Name: Odum Augustine chukwuebuka
Dept: Medicine and surgery
Mat no: 19/MHS01/281
Course code: PHY 102

COVID-19 Holiday assignment

Section A

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 conducting sphere that is insulated so that there is no conducting path to the ground. The repulsive force between the protons 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 farther away from the rod. The region of the sphere nearest to the positively charged rod has an excess of negative charge because of the migration of protons away from this location. If an ~~ground~~ earthed conducting wire is connected to the sphere, some of the protons leave the sphere and travel to the earth. If the earthed wire is removed, the conducting sphere is left with excess induced negative charge. If the rubber rod is removed from the vicinity of the sphere, the induced negative charge remains on the underground sphere and becomes uniformly distributed over the surface of the sphere.

Diagram:

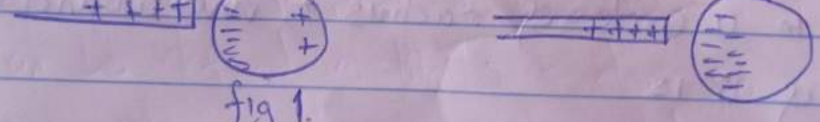
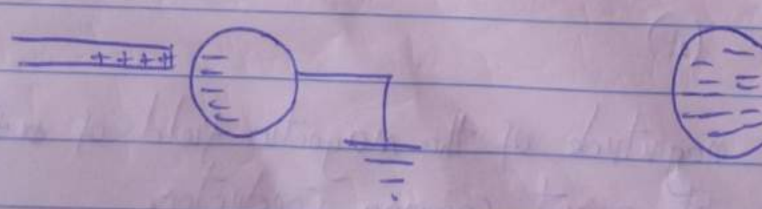


fig 1.



b. $k = 9\times10^{9}$

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

$F = 1N$

$d = 2m$

19/MHsd/281

Calculate the charge on each sphere

recall that

$k = 9\times10^{9}$

$F = \frac{kq_1 q_2}{r^2}$

$1 = \frac{9\times10^{9} \times (q_1 q_2 5\times10^{-5})}{2^2}$

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

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

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

$q_1 = 0.0000111\,C$

$q_2 = 0.000038\,C$

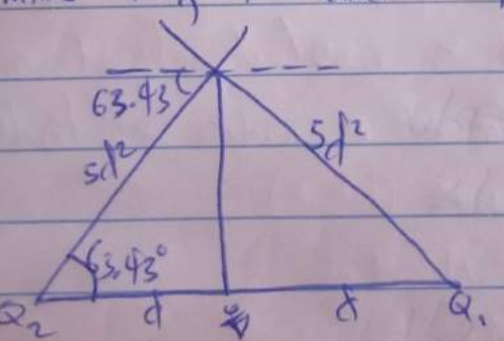
$q_1 = 1.11\times10^{-5}\,C$

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

1c. $Q = Q_2 = 8\mu C$

$d = 0.5m$

determine q if the electric field at a point P is zero



$\sqrt{2d^2+d^2} = d\sqrt{5}$ $\quad$ $\tan\theta = \frac{2d}{d}$

$\tan^{-1}(2) = 63.43°$

$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^{9}\times(8\times10^{-6})}{(d\sqrt{5})^2} = \frac{9\times10^{9}\times8\times10^{-6}}{(\sqrt{5}/2)^2} = 57600\,N/C$

$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^{9}\times(8\times10^{-6})}{(d\sqrt{5})^2} = 57600\,N/C$

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

19/PHS01/281

Vector	θ	x-Component	y-Component
$E_1 = 57600 N/C$	$63.43°$	$57600 \cos 63.43$ $= -25764$	$57600 \sin 63.43$ $= +51516.8$
$E_2 = 57600 N/C$	$63.43°$	$57600 \cos 63.43$ $= +25764$	$57600 \sin 63.43$ $= +51516.8$
$E_q = 9\times10^9 q N/C$	$90°$	$9\times10^9 q \cos 90$ $= 0$	$9\times10^9 q \sin 90$ $= 9\times10^9 q$
		$\Sigma f_x = 0$	$\Sigma f_y = 103033.6 + 9\times10^9$

E. 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 the formula

$q = \frac{-10264.52568}{9\times10^9}$

$q = -1.140502853\times10^{-6}$

$\simeq q = -11.4 C/C$

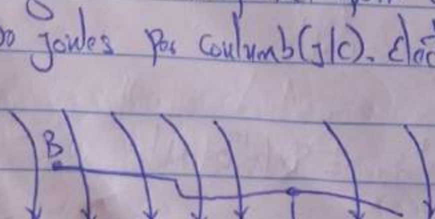
3a)

3a 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, $\lambda = \frac{dQ}{dL}$, $dQ = \lambda dL$

b) the 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 coulumb(J/C). electric potential difference is a scalar quantity.



Consider the diagram above, suppose a test charge q_0 is moved to a point A to point B along an arbitrary path inside an electric

191/MHS01/281

field E exerts a force $F = \frac{q}{q_0}E$ on the charge as shown in the diagram. To move the test charge from A to B at constant velocity, an external force $F = -\frac{q}{q_0}E$ must act on the charge. Therefore the elemental work done dW is given as:

$$dW = F.dL \quad ...(i)$$

but

$$F = -\frac{q}{q_0}E \quad ...(ii)$$

substituting equation (2) in (1) yields

$$dW = -q_0 E dL \quad ...(iii)$$

Then total work done in moving the test charge ~~from~~ from A to B is:

$$W(A \cap B)_{Ag} = -\frac{q}{q_0}\int^{B} E dL \quad ....(iv)$$

from the definition of electric potential difference it follows ~~do~~ that:

$$V_B - V_A = \frac{W(A \cap B)_{Ag}}{\frac{q}{q_0}} \quad ....(5)$$ Putting equation (4) in (5) yields

$$V_B - V_A = -\int_A^B E dL \quad ....(6)$$

Section B

4a. Magnetic flux is defined as the strenght of the magnetic field which can be represented by lines of forces. It is represented by the symbol ϕ. mathematically given as ~~[illegible]~~ $\phi = B.dA$

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

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

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

$$\omega = 62222222222.22222 T^{-1}$$

4c. An electron of mass 9.11×10^{-31} kg and charge 1.6×10^{-19} C in motion in a magnetic field of 3.5×10^{-1} tesla perpendicular with the field will have an angular frequency of ~~[illegible]~~. 6222222222.2222T

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

substituting we have $\omega = \frac{v}{r} = \frac{qB}{m} = \frac{1.6\times10^{-10} \times 3.5\times10^{-10}}{9.11\times10^{-31}}$

~~since~~ ~~gc~~ since cyclotron frequency is equal to 6222222222.2222T^{-1} having a unit as $1/T$ which is equal to the unit of frequency dimensionally

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

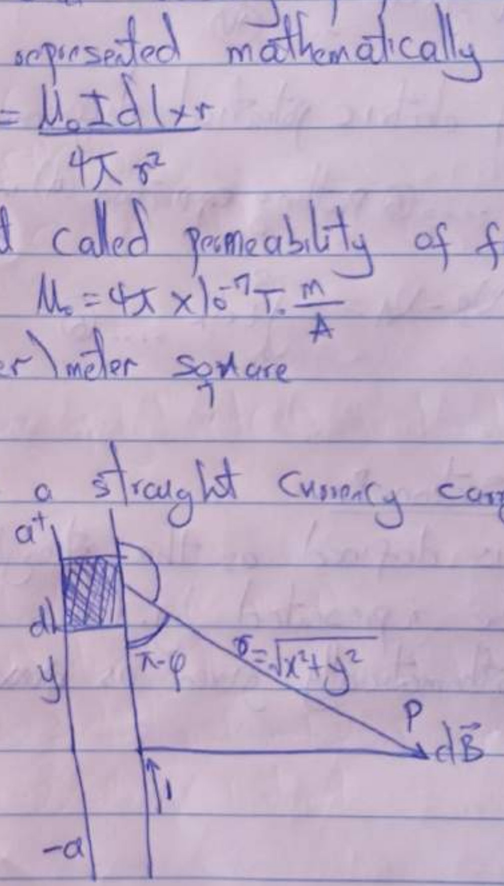
$$dB = \frac{\mu_0 I \, dl \times r}{4\pi r^2}$$

where μ_0 is a constant called permeability of free space.

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

The unit of B is weber/meter square

5b. Magnetic field of a straight current carrying conductor



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

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

from diagram $r^2 = x^2+y^2$ (pythagoras theorem)

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

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

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

19/11/2021 281

recall that $dl = dy$

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

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

Using special Integrals:

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

equation (***) therefore becomes

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

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

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

When the lenght $2a$ 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,

$$(x^2+a^2)^{1/2} \simeq a, \text{ as } a \to \infty$$

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

In a physical situation, we have axial symmetry about the y-axis. thus, at all points in a circle of radius r, and around the conductor, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r} \;\ldots\; (*)$$

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