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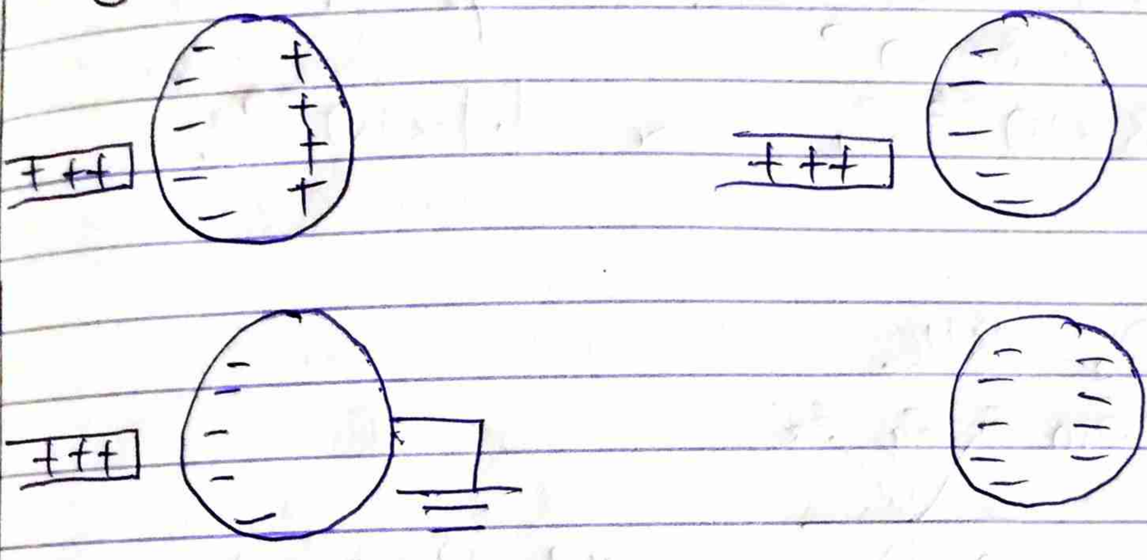
1a Charging by induction: This can be obtained without touching it, by a process called electrostatic Induction



1b $k = 9\times10^{9}$

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

$f = 1N$

$d = 2.0m$

$f = \frac{kq_1q_2}{r^2} = 1 = \frac{9\times10^{9}(q_1q_2\,5\times10^{-5})}{2^2}$

$2^2 = 9\times10^{9}\times5\times10^{-5}q_1 + 9\times10^{9}q_2$

$4 = 4.5\times10^{5}q_1 + 9\times10^{9}q_2$

Quadratic Equation

$9\times10^{9}q_2^{2} - 4.5\times10^{5}q_1 + 4 = 0$

$q_1^{2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$q_1 = \frac{-(-4.5\times10^{5}) \pm \sqrt{(-4.5\times10^{5})^2 - 4(9\times10^{9}}}{2\times9\times10^{9}}$

$$q = \frac{4.5\times10^{5} \pm \sqrt{2.025\times10^{11} - 4(3.6\times10^{10})}}{1.8\times10^{10}}$$

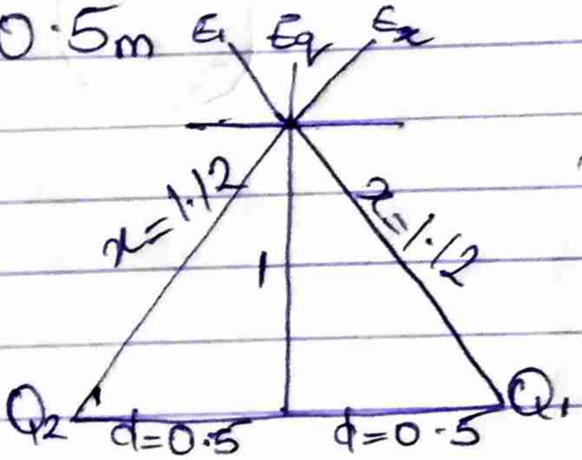
$$q = \frac{4.5\times10^{5} \pm \sqrt{5.85\times10^{10}}}{1.8\times10^{10}} = \frac{4.5\times10^{5} \pm 2.41\times10^{5}}{1.8\times10^{10}}$$

$$q_1 = \frac{4.5\times10^{5} + 2.41\times10^{5}}{1.8\times10^{10}} \text{ or } q_2 = \frac{4.5\times10^{5} - 2.41\times10^{5}}{1.8\times10^{10}}$$

$$q_1 = 3.8\times10^{-5}\,C \text{ or } 1.1\times10^{-5}\,C$$

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

$d = 0.5m$



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

$x^2 = 1 + 0.25$

$x^2 = 1.25$

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

$x = 1.12$

$$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^{9}\times 8\times10^{-6}}{\cancel{0.5^2}\ 1.12^2} = 57397.959$$

$$E_2 = \frac{kq_1}{r^2} = \frac{9\times10^{9}\times 8\times10^{-6}}{1.12^2} = 57397.959$$

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

Vector	Angle	x-Component	y-Component
$E_1 = 57397.959$	$63.4°$	$E_1 \cos\theta =$ $57397.959 \cos 63.4 = 25700.45$	$E_1 \sin\theta =$ $57397.959 \sin 63.4 = 51322.628$
$E_2 = 57397.959$	$63.4°$	25700.45	51322.628
$E_q = 9\times10^9 q$	$90°$	$E_q \cos\theta = 0$ $\Sigma x = 0$	$9\times10^9 q =$ $\Sigma y = 10264.52568$

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

$$E_q = \sqrt{(0)^2 + (10264.52568)^2}$$

Since $E_q = 0 \therefore 9\times10^9 q \times 10264.52568$

Making q the subject of formula

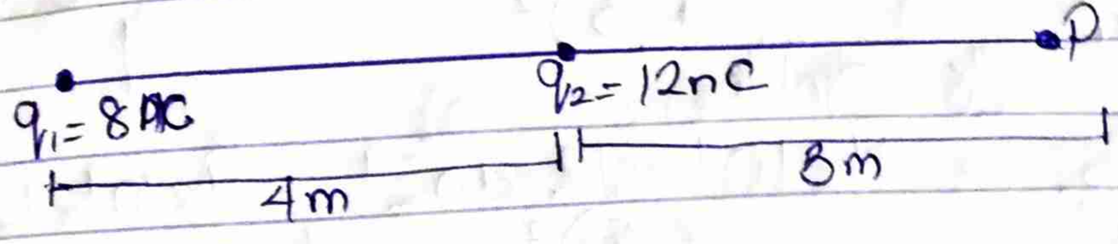
$$q = \frac{10264.52568}{9\times10^9}$$

$$q = 1.140502853\times10^{-6}$$

$$q = 1.14\,\mu C$$

2a) Electric field is a region of space in which an electric charge will experience an electric force while electric field intensity can be defined as force per unit charge. which can be mathematically written as; $E = \frac{F\,(N)}{q_0\,(C)}$

It is measured in newton per Coloumb (N/C).

b) 

$E = E_1 + E_2$

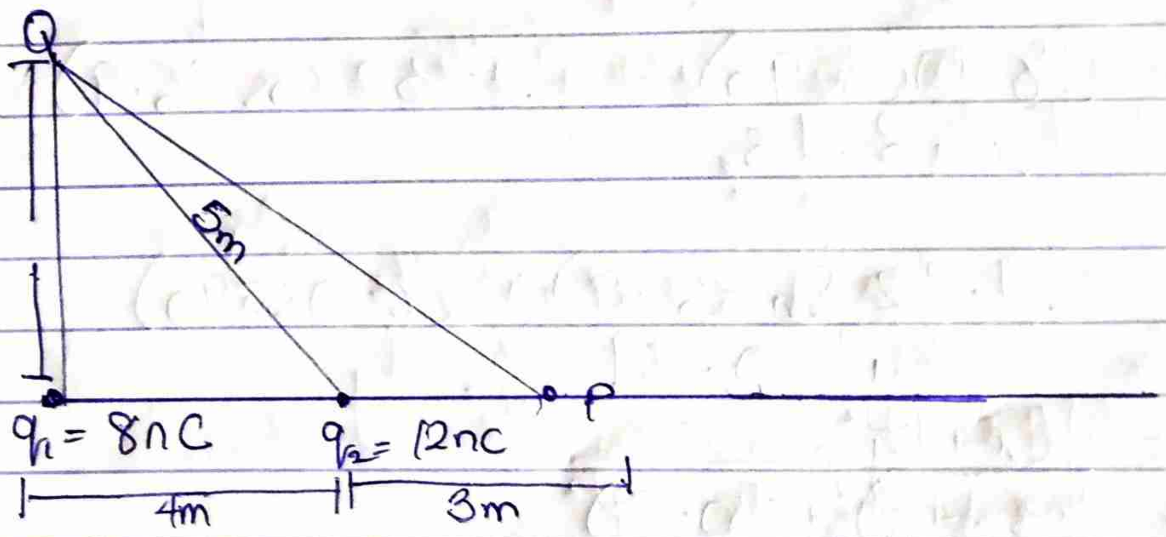
$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = \frac{9\times10^9 \times 8\times10^{-9}}{49} =$

~~1.46×10~~ 1.469 N/C

$E_2 = \frac{Kq_2}{r_1^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = \frac{9\times10^9 \times 12\times10^{-9}}{9}$

$= 12.0$ N/C

$E = 1.469 + 12 = \underline{13.5 \text{ N/C}}$

ii) 

Using Pythagoras Theorem

$Hyp = 3^2 + 4^2$

$Hyp = 9 + 16$

$Hyp = \sqrt{25} = 5$

$E = E_1 + E_2$

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

$8.0 N/C$

$E_2 = \frac{kq_2}{r_2^2} = \frac{9\times10^9 \times 12\times10^{-9}}{(5)^2} = \frac{9\times10^9 \times 12\times10^{-9}}{25}$

$= 4.32 N/C$

Vector	Angle	x-Component	Y-Component
$E_1 = 8.0 N/C$	90°	$8.0 \cos 90 = 0$	$8.0 \sin 90 = 8.0$
$E_2 = 4.32 N/C$	36.9	$4.32 \cos 36.9$ $= 3.45$	$4.32 \sin 36.9$ $= 2.59$

$E_x = (8.0 \cos 90) + (4.32 \cos 36.9)$

$E_x = 3.45$

$E_y = (4.32 \sin 36.9) + (8.0 \sin 90)$

$E_y = 10.59$

$E = \sqrt{E_x^2 + E_y^2}$

$E = \sqrt{(3.45)^2 + (10.59)^2}$

$E = \underline{\underline{11.2 N/C}}$

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

b) $M = 9.11 \times 10^{-31} kg$
$r = 1.4 \times 10^{-7} m$
$B = 3.5 \times 10^{-1} Wb^{-2}$
Cyclotron frequency = angular speed
$\omega = \frac{v}{r} = \frac{qb}{m} = W = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{\cancel{9 \times 10^{-31}}\ 9.11 \times 10^{-31}} =$
~~$W = 622T^{-1}$ or $622.22T^{-1}$~~ $W = 6.14 \times 10^{10} T$

5a Biot Savart Law states that the magnetic field is directly porportional to the product permeability of free space (μ), the current (I), the change in length, the radius, and inversly porpotional to square of radius (r^2).
It can be mathematically written by
~~$dB = \frac{\mu I dl \times r}{4\pi}$~~ $dB = \frac{N_0}{4\pi} \frac{I d\vec{l} \times r}{r^2}$
Where N_0 is a constant called permeability of free space
$N_0 = 4\pi \times 10^{-7} T \times \frac{m}{A}$

The unit of B is weber/meter square.

5b Magnitude of field dB

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

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

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

~~Sin~~ From diagram $r^2 = x^2 + y^2$ (pythagoras theorem)

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

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

Substituting 1 & 2, we have

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

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

Recall $dl = dy$

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

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

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 becomes

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

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

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

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

~~4c The answer~~ Answer to No 4C

4c We were given the mass = 9.11×10^{-31} kg,

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

$B = 3.5\times10^{-18}\ \mathrm{Wb}^{-2}$, And we were asked to find Cyclotron frequency.

The Cyclotron frequency is equal to the angular speed where $\omega = \frac{qB}{m}$, therefore the figures were substituted to give ω 6.14. Angular speed is often refered to as Cyclotron frequency because the charge particle Circulates at this angular frequency or speed.