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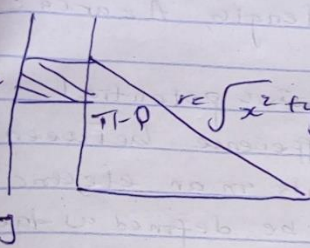
Biot savart Law is an equation that describes the magnetic field created by a current carrying wire and allows you to calculate its strength at various path.

5b) Magnetic field of a straight current charging Conductor:



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

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

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

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

But $\sin(\pi-\theta) = \frac{x}{\sqrt{x^2+y^2}} = \frac{x}{(x^2+y^2)^{1/2}}$ (eqtn 2)

Substitute eqtn (ii) into (i)

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

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

eqtn (iii)

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

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

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

$$B = \frac{\mu_0 I}{4\pi x} = \frac{\mu_0 I}{2\pi r}$$

7) Magnetic flux can be defined as the number of magnetic field lines passing through a given close surface.

$\Phi B = B \cdot A = BA\cos\theta$.

4b Data

$m_e = 9.11 \times 10^{-3}$ kg

$r = 1.4 \times 10^{-7}$ m

$B = 3.5 \times 10^{-1}$ weber/m²

Cycloton frequency = Angular speed.

$q = 1.6 \times 10^{-9}$

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

$M_e v = qBr$

$v = \frac{qBr}{M_e}$

$$v = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$$

$$\frac{7.84 \times 10^{-27}}{9.11 \times 10^{-31}}$$

$= 8605.9 \simeq 8.61 \times 10^{3}\, m/s$

$$w = \frac{v}{r} = \frac{qB}{M_e}$$

$$= \frac{1.6 \times 10^{-19} \times 3.6 \times 10^{-4}}{9.11 \times 10^{-31}}$$

$$W = \frac{5.6 \times 10^{-20}}{9.11 \times 10^{-31}} = 6.14 \times 10^{11}$$

4c) In 4b parameters we were given mass of an electron as 9.11×10^{-31} kg, radius as 1.4×10^{-7} m, $B = 3.5 \times 10^{-1}$ weber/m^2. Asked to find the Cycloton frequency also known as angular speed. It is Cycloton frequency because of an acceleration called Cycloton.

Recall W = Angular Speed

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

Since Cycle from frequency = Angular Speed the Cycloton frequency $= 6.14 \times 10^{10}\, s^{-1}$ having a unit of $\frac{1}{T}$ which is the unit of frequency dimensionally.

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

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

Q = charge, V = volume, L = length, A = area.

Electric potential difference between two points in an electric field can be defined as the workdone per unit charge against electrical forces when a charge is transferred from one point to the other.

It is measured in Volt or Joule per Coulomb and it is a scalar quantity

V = workdone / Charge
$= q \times V$

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

$V_p =$

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

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

$$\frac{0.10\times10^{-6}}{4+x}+\left(\frac{-2\times10^{-6}}{x}\right)$$

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

$$=8\times10^{-6}=10\times10^{-6}x-2\times10^{-6}x$$

$$x=\frac{8\times10^{-6}}{8\times10^{-6}}$$

$$x=1.$$

∴ position along the x-axis is 1m where $V=0$

$$V=k\left[\frac{q_1}{r_1}+\frac{q_2}{r_2}\right]$$

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

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

~~i) $E_{net}=\sqrt{E_x^2+E_y^2}$~~

~~$\sqrt{13.5^2+0^2}$~~

~~$=\sqrt{182.25}$~~

~~$=13.5N/C$~~

~~ii) $E_1=kq_1=\frac{9\times10^9\times8\times10^{-9}}{3^2}=\frac{72}{4}$~~

~~$=\cancel{\frac{10}{8}}=\frac{72}{9}=8N/C$~~

~~$E_2=kq_2=\frac{9\times10^9\times12\times10^{-9}}{5^2}$~~

~~$=\frac{108}{25}=4.32N/C$~~

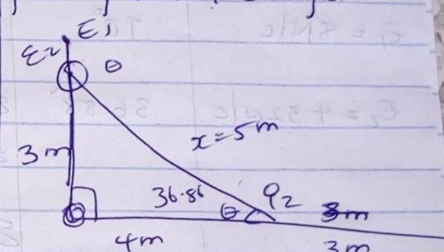
$$(4-x)(2\times10^{-6})=(10\times10^{-6})$$

$$8\times10^{-6}=2\times10^{-6}x=10\times10^{-6}x$$

$$x=\frac{8\times10^{-6}}{10^2\times10^{-6}}=0.67m$$

∴ position of $v=0.67m$

2a) Electric field is a region of space in which an electric charge will experience an electric force while Electric field Intensity is defined as the force per unit charge.



$$E_1=\frac{kq_1}{r^2}=\frac{9\times10^9\times8\times10^{-9}}{7^2}$$

$$=\frac{72}{49}=1.469$$

$$\simeq1.5N/C$$

$$E_2=\frac{kq_2}{r^2}=\frac{9\times10^9\times12\times10^{-9}}{3^2}$$

$$=\frac{108}{9}=12N/C.$$

Vector	Angle	x-component	y-component
$E_1 = 1.5 N/C$	$0°$	$E_1 = 1.5 \cos\theta = 1.5 N/C$	$E_1 = 1.5 \sin\theta = 0 N/C$
$E_2 = 12 N/C$	$0°$	$E_2 = 12 \cos\theta = 12 N/C$	$E_2 = 12 \sin\theta = 0 N/C$
		$\Sigma E_x = 13.5$	$\Sigma E_y = 0$

$E_{net} = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$
$= \sqrt{13.5^2 + 0^2}$
$= \sqrt{182.25}$
$= 13.5 N/C$

$E_1 = kQ_2$
$= \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = \frac{108}{25} = \cancel{4.32}$
$= 4.32 N/C.$

Vector	Angle	x component	y-component
$E_1 = 8 N/C$	$90°$	$E_1 = 8 \cos 90 = 0 N/C$	$E_1 = 8 \sin 90° = 8 N/C$
$E_2 = 4.32 N/C$	$36.88°$	$E_2 = 4.32 \cos 36.86 = 3.45 N/C$	$E_2 = 4.32 \sin 36.86 = 2.59 N/C$
		$\Sigma E_x = 3.45 N/C$	$\Sigma E_y = 10.59 N/C$

$E_{net} = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$
$= \sqrt{(3.45)^2 + (10.59)^2}$
$= \sqrt{11.9 + 112.14}$
$= \sqrt{124.04}$
$= 11.13 N/C$