87$	$\mathcal{E}_{2y} = 4.32\sin 36.87$
		$= 3.46 N/C$	$= 2.59 N/C$
		$\Sigma\mathcal{E}_x = 3.46 N/C$	$\Sigma\mathcal{E}_y = 10.59 N/C$

$$\mathcal{E} = \sqrt{\Sigma\mathcal{E}x^2 + \Sigma\mathcal{E}y^2}$$
$$= \sqrt{(3.46)^2 + (10.59)^2}$$
$$= \sqrt{11.97 + 112.15}$$
$$= \sqrt{124.12}$$
$$= 11.1 N/C$$

3) 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. It is measured in volt (V) or Joules per Coulomb (J/C). Electric potential difference is a scalar quantity.

Consider the diagram above, suppose 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 E exerts a force $F = q_0 E$ on the charge. ~~as shown~~ To move the test charge from A to B at constant velocity, an external force of $F = -q_0 E$ must act on the charge. Therefore the elemental work done dW is given as:

$$dW = F \cdot dl \quad \cdots (1)$$

But, $F = -q_0 E \quad \cdots (2)$

Substituting (2) in (1) yields

$$dW = -q_0 E dl \quad \cdots (3)$$

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

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

From the definition of electric potential difference, it follows that:

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

Putting (4) in (5) yields

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

c)

4a) Magnetic flux is a measurement of the total magnetic field which passes through a given area. It is a useful tool for helping describe the effects of the magnetic force on something occupying a given area. The S.I unit is Weber (Wb)

b) Cyclotron frequency = $\frac{qB}{m}$

$q = 1.6 \times 10^{-19} C$ $B = 3.5 \times 10^{-1}$ Weber/metre square

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

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

$f = 6.147 \times 10^{10} Hz$

c) - Biot Savart Law states that the magnetic intensity dH at a point A due to current ~~flo~~ I flowing through a small element dl is

(1) Inversely proportional to r^2, where r is the distance from dl to A

(2) directly proportional to the sine of angle θ between the direction of current and the line joining the element dl from point A

(3) directly proportional to the current I and to the magnitude of the length element $d\vec{l}$.

(4) ~~Add~~ the vector dH is perpendicular both to dl (which points in the direction of the current) and to the unit vector $\hat{r}$ directed from $d\vec{l}$ towards A.

5b) Magnetic Field of a Straight Current Carrying Conductor

Applying the Biot-Savart law, we find the magnitude of the field $d\vec{B}$

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

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

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

$$r^2 = x^2 + y^2 \quad \text{(Pythagoras theorem)}$$

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

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

Substituting $(**)$ into $(*)$, we have

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

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

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:

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

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

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

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,

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

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

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 B is

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