Name: [illegible]
Dept: Pharmacy
Mat no: 19[illegible]067.
Course: Phy 102.

Covid-19 Holiday Assignment

1a) Charging by Induction: electric charges can be obtained on an object without touching it by a process called electrostatic induction.
Consider a positively charged rubber rod brought near a neutral (uncharged) conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the proton in the rod and those in the sphere causes a redistribution of charges on the sphere so that some protons move to the side of the sphere far that away from the rod in fig 13a. The region of the sphere nearest the positively charged rod has an excess of negative charge because of the connected to the sphere as in fig 13b. Some of the proton leaves the sphere and travel to the earth. If the wire to ground is then removed (fig 13d) the conducting sphere is left with excess of induced negative charge.

Fig 1.3a     fig 1.3c

Fig 1.3b     Fig 1.3d

b) $K = 9\times10^{9}$

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

$F = 1N$

$d = 2m$

Calculate the charge on each sphere?

Recall that

$$K = 9\times10^{9}$$

$$F = \frac{kq_1q_2}{r^2}$$

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

$$4 = 9\times10^{9}\times5\times10^{-5}q_1 + 9\times10^{9}q_2$$

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

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

$$q_1 = 0.0000111C$$

$$q_2 = 0.000038C$$

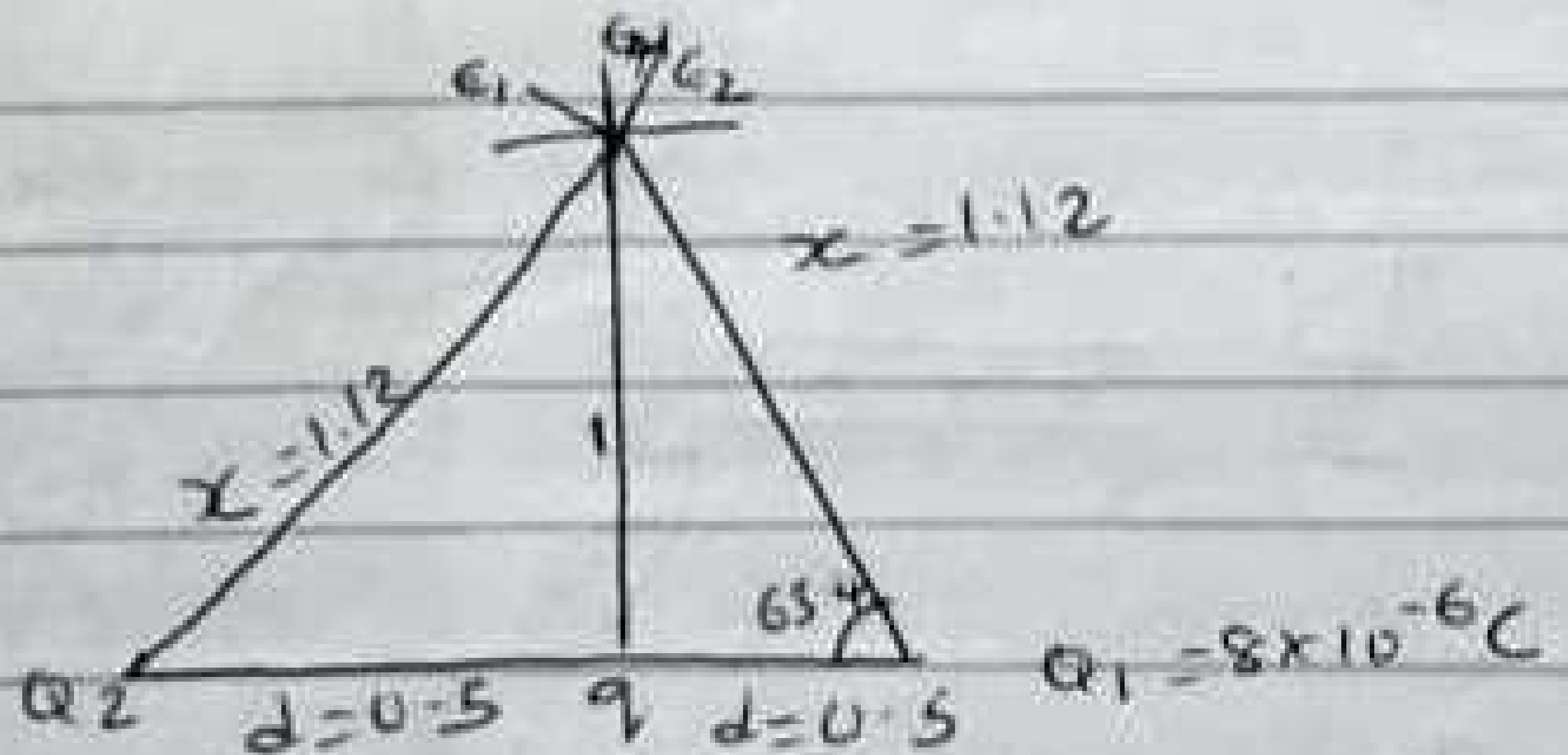
$$= q_1 = 1.11\times10^{-5}\,C$$

$$= q_2 = 3.8\times10^{-5}C$$

C $Q_1 = Q_2 = 8uc$

$d = 0.5m$

determine Q if electric field at a point P is zero




$$E_1 = \frac{kq_1}{r_2} = \frac{9\times10^{9}\times8\times10^{-6}}{(1.12)^2} = 5739.795918$$

$$E_2 = \frac{kq_1}{r^2} = \frac{9\times10^{9}\times8\times10^{-6}}{1.12^2} = 5739.795918$$

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

$$\tan\theta = \frac{opp}{adj} = \frac{1}{0.5} \quad \theta = \tan^{-1}(2)$$

$$\theta = 0.6344$$

| Vector | angle | x - Comp | y - Comp |
|---|---|---|---|
| $E_1 = 5739.795918$ | $63.4^\circ$ | $E_1 \times \cos\theta$ <br> $-2570.045785$ | $5132.262839$ |
| $E_2 = 5739.795918$ | $63.4^\circ$ | $2570.045785$ | $5132.262839$ |
| $E_q = 9\times10^9 q$ | $90^\circ$ | $E_q \cos\theta = 0$ <br> $\Sigma x = 0$ | $9\times10^9 q$ <br> $\Sigma y = 10264.52568$ |

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

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

Since $E = 0$

$0 = 9\times10^9 q + 10264.52568$

making $q$ subject of formulae

$$q = \frac{-10264.5268}{9\times10^9}$$

$q = 1.14050285 3\times10^{-6}$

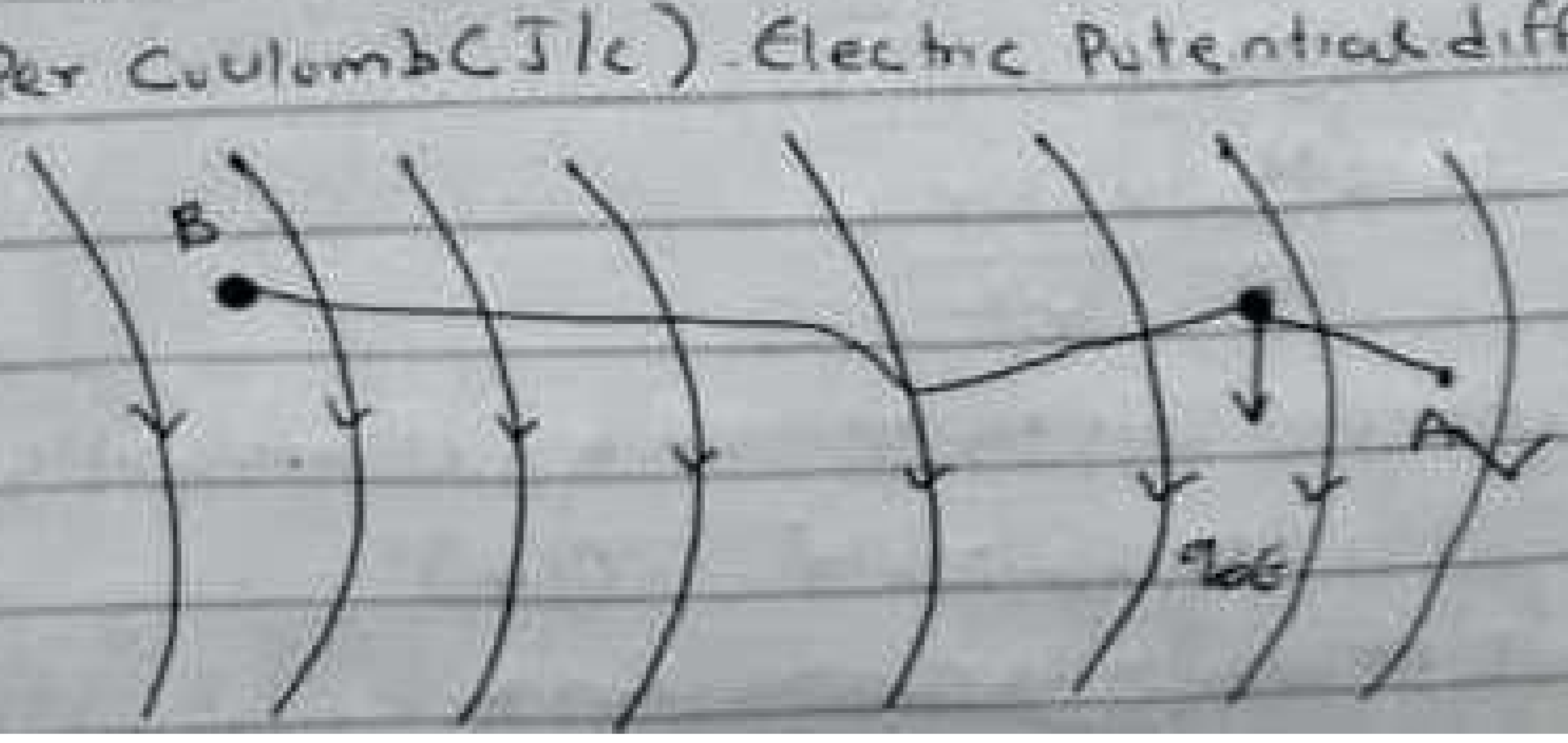
$= q = 11.44c$

3a) i) Volume change density, $P = \frac{dQ}{dv} = Pdv$

ii) Surface Change density, $\sigma = \frac{dQ'}{dA}$ n $dQ = \sigma dA$

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

3b) Electric Potential difference between two points in an electric field Can be defined as the work done per unit Charge against electrical forces when a charge is transported from one Point to the other. It is measured in volt (v) or Joules Per Coulomb (J/c). Electric Potential difference is a scalar quantity.



SECTION B

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 $\phi$ mathematically given as $\phi = B \cdot dA$

4b) $m = 9 \times 10^{-31} kg$, $r = 1.4 \times 10^{-7} m$, $B = 3.5 \times 10^{-1}$ weber/meter$^2$

Cyclotron frequency = angular speed

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

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

$$w = 622.2T^{-1}$$

c) mass of the electron $= 9.11 \times 10^{-31} kg$

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

iii) magnetic field of $3.5 \times 10^{-1}$ weber/meter square

Recall that angular speed is given as $w = \frac{v}{r} = \frac{qB}{m}$

Substituting we have $w = \frac{v}{r} = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-10}}{9.11 \times 10^{-31}}$

$$\frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = 62222222222.22222T^{-1}$$

so since cyclotron frequency is equal to angular speed the cyclotron frequency is equal to $62222222222.22222T^{-1}$; having a unit as $1/T$ which is equal to the unit of frequency dimensionally.

5) Biot-Savart law states that the magnetic field is directly proportional to the product permeability of free space ($\mu$), the current (I), the change in length the radius and inversely proportional to square of radius ($r^2$). It can be represented mathematically by

$$dB = \frac{\mu_0}{4\pi} \frac{I\, dl \times r}{r^2}$$

where $\mu_0$ is a constant called permeability of free space

$$\mu_0 = 4\pi \times 10^{-7} T \cdot m/A$$

The unit of B is weber/metre square

Scanned by TapScanner

5b) Magnetic Field of a Straight Current Carrying Conductor

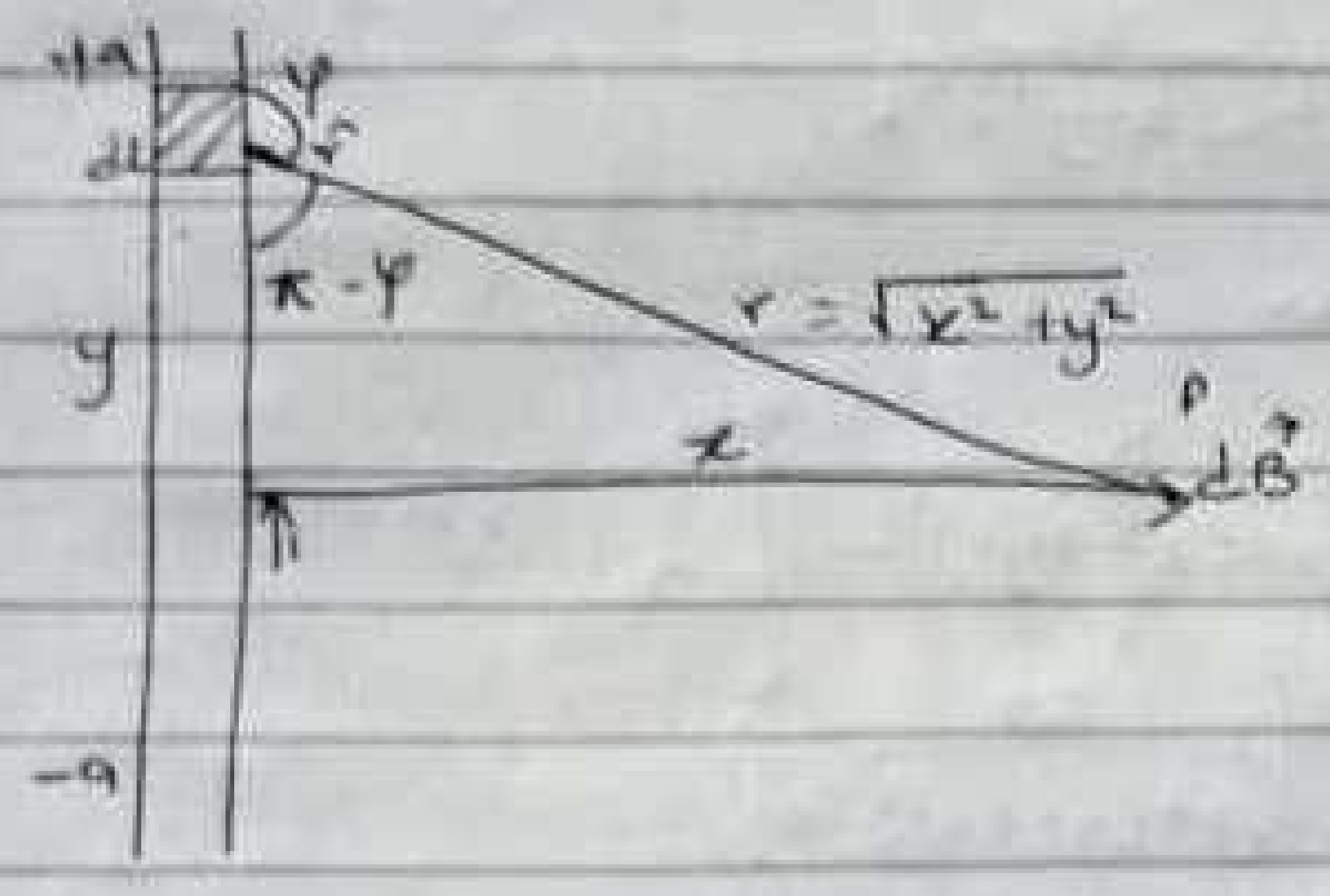



Fig: A section of a straight carrying Conductor

Applying the Biot-savart law,
magnitude of the field d B

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

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

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

From the diagram, $r^2 = x^2 + y^2$ (Pythagoras theorem)

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

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

Substituting eqn 2 into eqn 1 we have

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

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

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

Recall $dl = dy$

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

Using special Integrals:

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

Equation (3) therefore becomes

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

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

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

when the length $2a$ of the conductor is very great in comparison to its distance $x$ from Point P, we consider it infinitely long. 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 symmetery about the y-axis. Thus, at all Points in a circle of radius $r$, around the Conductor, the magnitude of B is $B = \frac{\mu_0 I}{2\pi r}$ ——— $(*)$

Equation $(*)$ defines the magnitude of the magnetic field of flux density B near a long straight current carrying conductor.