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Computer Engineering
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PHY 102 Assignment

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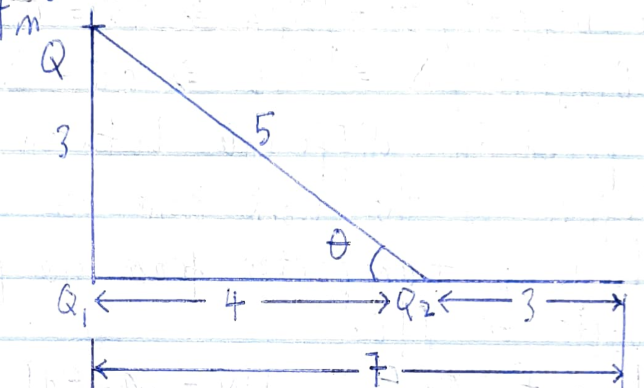
a) Electric field is a region of space in which an electric charge will experiences an electric force while the electric field strength (EV intensity) can be defined as the force per unit charge.

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

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



i) $E_1 = \frac{kq^1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.47 N/C$

$E_2 = \frac{kq^2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12 N/C$

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

ii) $r^2 = 3^2 + 4^2 \therefore r = \sqrt{9+16} = \sqrt{25}$
$r = 5m$
$\theta = \sin^{-1}(3/5) = 36.87°$

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

$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/C$

Vector	Angle	X components	Y components
$E_1 = 8N/C$	90°	$E_1x = 8\cos 90°$	$E_1y = 8\sin 90°$

Vector	Angle	X components	Y components
		$= 0\ N/C$	
$E_2 = 4.32\ N/C$	36.87°	$E_{2}x = 4.32 \cos 36.87^\circ = 3.46\ N/C$	$E_{2}y = 4.32 \sin 36.87^\circ = +2.59\ N/C$
		$\Sigma E_x = 3.46\ N/C$	$\Sigma E_y = 10.59\ N/C$

$E = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$

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

$E = 11.1\ N/C$

3) a) Volume Change Density, $\rho = dQ/dv \Rightarrow dQ = \rho dV$

Surface charge Density, $\sigma = dQ/dA \Rightarrow dQ = \sigma dA$

Linear charge Density, $\lambda = dQ/dL \Rightarrow dQ = \lambda dL$

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's measured in volts or J/C.

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

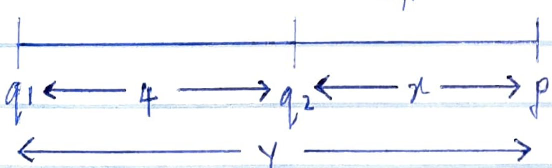
The workdone in moving a test charge from A to B

$W(A \rightarrow B)\ Ag = -q_0 \int_A^B E\, dl$

From the definition of electric potential difference $V_B - V_A = \frac{W(A \rightarrow B)\ Ag}{q_0}$

Because $V_B - V_A = -\int_A^B E\, dL$

c)



$V_p = 0$, $Q_1 = 10\mu c$, $Q_2 = -2\mu c$

$V_p = \frac{1}{4\pi\epsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right] \Rightarrow 0 = 9\times10^9\left[\frac{10\times10^{-6}}{4+x} - \frac{2\times10^{-6}}{x}\right]$

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

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

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

$\therefore V = 0$ 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's usually represented by the symbol ϕ

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

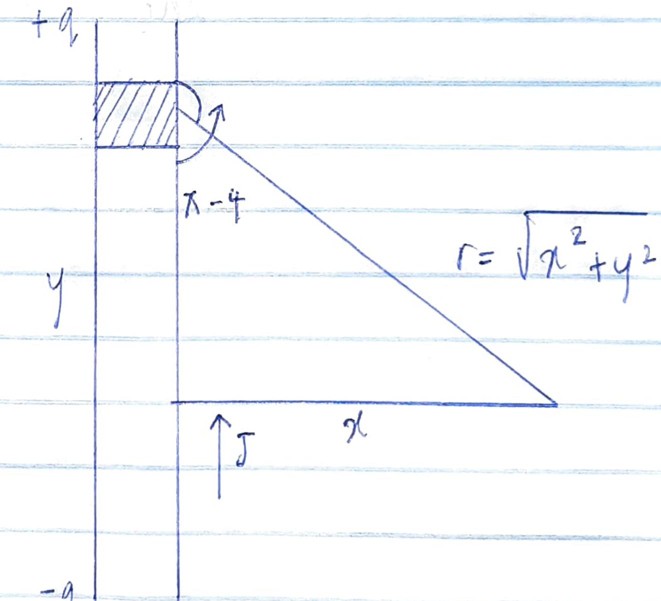
$B = 3.5 \times 10^{-1}$ weber/m^2, $m = 9.11 \times 10^{-31}$ kg, $q = -1.6 \times 10^{-19}$ C

$$f = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{2 \times 3.142 \times 9.11 \times 10^{-31}} = \frac{-5.6 \times 10^{-20}}{5.72 \times 10^{-30}} = -0.979 \times 10^{10}$$

$f = -9.79 \times 10^{9}$ 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 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 distances from point to wire.



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

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

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

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

Sub (II) into (I)

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

$dl = dy$

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

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

when length, 2a or a is larger than x

$(x^2+a^2)^{1/2} \triangleq a$, as $a \longrightarrow \infty$

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

There's axial symmetry about the y-axis. Thus all points are in a circle radius r $\therefore x = r$, $B = \dfrac{\mu_0 I}{2\pi r}$