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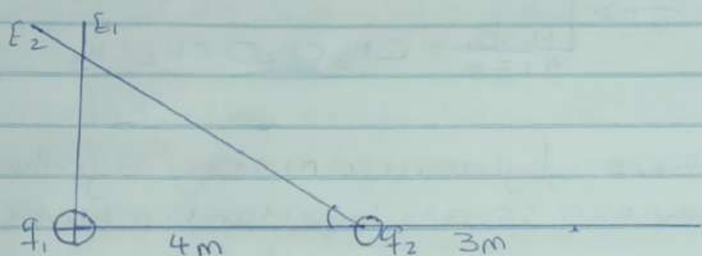
Physics 102 assignment

2a

Electric Field	Electric Field Intensity
Electric Field is a region of space in which an electric charge will experience an electric force	Electric Field Intensity is the force per unit charge

b



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

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

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

$$= 12\,N/C$$

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

$$= 13.5\,N/C.$$

3. 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 = dis~~tecence~~ance of Q to point B
r_A = distance of Q to point A

Due to several point charges

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

where V = electric potential
Q = Point charge
r = distance of Q

c. Q_1 4m q_2 $v=0$

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

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

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

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

$10 \times 10^{-6} x = (4+x)(2 \times 10^{-6})$

$10 \times 10^{-6} x = 8 \times 10^{-6} + 2 \times 10^{-6} x$

$8 \times 10^{-6} = 10 \times 10^{-6} x - 2 \times 10^{-6} x$

$8 \times 10^{-6} = 8 \times 10^{-6} x$

$x = \dfrac{8 \times 10^{-6}}{8 \times 10^{-6}} = 1m$

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

Where $v = 0$

$v = k\left[\dfrac{Q_1}{r_1} + \dfrac{Q_2}{r_2}\right]$

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

$\dfrac{2 \times 10^{-6}}{x} = \dfrac{10 \times 10^{-6}}{4-x}$

$[4-x][2 \times 10^{-6}] = 10 \times 10^{-6} x$

$8 \times 10^{-6} - 2 \times 10^{-6} x = 10 \times 10^{-6} x$

$8 \times 10^{-6} = 10 \times 10^{-6} x + 2 \times 10^{-6} x$

$8 \times 10^{-6} = 12 \times 10^{-6} x$

$x = \dfrac{8 \times 10^{-6}}{12 \times 10^{-6}} = 0.67m$

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 $M_e = 9.11 \times 10^{-31} kg$, $r = 1.4 \times 10^{-7} m$, $B = 3.5 \times 10^{-7} W/m^2$

Cyclotron frequency = angular speed $q = 1.6 \times 10^{-19}$

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

$M_e v = qBr$

$v = \dfrac{qBr}{m_e} = \dfrac{1.6 \times 10^{-19} \times 3.5 \times 10^{-7} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$

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

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

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

4c Mass of electron $= 9.11 \times 10^{-31}$ kg
radius $= 1.4 \times 10^{-7}$ m $B = 3.5 \times 10^{-1}$ W/m^2
and we were asked to find the cycloton frequency in 4b which is the same thing as angular speed. It is called cycloton frequency because it is a frequency of an acceleration called cyclotron.

Recall ω = angular speed

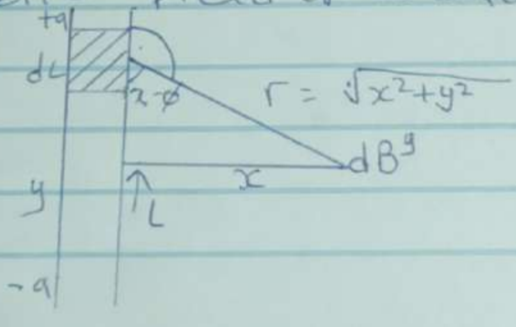
$$\omega = \frac{qB}{M_e}$$

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)

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

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

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

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

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

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