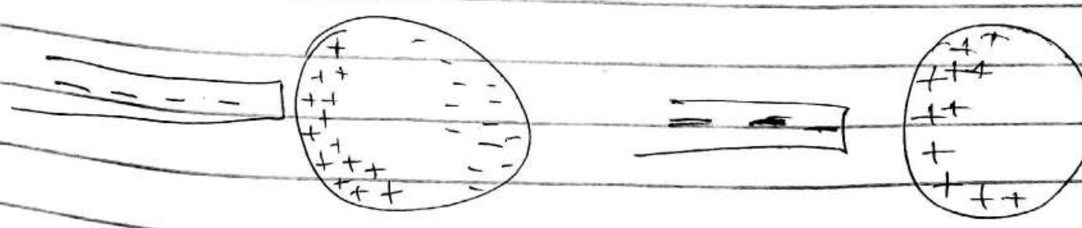
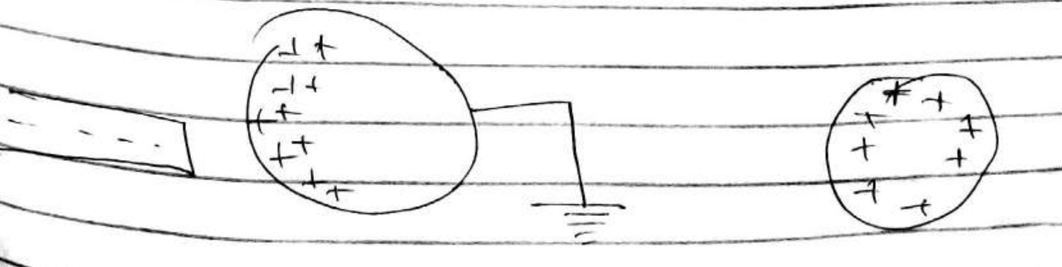
Name: Igerewari Tibiemugha Oye
Department: Medicine and Surgery
Matric number: 19/MHS01/195
Course: Physics 102

Assignment

1a How to Produce A Negatively charged Sphere By Induction

A negatively charged rubber rod is brought near a neutral conducting sphere that's 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 farthest away from the rod. The region of the sphere nearest to the negatively charged rod has an excess of positive charges because of the migration of electrons away from this location. If a ground conducting wire is connected to the sphere, some of the electrons leave the sphere to the ground/earth. When the ground wire is removed, the sphere is left with positive charge.





1b $q_1 + q_2 = 5.0 \times 10^{-5} C$

$F = 1.0N$, $K = 8.99 \times 10^9 Nm^2/C^2$

$r = 2.0m$

$F = \frac{K q_1 q_2}{r^2}$

$1 = \frac{8.99 \times 10^9 \times q_1 q_2}{2^2}$

$1 = \frac{8.99 \times 10^9 \times q_1 q_2}{4}$

$4 = 8.99 \times 10^9 \times q_1 q_2$

$q_1 q_2 = 4.449 \times 10^{-10} C^2$ --- (1)

$q_1 + q_2 = 5.0 \times 10^{-5} C$ --- (2)

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

Put $q_1 = 5.0 \times 10^{-5} - q_2$ into equation (1)

$q_1 q_2 = 4.449 \times 10^{10} C^2$

$(5.0 \times 10^{-5} - q_2) q_2 = 4.449 \times 10^{-10}$

$5.0 \times 10^{-5} q_2 - q_2^2 - 4.449 \times 10^{-10} = 0$

$-q_2^2 - 5.0 \times 10^{-10} q_2 - 4.449 \times 10^{-10} = 0$

$q_2^2 - 5.0 \times 10^{-10} q_2 + 4.449 \times 10^{-10} = 0$

using quadratic formula,

$a = 1$, $b = -5.0 \times 10^{-10}$, $c = 4.449 \times 10^{-10}$

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

$x = \frac{-(-5 \times 10^{-5}) \pm \sqrt{(-5.0 \times 10^{-5})^2 - 4(1 \times 4.449 \times 10^{-10})}}{2(1)}$

$x = \frac{5 \times 10^{-5} \pm \sqrt{2.5 \times 10^{-9} - 4(4.449 \times 10^{-10})}}{2}$

$x = \frac{5 \times 10^{-5} \pm \sqrt{2.5 \times 10^{-9} - 1.7796 \times 10^{-9}}}{2}$

$$x = \frac{5\times10^{-5} \pm \sqrt{1.204\times10^{-10}}}{2}$$

$$x = \frac{5\times10^{-5} + 2.684\times10^{-5}}{2} \text{ or } \frac{5\times10^{-5} - 2.684\times10^{-5}}{2}$$

$x = 3.842\times10^{-5}$ or 1.158×10^{-5}

when $q_2 = 3.842\times10^{-5}$

$q_1 = 5.0\times10^{-5} - 3.84\times10^{-5}$

$q_1 = 1.158\times10^{-5}$

when $q_2 = 1.158\times10^{-5}$

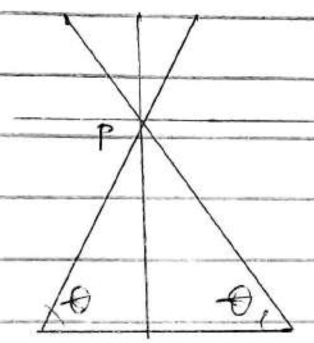
$q_1 = 5.0\times10^{-5} - 1.158\times10^{-5}$

$q_1 = 3.842\times10^{-5}$

when $q_1 = 3.842\times10^{-3}\,C$, $q_2 = 1.158\times10^{-5}\,C$

$q_1 = 1.158\times10^{-5}\,C$, $q_2 = 3.842\times10^{-5}\,C$

C



$Q_1 = Q_2 = 8\,\mu C$

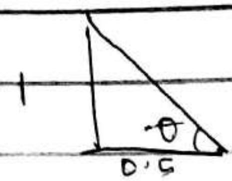
$d = 0.5$

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

$\tan\theta = 2$

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

$\theta = 63.4349$



$H^2 = 1^2 + 0.5^2$

$H^2 = 1 + 0.25$

$H = \sqrt{1.25}$

$H = 1.118 = r$

$E_1 = \frac{KQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.118)^2} = \frac{7200}{1.249924} = 5760.350229$

$E_2 = \frac{KQ_2}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.118)^2} = \frac{7200}{1.249924} = 5760.350229$

$E_q = \frac{Kq}{r^2} = \frac{9 \times 10^9 q\,C}{1^2} = 9 \times 10^9 q\,C$

Vector	Angle	x-Component	y-component
$E_1 = 5760.350229$	$63.4349°$	$E_1 \cos\theta = -2576.111328$	$E_1 \sin\theta = 5152.211679$
$E_2 = 5760.350229$	$63.4349°$	$E_2 \cos\theta = 2576.111328$	$E_2 \sin\theta = 5152.211679$
$E_q = 9 \times 10^9 q$	$90°$	$E_q \cos\theta = 0$	$E_q \sin\theta = 9 \times 10^9 q$
		$\Sigma x = 0$	$\Sigma y = 10304.42336$

$\text{Magnitude} = \sqrt{(\Sigma x)^2 + (\Sigma y)^2}$

$E_q = \sqrt{0^2 + (10304.42336)^2}$

Since $E_q = 0$

$0 = 9 \times 10^9 q + 10304.42336$

$q = \frac{-10304.42336}{9 \times 10^9}$

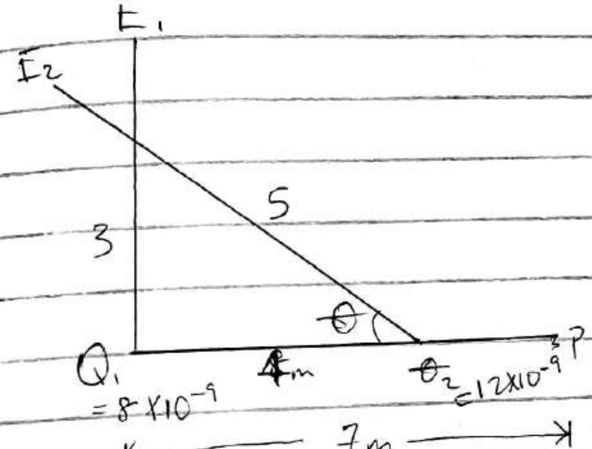
$q = -1.1449 \times 10^{-6}$

$q = -1.1\,\mu C$

2a Electric Field

An electric field is a region of Space in which an electric charge will experience an electric force, While ~~an~~ Electric field Intensity is defined as the force per unit charge.

b



$\tan\theta = \frac{3}{4}$ $\quad Q_1 = 8\times10^{-9}$

$Q_2 = 12\times10^{-9}$

$\tan\theta = 0.75$

$\theta = \tan^{-1} 0.75$

$\theta = 36.8699$

$E_{net} = E_1 + E_2$

$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = \frac{72}{49} = 1.4694\,N/C$

$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = \frac{108}{9} = 12\,N/C$

i) $\therefore E_{net} = E_1 + E_2$

$E_{net} = 1.4694 + 12$

$E_{net} = 13.4694\,N/C$

$E_{net} \approx 13.5\,N/C$

ii) $E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9\times8\times10^{-9}}{3^2} = \frac{72}{9} = 8N/C$

$E_2 = \frac{K\cdot Q_2}{r^2} = \frac{9\times10^9\times12\times10^{-9}}{5^2} = \frac{108}{25} = 4.32N/C$

Vector	Angle	X-Component	Y Component
$E_1 = 8N/C$	$90°$	$E_1 \cos\theta = 0$	$E_1 \sin\theta = 8$
$E_2 = 4.32N/C$	$36.8699°$	$E_2 \cos\theta = -3.455$	$E_2 \sin\theta = 2.592$
		$\Sigma Ex = -3.455$	$\Sigma Ey = 10.592$

$E_{net} = \sqrt{\Sigma Ex^2 + \Sigma Ey^2}$

$E_{net} = \sqrt{(-3.455)^2 + (10.592)^2}$

$E_{net} = \sqrt{11.937025 + 112.190464}$

$E_{net} = \sqrt{124.127489}$

$E_{net} = 11.14125$

$E_{net} \simeq 11.14N/C$

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

b $M_e = 9.11\times10^{-31}kg$

$r = 1.4\times10^{-7}m$

$B = 3.5\times10^{-2}$ weber/meter^2

$w = ?$

$W = \frac{v}{r} = \frac{qB}{m} = \frac{-1.60\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}}$

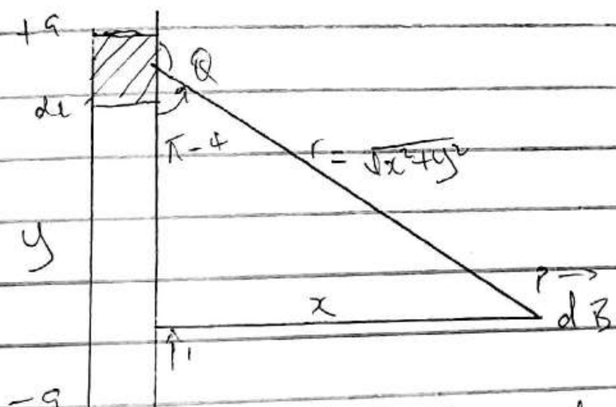
$W = -6.147\times10^{11}$ rad/s

c The answer is negative since it is an electron

5 Biot Savart law is an equation that describes the magnetic field created by current-carrying wire and allows you to calculate its strength at various points.

$$B = \frac{\mu_0}{4\pi} \int \frac{I\,dl \sin\theta}{r^2}$$

6



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

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

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

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

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

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

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

Substituting equation (2) into (1) we have

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

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

Recall $dl = dy$

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

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

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) therefore becomes

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

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

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

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 larger than x,

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

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

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

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