NAME: BELLO NIMATH LOLA

MATRIC NO: 19/MHS02/036

DEPARTMENT: NURSING

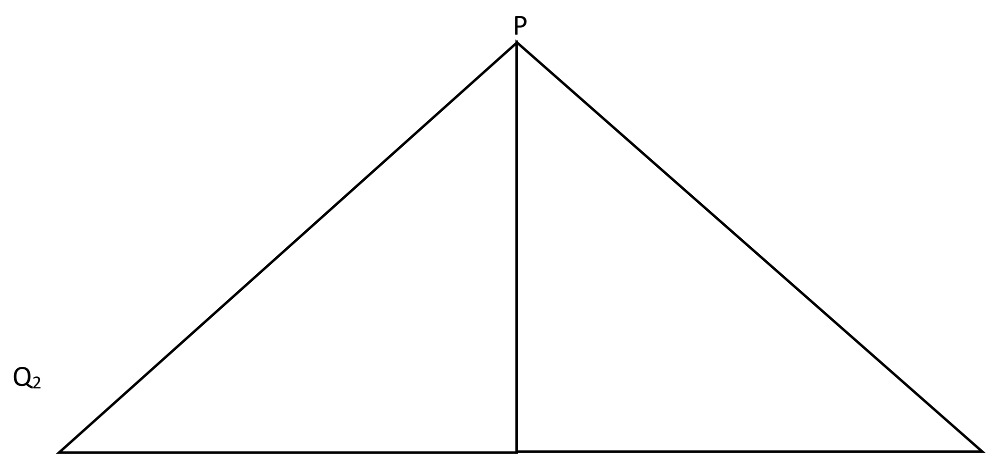
COURSE CODE: PHY 102 ASSIGNMENT

QUESTION 1

a) Explain with the aid of a diagram how u can produce a negatively charged sphere by method of induction

b) Each of two small spheres is charged positively, the combined charge being 5.0×10^{-5} C. If each sphere is repelled from the other by a force of 1.0N when the sphere are 2.0m apart, calculate the charge on the each sphere.

c) 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 is zero



Answers

a) 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 bought near a neutral (unchanged) conducting sphere that is insulated so that there is no conducting path to ground as shown below. The repulsive force between the protons in the rod and those in the sphere causes a redistribution of charges on the sphere farthest away from the rod (fig1.3a). The region of the sphere nearest the positively charged rod has an excess negative charge because of the migration of protons away from its location. If a grounded conducting wire is then connected to the sphere, as in (fig1.3b) some of the protons leave to the earth. If the wire to ground is then removed (fig1.3c) the conducting sphere is left with an excess of induced negative charge.

Finally, when the rubber rod is removed from the vicinity of sphere (fig1.1d) the induced negatively charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

Diagrams:

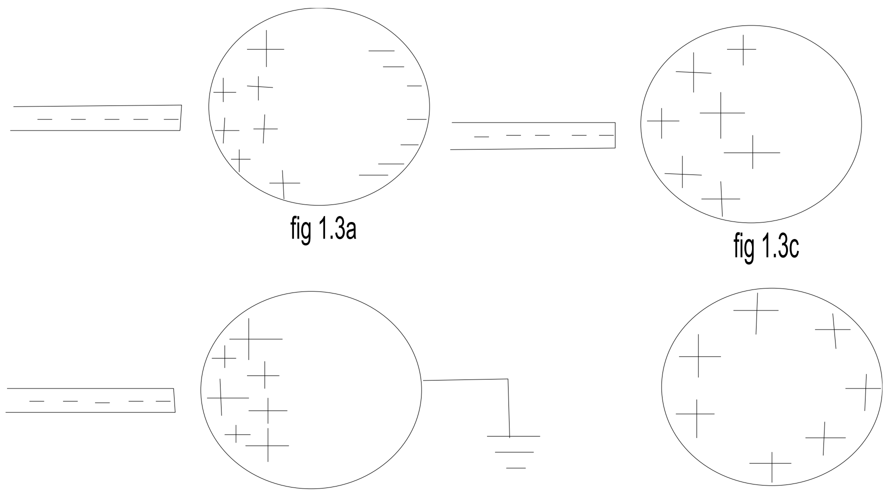


fig 1.3a

fig 1.3c

fig 1.3b

fig 1.3d

b.) $K = 9 \times 10^9$

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

$F = 1N$

$d = 2m$

Calculate the charge on each sphere?

Recall, $F = \frac{K\, q1\, q2}{r2}$

$F = \frac{9 \times 10^{9}\ (q1\, q2 \times 5\ \times\ 10^{-5}}{2^2}$

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

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

Quadratic equation is gotten, therefore,

$9 \times 10^9 q_2 - 4.5 \times 10^5 q_1 + 4 = 0$

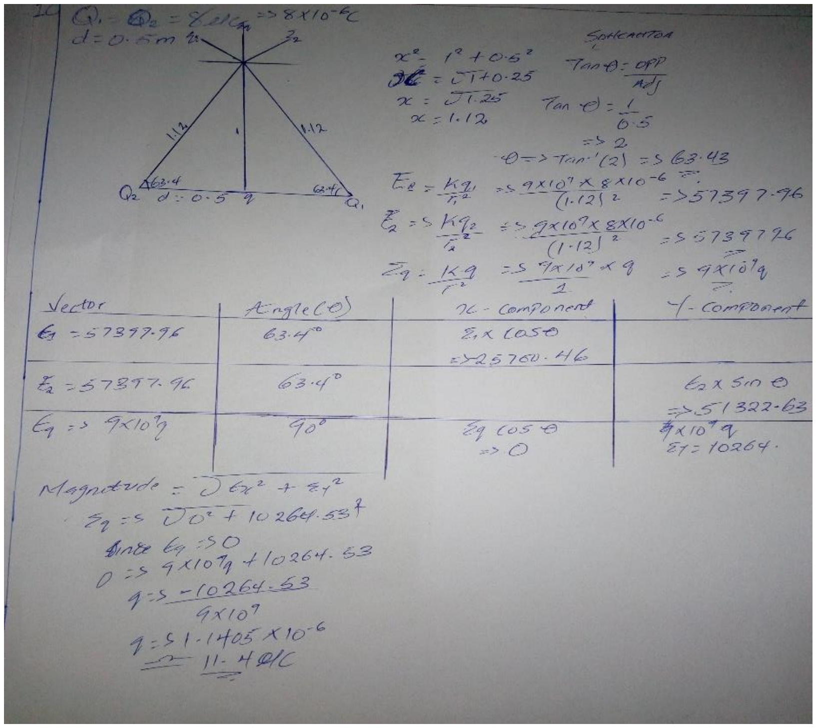
$q_1 = 0.000111C$

$q_2 = 0.000038C$

$\approx q_1 = 1.11 \times 10^{-5}C$

$\approx q_2 = 3.8 \times 10^{-5}C$

c)



$Q_1 = Q_2 = 8\mu C \Rightarrow 8\times10^{-6}C$
$d = 0.5m$

1.12, 1.12, 63.4, 63.4, Q_2, $d = 0.5$, q, Q_1

$x^2 = 1^2 + 0.5^2$
$x = \sqrt{1+0.25}$
$x = \sqrt{1.25}$
$x = 1.12$

SOHCAHTOA
$\tan\theta = \frac{opp}{adj}$
$\tan\theta = \frac{1}{0.5} \Rightarrow 2$
$\theta \Rightarrow \tan^{-1}(2) \Rightarrow 63.43$

$E_1 = \frac{kq_1}{r_1^2} \Rightarrow \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} \Rightarrow 57397.96$
$E_2 \Rightarrow \frac{kq_2}{r_2^2} \Rightarrow \frac{9\times10^9\times 8\times10^{-6}}{(1.12)^2} \Rightarrow 57397.96$
$E_q = \frac{kq}{r^2} \Rightarrow \frac{9\times10^9 \times q}{1} \Rightarrow 9\times10^9 q$

Vector	Angle(θ)	x-component	y-component
$E_1 = 57397.96$	$63.4°$	$E_1 \times \cos\theta \Rightarrow 25760.46$	
$E_2 = 57397.96$	$63.4°$		$E_2 \times \sin\theta \Rightarrow 51322.63$
$E_q \Rightarrow 9\times10^9 q$	$90°$	$E_q \cos\theta \Rightarrow 0$	$9\times10^9 q$; $E_y = 10264.$

Magnitude $= \sqrt{E_x^2 + E_y^2}$
$E_q \Rightarrow \sqrt{0^2 + 10264.53^2}$
Since $E_q \Rightarrow 0$
$0 \Rightarrow 9\times10^9 q + 10264.53$
$q \Rightarrow \frac{-10264.53}{9\times10^9}$
$q \Rightarrow 1.1405\times10^{-6}$
$\simeq 11.4\mu C$

QUESTION 3

a) State the formulation of the following identities of charges:
i. Volume charge density ii. Surface charge density iii. Linear charge density

b) Explain with appropriate equations, the electric potential difference

c) Two point charges Q1 = 10μC and Q2 = -2μ are arranged along the X-axis at x = 0 and x =4m respectively. Find the position along the X-axis where v = 0

<u>Answers</u>

a) i. Volume charge density, $\rho = \frac{dQ}{dV} \rightarrow dQ = \rho dV$

ii. Surface charge density, $\sigma = \frac{dQ}{dA} \rightarrow dQ = \sigma dA$

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

b) Electric potential difference

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 Coulomb(J/C). Electric potential difference is a scalar quantity.

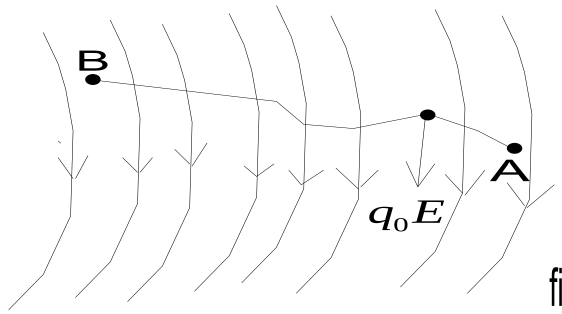


fig. 4.1

Consider the diagram above, suppose a test charge q_o is moved from point A to point B along an arbitrary path inside an electric field$E$. The electric field E exerts a force $F = q_oE$ on the charge as shown in fig 3.1. To move the test charge from A to B at constant velocity, an external force of $F = -q_oE$ must act on the charge. Therefore, the elemental work done dW is given as:

$$dW = F.dL \qquad \dots \qquad (1)$$

But

$$F = -q_0E \qquad \dots \qquad (2)$$

Substituting equation (2) in (1) yields

$dW = -q_0EdL \qquad \dots \qquad (3)$W-q_0EdL $\qquad \dots \qquad (3)$

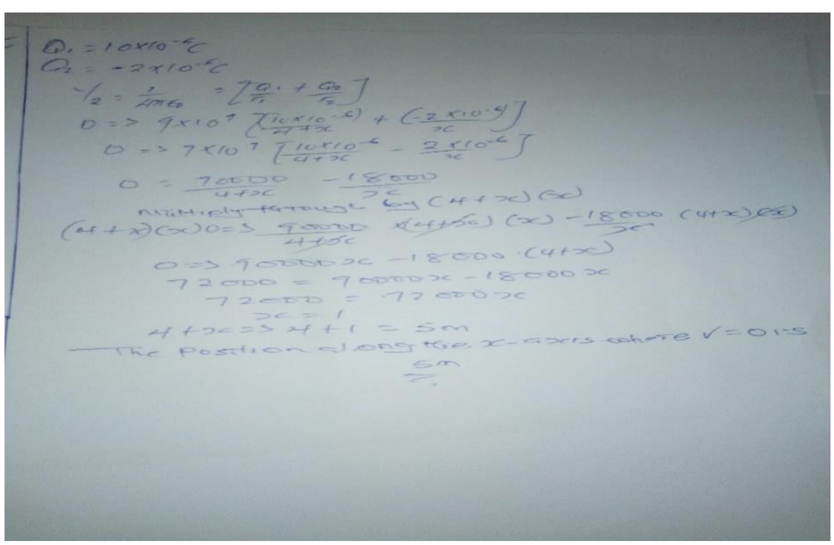
Then total work done in moving the test charge from A to B is:

$$W(A \to B)_{Ag} = -q_0 \int_A^B EdL \qquad \dots \qquad (4)$$

From the definition of electric potential difference, it follows that:

$V_B - V_A = \frac{W(A\to B)_{Ag}}{q_0} \qquad \dots \qquad (5)$ Putting equation (4) in (5) yields

$$V_B - V_A = -\int_A^B EdL \qquad \dots \qquad (6)$$

c) 
$Q_1 = 10\times10^{-6}C$
$Q_2 = -2\times10^{-6}C$
$V/2 = \frac{1}{4\pi\epsilon_0} = \left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$
$0 => 9\times10^{9}\left[\frac{(10\times10^{-6})}{4+x} + \frac{(-2\times10^{-6})}{x}\right]$
$0 => 9\times10^{9}\left[\frac{10\times10^{-6}}{4+x} - \frac{2\times10^{-6}}{x}\right]$
$0 = \frac{90000}{4+x} - \frac{18000}{x}$
multiply ~~through~~ by $(4+x)(x)$
$(4+x)(x)0 => \frac{90000}{4+x}\times(4+x)(x) - \frac{18000}{x}(4+x)(x)$
$0 => 90000x - 18000(4+x)$
$72000 = 90000x - 18000x$
$72000 = 72000x$
$x = 1$
$4+x => 4+1 = 5m$
— The position along the x-axis where $V = 0$ is
5m

QUESTION 4

a) What is magnetic fluz

b) An electron with a rest mass of 9.11×10^{-31}Kg moves in a circular orbit of radius 1.4×10^{-7} m in a uniform magnetic field of 3.5×10^{-1} weber/meter square, perpendicular to the speed with which electron moves. Find the cyclotron frequency of the moving electron

c) Discuss the answer in b).

Answers

a) 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 Φ.

Mathematically, $\Phi = B. Da$

b) $M = 9.11 \times 10^{-31}$Kg
$R = 1.4 \times 10^{-7}$ m
$B = 3.5 \times 10^{-1}$ weber/meter^2
Cyclotron frequency = angular speed
$\Theta = 90^0$
ω =?
$q = - 1.6 \times 10^{-19}$C

$$\omega = \frac{qB}{m} = \frac{-1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$$
$$= - 6.5 \times 10^{10} \text{ rad/s}$$

c) Since the cyclotron ω frequency is negative which is $- 6.5 \times 10^{10}$ rad/s. Hence, it means the charge particle electron circulates in a negative or an opposite direction at this angular frequency.

QUESTION 5

a) State the Biot-Savart Law.

b) Using the Biot-Savart Law, show that the magnitude of the magnetic field of a straight current – carrying conductor is given as

$$B = \frac{\mu I}{2\pi r}$$

Answers

a) 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 square of radius (r^2). It is represented mathematically by,

$$d\vec{B} = \frac{\mu_o}{4\pi}\frac{I\, d\vec{l} \times \hat{r}}{r^2}$$

Where μ_oa constant is called Permeability of free space.

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

The unit of $\vec{B}$ is weber\metre^2

b) Magnetic Field of a Straight Current Carrying Conductor

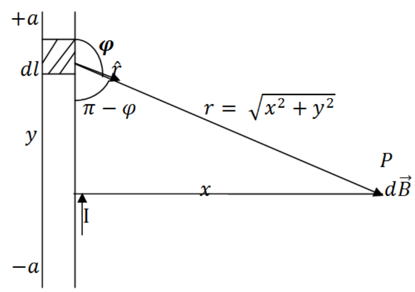


Fig 1: A section of a Straight Current Carrying Conductor

Applying the Biot - Savart law, we find the magnitude of the field $d\vec{B}$

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

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

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

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

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

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

Substituting $(**)$ into $(*)$, we have

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

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

Recall $dl = dy$

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

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

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

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

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

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

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 largerthan x,

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

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

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

$$B = \frac{\mu_o I}{2\pi r} \quad \dots \quad (\#)$$

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