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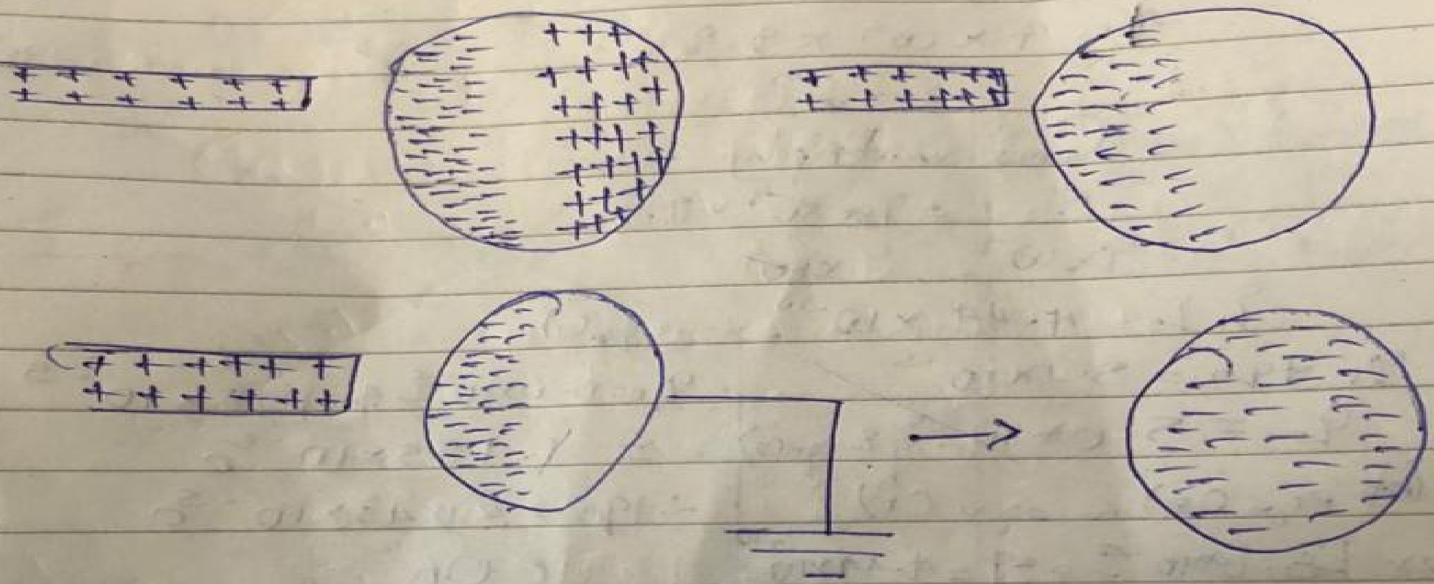
Course Code: Physics 101
Matric NO: 19/MHS061017.

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



Electric charges can be obtained on an object without touching it by a process called electrical induction

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

soln

$F = 1.0N$, $r = 2.0m$, $Q = 5.0\times10^{-5}$

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

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

$$1 = \frac{9\times10^9 \times q_1 q_2}{2^2}$$

Cross multiply

$$\frac{4}{9\times10^9} = \frac{\cancel{9\times10^9}\times q_1 q_2}{\cancel{9\times10^9}}$$

$q_1 q_2 = 4.44\times10^{-10}$ ... equ(1)

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

$q_1 = 5.0\times10^{-5} - q_2$ ... equ(2)

Put equ(2) in equ(1)

$q_2 \times [5.0\times10^{-5} - q_2] = 4.44\times10^{-10}$

$5.0\times10^{-5} q_2 - q_2^2 = 4.44\times10^{-10}$

$-q_2^2 + 5.0\times10^{-5} q_2 - 4.44\times10^{-10} = 0$

$q_2 = 3.845\times10^{-5}C$ or $q_2 =$

$q_2 = 1.155\times10^{-5}$

$q_1 = 5.0\times10^{-5} - 3.845\times10^{-5}$

$= 1.155\times10^{-5}C$

$\therefore q_2 = 3.845\times10^{-5}C$

OR

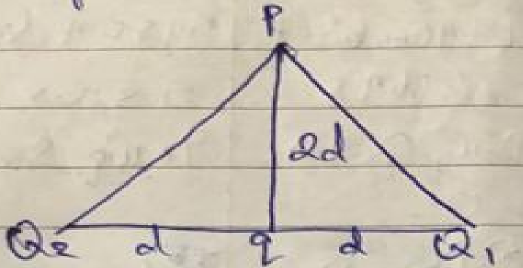
$q_1 = 5.0\times10^{-5} - 1.155\times10^{-5}$

$= 3.845\times10^{-5}C$

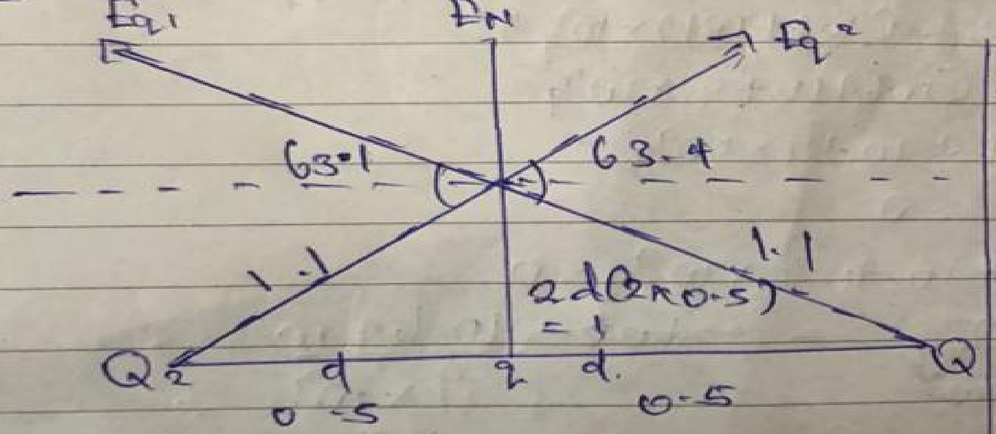
$q_1 = 1.165\times10^{-5}C$

Contraction of No 1

c) Three charges were positioned as shown in the figure below. If $Q_1 = Q_2 = 8\mu$ and $d = 0.5m$. Determine q if the electric field at P is zero

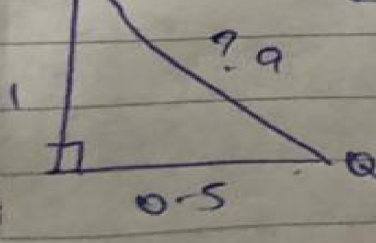


soln



$E_q = \frac{Kq}{8} = \frac{9\times10^9\times q}{1^2}$

$= 9\times10^9 q$ N/C



$\tan\theta = 1/0.5 = \theta \doteq 63.4$

$E_p = E_{q1} + E_{q2} + E_q$

$E_q = \frac{KQ_1}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{1.1^2}$

$= 59504$ N/C

$E_{q2} = \frac{KQ_2}{r^2} = \frac{9\times10^9\times8\times10^{-6}}{1.1^2} = 5.9504$ NC

Continuation of No 1

Vector	Angle	X - Comp	Y comp
$E_{q_1} = 59504$	63.4°	$x = 59504 \cos 63.4 = -26643$	$59504 \sin 63.1 = 53205$
$E_{q_2} = 59504$	63.4°	$59504 \cos 63.4 = 26643$	$59504 \sin 63.4$ 53205
$E_q = 9\times10^9 q$	90	$9\times10^9 q \cos 90 = 0$	$9\times10^9 q \sin 90 = 9\times10^9 q$
		$\Sigma f_x = 0$	$\Sigma f_y = 106410 + 9\times10^9 q$

$$E_p = \sqrt{0^2 + (106410 + 9\times10^9 q)^2}$$

$$E_p = \sqrt{(106410 + 9\times10^9 q)}$$

$$E_p = 106410 + 9\times10^9 q$$

at $E_p = 0$

$$106410 + 9\times10^9 q = 0$$

$$\frac{9\times10^9 q}{9\times10^9} = \frac{\cancel{100} - 106410}{9\times10^9}$$

$$q = -1.18\times10^{-5} C$$

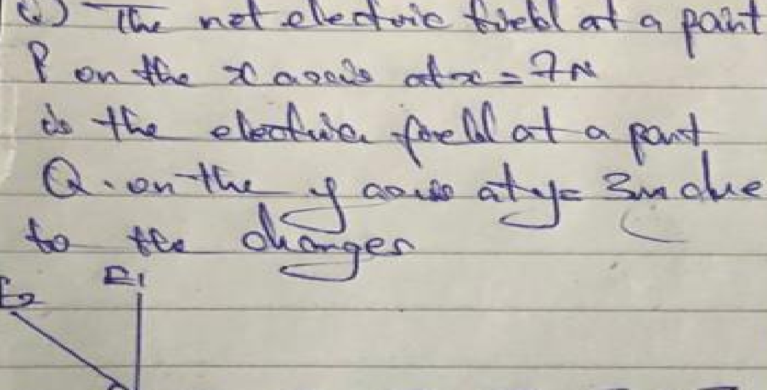
$$q = 12 uC$$

2a) **Electric field**: It is a region of space in which an electric charge will experience an electric force while electric field intensity can be defined as the force per unit charge.

b) 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



$\tan\theta = 3/4$

$\theta = \tan^{-1} 0.75$

$\theta = 36.9°$

$E_p = EQ_1 + EQ_2$

$EQ_1 = \frac{KQ}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469 N/C$

$EQ_2 = \frac{KQ}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 12 N/C$

$E_q = 1.469 + 12 = 13.469$

$\simeq 13.5 N/C$

ii) $E_{net}Q = E_1 + E_2$

$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2}$

$= 8 N/C$

$E_2 = KQ_2/r^2 = \frac{9\times10^9 \times 12\times10^{-9}}{5^2}$

$= 4.32 N/C$

Vector	Angle	X com	Y com
$E_1 = 8N/C$	90°	$8\cos90 = 0$	$8\sin90 = 8$
$E_2 = 4.32N/C$	36.90	$-4.52\cos36.9$ -3.45	$4.52\sin36.9$ 2.59
		$\Sigma fx = -3.45$	$\Sigma fy = 10.5$

$E_{net}Q = \sqrt{(-3.45)^2 + (10.59)^2}$

$= 11.14 N/C$

Question 4

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 $\phi = B$ and A

4b) $m = 9 \times 10^{-31}$ kg
$r = 1.4 \times 10^{-9}$ m
$B = 3.5 \times 10^{-1}$ m^2

Cyclotron frequency = angular speed

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

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

~~w = 6.222 252 222 2 . 222 22 T/T~~

$W = \pm 6.15 \times 10^{10}$ rad/sec.

4c) In the question we were given parameters such as

i) Mass of the electron = 9.11×10^{-31} kg

ii) A radius of 1.4×10^{-9} m

iii) Magnetic field of 3.5×10^{-1} weber/meter square

and we were asked to find the cyclotron frequency which is equal or the same thing as angular speed. It is called cyclotron frequency because ~~it~~ is a frequency of an accelerator called cyclotron. Recall that

Continuation of 4c

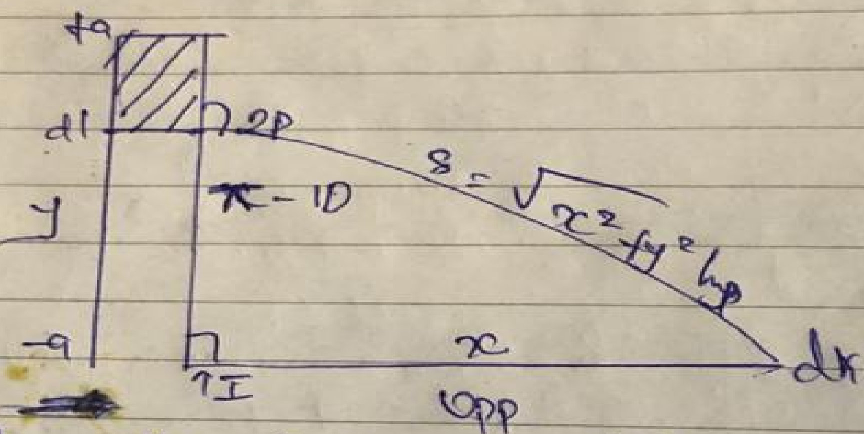
angular speed is given as $\omega =$ Substituting we have

$$\omega = \frac{1.6 \times 10^{-10} \times 10 \times 3.5 \times 10^{-10}}{9 \times 10^{-31}}$$

$$= 622222.222\ s^{-1}$$

5a) Biot Savart law states that the magnetic field is directly proportional to the product permeability of free space, the current (I), the change in length the radius and inversely proportional to square of radius (r^2) It can be represented mathematically by Where is a constant called permeability of free space. The unit is weber / metre square

5b)



Applying the Biot - Savart law we find the magnitude of field dB

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

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

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

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

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

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

Substituting eqn 2 into 1 we have

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

Using law of Biot Savart

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

Recall $dl = dy$

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

Using special integrals

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

Equation 3 therefore becomes

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

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

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

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

With the length 2a of the conductor is very great in comparison to its distance from point p. we consider it infinitely long. That is, when a is much larger than x

$(x^2+a^2)^{1/2} = a$ 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, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r} \quad \text{------ (4)}$$