

NWOKORIE PASCAL CHINAMDI

MECHATRONICS ENGINEERING

19/RNG/05/043

PH 102 ASSIGNMENT

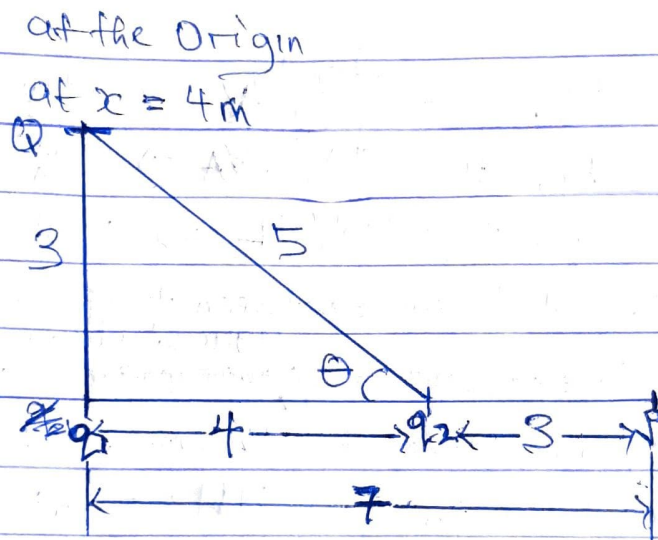
2)

a) Electric field is a region of space in which an electric charge will experience an electric force, while the electric field strength (E) intensity can be defined as the force per unit charge.

$$E = \frac{F(N)}{q_0(C)}$$

b) $Q_1 = 8 \mu C$

$Q_2 = 12 \mu C$



$$i) E_1 = \frac{kq_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = 1.47 \text{ N/C}$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{3^2} = 12 \text{ N/C}$$

$$\Sigma E = E_1 + E_2 = 1.47 + 12 = 13.5 \text{ N/C}$$

$$ii) r^2 = 3^2 + 4^2 \therefore r = \sqrt{9+16} = \sqrt{25}$$

$$r = 5 \text{ m}$$

$$\theta = \sin^{-1}(3/5) = 36.87^\circ$$

$$E_1 = \frac{kq_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{3^2} = 8 \text{ N/C}$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = 4.32 \text{ N/C}$$

Vector	Angle	x component	y component
$E_1 = 8 \text{ N/C}$	90°	$E_{1x} = 8 \cos 90^\circ = 0 \text{ N/C}$	$E_{1y} = 8 \sin 90^\circ = 8 \text{ N/C}$
$E_2 = 4.32 \text{ N/C}$	36.87°	$E_{2x} = 4.32 \cos 36.87^\circ = 3.46 \text{ N/C}$	$E_{2y} = 4.32 \sin 36.87^\circ = 2.59 \text{ N/C}$
		$\sum E_x = 3.46 \text{ N/C}$	$\sum E_y = 10.59 \text{ N/C}$

$$E = \sqrt{(\sum E_x)^2 + (\sum E_y)^2} = \sqrt{(3.46)^2 + (10.59)^2} = \sqrt{11.97 + 112.15} = \sqrt{124.12}$$

$$E = 11.1 \text{ N/C}$$

3) a) Volume Charge Density, $\rho = \frac{dQ}{dV} \Rightarrow dQ = \rho dV$
 Surface Charge Density, $\sigma = \frac{dQ}{dA} \Rightarrow dQ = \sigma dA$
 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 volts or J/C

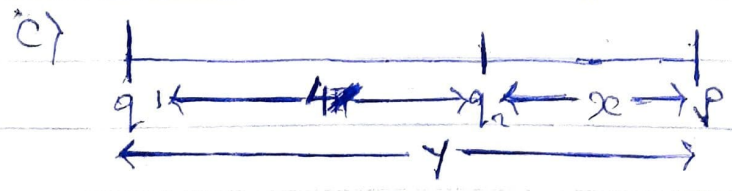
$$dW = F \cdot dL, \text{ but } F = -q_0 E \therefore dW = -q_0 E dL$$

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

$$W_{CA \rightarrow B} = -q_0 \int_A^B E dL$$

From the definition of electric potential difference $V_B - V_A = \frac{1}{q_0} W_{CA \rightarrow B}$

$$\text{Because } V_B - V_A = - \int_A^B E dL$$



$$V_P = 0, Q_1 = 10 \mu\text{C}, Q_2 = -2 \mu\text{C}$$

$$V_P = \frac{1}{4\pi\epsilon_0} \left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} \right] \Rightarrow 0 = 9 \times 10^9 \left[\frac{10 \times 10^{-6}}{4+x} - \frac{2 \times 10^{-6}}{x} \right]$$

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

$$2(4+x) = 10x \Rightarrow 8+2x = 10x \Rightarrow 8x = 8 \therefore x = 1$$

$$y = x + 4 \Rightarrow y = 1 + 4 \therefore y = 5$$

$\therefore V = 0$ at 5m on the x axis.

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

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

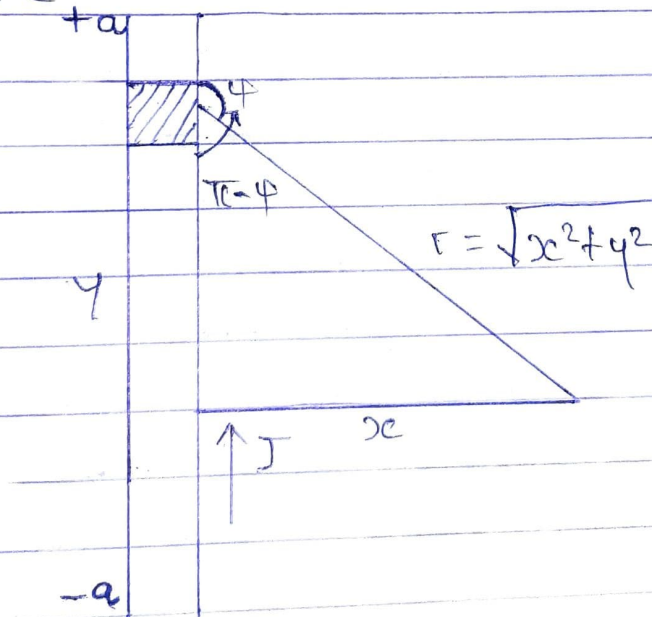
$B = 3.5 \times 10^{-1} \text{ Weber/m}^2$, $m = 9.1 \times 10^{-31} \text{ kg}$, $q = -1.6 \times 10^{-19} \text{ C}$

$f = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{2 \times 3.142 \times 9.1 \times 10^{-31}} = \frac{-5.6 \times 10^{-20}}{5.72 \times 10^{-30}} \approx -9.79 \times 10^9 \text{ Hz}$

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

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 a) Biot - Savart law states that 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 wire.



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

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

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

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

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

Sub (1) into (1).

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

$$dl = dy$$

$$B = \frac{\mu_0 I \times}{4\pi} \int_{-a}^a \frac{dy}{(x^2 + y^2)^{3/2}} = \frac{\mu_0 I}{4\pi} \left[\frac{y}{x^2(x^2 + y^2)^{1/2}} \right]_{-a}^a$$

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

When length $2a$ or a is larger than x .

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

$$\therefore B = \frac{\mu_0 I}{2\pi x} \left(\frac{2a}{a} \right) \Rightarrow B = \frac{\mu_0 I}{2\pi x}$$

There is axial symmetry about the y axis. Thus all points are in a circle of radius r $\therefore r = x$, ~~$B = \frac{\mu_0 I}{2\pi r}$~~ $B = \frac{\mu_0 I}{2\pi r}$