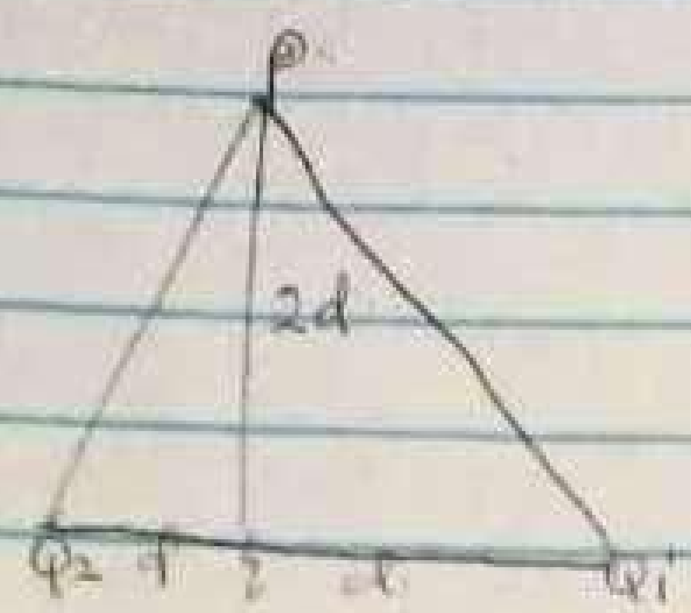
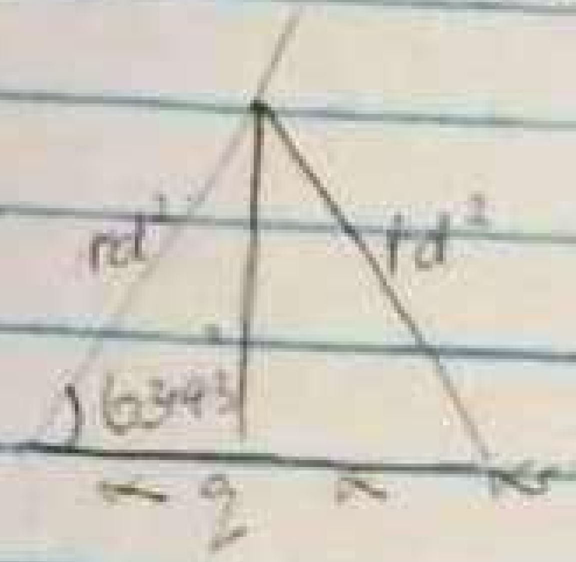
k) Three charges were positioned as shown in the figure below. If $q_1 = q_2 = 8\mu C$ and $d = 0.5m$, determine q if the electric field at $P = 2600$



Solution



$\sqrt{2d^2 + d^2} = d/3 = 7m$ $\theta = \frac{2d}{d}$

$d = 0.5$

$E_1 = \frac{Kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(d\sqrt{5})^2} = \frac{9\times10^9 \times 8\times10^{-5}}{(5\sqrt{5}/2)^2} = 5.7600N/C$

$E_2 = \frac{Kq}{r^2} = \frac{9\times10^9 \times (8\times10^{-6})}{(d/\sqrt{5})^2} = 5.9600N/C$

$E_q = \frac{Kq}{r^2} = \frac{9\times10^9 \times q}{(2d)^2} = \frac{9\times10^9}{1^2} = 9\times10^5 q N/C$

2

1

26

KANTIOK EABRANG JEREMIAH

MEDICAL LABORATORY SCIENCE

17/MHS06/019

1 Explain with The aid of a diagram how you can produce a negatively charged sphere by method of conduction

2 Electric charges can be obtained on an object without touching it by a process called electronic radiation

Consider a negatively charged rubber rod brough a neutral conducting sphere that is insulated so that there is no conducting path to ground The repulsive force between the electrons in the rod and those in the sphere causes a redistribution of charges in the sphere so that some electrons move to the side of the sphere farthest away from the rod The region of sphere nearest the negatively charged rod has an excess of positive charge because of the migration of electrons away from this location if a grounded conducting wire is the connected to the sphere. Some of the electrons leave the sphere and travel to the earth. if the wire to ground is then removed, the conducting sphere is left with an excess of induced positive charge

Finally when rubber rod is removed from The vicinity of the sphere, the induced positive charg remaing on the ungrounded sphere and becomes uniformly distributed over the spheres surface

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

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

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

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

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

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

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

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

$x = 1$.

∴ position along the x-axis is 1m

where $V = 0$

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

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

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

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

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

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

3 formulation of identities of charge.

(i) volume charge density $\rho = \frac{dQ}{dV} = dQ = \rho dV$

(ii) surface charge density $\sigma = \frac{dQ}{dA} = dQ = \sigma\, dA$

(iii) linear charge density $\lambda = \frac{dQ}{dx} = dQ = \lambda\, dL$

(b) Electric potential difference equation

due to a single point charge

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

where Q = point charge V = Electric potential

r_B = distance of Q to point B.

r_A = distance of Q to point A

Due to several point charges

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

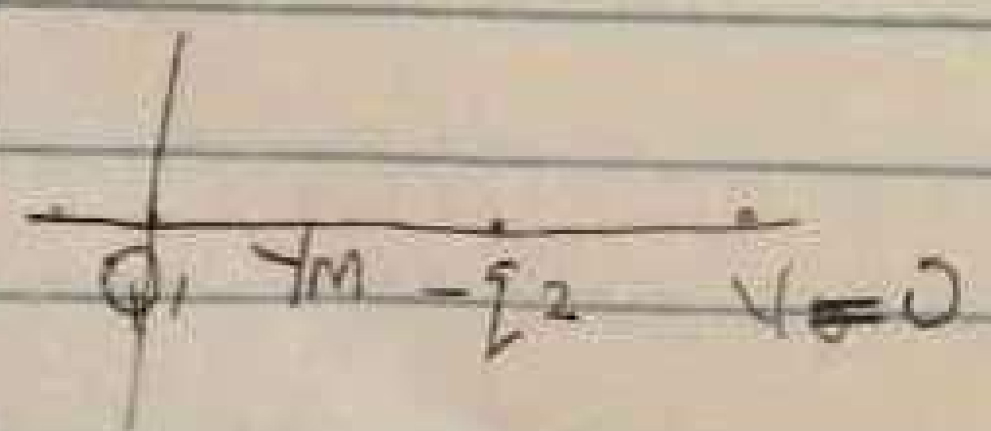
Q = point charge

r = distance of Q

3c point charge $Q_1 = 10\mu C$ $Q_2 = -2\mu C$ along x axis $x = 0$ $x_2 = 4m$

find the position along the x-axis where $V = 0$

$$V_P = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right)$$ recall $\frac{1}{4\pi\varepsilon_0}$ = 9×10^9 CK.



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

$4 = 9 \times 10^9 (5 \times 10^{-5} - q_2) q_2$

$4 = 4.5 \times 10^{-5} q_2 - 9 \times 10^9 q_2^2$

$-9 \times 10^9 q_2^2 + 4.5 \times 10^{-5} q_2 - 4 = 0$

Using quadratic formula

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

$a = 9 \times 10^9$, $b = 4.5 \times 10^{-5}$ $c = -4$

$$q = \frac{-4.5 \times 10^{-5} \pm \sqrt{(4.5 \times 10^{-5})^2 - 4(-9 \times 10^9)(-4)}}{2(-9.0 \times 10^9)}$$

$$= \frac{-4.5 \times 10^{-5} \pm \sqrt{(2.025 \times 10^{-9})^2 - 4(-9 \times 10^9)(-4)}}{-18.0 \times 10^9}$$

$$= \frac{-4.5 \times 10^{5} \pm \sqrt{3.6 \times 10^{10}}}{-18.0 \times 10^9}$$

$$= \frac{-4.5 \times 10^5 \pm 189736.6596}{-19.0 \times 10^7}$$

$$= \frac{+4.5 \times 10^5 - 189736.6596}{-18.0 \times 10^7}$$

$q = 1.10 \times 10^{-5}\ C$

$\therefore$ Recall $q_1 = 5 \times 10^{-5} - q_2$. Making q_2 subject of the fm.

$\therefore q_2 = 5 \times 10^{-5} - q_1$

$q_2 = 5 \times 10^{-5} - 1.10 \times 10^{-5}$

$q = 3.9 \times 10^{-5} C$

$\therefore q_2 = 3.9 \times 10^{-5} C$

$q_1 = 1.10 \times 10^{-5} C$

because it is a frequency of an accelerator called cyclotron
Recall w = angular speed

$$w = \frac{qB}{me}$$

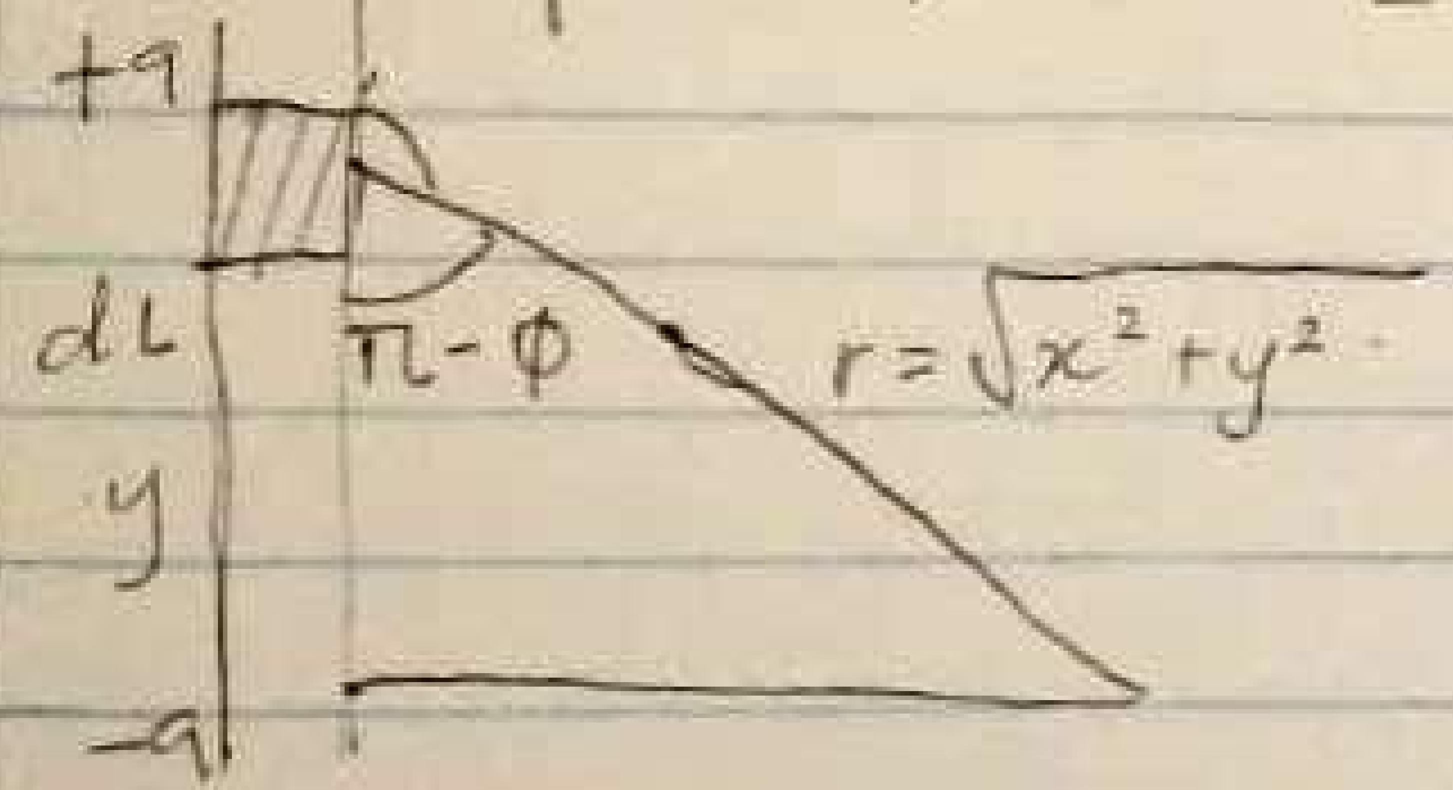
Since cyclotron frequency = angular speed, the cyclotron frequency = 6.14×10^{-10} C' having a unit of $\frac{1}{t}$ which is the unit of frequency dimensionally.

5a Bio-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). Mathematically:

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

where μ_0 (permeability of free space) $= 4\pi \times 10^{-7}$ T m/A, r = radius, $d\vec{B}$ = magnetic field, I = steady current, dL = length of wire, unit is w/m².

5b Magnetic field of a straight current carrying conductor



~~magnetic field~~ applying Bio-Savart law, we find the magnitu-

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

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

$x = 0.69m$

$\therefore$ position of $v=0$ is $0.67m$

4a Magnetic flux is defined as the strength of the magnetic field which can be represented by line of force. It is denoted as ϕ

$\phi = B\,dA$

b $m_e = 9.11\times10^{-31}$ kg, $r = 1.4\times10^{-7}$ m $B = 3.5\times10^{-1}$ w/m^2

cycloton frequency = angular speed $q = 1.6\times10^{-19}$

$F_B = qvB = \dfrac{m_e v^2}{r}$

$M_e v = qBr$

$v = \dfrac{qBr}{m_e} = \dfrac{1.6\times10^{-19}\times3.5\times10^{-1}\times1.4\times10^{-7}}{9.11\times10^{-31}}$

$v = 8.61\times10^{-3}$ m/s

$\omega = \dfrac{v}{r} = \dfrac{qB}{m_e} = \dfrac{1.6\times10^{-19}\times3.6\times10^{4}}{9.11\times10^{-31}}$

$\omega = 6.14\times10^{10}c^{-1}$

4c in 4b we were given parameters mass of electron = 9.11×10^{-31} kg radius = 1.4×10^{3} m $B = 3.5\times10^{-1}$ w/m^2.

And we were asked to find the cyclotron frequency which is the same thing as angular speed it is called cycloton frequency at the point C from the diagram

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

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

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

from the diagram $r^2 = x^2 + y^2$

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

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

Substitute (ii) into (i)

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

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

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

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

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

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

Vector	θ	x component	Y component
$E_1 = 57600\,N/C$	63.43	$57600 \cos 63.43 = -25764$	$57600 \sin 63.43 =$ [illegible]
$E_2 = 57600\,N/C$	63.43	$57600 \cos 63.43 = 25764$	$57600 \sin 63.43 =$ [illegible]
$E_3 = 9\times10^3\,N/C$	90°	$9\times10^9 q \cos 90$ $\Sigma f x = 0$	$9\times10^9 \sin 90 = 9\times10^9 q$ $\Sigma f y = 103033.6 + 9\times10^9 q$

$E_{res} = \sqrt{(\Sigma f x)^2 + (\Sigma f y)^2}$ E net at a point = 0

$\therefore\ 0 = \sqrt{0^2 + (103033.6 + 9\times10^9 q)^2}$

$0 = 103033.6 + 9\times10^9 q$

$q = \dfrac{-103033.6}{9\times10^9}$

$q = -1.1448\times10^{-5}$

$q = -11.4\times10^{-6}$

$q = -11.4\,\mu C$

2 Electric field & electric field intensity

Electric field	Electric field intensity
1 It is a region of space in which an electric charge will experience an electric force	It is the force per unit charge.

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

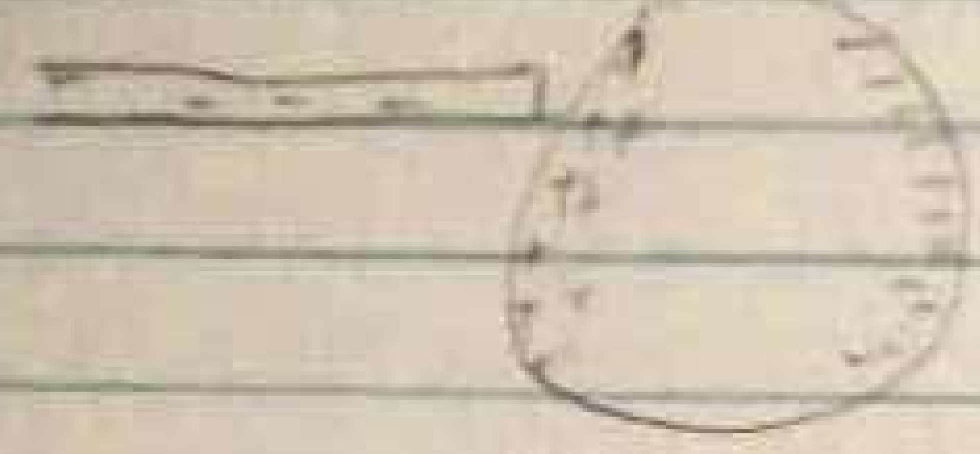


Fig A

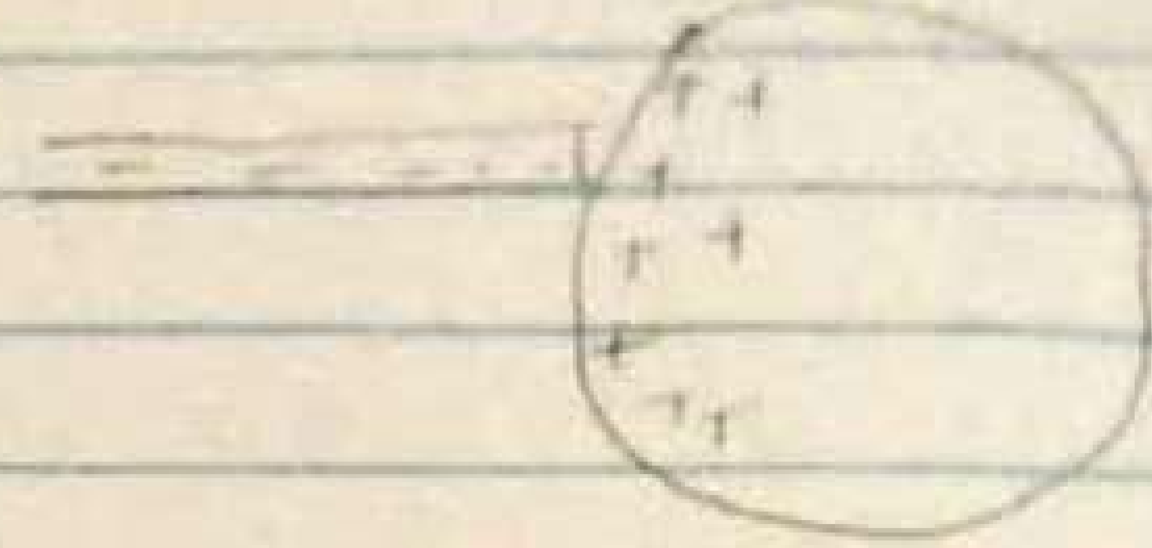


Fig C

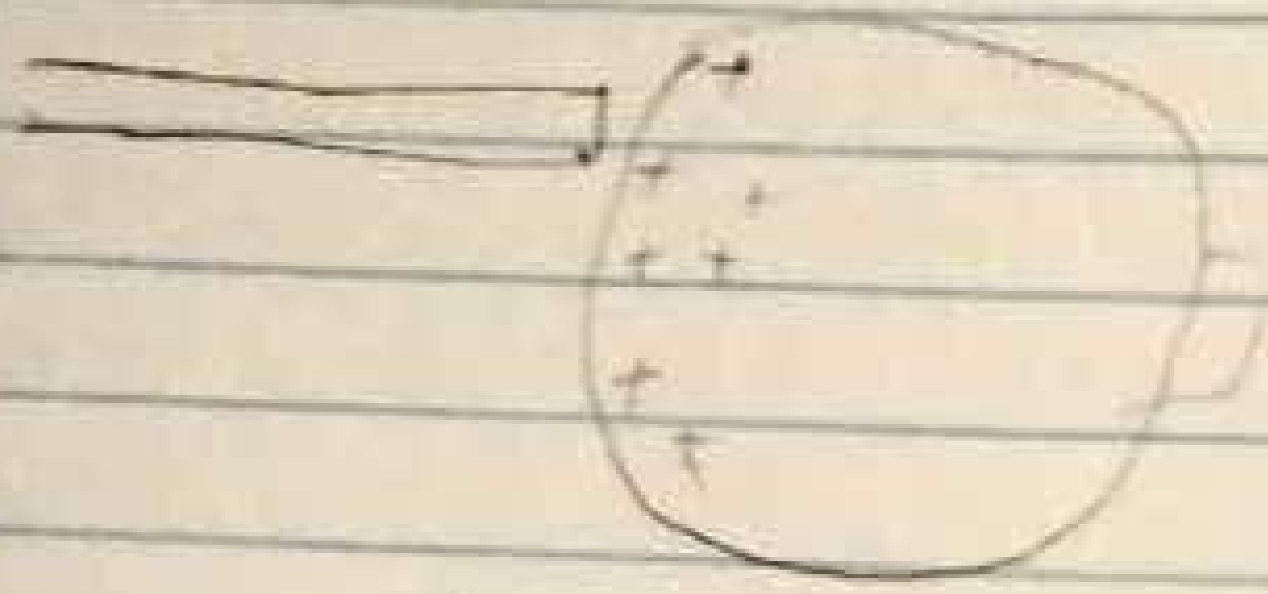


Fig B

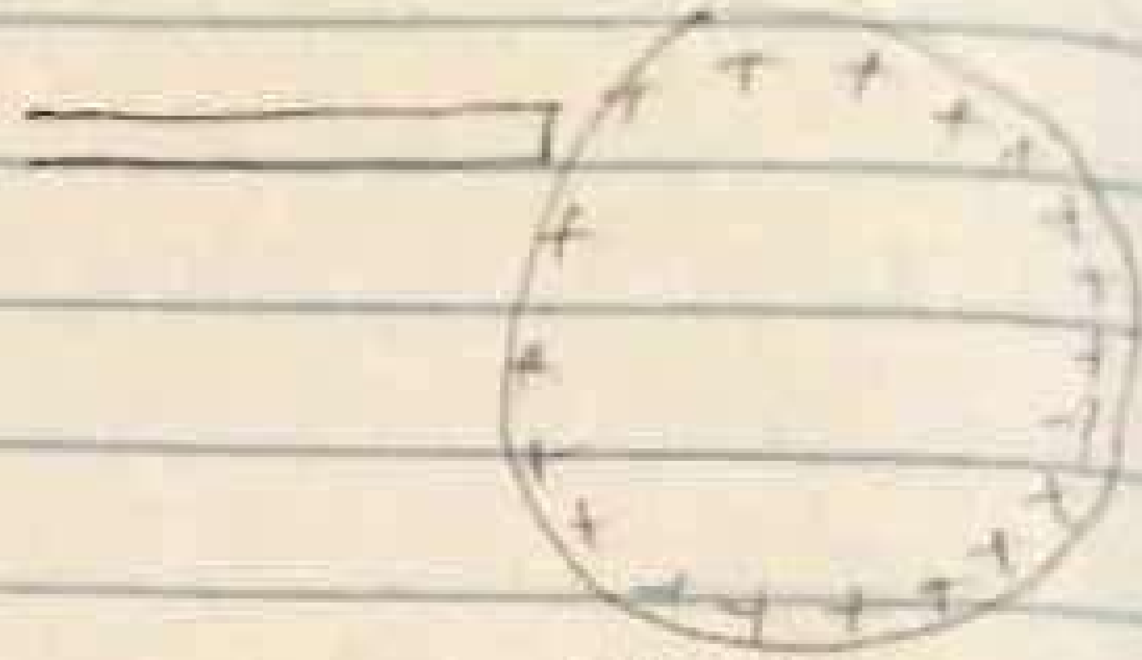


Fig D

6\. Each of two small sphere is charged positively, the combined charge being 5.0×10^{-5} if each sphere is repelled from the other by a force of 1.0N when the spheres are 2.0m apart. Calculate the charge of each sphere

solution

$q_1 + q_2 = 5 \times 10^{-5}C \therefore q_1 = 5 \times 10^{-5} - q_2$

parameters $F = 1.0N$ $r = 2.0m$

Recall $F = \frac{Kq_1q_2}{r^2}$, $1.0N = \frac{9 \times 10^9 (q_1)(q_2)}{(2)^2}$

$\therefore 1.0 = \frac{9 \times 10^9 (q_1)(q_2)}{4}$

$= 4 = 9 \times 10^9 (q_1)(q_2)$ replacing $q_1 = 5 \times 10^5 - q^2$