NAME: OFODI CHRISTABEL

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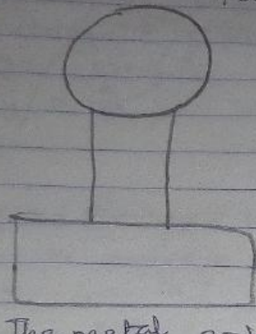
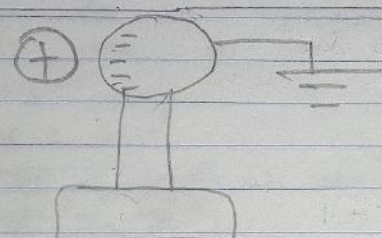
(a)



The metal sphere is mounted on a stand

The presence of a positive charge induces e^- to move from the left to the right side of the balloon



If a grounded conducting wire is then connected to the sphere, some of the positive charges leave the sphere and travel to the earth

When the wire to the ground is then removed, the conducting sphere is left with excess of induced negative charge.

1b) $q_1 + q_2 = 5\times10^{-5}\,C$ - - - (1)

$K = 9\times10^{9}$

$r = 2m$

$F = 1.0N$

$$F = \frac{Kq_1q_2}{r^2} \Rightarrow 1 = \frac{9\times10^{9}q_1q_2}{4}$$

$$9\times10^{9}(q_1q_2) = 4$$

$$q_1q_2 = \frac{4}{9\times10^{9}} \quad \text{- - - (2)}$$

from equation (1)

$$q_1 = 5\times10^{-5} - q_2 \quad \text{- - - (3)}$$

Substitute equation (3) into (2)

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

$$5\times10^{-5}q_2 - q_2^2 = \frac{4}{9\times10^9}$$

$$q_2^2 - 5\times10^{-5}q_2 - \frac{4}{9\times10^9} = 0$$

Solving the quadratic equation, we'll get:

$q_2 = 3.84\times10^{-5}C$ or $1.15\times10^{-5}C$

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

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

$q_1 = (5\times10^{-5}) - (3.84\times10^{-5})$

$q_1 = 1.16\times10^{-5}C$

when $q_2 = 1.15\times10^{-5}C$

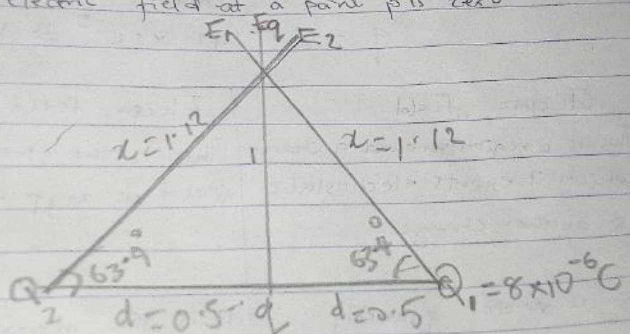
$q_1 = (5\times10^{-5}) - (1.5\times10^{-5})$

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

1c $Q_1 = Q_2 = 8\mu C$

$d = 0.5m$

Find Q if electric field at a point p is zero



To find θ

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

$\tan\theta = 1/0.5$

$\theta = \tan^{-1}(1/0.5)$

$\theta = 63.4$

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

$x^2 = 1 + 0.25$

$x = \sqrt{1+0.25}$

$x = 1.12$

$$E_1 = \frac{kq}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} = 57397.95918$$

$$E_2 = \frac{kq}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{(1.12)^2} = 57397.95918$$

$$E_q = \frac{kq}{r^2} = \frac{9\times10^9\times q}{1} = 9\times10^9 q$$

VECTOR

	Angle	x-component	y-component
$E_1 = 57397.95918$	63.4°	$E_1 \times \cos\theta$ $= 57397.95918 \times \cos 63.4$ $= -25700.45785$	$E_1 \sin\theta$ $= 51322.62839$
$E_2 = 57397.95918$	63.4°	$= 25700.45785$	$= 51322.62839$
$E_q = 9\times10^9 q$	90°	$E_q \cos\theta = 0$ $\Sigma x = 0$	$E_q \sin\theta =$ $= 9\times10^9 q$ $\Sigma y = 102645.2568$

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

$$E_q = \sqrt{(0)^2 + (102645.2568)^2}$$

$$= \cancel{\sqrt{1.0264\times10^{5}}}$$

Since $E_1 = 0$

$$0 = 9\times10^9 q + 102645.2568$$

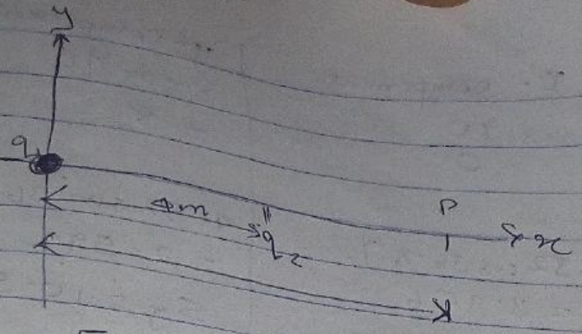
$$\frac{\cancel{9\times10^9} q}{\cancel{9\times10^9}} = \frac{-102645.2568}{9\times10^9}$$

$$q = -\frac{102645.2568}{9\times10^9}$$

$$q = -1.141\times10^{-5} \cong 1.14\times10^{-5}$$

2a) Electric field	Electric field Intensity
i) This is a region around a charge in which it exerts electrostatic force on another charge	This is the strength of electric field at any point in space.
ii) It is a vector quantity	It is the magnitude of the vector.

2i)



For $q_1 = \frac{kq}{r^2}$

where $r = 7m$

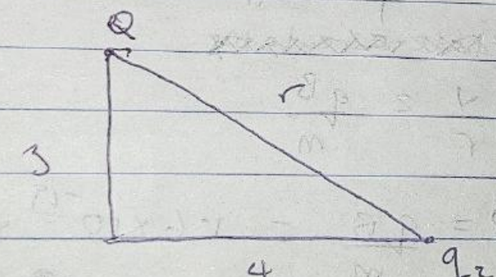
$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^{9} \times 8\times10^{-9}}{7^2} = 1.46 N/C$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^{9}\times12\times10^{-9}}{(7-4)^2} = 12$$

Since they both lie on the x-axis, they have no y component

$$\therefore E_p = E_1 + E_2$$
$$= 1.46 + 12$$
$$= 13.46 N/C$$

2bii) $E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^{9}\times 8\times10^{-9}}{3^2}$



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

$\theta = \tan^{-1}(3/4)$

$\theta = 36.87^\circ$

$$r^2 = 4^2 + 3^2$$
$$r = \sqrt{16+9}$$
$$r = 5$$

$$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^{9}\times12\times10^{-9}}{5^2} = 4.32$$

VECTOR	Angle	x - component	y - component
8	90	$8\cos 90$ 0	$8\sin 90$ $= 8$
4.32	36.87	$4.32\cos 36.87$ $= 3.456$	$4.32\sin 36.87$ $= 2.592$
		$\Sigma x = 3.456$	$\Sigma y = 10.592$

$$E_Q = \sqrt{(\Sigma_x)^2 + (\Sigma_y)^2}$$

$$E_Q = \sqrt{(3.456)^2 + (10.592)^2}$$

$$= 11.14 N/C$$

4a) Magnetic flux is the strength of the magnetic field which can be represented by line of forces. It is represented by the symbol "Φ". It is mathematically represented as:

$$\Phi = B \cdot dA$$

4b.

$m = 9\times10^{-31}$ kg

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

$B = 3.5\times10^{-1}$ weber/meter^2

Remember:

The angular speed is often refferred to as the cyclotron frequency

~~[illegible]~~

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

$$\omega = \frac{qB}{m} = \frac{1.6\times10^{-19} \times 3.5\times10^{-1}}{9\times10^{-3}}$$

$$= 6.22\times10^{-18} \text{ rad/s}$$

4c- We were given parameters:-

$r = 1.4\times10^{-1}$ m

$m = 9\times10^{-31}$ kg

$B = 3.5\times10^{-1}$ weber/m^2

And we were asked to find the cyclotron frequency using the above parameters.

~~I~~ I used the fomular ($\omega = \frac{qB}{m}$ because the charged particle that circulates in the angular speed is the type of accelerator called cyclotron.

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

Substituting the parameters needed in the formula, my answer was 6.22×10^{-18} rad/s

iii) The Biot-Savart Law states that magnetic field is directly proportional to the product permeability of free space (μ), the current (I) the change in length, the radius and inversely proportional to the square of radius (r^2)

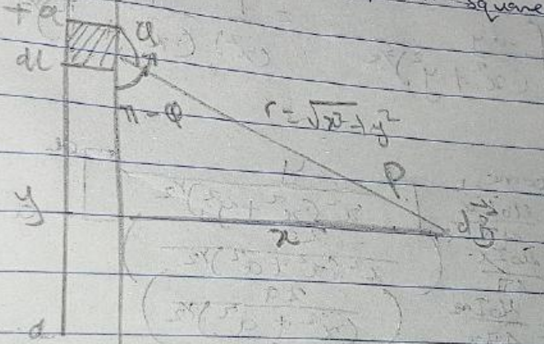
It can be represented mathematically by:

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

where μ_0 is the permeability of free space $= 4\pi \times 10^{-7}\, T \cdot \frac{m}{A}$

where $d\vec{B}$ is the weber/metre square

b)



The above diagram is a section of a straight current carrying conductor

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

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

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

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

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

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

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

Substitute equation (2) into equation (1):

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

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

Remember, $dl = dy$

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

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

Integrating,

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

Equation 3 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 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,

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

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

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:

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