④

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

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

· Recall. $dl = dy$

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

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

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

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. That B, when a is much larger than x, $(x^2+a^2)^{1/2} \simeq a$, 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, around the conductor, the magnitude of B is: $B = \frac{\mu_0 I}{2\pi r}$ --

Magnitude of the magnetic field of flux density B near a long straight current carrying conductor.

$K = 9 \times 10^9$

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

$F = 1N$

$d = 2m$

Charge on each sphere = ?

$F = \frac{Kq_1q_2}{r^2}$

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

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

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

Quadratic eqn

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

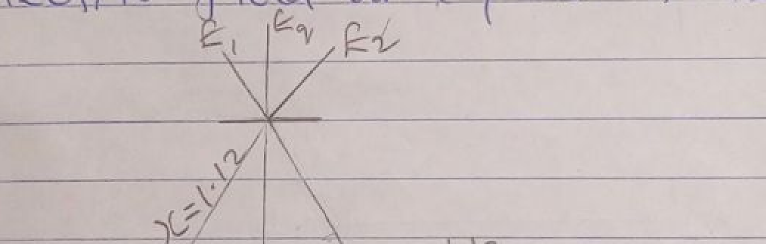
$q_1 = 0.0000111C \simeq 1.11 \times 10^{-5} C$

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

c.) $Q_1 = Q_2 = 8uC$

$d = 0.5m$

If Electric field at a point P is zero.



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

$x^2 = 1 + 0.25$

$x^2 = 1.25$

$x = \sqrt{1.25}$

$x = 1.12$

$\tan\theta = \frac{opp}{adj}$

$\tan\theta = \frac{1}{0.5}$

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

$\theta = 63.4$

$E_1 = \frac{Kq_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-6}}{(1.12)^2} = 57397.9598$

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Section A Assignment

1a) Charging by Induction:-

Electric charges can be obtained on an object without touching it, by a process called electrostatic induction. Consider a negatively 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 electrons in the rod and those in the sphere causes a redistribution of charges in the sphere so that some electrons move to the side of the sphere farthest from the rod.

The induced positive charge remains on the ungrounded sphere and becomes uniformly distributed over the surface of the sphere.

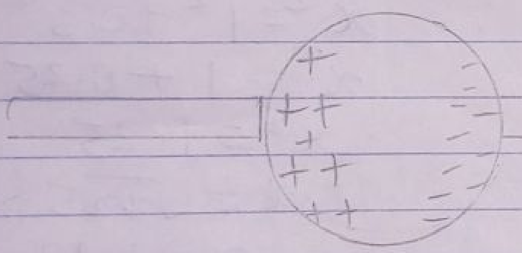


fig 1.3a

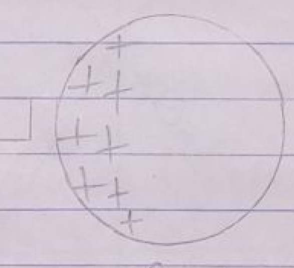


fig 1.3c

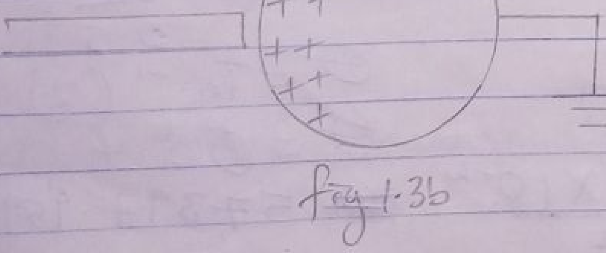


fig 1.3b

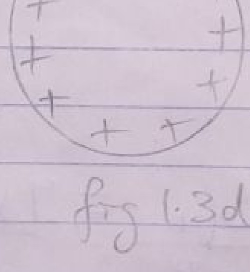


fig 1.3d

- Surface charge density, $\sigma = \frac{dQ}{dA}$ in $dQ = \sigma dA$

Linear charge density, $\lambda = \frac{dQ}{dl}$ in $dQ = \lambda dl$

3b.) Electric Potential difference

The Electric potential difference between Two points in an electric field can be defined as the workdone per unit charge against electrical forces when a charge is transported from one point to another. It is measured in volt (v) or Joules per coulomb (J/C). It is a scalar quantity.

Elemental work done dW is given as

$$dW = F \cdot dL \quad --(1)$$

But $\quad F = -q_o E \quad --(2)$

Substituting eqn (2) in (1) $\Rightarrow dW = -q_o E dl \quad --(3)$

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

$$W(A'nB)_{Ag} = -q_o \int_A^B E dL \quad --(4)$$

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

$$V_B - V_A = \frac{W(A'nB)_{Ag}}{q_o} \quad --(5)$$

Put equ (4) in (5) gives $V_B - V_A = -\int_A^B E dL \quad --(6)$

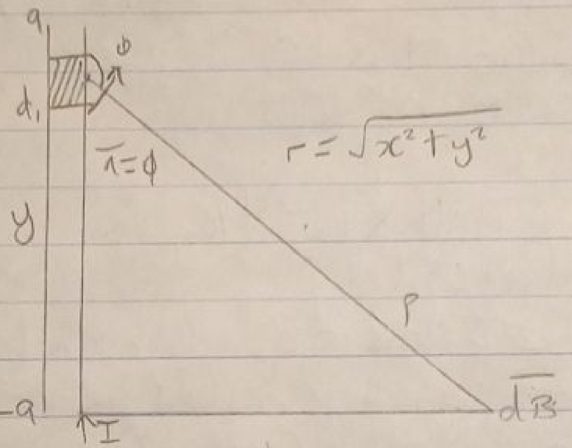
5.) Biot-Savart law states that the magnetic field is directly proportional to the product permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to the square of the radius (r^2). It can be represented mathematically by:-

$$dB = \frac{\mu_0 I dl \times r}{4\pi r^2}$$ where μ_0 is a constant called permeability of free space

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

unit of B is weber / m^2

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



A section of a straight current carrying conductor. Applying the Biot-Savart law, we find the magnitude of the field dE

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

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

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

from diagram, $r^2 = x^2 + y^2$

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

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

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 ϕ. 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

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

$w = \frac{qB}{m} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{6.9 \times 10^{-31}}$

$w = 6.22 \times 10^{10} T^{-1}$

4c.) mass of electron $= 9.11 \times 10^{-31} Kg$

radius $= 1.4 \times 10^{-7} m$

Magnetic field $= 3.5 \times 10^{-1}$ weber/meter^2

Cyclotron frequency can be called Angular speed

Recall that Angular Speed $(\omega) = \frac{v}{r} = \frac{qB}{m}$

Substituting we have, $w = \frac{v}{r} = \frac{qB}{m}$

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

$= 6.22 \times 10^{10} T^{-1}$

So cyclotron frequency $= 6.22 \times 10^{10} T^{-1}$, the unit is equal to unit of frequency dimensionally.

$$E_2 = \frac{Kq_2}{r^2} = \frac{9\times10^9 \times 8\times10^{-6}}{(1.12)^2} = 57397.95918$$

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

Vector	Angle	X-component	Y-component
$E_1 = 57397.95918$	$63.4°$	$E_1\cos\theta =$ 2570.046785	$E_1\sin\theta =$ 5132.262839
$E_2 = 57397.95918$	$63.4°$	2570.045785	5132.262839
$E_q = 9\times10^9 q$	$90°$	$E_q\cos\theta = 0$	$9\times10^9 q$
		$Ex = 0$	$Ey = 10264.52568$

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

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

Since $E_q = 0$

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

Making q subject of formula

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

$q = 1.140502853\times10^{-16}$

$q = 11.4\mu C$

2.) Electric field and Electric field intensity

Electric field	Electric field intensity
It is a region of space in which an electric charge will experience an electric force.	It is the force per unit charge

2b.) Volume charge density, $\rho = \frac{dQ}{dv}$ 'A $dQ = \rho dv$