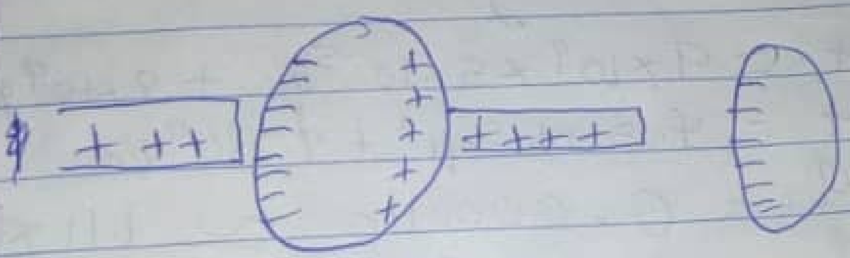
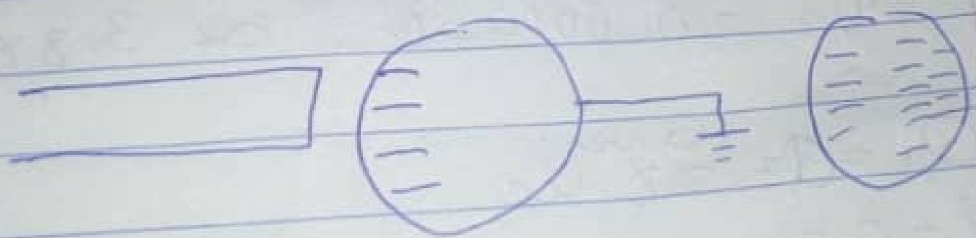
Name: ONIJAGBE ANGEL MORENIKEJI | Matric no: 19/MHS01/547
Dept: MBBS | Semester: 2nd semester
Level: 100

PHY 102 Assignment

1a. Charging by Induction; Electric charges can be obtained on an object without touching it by a process called Electrostatic Induction. For instance, consider a positively charged rubber rod brought near a neutral conducting sphere that is insulated so that there is no conducting path to ground as below

DIAGRAM;





Given;

1b $k = 9 \times 10^9$

$q_1 + q_2 = 5 \times 10^5 c$

$F = 1N$

$d = 2m$

Calculate the charge on each sper;

Recall; $K = 9 \times 10^9$

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

$$1 \cancel{=} \frac{9 \times 10^9 \times / q_1 q_2 (5 \times 10^{-5})}{2^2}$$

$4 = 9 \times 10^9 \times 5 \times 10^{-5} q_1 + 9 \times 10^9 q_2$

$4 = 4.5 \times 10^5 q_1^2 + 9 \times 10^9 q_2$

$q_1 = 0.000011c \simeq 1.11 \times 10^{-5} c$

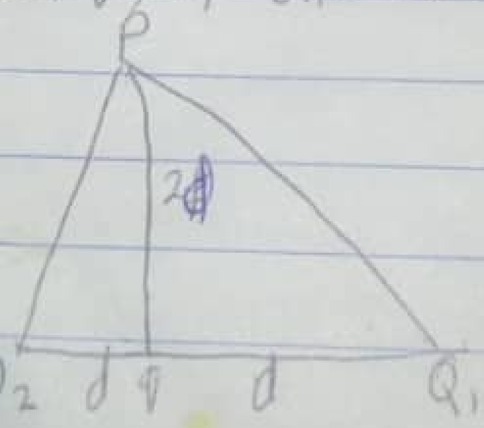
$q_2 = 0.000038c \simeq 3.8 \times 10^{-5} c$

1c. Given:

$Q_1 = Q_2 = 8 \mu c$

$d = 0.5m$

determine q, if the electric field at P is Zero



magnitude $= \sqrt{(E_x)^2 + (E_y)^2}$

$E_q = \sqrt{0^2 + (\cancel{100}\,64.52568)^2}$

Since $E_q = 0$

$0 = 9 \times 10^9 q + 10264.52568$

making q the subject of formula

$$q = \frac{10264.52568}{9 \times 10^9}$$

$q = 1.140502853 \times 10^{-6} \sim 1.14\mu C$

3a(i) Volume charge density, $\rho = \frac{dQ}{dv}$ n $dQ = \rho dv$

(ii) Surface charge density, $\sigma = \frac{dQ}{dA}$ n $dQ = \sigma dA$.

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

3b Electric Potential difference; The electric potential difference between two points in an electric field can be defined as the work done against electrical forces per unit charge when a charge is transported from one point to the other. It is measured in volt (V) or joules per ~~volt~~ coulomb (J/C). Electric potential difference is a scalar quantity

Putting equ (4) into equ (5) gives;

$$V_B - V_A = -\int_A^B E\,dl \quad \text{--- (6)}$$

SECTION B

4(a) Magnetic flux ~~may~~ be defined as the strength of the magnetic field which can be represented by lines of forces. It is represented by the symbol ϕ.

4(b) $m = 9\times10^{-31}$ kg, $r = 1.4\times10^{-7}$ m, $B = 3.5\times10^{-1}$ weber/meter²

cyclotron of frequency = angular speed

$$w = v/r = qB/r8$$

$$w = qB/m = \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9\times10^{-31}}$$

$$w = 62222222222.22222\,T^{-1}$$

4c. mass of the electron $= 9.11\times10^{-31}$ kg.

A radius of 1.4×10^{-7} m

magnetic field $= 3.5\times10^{-1}$ weber/meter²

cyclotron frequency = ?

Recall, angular speed $= v/r = qB/m$

$$w = v/r = qB/m = \frac{1.6\times10^{-10}\times3.5\times10^{-10}}{9.11\times10^{-31}} =$$

$$\frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = 6222222222.2 \, T$$

∴ Since cyclotron frequency is equal to angular speed, the cyclotron frequency is equal to 6222222222.22222 T^{-1}, having a unit of $1/T$ which is equal to the unit of frequency dimension

5a. 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 the radium (r^2). It can be represented mathematically as;

$$d.B = \frac{\mu_0}{4\pi} \cdot \frac{I \, dL \times r}{r^2}$$

where μ_0 is a constant called permeability of free space

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

The unit of B = weber/metre square.

5b. Magnetic field of a straight current carrying conductor.

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

Using special Integrants;

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

Equation (3) ∴ becomes;

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

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

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

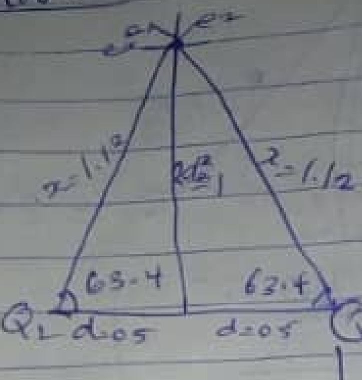
When the length $2a$ of the conductor is very great in comparison to its distance x from point P, we consider it infinitely long. i.e, when (a) is too much larger than x.

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

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

In a physical situation, we have axial

Solution



$Q_1 = 8 \times 10^{-6} C$

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

$x^2 = 1.25$

$x = \sqrt{1.25} = 1.12$

$\tan\theta = opp/adj$

$\tan\theta = 1/0.5 = 2$

$\tan^{-1}(2) = 6.34$

$$E_1 = \frac{kq_1}{r_1^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 5739.795918$$

$$E_2 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 5739.795918$$

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

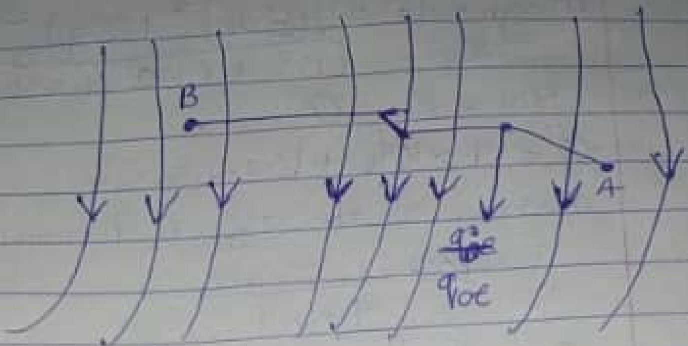
Vector	Angle	x-comp.	y-Component
$E_1 = 5739.795918$	63.4^0	$E_1\cos\theta = 2570.045785$	5132.262839
$E_2 = 5739.795918$	63.4^0	2570.045785	5132.262839
$E_q = 9\times10^9 q$	90^0	$E_q\cos\theta = 0$ $E_x = 0$	$9\times10^9 q$ $E_y = 10264.52569$

(3)

Symmentry about the y-axis. Thus; at all points in a circle of radius, r around the conductor, the magnitude of B is

$$B = \frac{\mu_0 I}{2\pi r} \quad \text{——— (1)}$$

Equation (1) defines the magnitude of the magnetic field ~~off~~ of flux density B near a long, straight current carrying conductor.



Consider the diagram above, suppose a test charge q_0 is moved from point A to point B along an arbitrary path inside an electric field E. The electric field exerts a force, $F = q_0E$ on the charge as shown in the diagram above. To move the test charge from A to B at constant velocity an external force of $F = -q_0E$ must act on the charge. Therefore, the elemental workdone, dW, is given as:

B $\quad dw = F.dl$ —— (1)

But $\quad F = -q_0E$ -- (2)

Substituting equation (2) in (1) yields; $dw = -q_0E\,dl$ — (3)

Then total workdone in moving the test charge from A to B is; $no(A'nB)ng = -q_0 \int_A^B E\,dl$ — (4)

From the definition of electric potential difference, it follows that $V_B - V_A = \frac{lo(n'nB)nq}{q_0}$ — (5)

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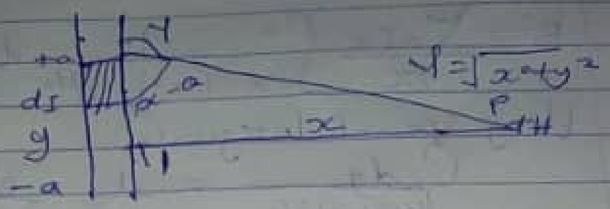

$$B = \frac{\mu_0 I}{4\pi}\int_{-a}^{a} \frac{dl \sin\theta}{r^2}$$

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

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

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

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

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

Substituting equ (2) into equ (1)

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

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

Recall, $dl = dy$

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