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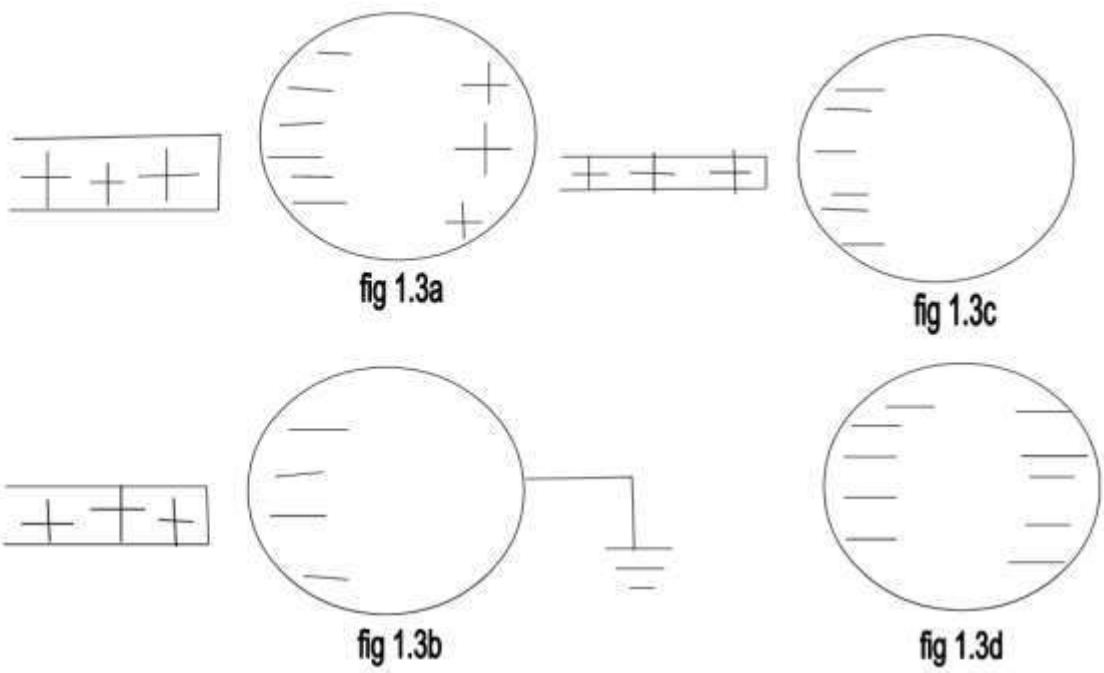
MATRIC NO.: 19/MHS02/114
COURSE CODE: PHY. 102

ASSIGNMENT.

SECTION A.

1a. Electric charges can be obtained on an object without touching it, by a process called electrostatic induction. Consider a negatively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod (fig. 1.3a). The region of the sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducting wire is then connected to the sphere, as in (fig. 1.3b), some of the electrons leave the sphere and travel to the earth. If the wire to ground is then removed (fig 1.3c), the conducting sphere is left with an excess of induced positive charge. Finally, when the rubber rod is removed from the vicinity of the sphere (fig. 1.3d), the induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

Diagram:



1b.

1b $q_1 + q_2 = 5 \times 10^{-5} C$

$F = 1N$

$d(1) = 2m$

$K = 9 \times 10^9$

from

$$f = \frac{kq_1 q_2}{r^2}$$

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

$$4 = 9 \times 10^9 (q_1 q_2)$$

$$q_1 q_2 = 4.4 \times 10^{-10} C^2$$

Recall

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

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

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

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

$$q_1 = 1.11 \times 10^{-5} C$$

$$q_2 = 3.8 \times 10^{-5} C$$

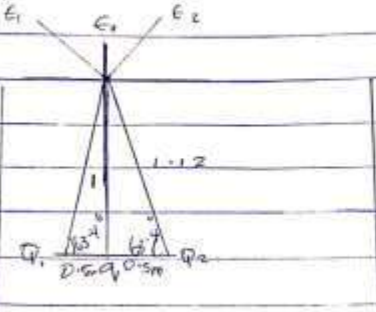
c $Q_1 = Q_2 = 8 \mu C$

$d = 0.5m$

1c.

1c $Q_1 = Q_2 = 8\mu C$

$d = 0.5m$



$\tan\theta = \frac{opp}{adj}$

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

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

$\theta = 63.4$

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

$= 1 + 0.25$

$x^2 = 1.25$

$x = \sqrt{1.25}$

$x = 1.12$

$E_1 = \frac{kq_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2} = 5739.795918$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2} = 5739.795918$

$E_q = \frac{kq}{r^2} = \frac{9 \times 10^9 \times q}{1} = 9 \times 10^9 q$

Vector	Angle	x - Component	y - Component
$E_1 = 5739.795918$	63.4°	$E_1 \cos\theta$ $= -2570.046$	$E_1 \sin\theta$ $= 5132.263$
$E_2 = 5739.795918$	63.4	2570.046	5132.263
$E_q = 9 \times 10^9 q$	90°	0 $= 0$	$9 \times 10^9 q$ $= 10264.526$

$E = \sqrt{0^2 + (10264.526)^2}$

$0 = 9 \times 10^9 q + 10264.526$

$q = \frac{-10264.526}{9 \times 10^9}$

$q = 1.141 \times 10^{-6} C = 11.44 C$

2a. An electric field is a region of space in which an electric field will experience an electric force

<u>WHILE</u>

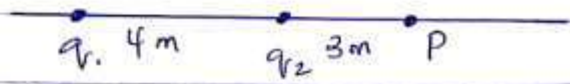
Electric field intensity is defined as the electric force per unit charge.

2b. i.

i) $q_1 = +8nC = 8 \times 10^{-9} C$

$q_2 = 12nC = 12 \times 10^{-9} C$

$K = 9 \times 10^{9}$



$E_1 = \frac{Kq_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = \frac{72}{49}$

$= 1.47 NC^{-1}$

$E_2 = \frac{Kq_2}{r_2^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{3^2} = \frac{108}{9}$

$= 12 NC^{-1}$

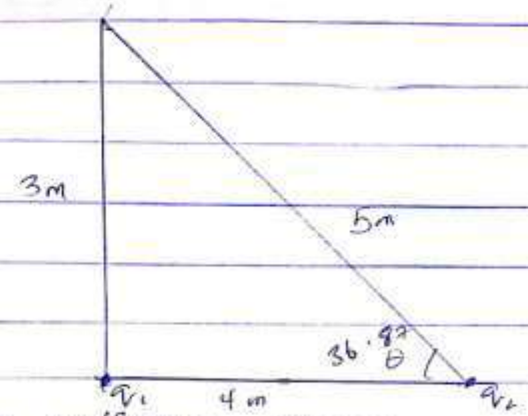
Vector	Angle	X Component	Y - Component
1.47	0	$1.47 \cos 0$ $= 1.47$	$1.47 \sin 0$ $= 0$
12	0	$12 \cos 0$ $= 12$	$12 \sin 0$ $= 0$
		13.47	0

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

$= 13.47 NC^{-1} \approx 13.5 NC^{-1}$

ii.

ii)



$\sin\theta = \frac{opp}{hyp}$

$\theta = \sin^{-1}(3/5)$

$= \sin^{-1}(0.6)$

$= 36.87^0$

from pythagoras theorem

$x^2 = 3^2 + 4^2$

$= 9 + 16$

$x^2 = 25$

$x = 5m$

$E_1 = \frac{Kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = \frac{72}{9}$

$= 8Nc^{-1}$

$E_2 = \frac{Kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = \frac{108}{25}$

$= 4.32Nc^{-1}$

Vector	Angle	x - Component	y - Component
$8Nc^{-1}$	90	8 Cos 90 = 0	8 Sin 90 = 8
$4.32Nc^{-1}$	36.8	4.32 Cos 36.8 = 3.46	4.32 Sin 36.8 = 2.59
		3.46	10.59

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

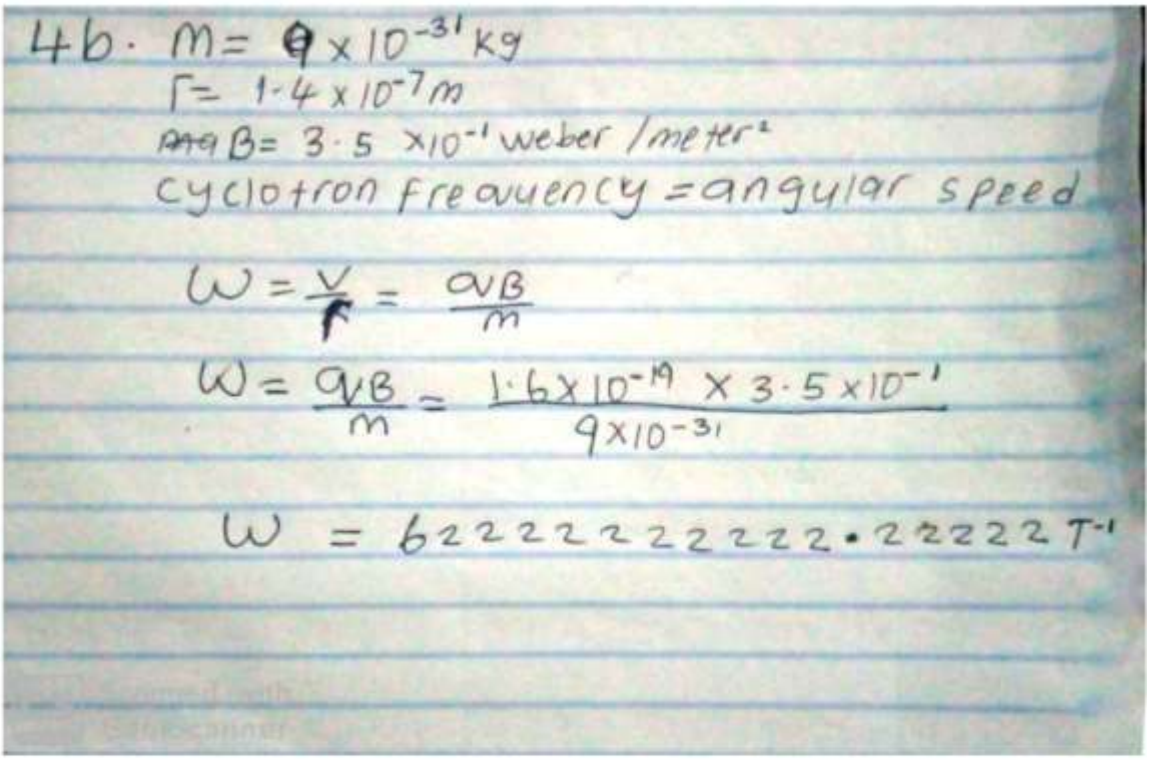
$= \sqrt{124.1197}$

$= 11.14Nc^{-1}$

SECTION B.

4a. Magnetic flux is defined as the strength of the magnetic field represented by lines of force. It is mathematically given as Φ= B. d A. It is represented by the symbol Φ.

4b.


$$4b.\ m = 9 \times 10^{-31}\ kg$$
$$r = 1.4 \times 10^{-7} m$$
$$B = 3.5 \times 10^{-1}\ weber/meter^2$$
cyclotron freauency = angular speed
$$\omega = \frac{v}{r} = \frac{qvB}{m}$$
$$\omega = \frac{qvB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$$
$$\omega = 62222222222.22222\ T^{-1}$$

4c. In the question we were given paramiters:
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 we were asked to find the cyclotron frequency which is the same as angular speed.it is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.
Recall that angular speed is given as $\omega = \frac{v}{r} = \frac{qB}{m}$
Also recall from the last solution that, ω= 62222222222.22222T^{-1}
SO since cyclotron frequency is equal to angular speed the cyclotron frequency is =62222222222.22222^{T-1}, having a unit as 1\T which is equal to the unit of frequency dimensionally.

5b.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(a constant) is 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

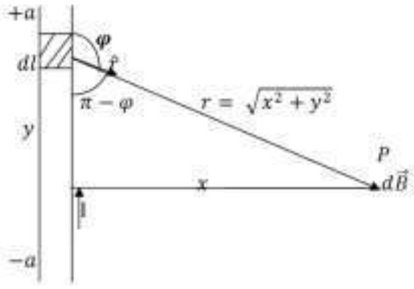


Fig 1: A section of a Straight Current Carrying Conductor

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

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

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

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 $dl = dy$

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

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