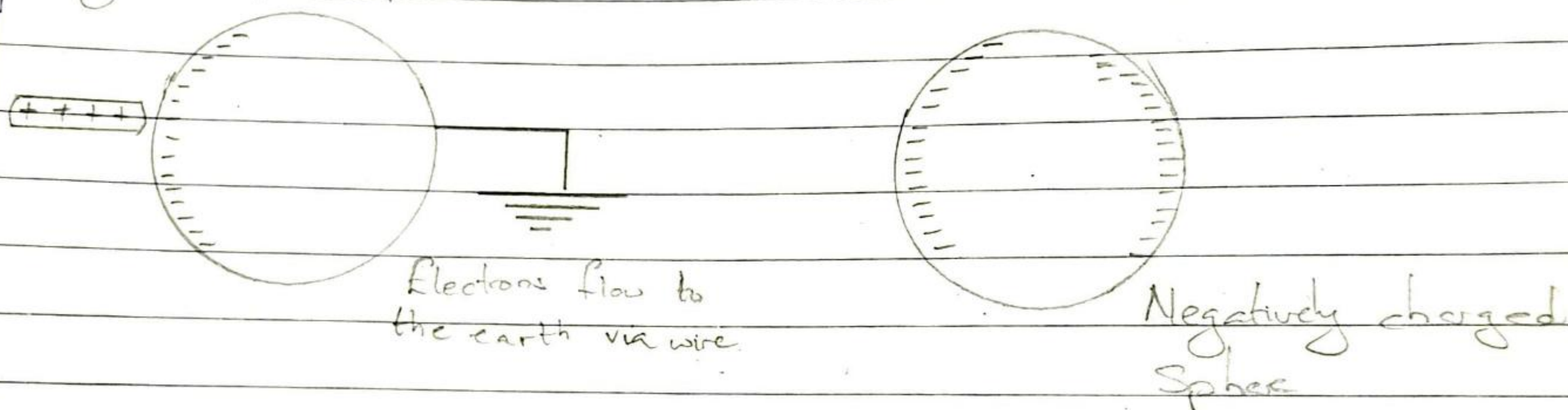
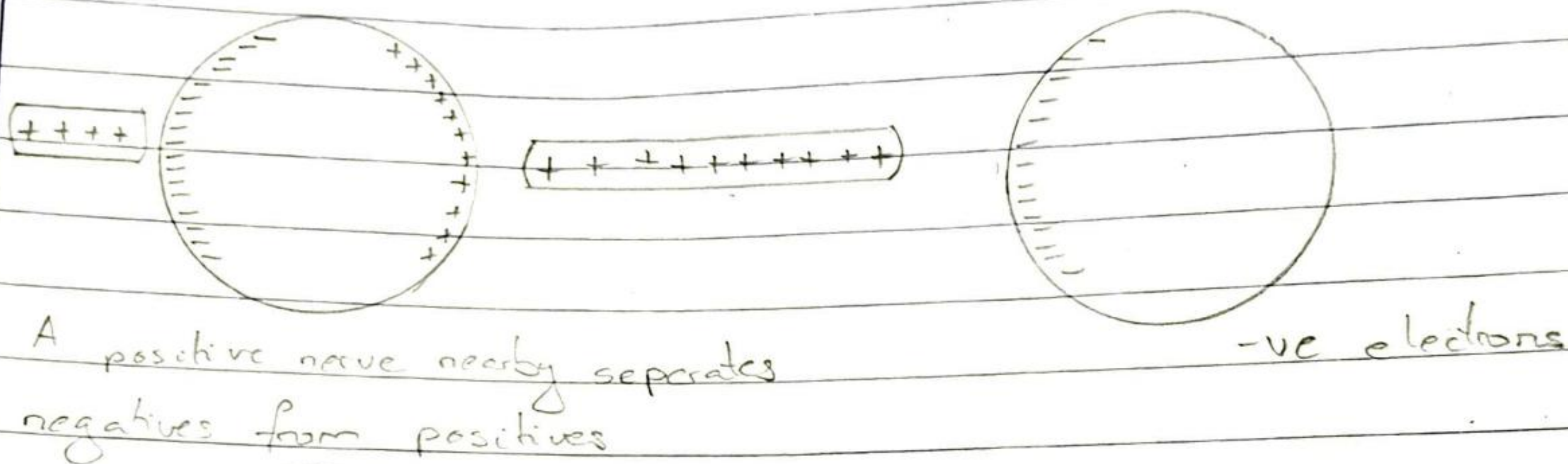


PHY 102 Assignment

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 Dept: NURSING  
 Course code: PHY 102  
 MATRIC NO: 19/MHS02/051

# 1. Production of a Negatively Charged Sphere by Induction



b  $k = 9 \times 10^9 \text{ Nm}^2\text{C}^{-1}$ ,  $F = 1.0 \text{ N}$ ,  $d = 2.0 \text{ m}$

Soln

$$q_1 + q_2 = 5 \times 10^{-5} \text{ --- (1)}$$

$$F = \frac{k q_1 q_2}{r^2}$$

$$1 = \frac{9 \times 10^9 (q_1 q_2)}{2^2}$$

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

$$q_1 q_2 = 4.44 \times 10^{-10} \text{ --- (2)}$$

from eqn (1)

$$q_2 = 5 \times 10^{-5} - q_1 \text{ --- (3)}$$



Substitute eqn (3) into (2)

$$q_1 (5 \times 10^{-5} - q_1) = 4.44 \times 10^{-10}$$

$$5 \times 10^{-5} q_1 - q_1^2 = 4.44 \times 10^{-10}$$

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

$$\therefore q_1^2 - 5 \times 10^{-5} q_1 + 4.44 \times 10^{-10} = 0$$

Using Quadratic Formula

$$q_1 = \frac{-(-5 \times 10^{-5}) \pm \sqrt{(-5 \times 10^{-5})^2 - 4(1)(4.44 \times 10^{-10})}}{2(1)}$$

$$q_1 = \frac{5 \times 10^{-5} \pm \sqrt{2.5 \times 10^{-9} - 1.776 \times 10^{-9}}}{2}$$

$$q_1 = \frac{5 \times 10^{-5} \pm \sqrt{7.24 \times 10^{-10}}}{2}$$

$$= \frac{5 \times 10^{-5} \pm 2.69 \times 10^{-5}}{2}$$

$$q_1 = \underline{3.84 \times 10^{-5} \text{ C}}$$

from eqn (3)

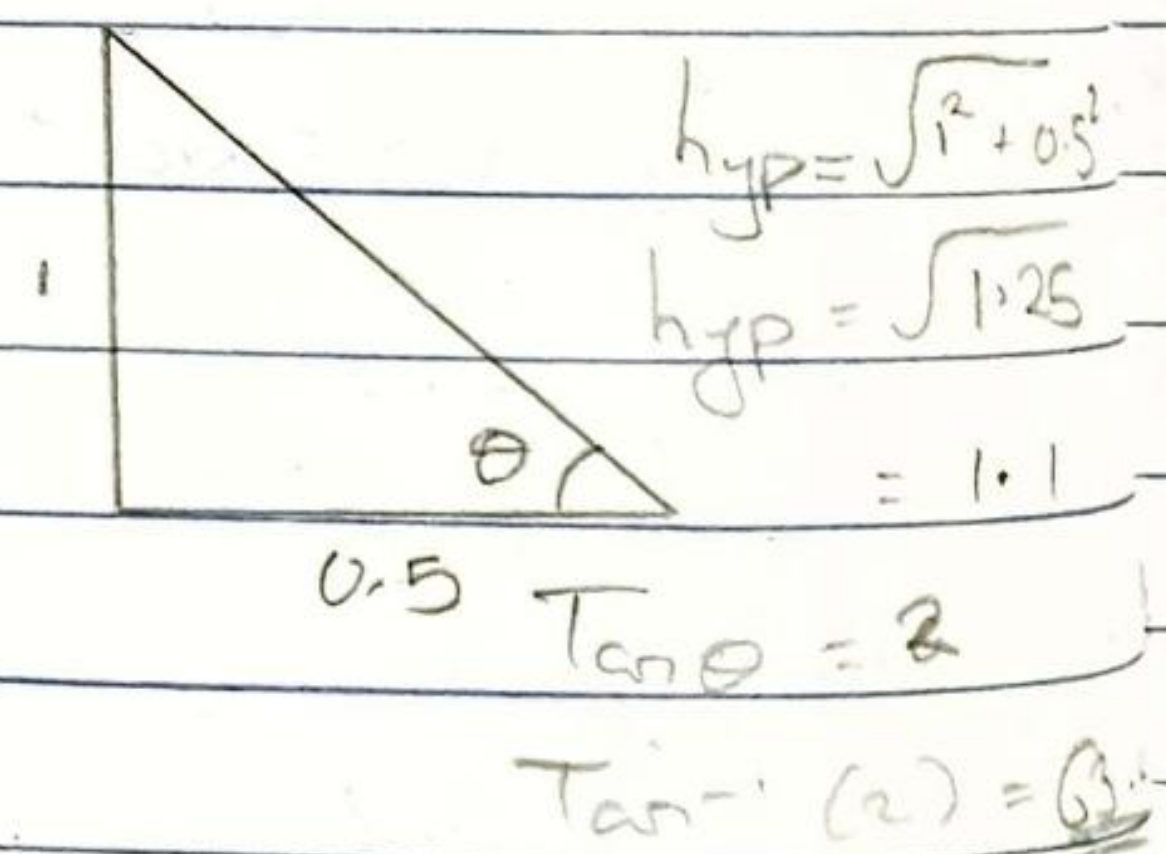
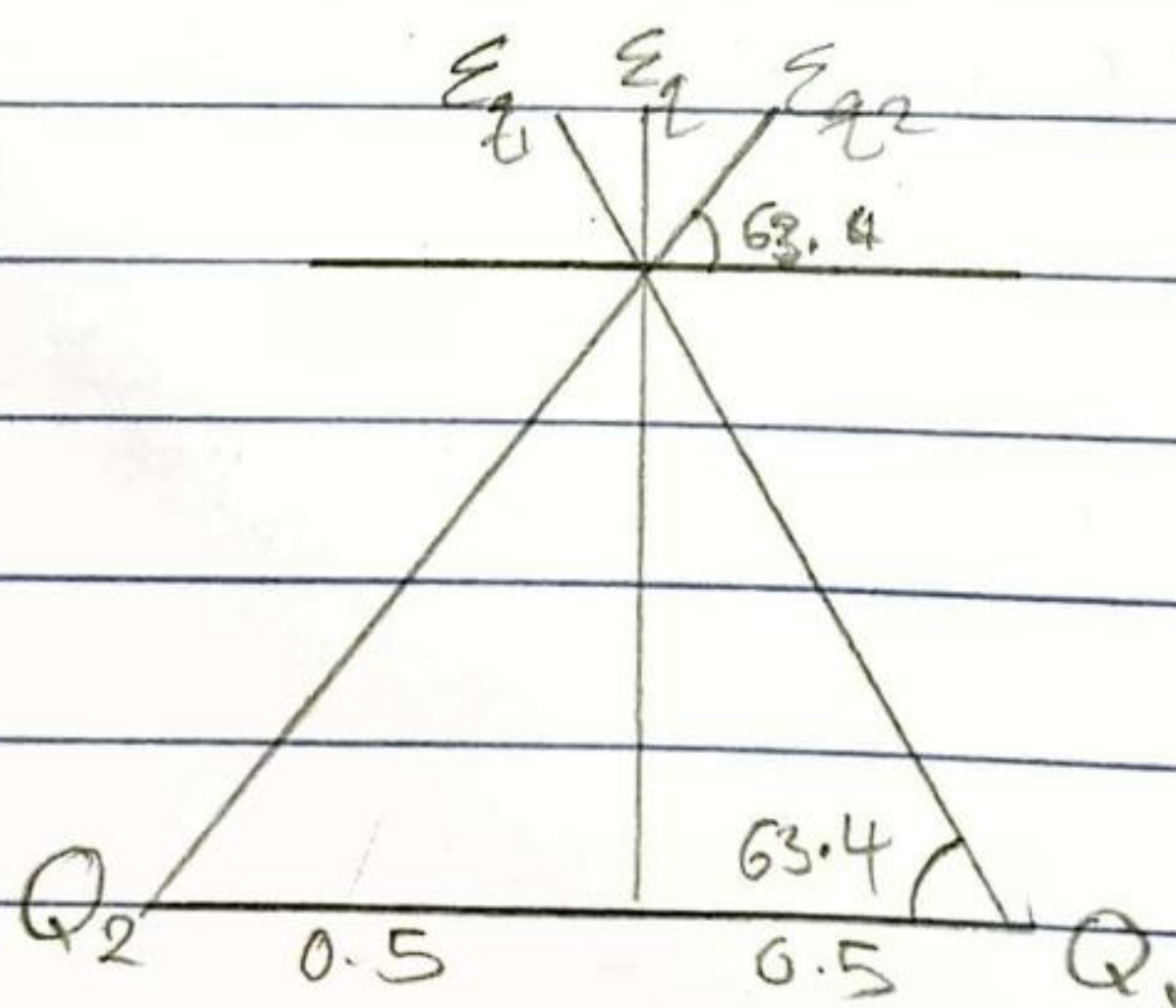
$$q_2 = 5 \times 10^{-5} - 3.84 \times 10^{-5}$$

$$= \underline{1.16 \times 10^{-5} \text{ C}}$$

$$\therefore q_1 = 3.84 \times 10^{-5} \text{ C}$$

$$q_2 = 1.16 \times 10^{-5} \text{ C}$$

c  $Q_1 = Q_2 = 8 \text{ nC}$ ,  $d = 0.5 \text{ m}$



$$\text{hyp} = \sqrt{1^2 + 0.5^2}$$

$$\text{hyp} = \sqrt{1.25}$$

$$= 1.1$$

$$\tan \theta = 2$$

$$\tan^{-1}(2) = 63.4^\circ$$

$$E_p = E_{q_1} + E_{q_2} + E_q$$

$$E_{q_1} = \frac{kq_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{1.1^2} = 59504 \text{ NC}^{-1}$$



$$E_{q2} = \frac{kq_2}{r_2^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{1.1^2} = 59504 \text{ NC}^{-1}$$

$$E_q = \frac{kq}{r^2} = \frac{9 \times 10^9 q}{1^2} = 9 \times 10^9 q \text{ NC}^{-1}$$

Vector	Angle	x-component	y-component
$E_{q1} = 59504$	$63.4^\circ$	$59504 \cos 63.4$ $= -26643.46$	$59504 \sin 63.4$ $= 53205 \text{ NC}^{-1}$
$E_{q2} = 59504$	$63.4^\circ$	$59504 \cos 63.4$ $= 26643.46$	$59504 \sin 63.4$ $= 53205 \text{ NC}^{-1}$
$E_q = 9 \times 10^9 q$	$90^\circ$	$9 \times 10^9 q \cos 90 = 0$ $E_{xc} = 0$	$9 \times 10^9 q \sin 90 = 9 \times 10^9 q$ $E_y = 106410 + 9 \times 10^9 q$

$$E_p = \sqrt{0^2 + (106410 + 9 \times 10^9 q)^2}$$

$$E_p = 106410 + 9 \times 10^9 q$$

$$\text{At } E_p = 0$$

$$106410 + 9 \times 10^9 q = 0$$

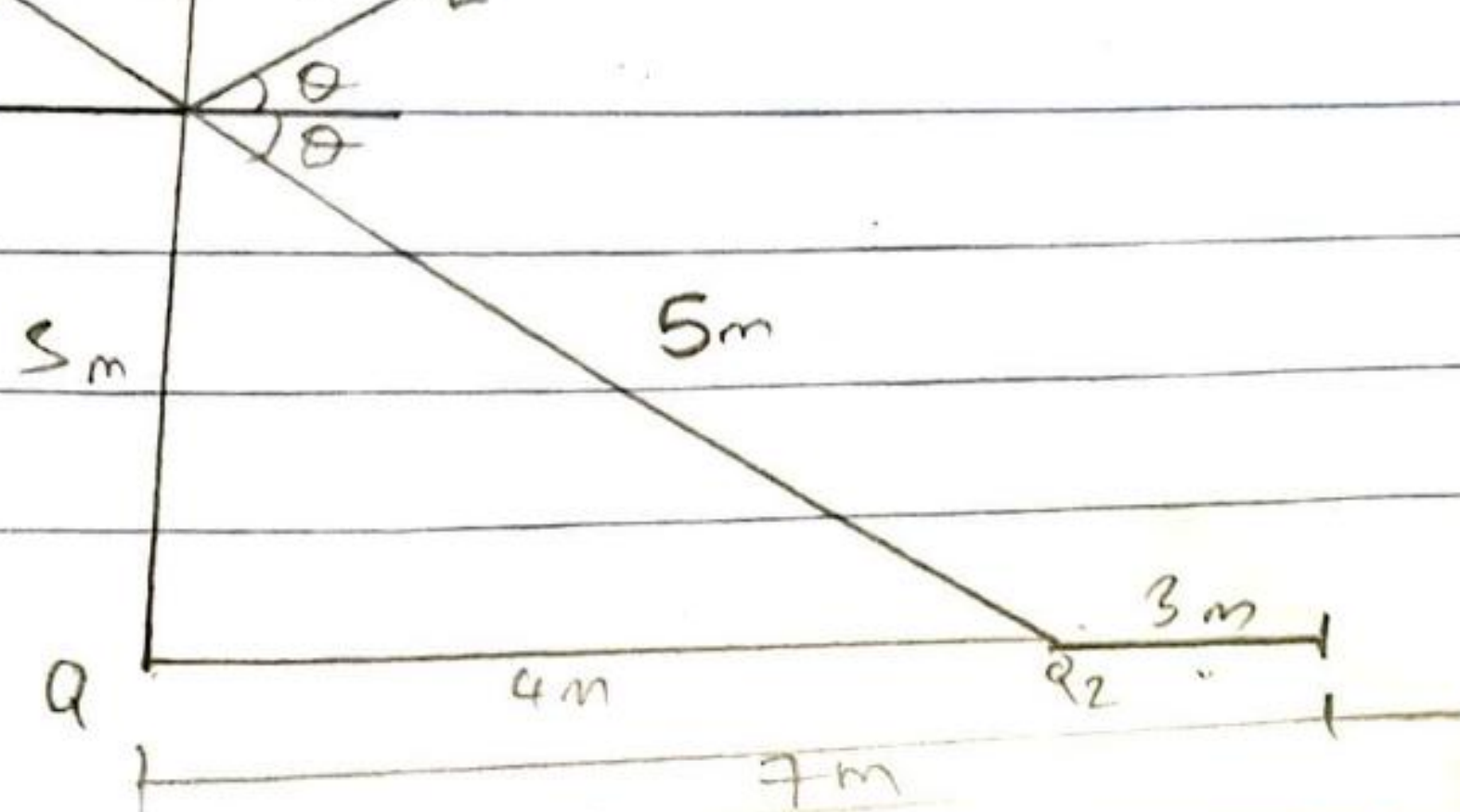
$$\frac{9 \times 10^9 q}{9 \times 10^9} = \frac{-106410}{9 \times 10^9}$$

$$q = -1.18 \times 10^{-5} \text{ C}$$

$$= \underline{\underline{1.18 \mu\text{C}}}$$

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

b  $Q_1 = 8 \text{ nC}$   $Q_2 = 12 \text{ nC}$





$$i \quad E_{net} = E_Q + E_{Q_2}$$

$$E_{Q_1} = \frac{kQ_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = 1.469 \text{ N/C}^{-1}$$

$$E_{Q_2} = \frac{kQ_2}{r_2^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = 4.32 \text{ N/C}^{-1}$$

$$E_{net} = 8 + 12$$

$$= 20 \text{ N/C}$$

Vector	Angle	x-comp	y-comp
$E_1 = 8 \text{ N/C}$	$90^\circ$	$E_{1x} = 8 \times \cos 90$ $= 0$	$E_{1y} = 8 \sin 90$ $= 8$
$E_2 = 4.32 \text{ N/C}$	$36.9^\circ$	$E_{2x} = -4.32 \cos 36.9$ $= -3.45$	$E_{2y} = 4.32 \sin 36.9$ $= 2.59$
		$E_{fx} = -3.45$	$E_{fy} = 10.59$

4 Magnetic flux through a surface is the surface integral of the normal component of the magnetic field flux density passing through that surface. The S.I unit is weber. it is represented by the symbol  $\phi$ .

$$b \quad m_e = 9.11 \times 10^{-31} \text{ kg}, \quad r = 1.4 \times 10^{-7} \text{ m}, \quad B = 3.5 \times 10^{-1} \text{ Wb m}^{-2}$$

$$\theta = 90^\circ; \quad \omega = ?, \quad q = -1.6 \times 10^{-19} \text{ C}$$

$$\omega = \frac{qB}{m_e}$$

$$= \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$

$$= -6.15 \times 10^{10} \text{ rad s}^{-1}$$

c The same parameters were given;

Mass of electron, magnetic field and radius

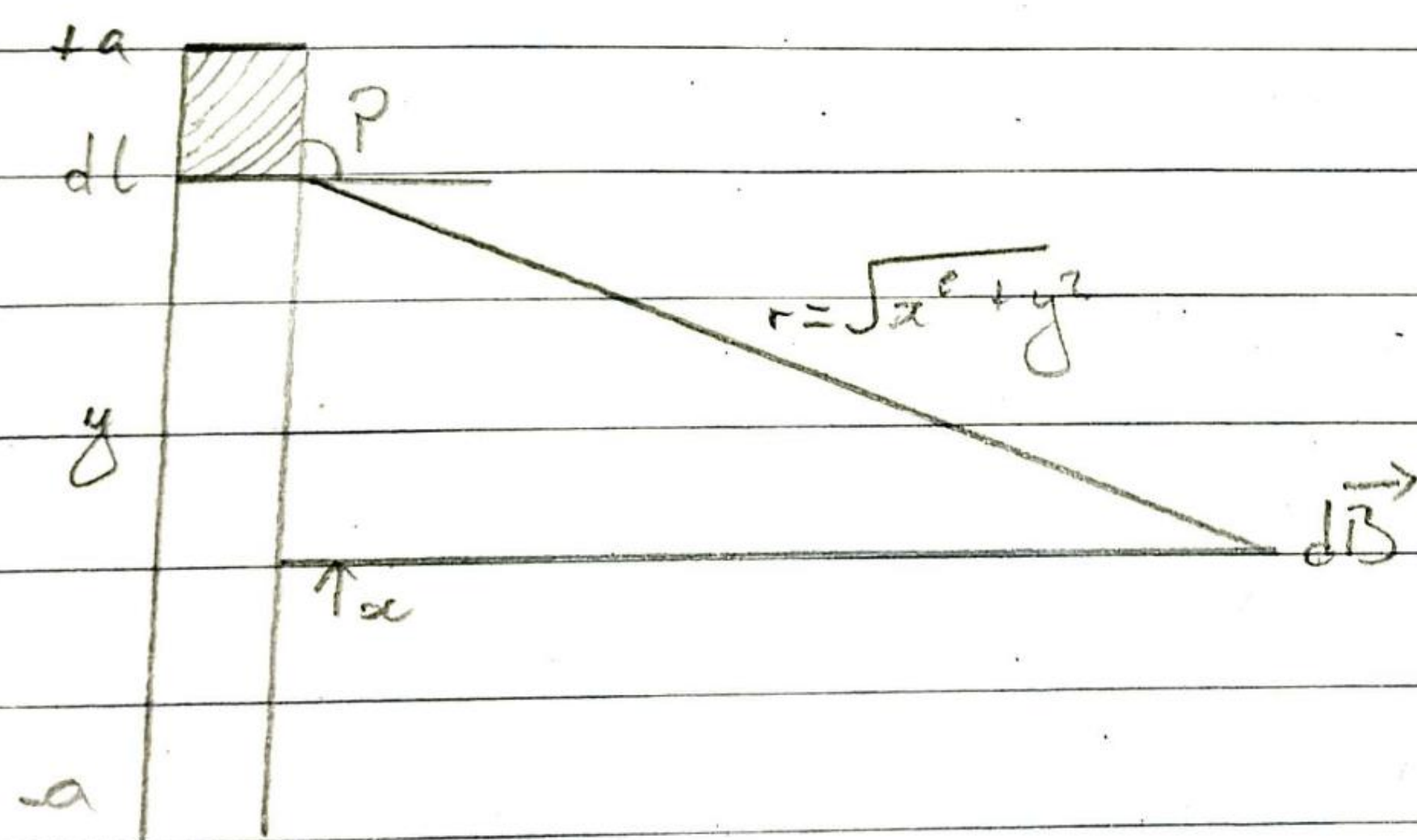
We were asked to find the cyclotron frequency which equal or the same thing as angular speed.

$$\text{Angular speed } (\omega) = \frac{v}{r} = \frac{qB}{m}$$



5 Biot-Savart law states that the magnetic intensity at any point due to a steady current in an infinitely long straight wire is directly proportional to the current and inversely proportional to the distance from point to wire.

6 Magnetic field 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 diagram  $r^2 = x^2 + y^2$  ----- (1)

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

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

Substitute eqn (2) into (1)

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

Recall  $dl = dy$

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

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

Using separate integrals

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

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

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

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

When the length  $2a$  of the conductor is very great in comparison to its distance  $x$  from point P, we consider it infinitely long.

ie, when  $a$  is much larger than  $x$ ;  $(x^2 + a^2)^{1/2} = a$ , as  $a \rightarrow \infty$

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