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College: GEOLOGY (SCIENCES) LEVEL: 100L

The charge as -1.60×10^{-19} C and the magnetic field of 3.5×10^{-1} weber/meter^2. We were asked to find the cyclotron frequency which is also equal to the angular speed, $w = -6.147\times10^{10}$ rad/s. Therefore, the cyclotron frequency $= -6.147\times10^{10}\ T^{-1}$.

Section A

2a Electric field Intensity

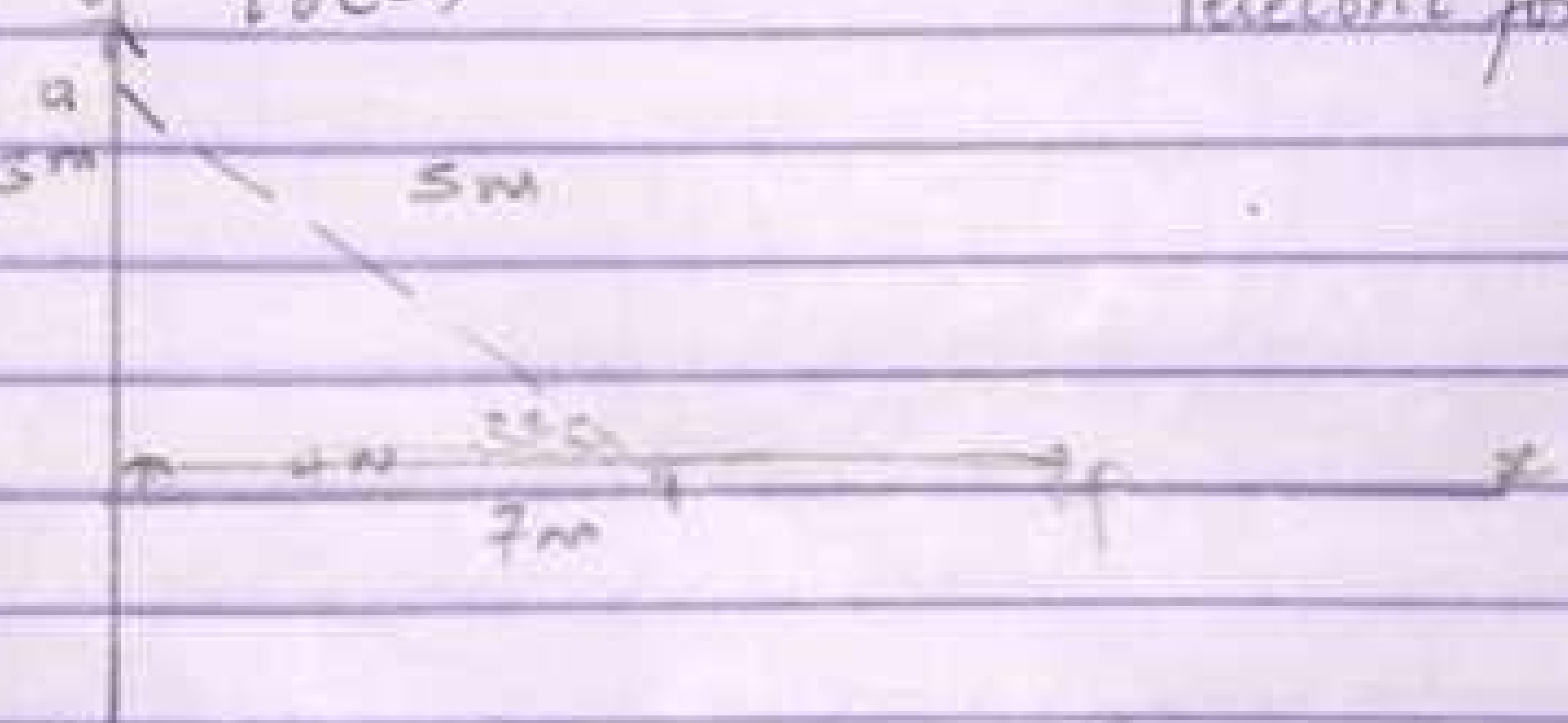
Electric field intensity [E] is the force per unit charge.

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

Electric field.

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

b



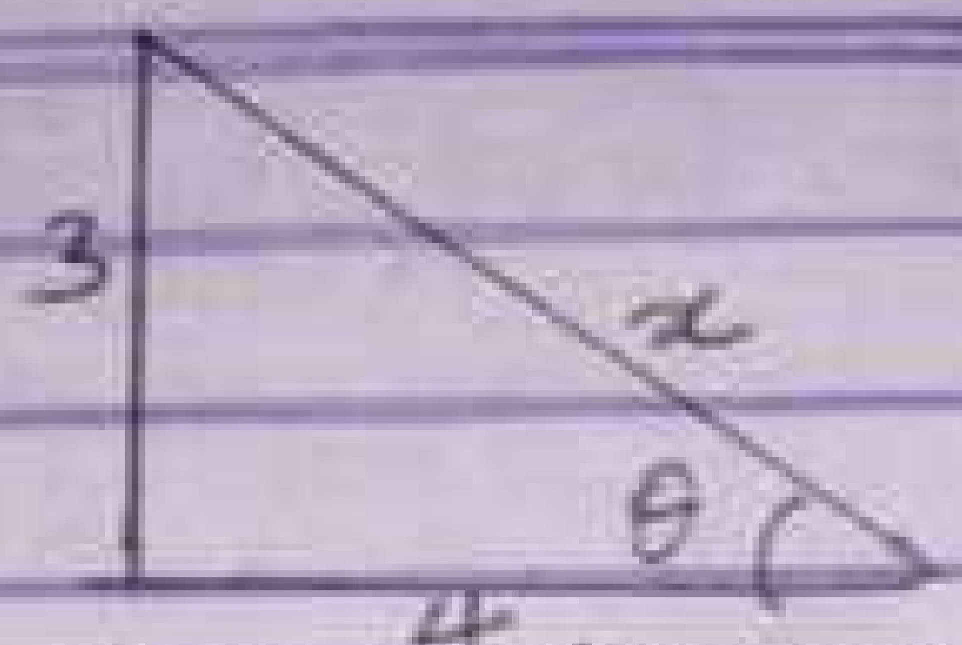
$K = 9\times10^{9}\ Nm^2C^{-2}$, $q_1 = 8\times10^{-19}$ C

$q_2 = 12\times10^{-9}$ C

i $q_1\ top = \frac{Kq_1}{r^2} = \frac{(9\times10^{9})(8\times10^{-9})}{(7)^2} = 1.47$ N/C

$q_2\ top = \frac{Kq_2}{r^2} = \frac{(9\times10^{9})(12\times10^{-9})}{(3)^2} = 12$ N/C

$E\ net = (12+1.47) = 13.47 \simeq 13.5$ N/C ii)



using pythegoras theorm

$x\sqrt{3^2+4^2} = 5$

$\tan\theta = 3/4$; $\tan\theta = 0.75$

$\therefore \theta = \tan^{-1} 0.75 = 36.87°$

q_1 to $Q = \frac{Kq_1}{r^2} = \frac{(9\times10^9)(8\times10^{-9})}{(3)^2} = 8 N/C$

q_2 to $Q = \frac{Kq_2}{r^2} = \frac{(9\times10^9)(12\times10^{-9})}{(5)^2} = 4.32 N/C$

$0 = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{x} + \frac{Q_2}{x+4}\right]$ divide through by $\frac{1}{4\pi\varepsilon_0}$

$0 = \left[\frac{Q_1}{x} + \frac{Q_2}{x+4}\right]$

$-Q_2/x+4 = \frac{Q_1}{x} = -\left(\frac{-2\times10^{-6}}{x+4}\right) \times \frac{10\times10^{-6}}{x}$

$2\times10^{-6}x = 10\times10^{-6}x + 4\times10^{-5}$

$8\times10^{-6}x = -4\times10^{-5}$

$x = \frac{-4\times10^{-5}}{8\times10^{-6}} = -5$

$x = -5$

For y, $V = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{y} + \frac{q_2}{4-y}\right]$ divide through by $\frac{1}{4\pi\varepsilon_0}$

$0 = \left[\frac{Q_1}{y} + \frac{Q_2}{4-y}\right]$

$-\frac{Q_2}{4-y} = \frac{Q_1}{y} = -\left[\frac{-2\times10^{-6}}{4-y}\right] = \left[\frac{10\times10^{-6}}{y}\right]$

$2\times10^{-6}y = 4\times10^{-5} - 10\times10^{-6}y$

$12\times10^{-6}y = 4\times10^{-5}$

$y = \frac{4\times10^{-5}}{12\times10^{-6}} = 3.33 \therefore y = 3.33$

for Z, $V = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q'}{4} + \frac{Q_2}{4+z}\right]$ divide through by $\frac{1}{4\pi\varepsilon_0}$

$$0 = \left[\frac{Q'}{4} + \frac{Q_2}{4+z}\right]$$

$$\frac{-Q_2}{4+z} = \frac{Q'}{4} = -\left[\frac{-2\times10^{-6}}{4+z}\right] = \left[\frac{10\times10^{-6}}{4}\right]$$

$$8\times10^{-6} = 4\times10^{-5} + 10\times10^{-6}z$$

$$-3.2\times10^{-5} = 10\times10^{-6}z$$

$$z = \frac{-3.2\times10^{-5}}{10\times10^{-6}} = -3.2$$

when $V = 0$, $x = -5m$ and $3.33m$

VECTOR	ANGLE	x-COMPONENT	Y-COMPONENT
q_1 to $Q = 8N/C$	$90°$	$8\cos 90° = 0N/C$	$8\sin 90° = 8N/C$
q_2 to $Q = 4.32N/C$	$36.87°$	$4.32\cos 36.87° = 3.46N/C$	$4.32\sin 36.87° = 2.592N/C$
		$\Sigma E_x = 3.46N/C$	$\Sigma E_y = 10.592N/C$

$E_{net} = \sqrt{(\Sigma E_x)^2 + (\Sigma E_y)^2}$, $E_{net} = \sqrt{(3.46)^2 + (10.592)^2}$

$\therefore E_{net} = 11.14\ N/C$

3. i Volume charge density, $\rho = \frac{dQ}{dV}$ $\therefore dQ = \rho dV$

ii Surface Charge Density, $\sigma = \frac{dQ}{dA}$ $\therefore dQ = \sigma dA$

iii Linear Charge density, $\lambda = \frac{dQ}{dL}$ $dQ = \lambda dL$

3b Electric potential Difference between 2 points in an electric field is the work done per unit charge against electrical forces when a charge is transported from one point to the other. It is measured in volt (V) or Joules per coulomb (J/C).

Work done, $dW = F \cdot dL \ldots (1)$

But $F = -q \cdot E \ldots (2)$

Subset eqn (2) into (1), $dW = -q_0 E\, dL \ldots (3)$

Total workdone in moving the test charge from A to B is:

$$W(A \to B)_{Ag} = -q_0 \int_A^B E\, dL \ldots (4)$$

From the definition of electric potential difference,

$$V_B - V_A = \frac{W(A \to B)_{Ag}}{q_0} \ldots (5)$$

Subset eqn (4) into (5)

$$V_B - V_A = -\int_A^B E\, dL \ldots (6)$$

$Q_1 = 10nC,\ Q_2 = -2nC,\ x = 0\ x = 4$

$V = 0$

For x, $V = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$

using special integrals:

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

∴ Equation (3) becomes

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

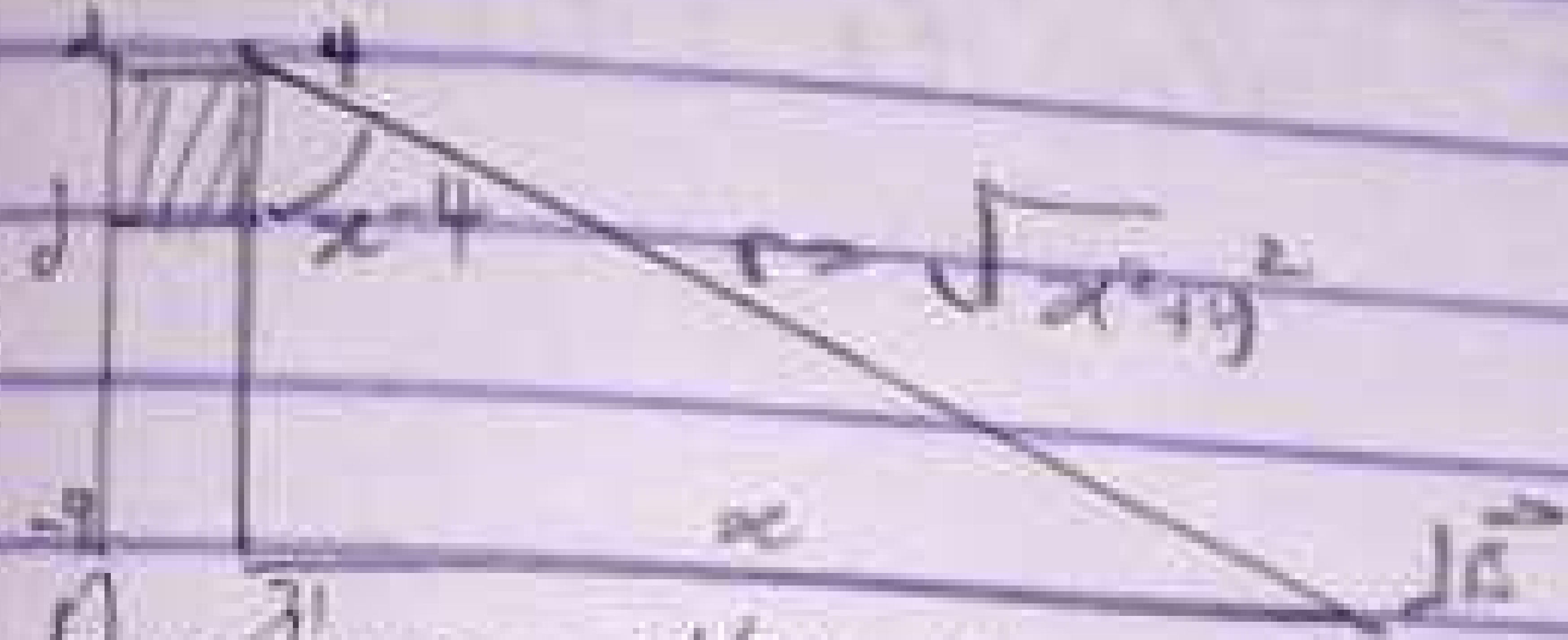
$$B = \frac{\mu_0 I x}{4\pi}\left[\frac{2a}{x^2(x^2+a^2)^{1/2}}\right]$$

proportional to the product permeability of the free space (μ_0), the current (I), the change in length ($d\vec{l}$), the radius (r) and inversely proportional to the square of radius (r^2).

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\, d\vec{l} \times \hat{r}}{r^2}$$

$\mu_0 = 4\pi \times 10^{-7}$ T.m/

5b



Applying the Bio-Savart law, we find the magnitude of the field $d\vec{B}$

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

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

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

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

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

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

Subst (2) into (1) we have

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

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

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

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

Magnetic flux is defined as the strength of magnetic field represented by lines of force. It is usually represented by the symbol ϕ.

$m_e = 9.11 \times 10^{-31}$ Kg, $q = -1.60 \times 10^{-19} C$

$r = 1.4 \times 10^{-7} m$; $B = 3.6 \times 10^{-1}$ weber/metre^2

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

$$\therefore W = \frac{-1.60\times10^{-19} \times (3.5\times10^{-1})}{9.11\times10^{-31}}$$

$$\therefore \omega = -6.147\times10^{10} \text{ rad/s}$$

We were given the mass of electron $= 9.11\times10^{-31}$ kg the radius as 1.4×10^{-7} m,

SECTION B

Bio Savart Law is a mathematic expression which illustrates the magnetic field produced by a stable electric current in the particular electromagnetism of physics. It states that, " the magnetic field is directly

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

Recall that $dl = dy$

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

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