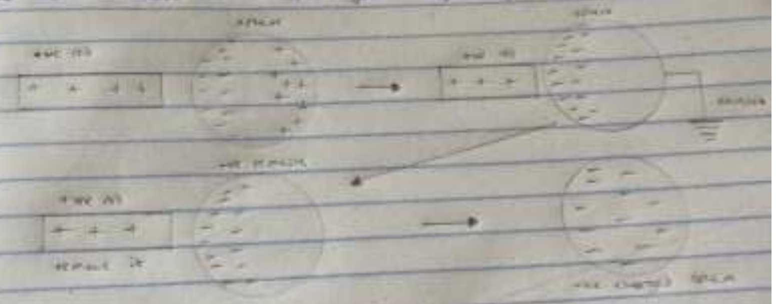
NAME: TIERUN EDWARD ENOGHENE
MATRIC NO: 19/SCI01/044
DEPARTMENT: COMPUTER SCIENCE
COVID-19 HOLIDAY ASSIGNMENT

1a) To charge a metal sphere negatively through induction, you bring a positively charged rod near its surface at one end, say the left surface. The electrons get attracted to the left edge and the positive charges repel to the right side. Now you can earth the sphere and by doing so the electrons from the earth flow to the sphere and neutralize the positive charge collected on the right side. After this we can then remove the positively charged rod from the left side and the negative charges which were attracted to it will be distributed over the metal surface and the sphere gets negatively charged.



1b) Solution

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

$F = 1.0N$, $r = 2.0m$, $K = 9 \times 10^9 Nm^2/C^2$

From Coulomb's Law

$$F = \frac{Kq_1q_2}{r^2}$$

Let the product of the charges be $q_{(P)}$

$$q_{(P)} = \frac{(1.0)N(2.0m)^2}{9 \times 10^9}$$

$$= 4.44 \times 10^{-10} C^2$$

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

$q_1 q_2 = 4.445 \times 10^{-10} C^2$ — ②

$q_1 = 5.0 \times 10^{-5} C - q_2$ — ③

Substituting eqn ③ into ②

$(5.0 \times 10^{-5} - q_2) \times q_2 = 4.449 \times 10^{-10} C^2$

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

$\Rightarrow q_2^2 - (5.0 \times 10^{-5}) q_2 + 4.449 \times 10^{-10}$

Using quadratic formula

$$q_2 = \frac{(5.0 \times 10^{-5}) \pm \sqrt{(5 \times 10^{-5})^2 - 4(4.445 \times 10^{-10})}}{2}$$

$q_2 = 3.840 \times 10^{-5} C$ (because the charges are positive)

Recall eqn ③

~~$q_1 + q_2 = 5/10$~~

$q_1 = 5.0 \times 10^{-5} C - 3.840 \times 10^{-5} C$

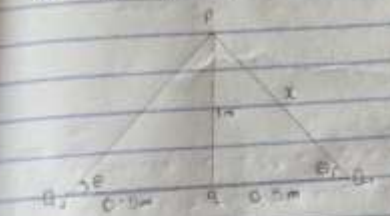
$q_1 = 1.157 \times 10^{-5}$

$\therefore q_1 = 1.157 \times 10^{-5} C$

$q_2 = 3.840 \times 10^{-5} C$

1c) Solution

$Q_1 = Q_2 = 8 \mu C$, $d = 0.5m$



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

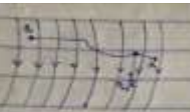
$= 1 + 0.25$

$x^2 = 1.25$

$x = \sqrt{1.25}$

$x = 1.12m$

$$E_1 = \frac{KQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2} = 57397.959$$



Consider the diagram above, suppose a test charge is moved from point to point along an arbitrary path in the electric field. The electric field exerts a force on the charge as shown. To move the test charge from ∞ at constant velocity, an external force must act on the charge. Therefore, the elementary work done is given as;

But,

Substituting eqn in yields;

Then total work done is done in moving the test charge from ∞ to is:

From the definition of electric potential difference, it follows that;

3c) Solution

$x_1 = 0$, $x_2 = 4m$

Find V (potential difference) = 0

$$V = \frac{k Q}{r}$$

From the right side let $r = x$

$$V_P = \frac{1}{4\pi\varepsilon_0} \times \left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right)$$

$$V_P = 9 \times 10^9 \times \left(\frac{10 \times 10^{-6}}{x} + \frac{(-2 \times 10^{-6})}{4 - x}\right)$$

Since $Q_1 = Q_2$, $E_1 = E_2 = 57597.459$

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

To find θ = $\tan\theta = \frac{1}{0.5} = 2$

$$\theta = \tan^{-1}(2) = 63.43$$

Also, $\theta_1 = \theta_2 = 63.43°$

$\theta_q = 90°$

Vector	θ	x component	y component
E_1	63.4°	$E_1 x \cos\theta$ = 25673.15	$E_1 y \sin\theta$ = 51336.08
E_2	63.4°	$E_2 x \cos\theta$ = -25673.15	$E_2 y \sin\theta$ = 51336.08
E_q	90°	$E_q \cos\theta$ = 0	$E_q y \sin\theta$ = $9 \times 10^9 q$

$\Sigma x = 0$ $\Sigma y = 102672.16$

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

$= 102672.16$

$E_q = 102672.16$, $E = 0$

$102672.16 - 9 \times 10^9 q = 0$

$$q = \frac{-102672.16}{9 \times 10^9}$$

$= 1.14 \times 10^{-5}$

$\therefore q = -11.4 \mu C$

~~4a) The electric field is a region around a charge in which it exerts electrostatic force on other charges, while the electric field at any point in space is the electric field intensity.~~

) Electric Potential Difference

The electric potential difference between 2 points in an electric field can be defined as the work done per unit charge against electrical forces when a charge is transported from one point to the other. It is measured in volts or joules per coulomb. Electric potential difference is scalar quantity.

ii) a radius of 1.4×10^{-7} m

iii) magnetic field of 3.5×10^{-1} weber $/m^2$

And we asked to find cyclotron frequency which is equal to angular speed. recall that angular speed is $\omega = \frac{v}{r} = \frac{qB}{m}$

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

$= 6.22 \times 10^{10} T^{-1}$

So since cyclotron frequency is equal to angular speed the cyclotron frequency is equal to 62222222222.22222T^{-1}.

5a) Biot - Savart Law states that the magnetic field is directly proportional to the product of permeability of free space (μ_0) current (I), the change in length (δl), the radius and inversely proportional to the square of radius (r^2). Mathematically,

$$\vec{\delta B} = \frac{\mu_0 I \vec{\delta l} \times \vec{r}}{4\pi r^2}$$

when $V_r = 0$

$$9 \times 10^9 \times \left(\frac{10 \times 10^{-6}}{x} - \frac{2 \times 10^{-6}}{4 - x} \right)$$

$$9 \times 10^9 \times \left(\frac{(10 \times 10^{-6})(4 - x) - (2 \times 10^{-6})(x)}{(x)(4 - x)} \right) = 0$$

$$\Rightarrow 9 \times 10^9 \times \left(\frac{4 \times 10^{-5} - 10 \times 10^{-6} x - 2 \times 10^{-6} x}{4x - x^2} \right) = 0$$

$$9 \times 10^9 \times \left(\frac{4 \times 10^{-5} - 1.2 \times 10^{-5} x}{4x - x^2} \right) = 0$$

$$= \frac{360000 - 108000x}{4x - x^2} = 0$$

$360000 - 108000x = 0$

$x = \frac{360000}{108000}$

$x = 3.33m$

4a) Magnetic flux is defined as the strength of the magnetic field which can be represented by line of forces. It is represented by the symbol ϕ. Mathematically given as $\phi = B \cdot \delta A$

4b) Solution

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

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

magnetic field, $B = 3.5 \times 10^{-1}$ weber $/m^2$

Cyclotron frequency = angular speed

$\omega = \frac{v}{r} = \frac{qB}{m}$

$\omega = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-31}}$

$\omega = 6.222 \times 10^{10} T^{-1}$

We were given the following.

i) mass of electron $= 9.11 \times 10^{-31}$ kg