

unit as $\frac{1}{\text{A}}$ which is equal to the unit of frequency dimensionally
or rad/s

(a) Biot-Savart law states that the magnetic field is directly proportional to the product permeability of free space (μ_0), 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;

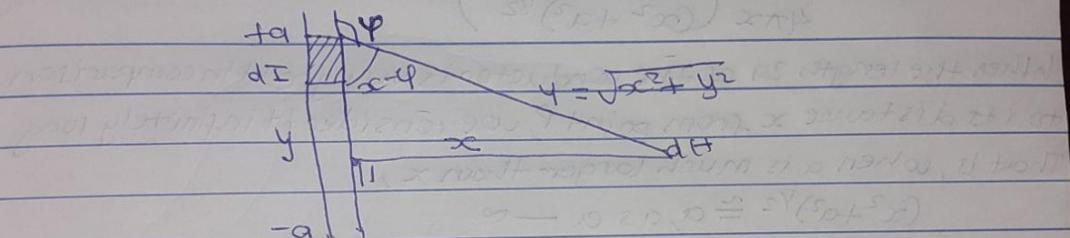
$$d\mathbf{B} = \frac{\mu_0}{4\pi} \frac{I dl \times \hat{r}}{r^2}$$

where μ_0 is a constant called permeability of free space

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

The unit of B = weber / meter square

b) Magnetic field of a straight current carrying conductor.



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

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

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

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

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

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

Substituting (2) into (1), we have

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

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

$$c. Q_1 = Q_2 = 8 \text{ MC}$$

$$d = 0.5 \text{ m}$$

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

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

$$\tan \theta = \frac{1}{0.5} = 1.12$$

$$\theta = \tan^{-1} 1.12$$

$$\theta = 63.4^\circ$$

$$Q_2 = d = 0.5 \text{ m}$$

$$d = 0.5 \text{ m}$$

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

$$E_1 = k \frac{Q_1}{r_1^2} = 9 \times 10^9 \times 8 \times 10^{-6} = 72,000 = 57397.9518$$

$$E_1, E_2$$

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

$$x^2 = 1 + 0.25$$

$$x^2 = 1.25$$

$$x = \sqrt{1.25}$$

$$x = 1.12$$

$$2d=1$$

$$63.4^\circ$$

$$63.4^\circ$$

$$E_2 = k \frac{Q_2}{r_2^2} = 9 \times 10^9 \times 8 \times 10^{-6} = 57397.9518$$

$$E_q = k \frac{q}{r^2} = 9 \times 10^9 \times q = 7.2 \times 10^9 q$$

Vector	Angle	x-comp	y-comp
$E_1 = 57397.9518$	63.4°	-25700.45454	51322.62179
$E_2 = 57397.9518$	63.4°	25700.45454	51322.62179
$E_q = 7.2 \times 10^9 q$	90°	0	$q \cdot 0 \times 10^9 q$

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

$$E_q = \sqrt{(0)^2 + (102645.2436 + q \cdot 0 \times 10^9 q)^2}$$

$$E_q = 7.2 \times 10^9 q + 102645.2436$$

$$\text{Since } E_0 = 0$$

$$0 = 7.2 \times 10^9 q + 102645.2436$$

$$q = -102645.2436$$

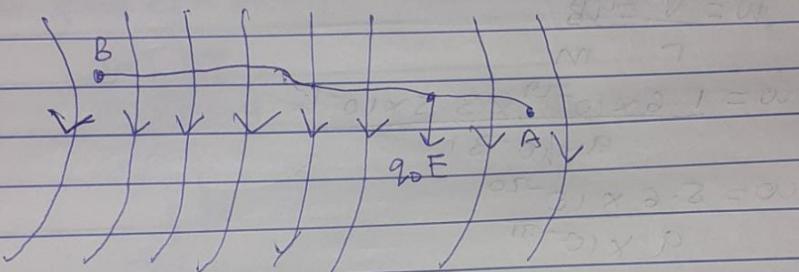
$$q = -1.140502853 \times 10^{-6}$$

3(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.



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, E exerts a force $F = q_0 E$ 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 $F = -q_0 E$ must act on the charge. Therefore, the elemental work done

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

$$F = -q_0 E \quad (ii)$$

Substituting equation (ii) in (i) yields

$$dW = -q_0 EdL \quad (iii)$$

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

$$W(A \rightarrow B)_{Ag} = -q_0 \int_A^B EdL \quad (iv)$$

From the definition of electric potential difference, it follows:

Recall $dl = dy$

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

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

Using special integrals: $\int_{-a}^a \frac{1}{(x^2 + y^2)^{3/2}} dy = \frac{\pi a}{x}$

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

Equation (#) therefore becomes

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

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

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 ,

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

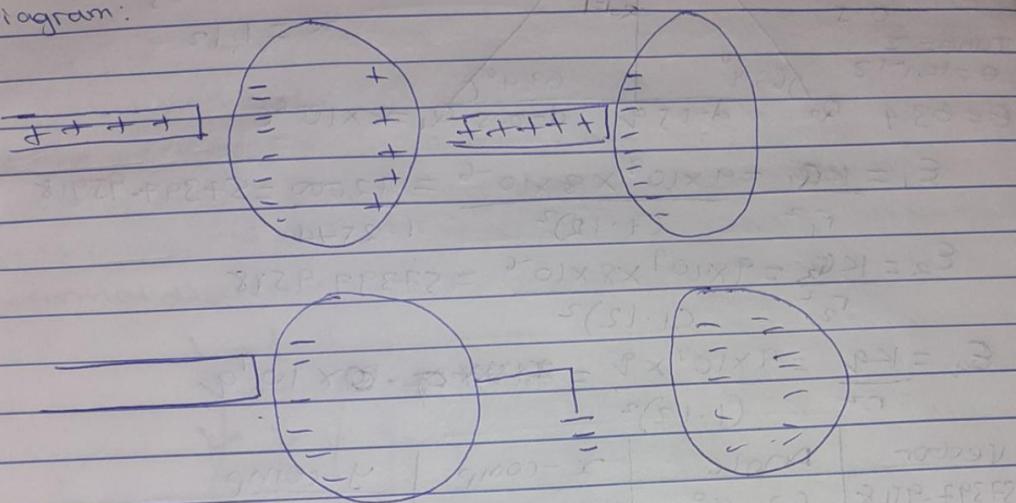
$$\therefore B = \frac{\mu_0 I}{2\pi x} \dots (\#)$$

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

PHY 102 ASSIGNMENT (SECTION A)

1a) $K = 9 \times 10^9$ 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 below.

Diagram:



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

$$q_1 + q_2 = 5.0 \times 10^{-5} C$$

$$F = 1 N$$

$$d = 2 m$$

calculate the charge on each sphere

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

$$F = \frac{K q_1 q_2}{r^2}$$

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

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

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

$$q_1 = 0.000011 C \approx 1.11 \times 10^{-5} C$$

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

$$V_B - V_A = k_1 (A \rightarrow B) A_g \quad (iv)$$

Putting equation (iv) in (v) yields

$$V_B - V_A = - \int_A^B E_d L \quad (v')$$

SECTION B

4a) Magnetic flux is defined as the strength of the magnetic field which can be represented by the forces. It is represented by the symbol ϕ . Mathematically given as $\phi = \int B \cdot dA$

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

Cyclotron frequency = angular speed

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

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

$$\omega = 5.6 \times 10^{-20} \text{ rad/s}$$

$$\omega = 0.622 \times 10^{11} \text{ rad/s}$$

$$\omega = 6.22 \times 10^{10} \text{ rad/s}$$

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

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

Magnetic field = $3.5 \times 10^1 \text{ weber/metre square}$

Cyclotron frequency?

Cyclotron frequency = Angular speed

Recall, Angular speed = $v = \frac{qB}{m}$

This is because it is a frequency of an acceleration called cyclotron.

$$\omega = \frac{v}{r} = \frac{qB}{m} = \frac{1.6 \times 10^{-19}}{9.11 \times 10^{-31}} \times 3.5 \times 10^1 = 6.22 \times 10^{10} \text{ rad/s}$$

So since cyclotron frequency is equal to angular speed, the cyclotron frequency is equal to $6.22 \times 10^{10} \text{ rad/s}$, having a

unit as rad/s or Hz .

(a) Biot-Savart law is proportional to current (I), the moral to the s ematically by

where N_0 is

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b) Magnetic

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