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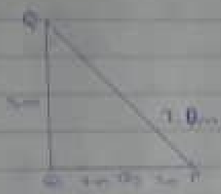
PHY 102

ASSIGNMENT

SECTION A

1a) An electric field is a region around a charge in which it exerts electrostatic force on another charge, while electric field intensity is the strength of electric field at any point in space.

1b)



where, $Q_1 = $ [illegible] nC
$Q_2 = 12\,nC$

Recall $E = kQ/r^2$

$E_1 = \frac{[9 \times 10^9\, Nm^2/C^2] \cdot [\text{[illegible]}]}{[\text{[illegible]}]^2}$

$E_1 = $ [illegible] N/C

$E_2 = \frac{[9 \times 10^9\, Nm^2/C^2] \cdot [\text{[illegible]}\, C]}{[\text{[illegible]}]^2}$

$E_2 = $ [illegible] N/C

2a. i) Volume charge density

$\rho = q/V$ where q is the charge

V is the volume of distribution

ii) Surface charge density

$\sigma = q/A$ where, q is the charge

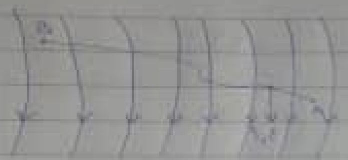
A is the area of the surface

iii) Linear charge density

$\lambda = q/L$, where, q is the charge

L is the length over which it is distributed

2b.



Consider the diagram above, suppose a test charge q_0 is moved from a point A to point B along the arbitrary path inside an electric field E. The electric field E exerts a force $F = q_0E$ on the charge. 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 work done dW is given as:

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

the same cyclotron frequency is equal to cyclotron speed in cyclotron frequency is equal to 1.4907×10^{10} [illegible] [illegible] [illegible] [illegible] [illegible] accordingly

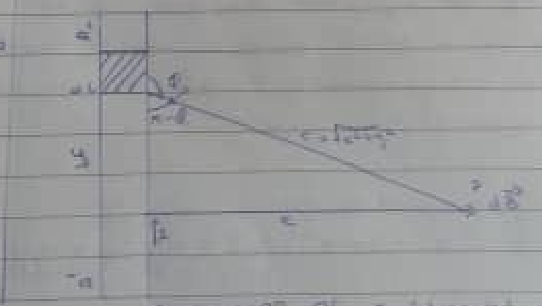
5a. Biot - Savart law states that the magnetic field is directly proportional to the product of the permeability of free space (μ), the current (I), the change in length, the radius and inversely proportional to the square of radius (r^2), it can be represented mathematically by

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I\,d\vec{l}\times\hat{r}}{r^2}$$ where

$d\vec{l}$ = incremental length of conductor carrying electric current I

$\hat{r}$ = unit vector [illegible] pointing [illegible] from the current [illegible] [illegible]

μ_0 = [illegible] is a constant called permeability of free space.

5b. 

A section of a straight carrying conductor

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

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

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

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

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

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

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

Substituting (2) into (1) we have,

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

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

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 (3) 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 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

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

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

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

$$B = \frac{\mu_0 I}{2\pi r} \longrightarrow (4)$$

Equation (4) defines the magnitude of the magnetic field or flux density B near a long straight current carrying conductor.

4a) Magnetic flux is defined as the strength of the magnetic field which can be represented by [illegible] at [illegible] it is represented by a symbol Φ and is mathematically given as $\Phi = B.A$

4b) Mass $= 9.11 \times 10^{-31}$ kg
Magnetic field $= 3.5 \times 10^{-4}$ w/m^{2}
Radius $= 1.4 \times 10^{-7}$ m
Cyclotron frequency $= ?$

Recall that
Cyclotron frequency = Angular speed (ω)
$\omega = \frac{qB}{m} = \frac{(1.6 \times 10^{-19}) \times (3.5 \times 10^{-4})}{9.11 \times 10^{-31}}$

$\omega = 6.14709 \times 10^{10}$ rad/sec

4c) In the question we were given parameters such as
mass of the electron $= 9.11 \times 10^{-31}$ kg
Radius $= 1.4 \times 10^{-7}$ m
magnetic field $= 3.5 \times 10^{-4}$ w/m^{2}

We were asked to find the cyclotron frequency of the moving electron which we recall is equal to angular speed (ω). It is called cyclotron frequency because it is a frequency of an accelerator called cyclotron.

We recalled that angular speed is given as $\omega = \frac{qB}{m}$
substituting we have, $\omega = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-4}}{9.11 \times 10^{-31}} = 6.14709 \times 10^{10}$ rad/sec

But $F = -q_0 E$ —— (2)

Substituting equation (2) in (1) yields

$$dw = -q_0 E \cdot dl \quad \text{—— (3)}$$

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

$$W(A \to B)_{ag} = -q_0 \int_A^B E\,dl \quad \text{—— (4)}$$

From the definition of electric potential difference we see that the work done per unit charge against electric forces when a ~~potential~~ ~~difference~~ ~~between~~ ~~two points~~ ~~in an electric field~~ charge is moved from one point to the other.

It follows that:

$$V_B - V_A = \frac{W(A \to B)_{ag}}{q_0} \quad \text{—— (5)}$$

Putting equation (4) in (5) yields

$$V_B - V_A = \int_A^B E\,dl$$

Vector	Angle	X component	Y component
$\varepsilon_1 = 1.47 N/c$	0°	$\varepsilon_{1x} = 1.47 \cos 0^\circ$	$\varepsilon_{1y} = 1.47 \sin 0^\circ$
		$\varepsilon_{1x} = 1.47 N/c$	$\varepsilon_{1y} = 0$
$\varepsilon_2 = 12 N/c$	0°	$\varepsilon_{2x} = 12 \cos 0^\circ$	$\varepsilon_{2y} = 12 \sin 0$
		$= 12 N/c$	$\varepsilon_{2y} = 0$

$\sum \varepsilon_x = 13.47 N/c$ $\quad \sum \varepsilon_y = 0$