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MATRIC NO 19/MHS01/079

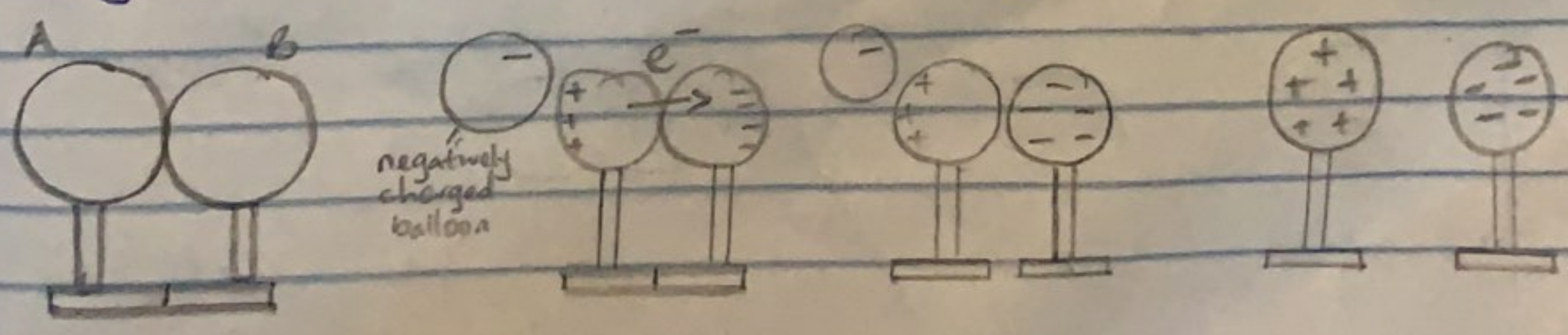
COURSE PHY 102

DEPT MBBS; 100L

1 Consider two metal spheres that are supported by insulating stands so that any charge acquired by the spheres cannot travel to the ground. The spheres are placed side by side so as to form a two sphere system. Being made of metal, electrons are free to move between spheres, from sphere A to B and vice versa.

If a rubber balloon is negatively charged and brought near the spheres, electrons within the two sphere system will be induced to move away from the balloon. This is simply the principle that like charges repel. Being present in a conductor, they are free to move about the surface of the conductor. Subsequently, there is a mass migration of electrons from sphere A to sphere B. This electron migration cause the two-sphere system to be polarized. The movement of electrons out of sphere A and into sphere B separates the negative charge from the positive charge

Looking at the spheres individually, it would be accurate to say that sphere A has an overall positive charge and sphere B has an overall negative charge. Once the two sphere system is polarized, sphere B is physically separated from sphere A using the insulating stand. Having been pulled further from the balloon, the negative charge likely redistributes itself uniformly about sphere B.



b Given that $F = 0.1$, $r = 2m$, $q_1 + q_2 = 5.0 \times 10^{-5} C$

From Coulomb's law; $F = \frac{kq_1q_2}{r^2}$

$$0.1 = \frac{9 \times 10^9 q_1 q_2}{2^2}$$

$$0.1 = 2.25 \times 10^9 q_1 q_2 \text{ --- (1)}$$

Recall $q_1 + q_2 = 5.0 \times 10^{-5} C$

$$q_1 = 5.0 \times 10^{-5} - q_2 \text{ --- (11)}$$

Sub equ 11 in equ 1

$$0.1 = 2.25 \times 10^9 (5.0 \times 10^{-5} - q_2) q_2$$

$$0.1 = (112500 - 2.25 \times 10^9 q_2) q_2$$

$$0.1 = 112500 q_2 - 2.25 \times 10^9 q_2^2$$

Quadratic; $-2.25 \times 10^9 q_2^2 + 112500 q_2 - 0.1 = 0$

Applying quadratic formula;

$$q_2 = \frac{-112500 \pm \sqrt{(112500)^2 - 4(-2.25 \times 10^9)(-0.1)}}{2(-2.25 \times 10^9)}$$

$$q_2 = \frac{-112500 \pm 116431.3}{-4.5 \times 10^9}$$

$$\therefore q_2 = -8.736 \times 10^{-7} \text{ or } 5.1 \times 10^{-5}$$

Sub $q_2$ when negative in equ 11

$$\therefore q_1 = 5.0 \times 10^{-5} - (-8.736 \times 10^{-7})$$

$$q_1 = 5.087 \times 10^{-5}$$

To prove $q_1 + q_2$ has to $= 5 \times 10^5$

$$5.087 \times 10^{-5} + -8.736 \times 10^{-7}$$

It is $= 5 \times 10^{-5}$

$$\therefore q_1 = 5.087 \times 10^{-5} \text{ and}$$

$$q_2 = -8.736 \times 10^{-7}$$

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c) $E_{net}$ at $p = 0$

$x^2 = 0.5^2 + (2 \times 0.5)^2$

$x^2 = 0.25 + 1$

$x^2 = 1.25$

$x = \sqrt{1.25}$

$x = 1.12$

$E_{net}$ at $p = 0$

$E_1 = \frac{kq}{r^2}$

$E_1 = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2}$

$E_1 = 5.74 \times 10^4$ N/C

$\tan\theta = \frac{2d}{d}$

$\theta = \tan^{-1} \frac{1}{0.5}$

$\theta = 63.4°$

$E_1 x = 5.74 \times 10^4$ N/C $\cos 63.4°$

$E_1 x = 2.57 \times 10^4$ N/C

$E_1 y = 5.74 \times 10^4$ N/C $\sin 63.4°$

$E_1 y = 5.13 \times 10^4$ N/C

$E_2 x = -2.57 \times 10^4$ N/C

$E_2 y = 5.13 \times 10^4$ N/C

$E_q = \frac{kq}{r^2} = \frac{9 \times 10^9 \times q}{(2 \times 0.5)^2} = 9 \times 10^9 q$ N/C

$E_q x = 0$

$E_q y = 9 \times 10^9 q$

$E_{net} = 0$

$E_{net} = \sqrt{(E_{1x} + E_{2}x) + (E_{1}y + E_{2}y + E_{q}y)}$

$0 = \sqrt{(2.57\times10^{4} - 2.57\times10^{4})^2 + (5.13\times10^{4} + 5.13\times10^{4} + 9\times10^{9}q)^2}$

$0 = 0 + \sqrt{(1.03\times10^{5} + 9\times10^{9}q)^2}$

$\sqrt{0} = 0 + \sqrt{(1.03\times10^{5} + 9\times10^{9}q)^2}$

$0 = 1.03\times10^{5} + 9\times10^{9}q$

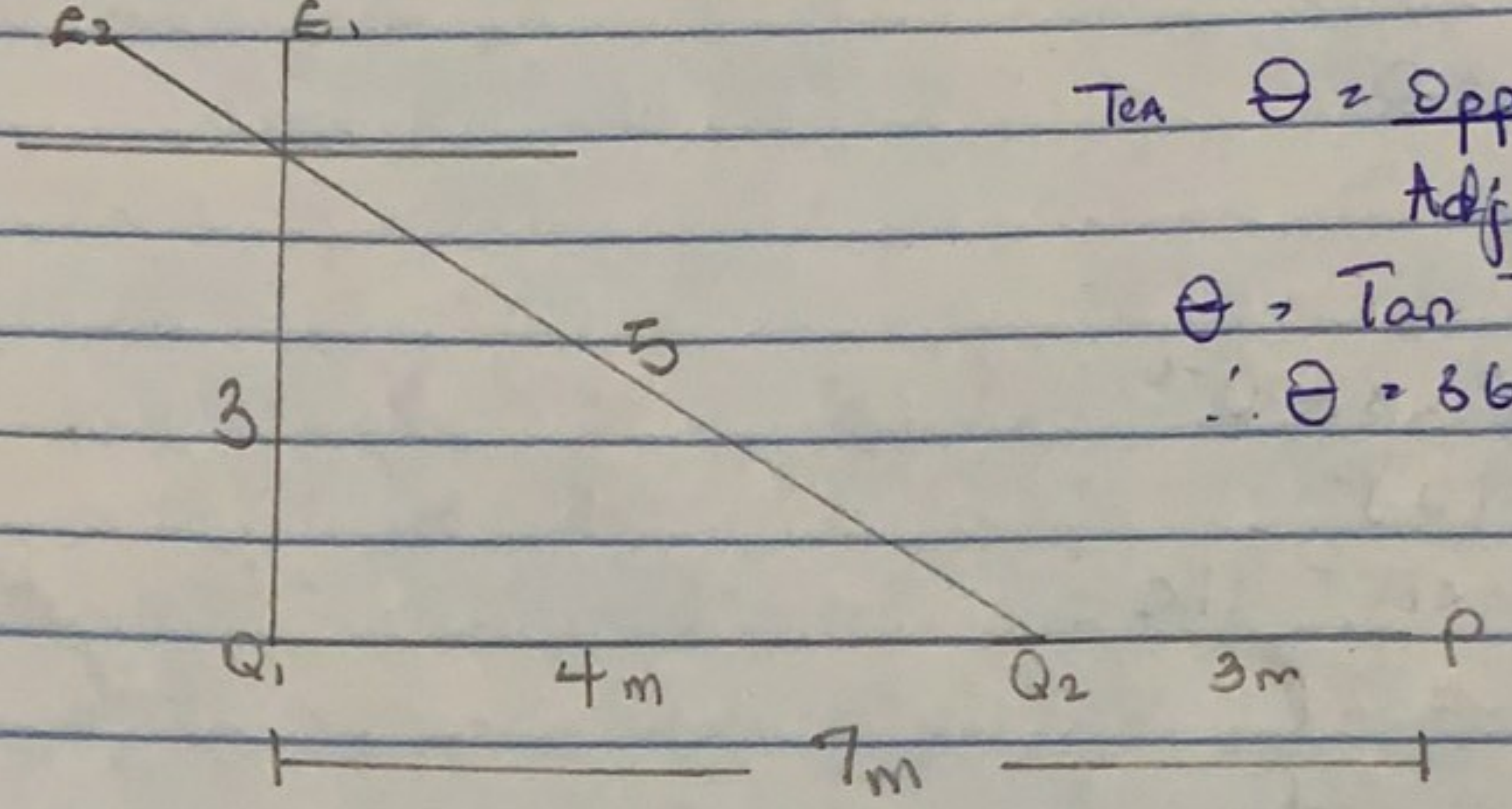
$-1.03\times10^{5} = 9\times10^{9}q$

$q = -1.14\times10^{-5}$

$q = -11.4\times10^{-6}\,C$

2a An electric field is a field which surrounds an electric charge and exerts force on other charges in the field, attracting or repelling them
Electric field intensity is the measure of intensity or strength of electrical force per unit charge at any given point in the electric field.

bi




Tan $\theta = \frac{Opp}{Adj}$

$\theta = Tan^{-1}(3/4)$

$\therefore \theta = 36.9°$

$E_{net} = E_1 + E_2$

$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2}$

$= 1.469 N/C$

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

$= 12 N/C$

$E_{net} = 12 + 1.469 N/C$

$\therefore E_{net} = 13.469 N/C \simeq 13.5 N/C$

ii $E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2}$

$= 8 N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2}$

$= 4.32 N/C$

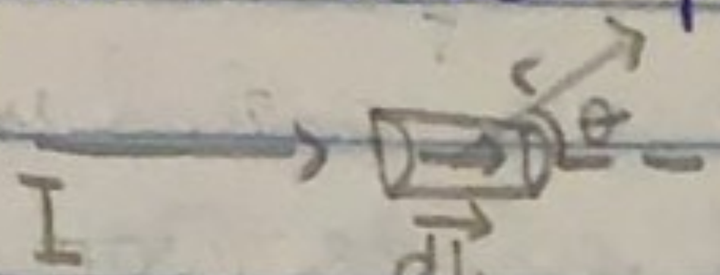
| Vector | Angle | x-comp | y-comp |
| --- | --- | --- | --- |
| $E_1 = 8N/C$ | $90°$ | $0$ | $8$ |
| $E_2 = 4.32N/C$ | $36.9°$ | $-3.45$ | $2.59$ |
| | | $E_x = -3.45$ | $E_y = 10.59$ |

$E_{net} = \sqrt{(-3.45)^2 + (10.59)^2}$

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

5a Biot Savart's 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 distance from point to wire.

b Imagine a small portion of an infinitely long straight wire



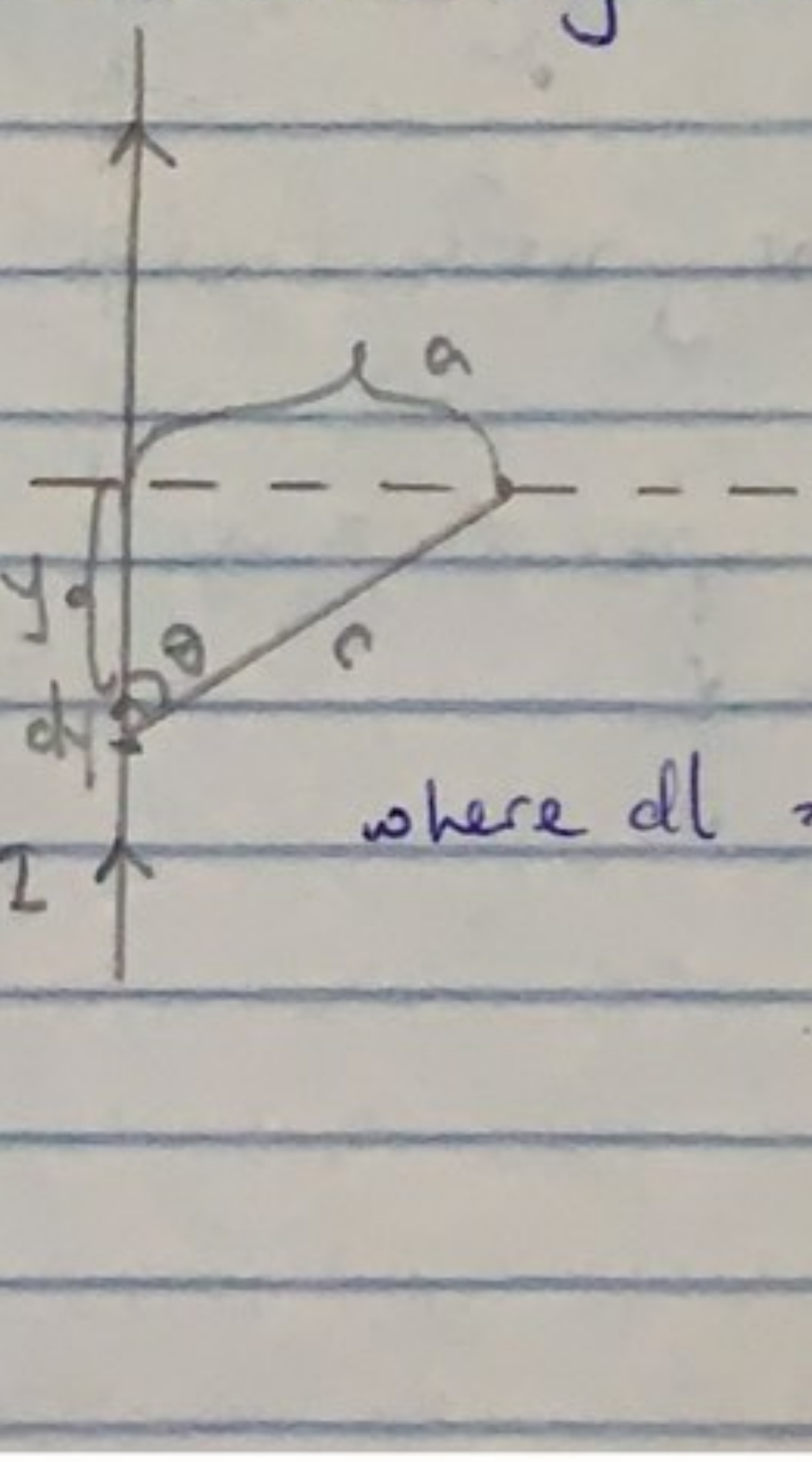

where dl is the length of the small segment of the wire.

$$\vec{dB} = \frac{\mu_0}{4\pi} \frac{I \vec{dl} \sin\theta}{r^2}$$

where $\vec{dB}$ = electric field for $\vec{dl}$

and $\frac{\mu_0}{4\pi} = 1 \times 10^{-7} \frac{TM}{A}$

For a long line current which is infinitely long




where dl = dy

$$dB = \frac{\mu_0}{4\pi} \frac{I\, dy \sin\theta}{r^2}$$

In terms of y

$$dB = \frac{\mu_0}{4\pi} \frac{I\, dy}{(y^2+a^2)} \frac{a}{(y^2+a^2)^{1/2}}$$

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

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

$$B = \frac{\mu_0 I}{2\pi a}$$

In a physical situation we have axial symmetry about the y-axis. Thus at all points in a circle of radius r, around the conductor, the magnitude of B is ; $B = \frac{\mu_0 I}{2\pi r}$

4a Magnetic flux is a measurement of the total magnetic field which passes through a given area

b Mass = $9.11 \times 10^{-31}$ kg, $r = 1.4 \times 10^{-7}$, magnetic field = $3.5 \times 10^{-1}$ weber/m$^2$

Cyclotron frequency = Angular speed = $\omega$

Recall $r = \frac{mv}{qB}$ and $\omega = \frac{v}{r}$

~~$\omega = v \div$~~

$$\omega = v \div \left[\frac{mv}{qB}\right]$$

$$\omega = \cancel{v} \times \frac{qB}{m\cancel{v}}$$

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

$$\omega = \frac{1.6 \times 10^{-19} \times 13.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$

$$\omega = 6.14 \times 10^{10} \text{ rad/s.}$$