Nnaemeka Okafor
Computer Engineering
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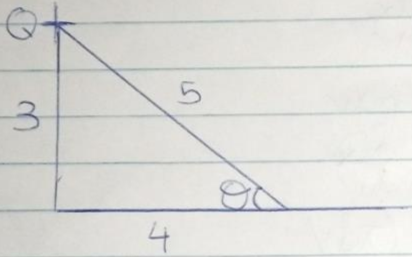
Phy 102

2a) Electric field is a region of space in which an electric charge will experience an electric force. The electric field strength ($\mathcal{E}$)/intensity can be defined as the force per unit charge

$$\mathcal{E} = \frac{F(N)}{q(C)}$$

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



i) $\mathcal{E}_1 = \frac{Kq_1}{r_1^2}$

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

$= 1.47 N/C$

$\mathcal{E}_2 = \frac{Kq_2}{r_2^2}$

$= \frac{9\times10^9 \times 12\times10^{-9}}{3^2}$

$= 12 N/C$

$\mathcal{E} = \mathcal{E}_1 + \mathcal{E}_2$

$= 1.47 + 12$

$= 13.5 N/C$

ii) $r^2 = 3^2 + 4^2$

$r = \sqrt{9+16}$

$r = \sqrt{25}$

$r = 5m$

$\theta = \sin^{-1}(3/5)$

$\theta = 36.87^\circ$

$\mathcal{E}_1 = \frac{Kq_1}{r_1^2}$

$= \frac{9\times10^9 \times 8\times10^{-9}}{3^2}$

$= 8 N/C$

$\mathcal{E}_2 = \frac{Kq_2}{r_2^2}$

$= \frac{9\times10^9 \times 12\times10^{-9}}{5^2}$

$= 4.32 N/C$

Vector	Angle	x Component	y Component
$\varepsilon_1 = 8N/C$	90°	$\varepsilon_{1x} = 8\cos 90^\circ = 0N/C$	$\varepsilon_{1y} = 8\sin 90^\circ = 8N/C$
$\varepsilon_2 = 4.32 N/C$	36.87°	$\varepsilon_{2x} = 4.32\cos 36.87^\circ = 3.46N/C$	$\varepsilon_{2y} = 4.32 \sin 36.87 = 2.59 N/C$
		$\Sigma\varepsilon_x = 3.46 N/C$	$\Sigma\varepsilon_y = 10.59 N/C$

$$\varepsilon = \sqrt{\Sigma\varepsilon_x^2 + \Sigma\varepsilon_y^2}$$
$$= \sqrt{(3.46)^2 + (10.59)^2}$$
$$= \sqrt{11.97 + 112.15}$$
$$= \sqrt{124.12}$$
$$\approx 11.1 N/C$$

3) i Volume charge density, $\rho = \frac{dQ}{dV}$

$$dQ = \rho dV$$

ii Surface charge density $\sigma = \frac{dQ}{dV}$

$$dQ = \sigma dV$$

iii Linear charge density $\lambda = \frac{dQ}{dV}$

$$dQ = \lambda dV$$

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 volts or J/C.

$dW = F \cdot dL$

but $F = -q_0\varepsilon$

$dW = -q_0 \varepsilon dL$

The work done in moving a test charge from A to B

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

From the definition of electric potential difference

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

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

B) Cyclotron frequency $= \frac{qB}{2\pi m}$

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

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

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

$$f = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{2 \times 3.142 \times 9.11 \times 10^{-31}}$$

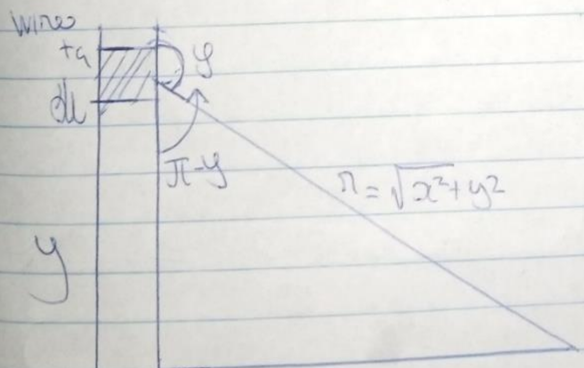
$$f = \frac{-5.6 \times 10^{-20}}{5.72 \times 10^{-30}}$$

$f = -0.979 \times 10^{10}$

$f = -9.79 \times 10^{9}$ Hz

c) The charge is negative because the electron is in motion. The frequency is a cyclotron frequency because it moves in a circular orbit

5) Bio-Savart law states the magnetic intensity at any point due to a steady current in an infinitely long straight wire is directly proportional to the current and inversely proportional to the distance from point to wires



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

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

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

$r^2 = \sqrt{x^2 + y^2}$

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

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

$\sin(\pi - \varphi) = \frac{x}{r}$

$= \frac{x}{(x^2 + y^2)^{1/2}}$ — II

Sub II into I

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

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

$dl = dy$

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

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

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

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

When length 2a or a is much larger than x $(x^2 + a^2)^{1/2} \simeq a$, as $a \to \infty$

∞ ∴ $B = \frac{\mu_0 I}{\cancel{4}\pi x} \left(\frac{2a}{a} \right)$

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

There is axial symmetry about the axis. Thus all points in a

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