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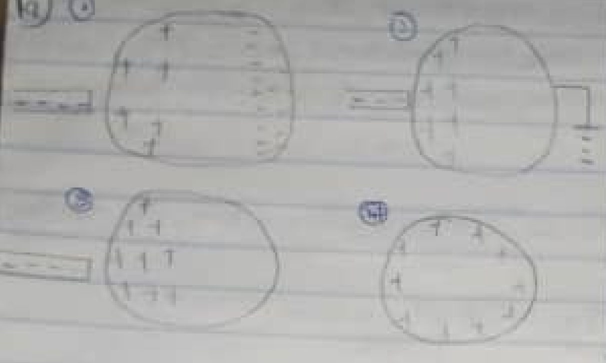
Section A

1a)



1b) Each of the small spheres is charged positively, the combined charge being $5.0\times10^{-5}C$. If each sphere is repelled from the other by a force when the spheres are 2.0m apart, calculate the charge on each sphere.

Solution

$F = \frac{kq_1q_2}{r^2} \Rightarrow \frac{Fr^2}{K} = q_1q_2$

$= \frac{1\times(2)^2}{(9\times10^9)} = 4.44\times10^{-10}C^2$

Now we have two equations for the two unknowns q_1 and q_2

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

$q_1q_2 = 4.44\times10^{-10}$

$\therefore (5.0\times10^{-5}q_1 - q_2) = 4.44\times10^{-10}$

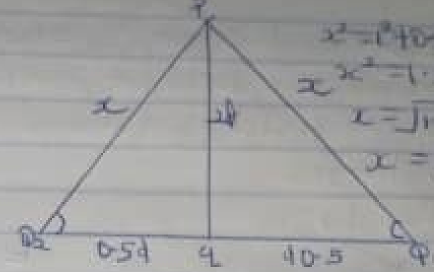
$= q_1^2 - (5.0\times10^{-5}q_1) + 4.44\times10^{-10} = 0$

A quadratic formula

$q_1q_2 = \frac{(5\times10^{-5}) \pm \sqrt{(5\times10^{-5})^2 - 4(4.44\times10^{-10})}}{2}$

$q_2 = 3.84\times10^{-5}C,\ q_2\ 1.16\times10^{-5}C$

1c)



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

$x^2 = 1.25$

$x = \sqrt{1.25}$

$x = 1.12$

$E_1 = \frac{kq_1}{r^2} = \frac{(9\times10^9)\times(8\times10^{-6})}{(1.12)^2} = 57.4\times10^{3}N/C$

$E_2 = \frac{(9\times10^9)\times(8\times10^{-6})}{(1.12)^2} = 57.4\times10^{-3}N/C$

$E_2 = \frac{(9\times10^9)\times q}{1} = 9\times10^9 q$

vector	angle	x-comp	y-comp
$q = 8N/C$	90^0	$0N/C$	$8N/C$
$E_2 = 4.32$	36.87^0	$-3.45N/C$	$2.59N/C$
		$E_x = -3.45N/C$	$E_y = 10.59N/C$

$E_{net} = \sqrt{\Sigma Fx^2 + \Sigma Fy^2}$

$E_{net} = 11.12N/C$

Where Q = charge

V = volume

L = length

A = area

3a) i) volume charge density, ρ =

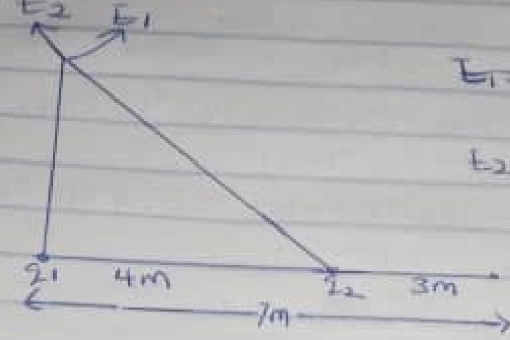
$\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$

2a) Electric field	Electric field intensity
- It's a region of space in which an electric charge will experience and electric force.	It is the force per unit charge

1c)

4 2b) $q_1 = 8nC$ at origin, $q_2 = 12nC$ on x axis at $x = 4m$
(i) Net electric field at point P on the x axis at $x = 7m$
(ii) electric field at a point Q on the y axis at $y = 3m$ due to the charges

4 i)

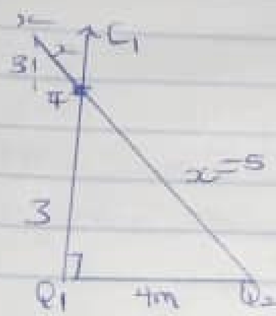


$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.49\ N/C \approx 1.5N$

$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{7^2} = 12\ N/C$

10 ∴ $E_{net} = E_1 + E_2 = (1.5 + 12)\ N/C =$
13.5 N/C

ii)



$c^2 = a^2 + b^2$
$= 4^2 + 3^2$
$= 5$

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

$E_2 = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32\ N/C$

3a) i) Volume charge density $\rho = \frac{dQ}{dV} \to dQ = \rho dV$

ii) Surface charge density $\sigma = \frac{dQ}{dA} \to dQ = \sigma dA$

iii) Linear charge density $\lambda = \frac{dQ}{dL} \to dQ = \lambda dL$

3b) Electric potential difference equation due to a single point charge

$V_B - V_A = \frac{Q}{4\pi\varepsilon_0} \cdot \left[\frac{1}{r_B} - \frac{1}{r_A}\right]$

Where Q = point charge

r_B = distance of Q to point B $\quad$ V = electric potential

r_A = distance of Q to point A

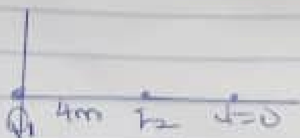
* due to several point charges

$$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$ where V = electric potential

Q = point charge

r = distance of Q

(3c) $V = \frac{kQ}{r}$ $\quad V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$ recall $\frac{1}{4\pi\varepsilon_0} = 9\times10^9 = k$



$$V_P = k\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

$$V_P = 9\times10^9 \times \left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right]$$

$$0 = 9\times10^9 \times \left[\frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x}\right]$$

$$0 = \frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4+x} = \frac{2\times10^{-6}}{x}$$

$$10\times10^{-6}x = (4+x)(2\times10^{-6})$$

$$10\times10^{-6}x = 8\times10^{-6} + 2\times10^{-6}x$$

$$8\times10^{-6} = 10\times10^{-6}x - 2\times10^{-6}x$$

$$8\times10^{-6} = 8\times10^{-6}x$$

$$x = \frac{8\times10^{-6}}{8\times10^{-6}}$$

$$x = 1$$

∴ Position along the x axis is 1m

Where $V = 0$

$$V = k\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

$$0 = \left[\frac{10\times10^{-6}}{4-x} + \frac{-2\times10^{-6}}{x}\right]$$

$$\frac{2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4-x}$$

$$(4-x)(2\times10^{-6}) = 10\times10^{-6}x$$

$$8\times10^{-6} - 2\times10^{-6}x = 10\times10^{-6}x$$

$$8\times10^{-6} = 10\times10^{-6}x + 2\times10^{-6}x$$

$$8\times10^{-6} = 12\times10^{-6}x$$

$$x = \frac{8\times10^{-6}}{12\times10^{-6}}$$

$$x = 0.67m$$

∴ Position of $V = 0$ is 0.67m

Section B

4a) magnetic flux can be 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 $\phi = B \cdot dA$

4b) $m = 9 \times 10^{-31} kg$

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

$B = 3.5 \times 10^{-1}$

$\therefore$ cyclotron frequency = angular speed

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

$$\omega = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9 \times 10^{-3}}$$

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

4c) ~~i)~~ In the question, we were give parameters such as

i) mass of the electron $= 9.11 \times 10^{-3} kg$

ii) Radius of $1.4 \times 10^{-7} m$

iii) magnetic field of $3.5 \times 10^{-1} w/m^2$

Then we are to calculate the cyclotron frequency which is equal to the angular speed. The cyclotron frequency is a frequency of an accelerator called cyclotron

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

substituting it into the equation, we have

$$\frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-3}} = 6.22 \times 10^{-10} T^{-1}$$