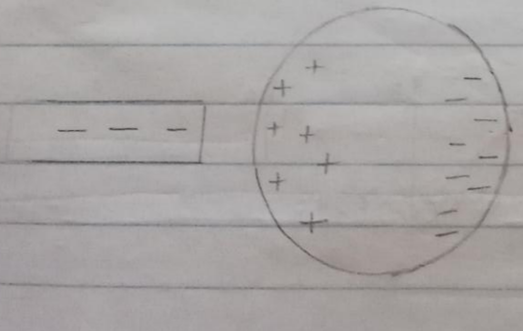
NAME: MGBOH BIYEUM EMILIA
MATRICULATION NUMBER: KIL/MHS/01/2045
DEPARTMENT: MBBS
COURSE CODE: PHY 102
ASSIGNMENT:

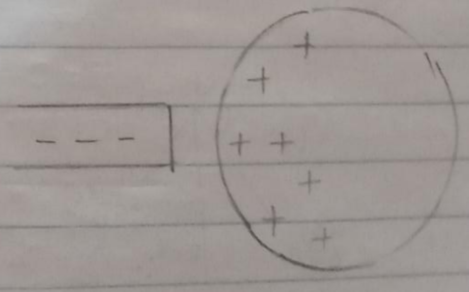
1. CHARGING BY INDUCTION

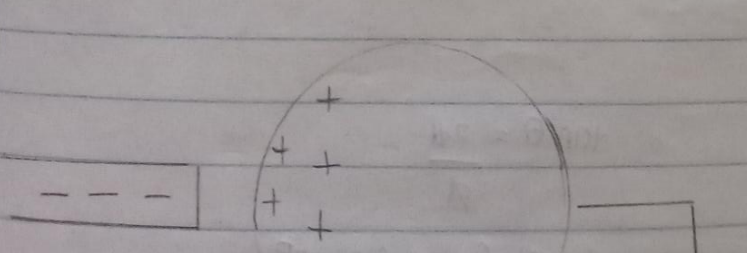
Electric charges can be obtained without touching it by a process called electrostatic induction.

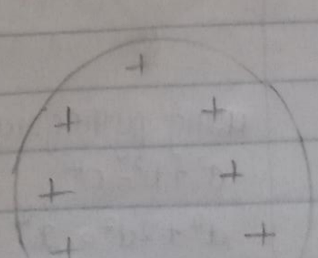
~~Consider~~ A negatively charged rubber rod is brought near a neutral (charged) conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere farthest away from the rod. 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, 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, the induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere









1b $q_1 + q_2 = 5\times10^{-5}C$ $\quad r = 2.0 \quad F = 1.0N$

$q_1 = 5\times10^{-5} - q_2$

$F_1 = \frac{kq_1q_2}{r^2}$

$1.0 = \frac{9\times10^9 q_1 q_2}{\cancel{4}}$

$4 = 9\times10^9 \times (5\times10^{-5} - q_2)q_2$

$4 = 4.5\times10^5 q_2 - 9\times10^9 q_2^2$

$-9\times10^9 q_2^2 + 4.5\times10^5 q_2 - \cancel{9\times10^9 q_2^2}\ 4 = 0$

Using the quadratic formula

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$q_2 = \frac{-4.5\times10^{-5} \pm \sqrt{(4.5\times10^5)^2 - 4(-9\times10^9)(-4)}}{2(-9\times10^9)}$

$q_2 = \frac{-4.5\times10^{-5} \pm \sqrt{5.8\times10^{10}}}{-1.8\times10^9}$

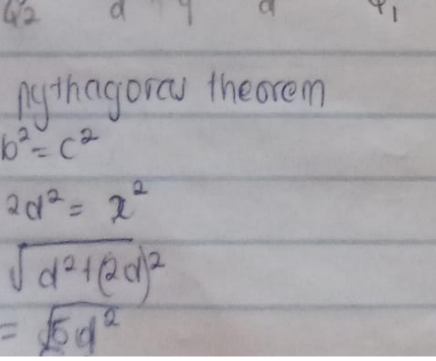
$q_2 = \frac{-4.5\times10^5 \pm 241867.7}{-18\times10^9}$

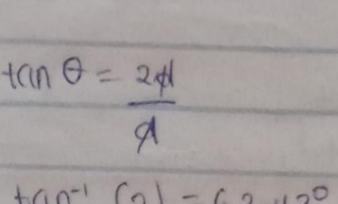
$q_2 = 1.156\times10^{-5}$ or $3.84\times10^{-5}C$

$q_1 = 1.156\times10^{-5}$ ~~or $3.84\times10^{-5}C$~~

$q_2 = 3.84\times10^{-5}C$

1c





using pythagoras theorem

$a^2 + b^2 = c^2$

$d^2 + 2d^2 = x^2$

$x = \sqrt{d^2 + (2d)^2}$

$x = \sqrt{5d^2}$

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

$\tan^{-1}(2) = 63.43°$

$d = 0.5m$

$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times (8\times10^{-6})}{(d\sqrt{5})^2} = 57600\ N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 (8\times10^{-6})}{(d\sqrt{5})^2} = 57600\ N/C$

$E_q = \frac{kq}{r^2} = \frac{9\times10^9 (q)}{(2d)^2} = 9\times10^9 q\ N/C$

	Vector	θ	X component	Y component
E_1	57600 N/C	63.43°	$-57600 \cos 63.43 = -25764$	$57600 \sin 63.43 = +51516.8$
E_2	57600 N/C	63.43°	$57600 \cos 63.43 = +25764$	$57600 \cos 63.43 = +51516.8$
E_q	$9\times10^9 q$ N/C	90°	$9\times10^9 q \cos 90 = 0$	$9\times10^9 q \sin 90 = 9\times10^9 q$
			$\Sigma E_x = 0$	$\Sigma E_y = 103033.6 + 9\times10^9 q$

$E_{net} = \sqrt{\Sigma E_x^2 + \Sigma E_y^2}$

but E_{net} at point $P = 0$

$0 = \sqrt{0^2 + (103033.6 + 9\times10^9 q)^2}$

$0 = 103033.6 + 9\times10^9 q$

$Q = \frac{-103033.6}{9\times10^9}$

$Q = -1.14481778\times10^{-5}$

$= -11.4\times10^{-6}$

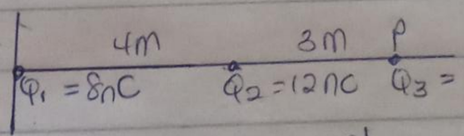
$= -11.4\mu C$

$= -11\mu C$

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

An Electric field can be defined as the force per unit charge.

2b



$E_1 = \frac{kQ_1}{r^2} = \frac{(9\times10^9)\times(8\times10^{-9})}{7^2} = 1.47\ N/C$

$E_2 = kQ_2 = (9\times10^9)\times(12\times10^{-9}) = 12\ N/C$

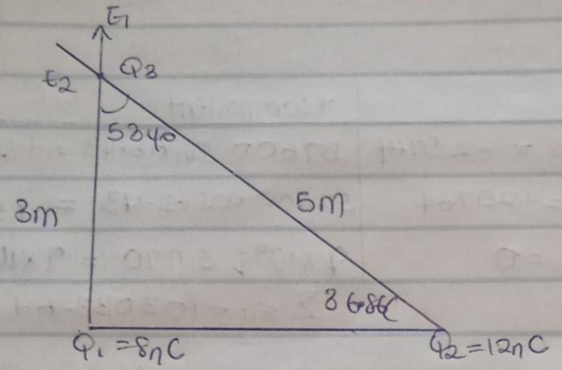
1

Vector	θ	X-component	Y-component
$E_1 = 1.47\,N/C$	$0°$	$1.47 \cos 0° = 1.47$	$1.47 \sin 0° = 0$
$E_2 = 12\,N/C$	$0°$	$12 \cos 0° = 12$	$12 \sin 0 = 0$
		$\Sigma E_x = 13.47$	$\Sigma E_y = 0$

$$E_{net} = \sqrt{\Sigma E_x^2 + \Sigma E_y^2} \quad \cancel{= \sqrt{(3.45)^2 + (10.6)^2}}$$
$$= \sqrt{(13.47)^2}$$

$E_{net} = 13.47\,N/C$

2bii



SOHCAHTOA

Using ~~pythagoras~~ theorem

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

$\theta = \tan^{-1}\frac{3}{4}$

$\theta = 36.86$

Using pythagoras theorem ; $a^2 + b^2 = c^2$

$c^2 = 3^2 + 4^2$

$c = \sqrt{9+16}$

$c = 5m$

$$E_1 = \frac{9\times10^9 \times (8\times10^{-9})}{3^2} = 8\,N/C$$

$$E_2 = \frac{9\times10^9 \times (12\times10^{-9})}{5^2} = 4.32\,N/C$$

Vector	Angle	X-component	Y-component
$E_1 = 8\,N/C$	$90°$	$8\cos 90° = 0$	$8 \sin 90° = \cancel{+}8$
$E_2 = 4.32$	$37°$	$4.32 \cos 37° = -3.45$	$4.32 \sin 37 = 2.6$

$\Sigma E_x = -3.45\,N/C$ $\quad \Sigma E_y = 10.6\,N/C$

The resultant $E = \sqrt{\Sigma E_x^2 + \Sigma E_y^2} = \sqrt{(-3.45)^2 + (10.6)^2}$

$E = 11.15\,N/C$

4 The magnetic flux is defined as the strength of a magnetic field represented by lines of force. It is usually ~~represented~~ represented by the symbol ϕ.

b) $m_e = 9.11 \times 10^{-31}$ $\quad r = 1.4 \times 10^{-7}$ m

magnetic field $= 3.5 \times 10^{-1}$ weber/meter square

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

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

$$\omega = 6.15 \times 10^{10} \text{ rad/s}$$

c) An electron of mass 9.11×10^{-31} kg and charge 1.6×10^{-19} C in motion in a magnet field of 3.5×10^{-1} Tesla perpendicular with the field will have an angul frequency of 6.15×10^{10} rad/s.

5 Biot - Savart law is summarized in the observations below

i The vector $d\vec{B}$ is perpendicular both to $d\hat{I}$ (which points in the direction of current) and to the unit vector $\hat{r}$ directed from $d\hat{l}$ toward P.

ii The magnitude of $d\vec{B}$ is inversely proportional to r^2 where r is the distance $d\hat{l}$ to P.

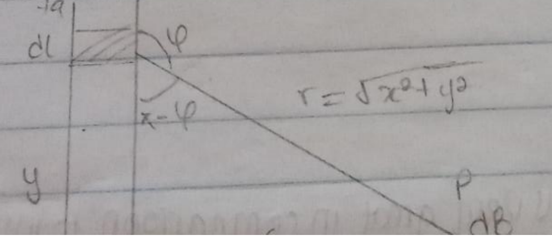
iii The magnitude ~~the~~ of $d\vec{B}$ is proportional to the current I and to the magn the length element $d\vec{l}$.

iv The magnitude of $d\vec{B}$ is proportional to $n\theta$, where θ is the angle betwe dl.

$\therefore$ Biot - Savart law is $$d\vec{B} = \frac{\mu_0 I d\hat{l} \times \hat{r}}{4\pi \cdot r^2}$$

where μ_0 is a constant called permeability of free space

5b



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

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

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

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

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

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl \sin(\pi-\varphi)}{x^2+y^2} \quad \dots *$$

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

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

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

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

recall $dl = dy$

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

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

Using special integrals

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

Equation (***) therefore becomes

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

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

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

When the length $2a$ of the conductor is very great in comparison to its distance

x from P, we consider it infinitely long. That is, when a is much larger than
$(x^2+a^2)^{1/2} \simeq a$, as $a \rightarrow \infty$

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

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

$$B = \frac{\mu_0 I}{2\pi r} \quad \ldots (H)$$

Equation (H) defines the magnitude of the magnetic field of flux dens
near a long, straight current carrying conductor