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DEPT: NURSING

MATRIC NO.:19/MHS02/015

COURSE CODE: PHY 102

ASSINGMENT.

SECTION A

1a. Charging by Induction:

Consider a positively charged rubber rod brought near a neutral (unchanged) conducting sphere that is insulated so that there is no conducting path to ground. The repulsive force between the protons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some protons move to the side of the sphere farthest away from the rod. The region of the sphere nearest the positively charged rod has an excess of negative charge because of the migration of protons away from this location. If a grounded conducting wire is then connected to the sphere, some of the electrons leaves the sphere and travel to the earth. If the wire to the ground is then removed, the conducting sphere is left with an excess of induced negative charge. Finally, when the rubber rod is removed from the vicinity of the sphere, the induced negative charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

Diagram:

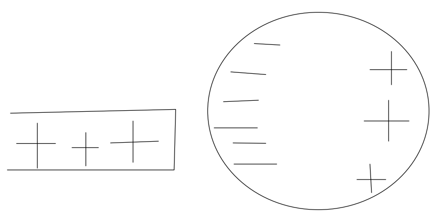

fig 1.3a

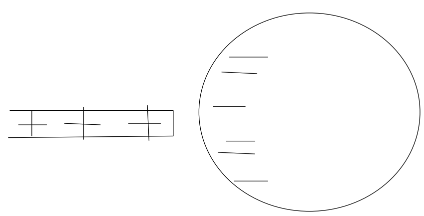

fig 1.3c

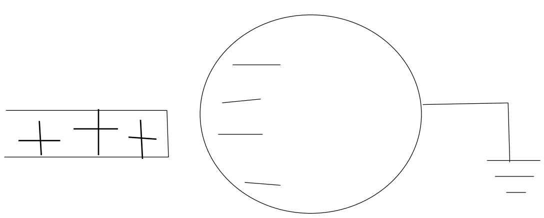

fig 1.3b

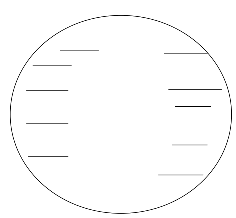

fig 1.3d

1b.

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1b) $q_1 = ?$ $q_2 = ?$ $q_1 + q_2 = 5.0 \times 10^{-5}$ ---- (i)

$F = 1.0N$ $d = 2.0m$

Recall that; $k = 9 \times 10^9$

$F = \frac{kq_1q_2}{r^2}$; $1 = \frac{9 \times 10^9 q_1 q_2}{(2)^2}$

$1 = \frac{9 \times 10^9 q_1 q_2}{4}$; $4 = 9 \times 10^9 q_1 q_2$

$\frac{4}{9 \times 10^9} = q_1 q_2$

$q_1 q_2 = 4.44 \times 10^{-10} C$

From

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

$q_1 q_2 = 4.4 \times 10^{-10} C$

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

$(5.0 \times 10^{-5} - q_2) q_2 = 4.4 \times 10^{-10} C$

$5.0 \times 10^{-5} q_2 - q_2^2 = 4.4 \times 10^{-10} C$

$q_2^2 - (5.0 \times 10^{-5}) q_2 + 4.4 \times 10^{-10} = 0$

$q_2 = 3.845 \times 10^{-5} C$ or $q_2 = 1.154 \times 10^{-5} C$

when $q_2 = 3.846 \times 10^{-5} C$, $q_1 = 1.154 \times 10^{-5} C$

when $q_2 = 1.154 \times 10^{-5} C$, $q_1 = 3.846 \times 10^{-5} C$

1c.

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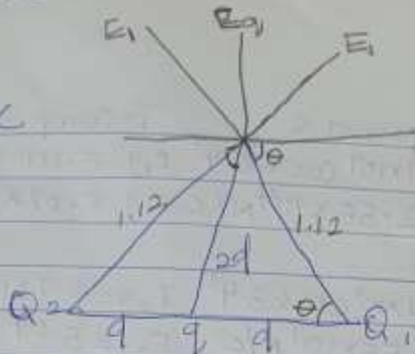


$Q = Q_2 = 8\mu C$

$d = 0.5m$

$x^2 = 1^2 + 0.5^2$

$x^2 = 1 + 0.25$

$x = \sqrt{1.25}$

$x = 1.12m$

$\tan\theta = \frac{1}{0.5} = 2$

$\theta = \tan^{-1} 2$

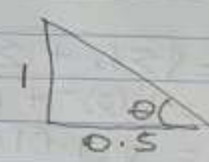
$\theta = 63.4°$

$E_p = E_1 + E_2 + E_q$

$E_p = \frac{kq_1}{r_1^2} + \frac{kq_2}{r_2^2} + \frac{kq}{r_q^2}$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2}$

$E_1 = 5.7\times10^4 N/C$



$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2}$

$E_2 = 5.7\times10^4 N/C$

$E_q = \frac{kq}{r^2} = \frac{9\times10^9\times q}{(1)^2}$

$E_q = 9\times10^9 q\, N/C$

1c continued

Vector	Angle	X-Components	Y-Component
$E_1 = 5.7\times10^4$ N/C	63.4°	$E_1x = 5.7\times10^4 \cos 63.4^\circ$ $E_1x = -2.55\times10^4$ N/C	$E_1y = 5.7\times10^4 \sin 63.4^\circ$ $E_1y = 5.09\times10^4$ N/C
$E_2 = 5.7\times10^4$ N/C	63.4°	$E_2x = 5.7\times10^4 \cos 63.4^\circ$ $E_2x = 2.55\times10^4$ N/C	$E_2y = 5.7\times10^4 \sin 63.4^\circ$ $E_2y = 5.09\times10^4$ N/C
$E_q = 9\times10^9 q$ N/C	90°	$E_qx = \cancel{\#}9\times10^9 q \cos 90^\circ$ $E_qx = 0$	$E_qy = 9\times10^9 q \sin 90^\circ$ $E_qy = 9\times10^9 q$
		$\Sigma fx = 0$	$\Sigma fx = 1.01\times10^5 + 9\times10^9 q$ N/C

$$E = \sqrt{\Sigma f_x + \Sigma f_y}$$
$$0 = \sqrt{(0)^2 + (1.01\times10^5 + 9\times10^9 q)^2}$$
$$0 = \sqrt{(1.01\times10^5 + 9\times10^9 q)^2}$$
$$0 = (1.01\times10^5) + (9\times10^9 q)$$
$$q = \frac{-1.01\times10^5}{9\times10^9}$$
$$q = 1.12\times10^{-5}\ C$$
$$q = 11.2\times10^{-6}\ C$$
$$q = 11 \mu C$$

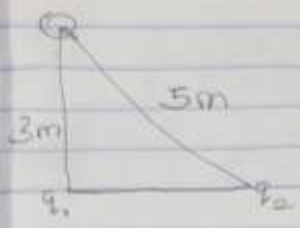
2.. Electric field.

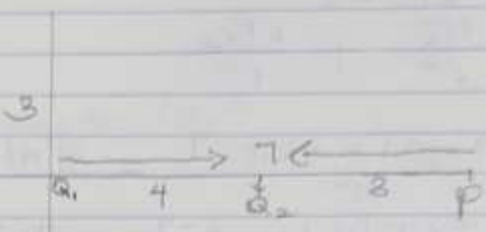
An electric field is a region of space in which an electric charge will experience an electric force.

Electric field intensity.

Electric field intensity can be defined as force per unit charge. It is measured by newton per coulomb(N/C).

2b.





$\tan\theta = \frac{4}{3}$

$\theta = \tan^{-1}\left(\frac{4}{3}\right)$

$\cancel{\theta = 36.87^\circ}$

$\theta = 53.13^\circ$

i) $E_p = E_1 + E_2$

$\frac{kQ_1}{r^2} + \frac{kQ_2}{r^2}$

$E_1 = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.47\ N/C$

$E_2 = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12\ N/C$

Vector (N/C)	Angle	X-component (N/C)	Y-component (N/C)
$E_1 = 1.47$	0°	$E_1x = 1.47 \times \cos 0$ $= 1.47$	$E_1Y = 1.47 \times \sin 0$ $= 0$
$E_2 = 12$	0°	$E_1x = 12 \cos 0$ $= 12$	$E_1Y = 12 \sin 0$ $= 0$
		$\Sigma_{Ex} = 1.47 + 12$ $= 13.47$	$\Sigma_{Ey} = 0$

$E = \sqrt{(\Sigma_{Ex})^2 + (\Sigma_{Ey})^2}$

$E = \sqrt{(13.47)^2 + (0)^2}$

$E = \sqrt{181.44 + 0}$

$E = \sqrt{181.44}$

$E = 13.47\ N/C$

ii) $E_b = E_1 + E_2$

$= \frac{KQ_1}{r^2} + \frac{KQ_2}{r^2}$

$E_1 = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{3^2} = 8\ N/C$

$E_2 = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = 4.32\ N/C$

Vector (N/C)	Angle	X-component (N/C)	Y-component (N/C)
$E_1 = 8$	90°	$E_1x = 8\cos 90^\circ$ $= 0$	$E_1Y = 8\sin 90^\circ$ $= 8$
$E_2 = 4.32$	36.87	$E_2x = 4.32\cos 36.87$ $= -3.46$	$E_2Y = 4.32\sin 36.87$ $= 2.59$
		$\Sigma_E x = -3.46$	$\Sigma_E Y = 10.59$

$E = \sqrt{(\Sigma_E x)^2 + (\Sigma_E Y)^2}$

$E = \sqrt{(-3.46)^2 + (10.59)^2}$

$E = \sqrt{11.97 + 112.15}$

$E = \sqrt{124.12}$

$E = 11.14\ N/C$

$\tan\theta = \frac{y}{x}$

$\theta = \tan^{-1}\left(\frac{y}{x}\right)$

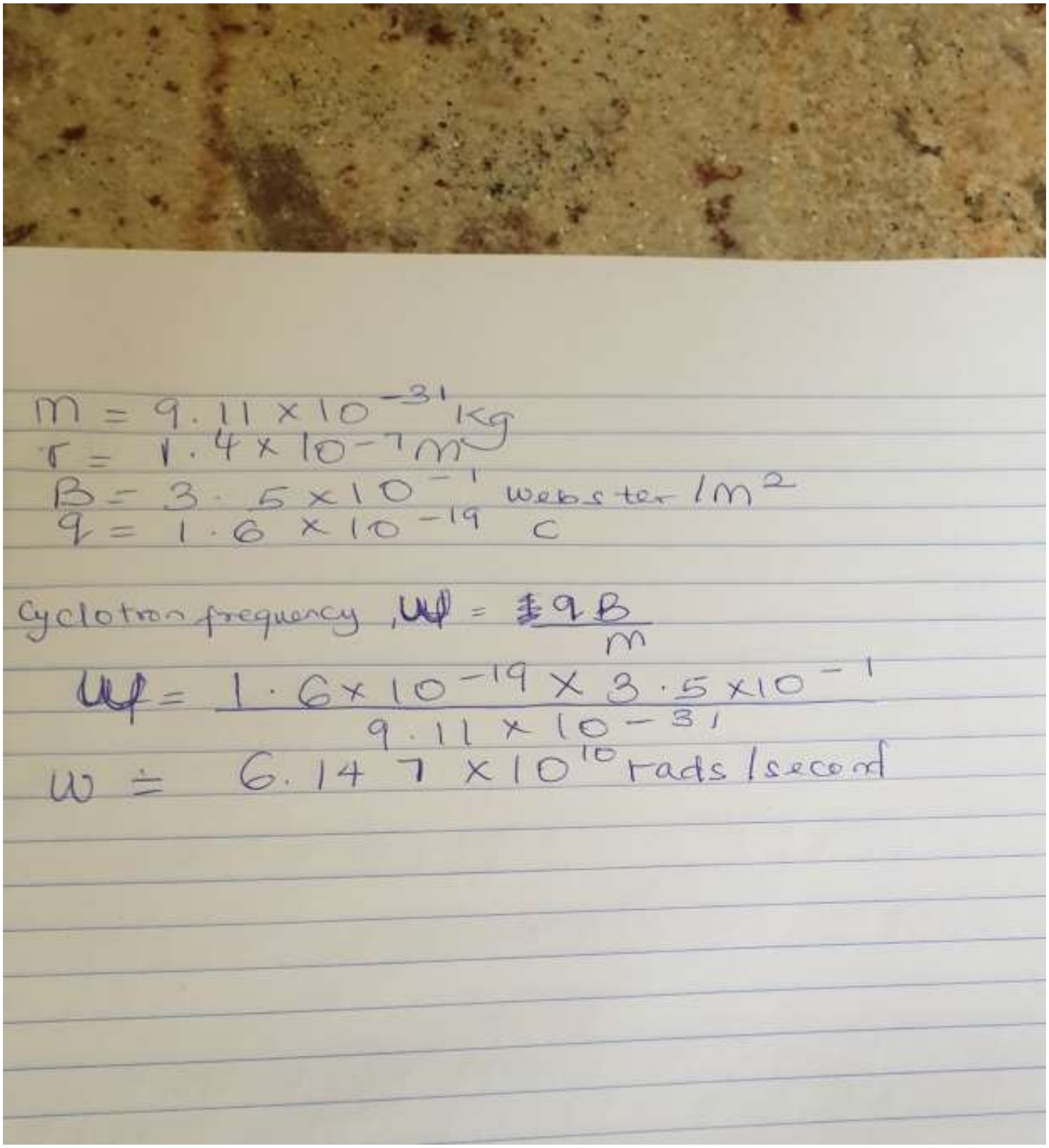
$\theta = \tan^{-1}\left(\frac{10.59}{-3.46}\right)$

$\theta = -71.90^\circ$

SECTION B

4. Magnetic flux can be defined as the strength of magnetic field represented by lines of force. It is represented by the symbol Φ.

4b.



$m = 9.11 \times 10^{-31}$ kg

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

$B = 3.5 \times 10^{-1}$ webster/m^2

$q = 1.6 \times 10^{-19}$ C

Cyclotron frequency, $\omega = \frac{qB}{m}$

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

$$\omega \doteq 6.147 \times 10^{10} \text{ rads/second}$$

4c. In the question we were given paramiters such as

i.mass of the electron =9.11x10^{-31} kg ii.A radius of 1.4x10^{-7}m

iii.magnetic field of 3.5x10^{-1}weber\meter square

and you are asked to find the cyclotron frequency which is equal or the same thing as angular speed.it is called cyclotron frequency because it is a frequency of an accelerator called cyclotron**.**

SO since cyclotron frequency is equal to angular speed the cyclotron frequency is equal to T^{-1}, having a unit as 1\T which is equal to the unit of frequency dimensionally.

5a. Biot-savart law states that the magnetic field is directly proportional to the product permeability of free space(μ), the current(I), the change in length, the radius and inversely proportional to square of radius (r^2). It can be represented mathematically by

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

where μ_o is a constant called Permeability of free space.

$$\mu_o = 4\pi \times 10^{-7}\ T.\frac{m}{A}$$

The unit of $\vec{B}$ is weber\metre square

5b. Magnetic Field of a Straight Current Carrying Conductor

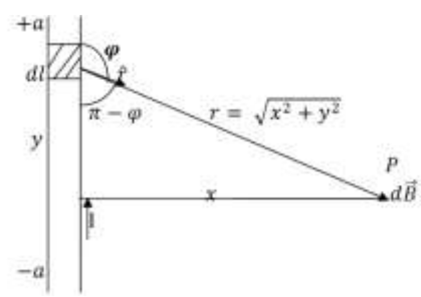


Fig 1: A section of a Straight Current Carrying Conductor

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

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

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

$$\therefore B = \frac{\mu_o I}{4\pi}\int_{-a}^{a}\frac{dlsin(\pi - \varphi)}{r^2}$$

From diagram, $r^2 = x^2 + y^2$ $(Pythagoras\ theorem)$

$$B = \frac{\mu_o I}{4\pi}\int_{-a}^{a}\frac{dlsin(\pi - \varphi)}{x^2 + y^2} \quad \ldots \quad (*)$$

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

Substituting $(**)$ into $(*)$, we have

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

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

Recall $dl=dy$

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

$$B=\frac{\mu_o Ix}{4\pi}\int_{-a}^{a}\frac{1}{(x^2\ +y^2\ )^{3/2}}dy\quad\ldots\qquad(***)$$

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 $(***)$ therefore becomes

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

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

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

When the length $2a$ of the conductor is very great in comparison to its distance x from point P, we consider it infinitely long. That is, when a is much largerthan x,

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

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

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

$$B=\frac{\mu_o I}{2\pi r}\qquad\ldots\qquad(\#)$$

Equation (#) defines the magnitude of the magnetic field of flux density B near a long, straight current carrying conductor.