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Physics assignment

Section A

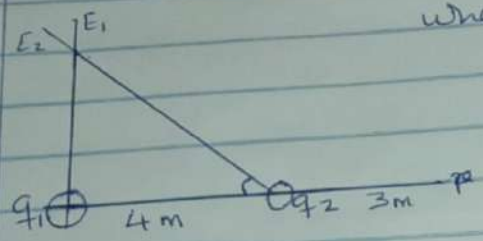
2a **Electric Field**

Electric field is a region of space in which an electric charge will experience an electric force

Electric Field Intensity

Electric field intensity can be defined as the force per unit charge.

b



when $Q_1 = 8nC$, $Q_2 = 12nC$
at $x = 4m$

i $E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = \frac{72}{49}$

$= 1.469 N/C \simeq 1.5 N/C$

$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = \frac{108}{9}$

$= 12 N/C$

$E_{net} = E_1 + E_2 = 1.5 N/C + 12 N/C = 13.5 N/C$

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 $\lambda = \frac{dQ}{dL} \rightarrow dQ = \lambda dL$

Where

Q = Charge, V = Volume, L = Length, A = Area

b) Electric Potential difference equation

$$V_B - V_A = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

where Q = Point charge

r_B = ~~difference~~ distance of Q to point B

r_A = distance of Q to point A

Due to several point charges

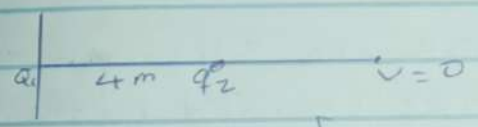
$$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]\cdots$$

where V = electric potential

Q = Point charge

r = distance of Q

c



$$V_P = k\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

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

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

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

$$10\times10^{-6}x = (4+x)(2\times10^{-6})$$
$$10\times10^{-6}x = 8\times10^{-6} + 2\times10^{-6}x$$
$$8\times10^{-6} = 10\times10^{-6}x - 2\times10^{-6}x$$
$$8\times10^{-6} = 8\times10^{-6}x$$
$$x = \frac{8\times10^{-6}}{8\times10^{-6}} = 1m$$

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

where $V = 0$

$$V = K\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$
$$0 = \left[\frac{10\times10^{-6}}{4-x} + \frac{-2\times10^{-6}}{x}\right]$$
$$\frac{2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4-x}$$
$$[4-x][2\times10^{-6}] = 10\times10^{-6}x$$
$$8\times10^{-6} - 2\times10^{-6}x = 10\times10^{-6}x$$
$$8\times10^{-6} = 10\times10^{-6}x + 2\times10^{-6}x$$
$$8\times10^{-6} = 12\times10^{-6}x$$
$$x = \frac{8\times10^{-6}}{12\times10^{-6}} = 0.67m$$

Position of $V=0$ is $0.67m$

Section B

4) Magnetic Flux is defined as the strength of the magnetic field which can be represented by the line of forces. It is denoted by ϕ.

4b $M_e = 9.11\times10^{-31}kg$, $r = 1.4\times10^{-7}m$, $B = 3.5\times10^{-1}\,W/m^2$

Cyclotron frequency = Angular speed $q = 1.6\times10^{-19}$

$$F_B = qvB = \frac{M_e v^2}{r}$$

$$M_e v = qBr$$
$$v = \frac{qBr}{m_e} = \frac{1.6\times10^{-19}\times3.5\times10^{-1}\times1.4\times10^{-7}}{9.11\times10^{-31}}$$

$v = 8.61 \times 10^{-3} m/s$

$$\omega = \frac{v}{r} = \frac{qB}{Me} = \frac{1.6 \times 10^{-19} \times 3.6 \times 10^{-1}}{9.11 \times 10^{-31}}$$

$$\omega = 6.14 \times 10^{10} e^{-1}$$

4 Mass of electron $= 9.11 \times 10^{-31}$ kg

radius $= 1.4 \times 10^{-7} m$ $\quad B = 3.5 \times 10^{-1} w/m^2$

and we were asked to find the cyclotron frequency in 4b which is the same thing as angular speed. It is called cyclotron frequency because it is a frequency of an acceleration called cyclotron.

Recall ω = angular speed

$$\omega = \frac{qB}{Me}$$

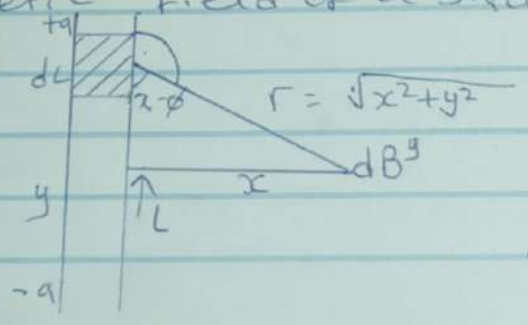
Since cyclotron frequency = angular speed

The cyclotron frequency $= 6.14 \times 10^{-10} e^{-1}$ having a unit of $\frac{1}{T}$ which is the unit of frequency dimensionally.

5a Biot-Savart law states that the magnetic field is directly proportional to the product permability of free space (μ) the current charge (I), the change in length, the radius and inversely proportional to the square of radius (r^2). Mathematically

$$d\hat{B} = \frac{\mu_0 I dl^y \times \hat{r}}{4\pi r^2}$$

b Magnetic Field of a straight current carrying conductor



A section of a straight current carrying conductor

Applying Biot-savart law, we find magnitude of the field

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

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

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

from the diagram $r^2 = x^2+y^2$

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dL \sin(\pi-\phi)}{x^2+y^2} \quad \text{----} \quad (1)$$

But $\sin(\pi-\phi) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{\frac{1}{2}}}$ ---- (11)

Substitute (11) into (1)

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

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

$dL = dy$; $B = \frac{\mu_0 I x}{4\pi}\int_{-a}^{a} \frac{1}{(x^2+y^2)^{3/2}}$ --- (111)

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

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

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