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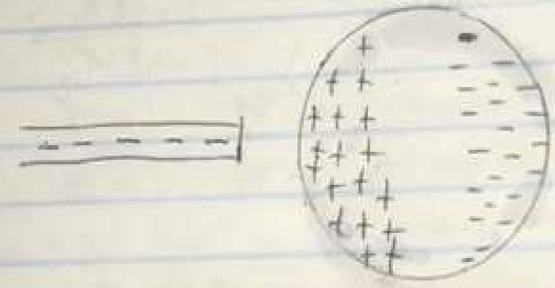
DEPT: Medicine and Surgery MATRIC NO: 19/MHS01/177

PHY 102 ASSIGNMENT

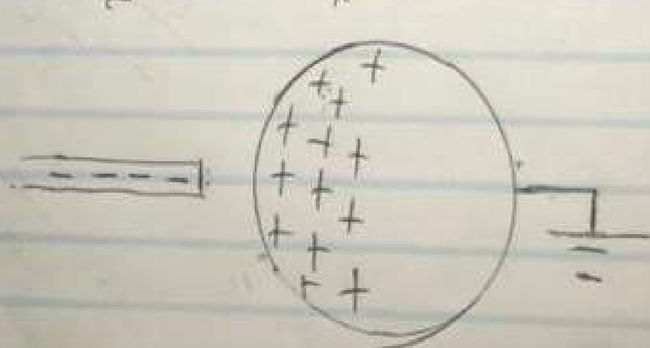
1a. Explain with the aid of a diagram ~~boy~~ how you can produce a negatively charged sphere by method of induction.

sol

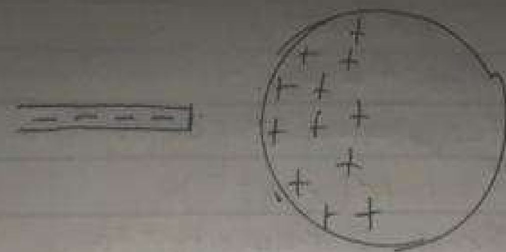
Consider a negatively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to the ground. The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges on the sphere so that some electrons move to the side of the sphere furthest away from the rod.



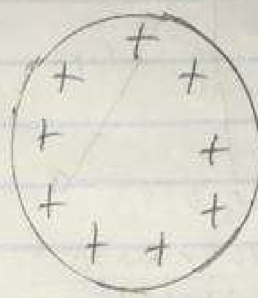
The region of the sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location. If a grounded conducting wire is then connected as shown below



Some of the electrons leave the sphere and travel to the earth. If the wire to ground is removed as shown on the next page ~~[illegible]~~, the conducting sphere is left with an induced positive charge.



Finally, when the rubber rod is removed from the vicinity of the sphere as shown below, the induced positive charge remains on the sphere and becomes uniformly distributed over the surface of the sphere as shown below



(16. Each of two small spheres is charged positively, the combined charge being 5.0×10^{-5} C. If each sphere is repelled from the other by a force of 1.0N when the spheres are 2.0m apart, calculate the charge on each sphere

Sol

$$f = \frac{kq_1q_2}{r^2} = \frac{9\times10^9 \times q_1 \times ((5.0\times10^{-5}) - q_1)}{2^2}$$

$$4 = 9\times10^9 \times q_1 \times [(5.0\times10^{-5}) - q_1]$$

$$4 = 9\times10^9 q_1 [(5.0\times10^{-5}) - q_1]$$

$$4 = 4.5\times10^5 q_1 - 9\times10^9 q_1^2$$

$$9\times10^9 q_1^2 - 4.5\times10^5 q_1 + 4 = 0$$

Using the quadratic equation $\frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$$\frac{4.5\times10^5 \pm \sqrt{2.025\times10^{11} - 1.44\times10^{11}}}{1.8\times10^{10}}$$

$= 3.844\times10^{-5}$ or 1.156×10^{-5} Coloumbs

$\therefore q_1 = 3.844 \times 10^{-5} C$ or $1.156 \times 10^{-5} C$

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

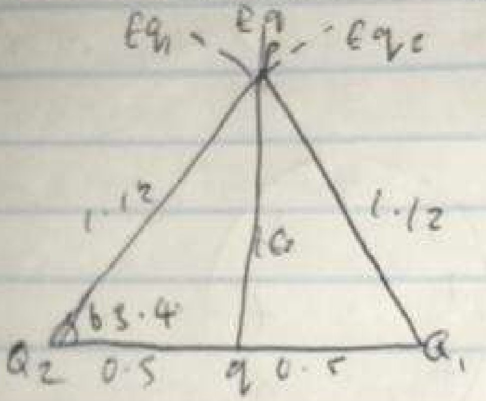
$q_2 = (5.0 \times 10^{-5} - \cancel{q_1}\ (3.844 \times 10^{-5})$ or

$(5.0 \times 10^{-5} - 1.156 \times 10^{-5}) C$

$q_2 = 1.156 \times 10^{-5} C$ or $3.844 \times 10^{-5} C$

1c $Q_1 = Q_2 = 8\mu C$, $d = 0.5M$

since the electric field at a point P is zero



$Eq_1 = \frac{kq_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2}$

$Eq_1 = Eq_2 = \cancel{57.8 \times 10}\ 5.74 \times 10^4 NC^{-1}$

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

Since the electric field at $P = 0$

$Eq = 0$

$0 = 9 \times 10^9 q$

$q = \frac{0}{9 \times 10^9}$

$q = 0$ coloumss

using special integration

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

eqn 3 therefore becomes

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

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

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

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

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

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

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

$$B = \frac{\mu_0 I}{2\pi r} \quad -(\#)$$

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

(4a What is magnetic flux?

Magnetic flux is the measure of the strength of the magnetic field in a particular location

(4b) An electron with a rest mass of 9.11×10^{-31} kg moves in a circular orbit of radius 1.4×10^{-7} m in a uniform magnetic field of 3.5×10^{-1} weber/meter square perpendicular to the speed with which the electron moves. find the cyclotron frequency of the moving electron.

$m = 9.11 \times 10^{-81}$ kg

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

$B = 3.5 \times 10^{-1}$

cyclotron frequency $(\omega) = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-81}}$

$\omega = 6.147 \times 10^{10}$ rads^{-1}

(4c) The angular speed is often reffered to as the cyclotron frequency because the charged particle circulates at this speed or frequency.

The above answer implies that the electron moves in a circular orbit in the uniform magnetic field at a speed of 6.147×10^{10} radians per second

(5a ~~State Biot-savart law~~

~~Biot-savart law is based on the following obsecvations for the magnetic field~~

(5a Biot-savart law states that $d\vec{B} = \frac{\mu_0}{4\pi} \int \frac{d\vec{l} \times r}{r^2}$

where μ_0 is a constant called permeability of free space

$d\vec{B}$ is the magnetic field at a specific point

$d\vec{l}$ is the length element of a wire carrying a steady current $\hat{i}$

(2a) Distinguish between electric field and electric field intensity

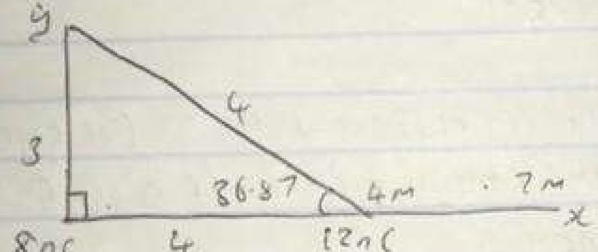
Sol

An electric field is a region of space in which an electric charge experiences an electric force but electric field intensity is the force per unit charge

(2b) A positive charge $Q_1 = 8nC$ is at the origin and a second positive charge $Q_2 = 12nC$ is on the x-axis at $x = 4m$. Find: (i) the net electric field at a point P on the x-axis at $x = 7m$
(ii) the electric field at a point Q on the y axis at $y = 3m$ due to the charges

Sol

(i)



$E_1(q_1 \text{ to } P) = \frac{kq}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469NC^{-1}$

$E_2(q_2 \text{ to } P) = \frac{kq}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12NC^{-1}$

net electric field $= E_1 + E_2 = 12 + 1.469 = 13.469NC^{-1}$

(ii) $E_1(q_1 \text{ to } Q) = \frac{kq}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8NC^{-1}$

$E_2(q_2 \text{ to } Q) = \frac{kq}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32NC^{-1}$

		x-component	Y-component
8	90°	$8\cos 90° = 0$	$8\sin 90° = -8$
4.32	36.87°	$4.32\cos 36.87° = 3.46$	$4.32\sin 36.87° = 2.59$
		-3.46	-10.59

$\sqrt{(-3.46)^2 + (10.59)^2} = 11.14NC^{-1}$

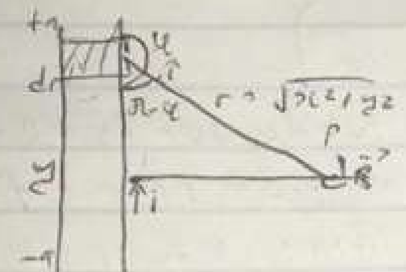
$\tan\theta = \frac{y}{x}$, $\tan\theta = \frac{11.14}{13.469}$, $\tan\theta = 0.827$, $\theta = 39.59°$

8b) Using the Biot-Savart law, show that the ~~magnitude~~ magnetic field of a straight current carrying conductor is given as $B = \frac{\mu_0 I}{2\pi r}$

Applying Biot-Savart law, the magnitude of the field $d\vec{B}$ was found to be $B = \frac{\mu_0 I}{4\pi} \int \frac{dl \sin\theta}{r^2}$

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

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



~~The se~~ A section of a straight current carrying conductor

from the diagram $r^2 = x^2 + y^2$ (Pythagoras theorem)

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

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

substitute eqn (2) into eqn (1) we have

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

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

recall $dl = dy$

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

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