PHY 102 (ASSIGNMENT)

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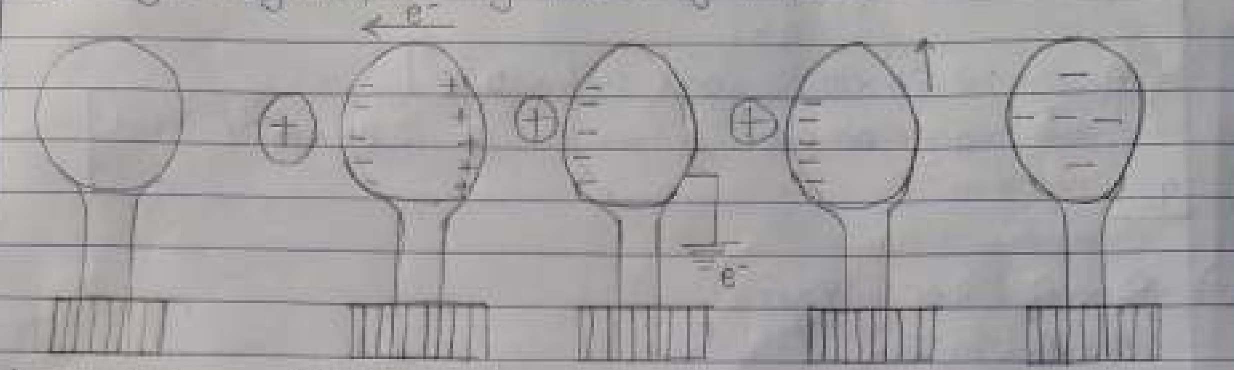
SECTION A

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

(i)



A neutral Sphere. | Electrons are attracted to the positive balloon. | Electrons enter sphere from ground, attracted to the + charge in the sphere. | The sphere has an excess of e^- having entered from the ground | Electrons redistribute uniformly

(b)

Charge is positive

Individual Charges $\Rightarrow q_1$ and q_2

$q_1 + q_2 = 5.0\times10^{-5}C$

$F = 1.0N$, $d = 2.0m$

$q_1 = ?$ and $q_2 = ?$

$/q_1/ = q_1$ and $/q_2/ = q_2$

Now, $F = \frac{kq_1q_2}{r^2}$, $q_1q_2 = \frac{Fr^2}{k}$

$q_1q_2 = \frac{1.0\times2^2}{9\times10^9} \Rightarrow 4.444\times10^{-10}C^2$

$q_1q_2 = 4.449\times10^{-10}C^2$

$q_1 + q_2 = 5.0\times10^{-5}C$ --- equ (i)

$q_1q_2 = 4.449\times10^{-10}C^2$ --- equ (ii)

Form equation (iii) from equ (i)

$q_2 = 5.0\times10^{-5}C - q_1$ --- equ (iii) put equ (iii) in equ (ii)

$q_1(5.0\times10^{-5}C - q_1) = 4.449\times10^{-10}C^2$

$5.0\times10^{-5}q_1 - q_1^2 = 4.449\times10^{-10}$

$q_1^2 - (5.0\times10^{-5}C)q_1 + 4.449\times10^{-10} = 0$

Using quadratic formula,

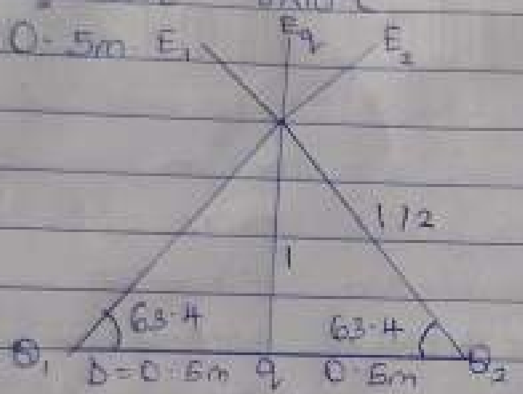
$$q_{1,2} = \frac{5\times10^{-5} \pm \sqrt{(5\times10^{-5})^2 - 4(4.449\times10^{-10})}}{2\times1}$$

$\boxed{q_{1,2} = 3.84\times10^{-5}C \text{ and } 1.16\times10^{-5}C}$

$\therefore$ the charge on each sphere are $q_1 = 3.84\times10^{-5}C$ and $q_2 = 1.16\times10^{-5}C$

1c) $Q_1 = Q_2 = 8\mu C = 8\times10^{-6}C$

$d = 0.5m$



$x^2 = 1^2 + 0.5^2 \Rightarrow x^2 = 1 + 0.25,$

$\sqrt{x^2} = \sqrt{1.25}$

$\boxed{x = 1.12,}$

$\tan\theta = \frac{Opp}{adj} = \frac{1}{0.5} = 2$

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

$\boxed{\theta = 63.43^\circ}$

$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} \boxed{\Rightarrow 5.74\times10^4 N/C}$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} \Rightarrow \boxed{5.74\times10^4 N/C}$

$E_q = \frac{kq}{r^2} = \frac{9\times10^9\times q}{1} \boxed{\Rightarrow 9\times10^9 q\, N/C}$

Vector	Angle	x - component	y - component
$E_1 = 5.74 \times 10^4$	$63.4°$	$E_1 \cos\theta$	$E_2 \sin\theta$
		$= -2.56 \times 10^3$	$= 5.13 \times 10^3$
$E_2 = 5.74 \times 10^4$	$63.4°$	$E_2 \cos\theta$	$E_2 \sin\theta$
		$= 2.56 \times 10^3$	$= 5.13 \times 10^3$
$E_q = 9 \times 10^9 q$	$90°$	$E_q \cos\theta$	$E_q \sin\theta$
		$= 0$	$= 9 \times 10^9 q$
		$\Rightarrow 0$	$\Rightarrow 1.026 \times 10^4 + 9 \times 10^9 q$

$E = \sqrt{0^2 + (1.026 \times 10^4 + 9 \times 10^9 q)^2}$

Electric field at P is zero

$0 = 0 + 1.026 \times 10^4 + 9 \times 10^9 q$

$\frac{-1.026 \times 10^4}{9 \times 10^9} = \frac{\cancel{9 \times 10^9} q}{\cancel{9 \times 10^9}}$

$q = -1.14 \times 10^{-6} C = -1 \mu C$

$\boxed{\therefore q = -1.14 \times 10^{-6} C \text{ or } -1 \mu C}$

2 (a) Electric field

This is a region of space in which an electric charge will experience an electric force

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Electric field intensity

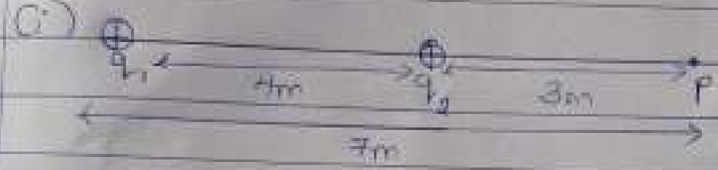
This can be defined as the force per unit charge.

2 (b) $Q_1 = 8nC = 8\times10^{-9}C$

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

$K = 9\times10^{9}$

(c)



$$E_1 = \frac{Kq_1}{r_1^2} = \frac{9\times10^{9}\times8\times10^{-9}}{7^2} = \frac{72}{49} \Rightarrow 1.47N/C$$

$$E_2 = \frac{Kq_1}{r_1^2} = \frac{9\times10^{9}\times12\times10^{-9}}{3^2} = \frac{108}{9} \Rightarrow 12N/C$$

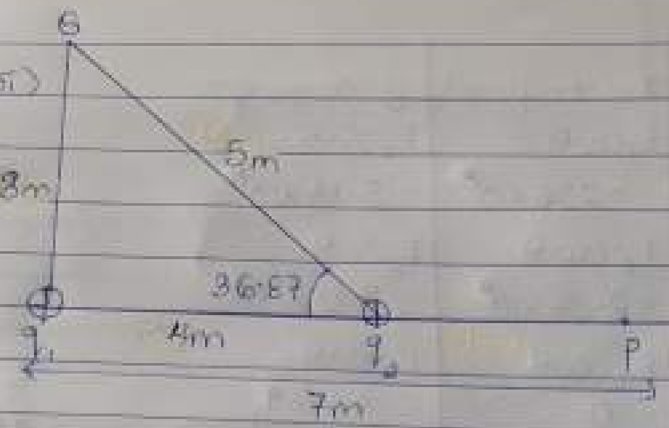
Vector	Angle	x-component	y-component
$E_1 = 1.47$	0	$E_1\cos\theta$ $=1.47\times\cos0$ $\Rightarrow1.47$	$E_1\sin\theta = 1.47\times\sin\theta$ $=0$
$E_2 = 12$	0	$E_2\cos\theta$ $=12\times\cos0$ $\Rightarrow12$	$E_2\sin\theta = 12\times\sin0$ $\Rightarrow0$
		$\Rightarrow13.47$	$\Rightarrow 0$

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

$$E = 13.47 + 0 \Rightarrow 13.47$$

$\therefore$ the net electric field $\Rightarrow 13.47N/C \Rightarrow 13.5N/C$

2b (ii)



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

$\sin\theta = (3/5)$

$\sin\theta = 0.6$

$\theta = \sin^{-1} 0.6$

$\theta = 36.87^\circ$

From pythagoras's theorem

$x^2 = 3^2 + 4^2 \Rightarrow 9+16$

$\sqrt{x^2} = \sqrt{25}, \; x = \sqrt{25}$

$x = 5m$

$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} \; \boxed{\Rightarrow 8N/C}$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} \; \boxed{\Rightarrow 4.32N/C}$

Vector	Angle	x - component	y - component
$E_1 = 8N/C$	90	$E_1 \cos 90$ $= 8\times\cos 90 = 0$	$E_1 \sin 90$ $= 8\times\sin 90 = 8$
$E_2 = 4.32N/C$	36.87	$E_2 \cos 36.87$ $\Rightarrow 8\times 36.87$ $\Rightarrow 3.46$	$E_2 \sin 36.87$ $= 4.32\times 36.87$ $\Rightarrow 2.59$
		$\Rightarrow 3.46$	$\Rightarrow 10.59$

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

$E = \sqrt{124.1197}$

$\boxed{E = 11.14N/C}$

$\therefore$ The electric field at point $Q = 11.2N/C$

A (a) Magnetic Flux

This may be defined as the strength of magnetic field represented by lines of force. It is usually represented by the symbol ϕ

A (b) Mass of electron $= 9.11 \times 10^{-31}$ kg

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

$B = 3.5 \times 10^{-1}$ webe /meter square

$F_B = qVB\sin\theta$

for perpendicular, where $\theta = 90^\circ$

$F_B = qvB$

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

Cyclotron frequency $(\omega) = \frac{qB}{m}$

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

$q = 1.60 \times 10^{-19}$ C

$B = 3.5 \times 10^{-1}$ webster/meter square

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

$\omega = \frac{1.60 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$

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

4c) Since the electron's magnetic field is perpendicular to the speed with which electron moves,

$F_B = qvB\sin\theta$ where $\theta = 90^\circ$

$\therefore F_B = qvB$

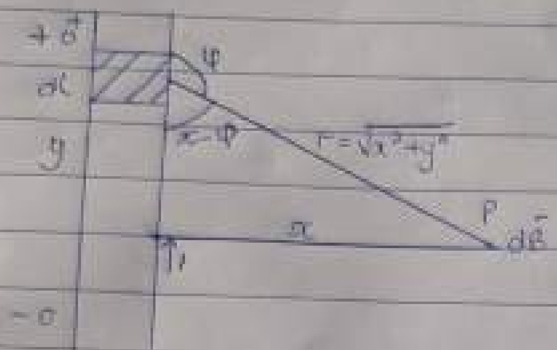
Also, since it's an electron, its charge $q = 1.60 \times 10^{-19}$ C and also

$\omega = \frac{v}{r}$ since the electron moves in a circular orbit.

5 (a) Biot - Savart law

It states how the value of magnetic field at a specific point in space from one short segment of current carrying conductor depends on each factor that influence the field

5 (b) Show that $B = \frac{\mu_0 I}{2\pi r}$



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

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

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

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 magnitude of B is

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

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