4. What is magnetic flux?

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 moving electron.

Solution

a. Magnetic flux is a measurement of the total magnetic field which passes through a given area. It is a useful tool for helping describe the effects of the magnetic force on something occupying a given area. The measurement of magnetic flux is tied to the ~~particular~~ area chosen.

It is written mathematically as,

$\phi = BA\cos\theta$

where A is the test Area.

B = magnetic field vector (magnitude B)

The S.I unit of magnetic flux is the Weber and the unit is Wb.

b. Solution

$M = 9.11\times10^{-31}$ kg.

$dH = \frac{k I dl \sin\theta}{r^2}$

$dH \propto \frac{I dl \sin\theta}{r^2}$

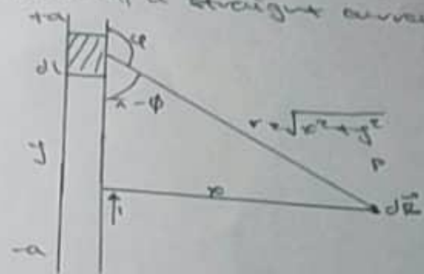
where k is constant and depends on the magnetic properties of the medium

$k = \frac{\mu_0 \mu_r}{4\pi}$

μ_0 = absolute ~~frequency~~ permeability of air or vacuum $= 4\pi \times 10^{-7}$ Wb/Am

μ_r = relative permeability of the medium.

b) Magnetic field of a straight current carrying conductor



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

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

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

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

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

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

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

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

Recall $dl = dy$

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

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

...ectric field at a point P on the x-axis ...

(c) The electric field at a point Q on the y axis at y= ... charges.

Solution

1. Electric field is a region of space in which an electric ... experiences an electric force.

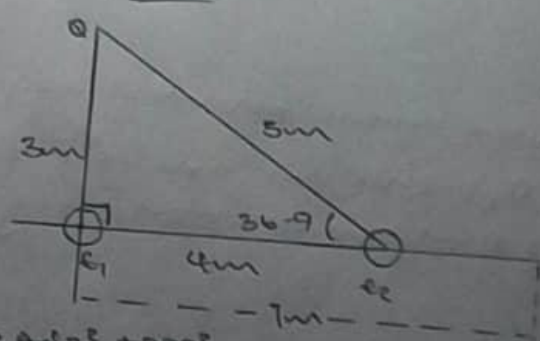
ii. The electric field strength (intensity) E, can be defi... unit charge. Mathematically, the magnitude of the ...

$$E = \frac{F[N]}{q_0[C]}$$

It is measured in Newton per coulomb [N/C]. The ... electric field intensity E at a point in space is t... direction of the force a positive test charge would ... placed at that point.

b.

Solution



$$Hyp^2 = Adj^2 + Opp^2$$

$$Hyp^2 = 3^2 + 4^2$$

$$= 9 + 16$$

$$= 25$$

$$= \sqrt{25} = 5m$$

$$\theta = \cos^{-1}\left[\frac{3}{4}\right]$$

$$= 36.9^\circ$$

$$dH = \frac{\mu_0 \mu_r}{4\pi} \times \frac{I\,dl\sin\theta}{x^2}$$

$$dH = \frac{K \times I\,dl\sin\theta}{x^2}$$

$$dH \propto \frac{I\,dl\sin\theta}{x^2}$$

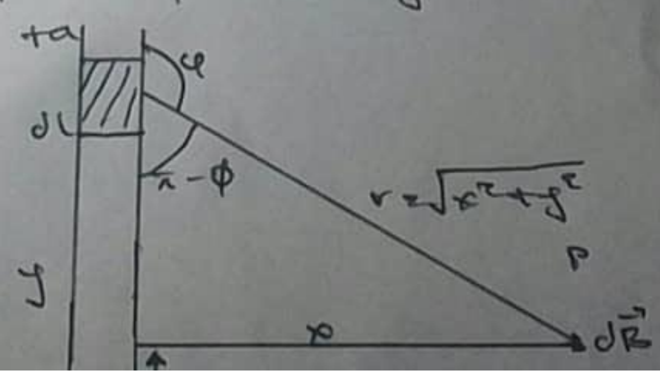
where K is constant and depends on the magnetic properties of the medium.

$$K = \frac{\mu_0 \mu_r}{4\pi}$$

μ_0 = absolute ~~frequency~~ permeability of air or vacuum is $4\pi\times10^{-7}$ Wb A^{-1}m^{-1}

μ_r = relative permeability of the medium.

6. Magnetic field of a straight current carrying conductor.



$$E_1 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 5\times10^{-9}}{(7)^2} = 1.4693\,N/C$$

$$E_2 = \frac{kQ_1}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{(3)^2} = 12\,N/C$$

$E_1 + E_2 = 13.469\,N/C \simeq 13.5\,N/C$

θ	E	$E_x = E\cos\theta$	$E_y = E\sin\theta$
90°	8	$= 8\cos 90^\circ = 0$	$8\sin 90^\circ = 8$
36.9°	4.32	$4.32\cos 36.9 = 3.455$	$4.32\sin 36.9^\circ = 2.594$
		$= -3.455$	$10.5938 = 10.594$

$$E = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8\,N/C$$

$$E_2 = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32\,N/C$$

$$= \sqrt{E_x^2 + E_y^2}$$

$$= \sqrt{(-3.455)^2 + (10.594)^2}$$

$$= 11.1\,N/C$$

$$\theta = \tan^{-1}\left[\frac{y}{x}\right] = \frac{10.594}{3.455}$$

$$= 71.9^\circ \simeq 72^\circ$$

3 a. state the formulation of the following identities of o
i. volume charge density.
ii. surface charge density.

Solution

a. Magnetic flux is a measurement of the total magnetic field which passes through a given area. It is a useful tool for helping describe the effects of the magnetic force on something occupying a given area. The measurement of magnetic flux is tied to the perpendicular area chosen.

It is written mathematically as,

$\phi = BA\cos\theta$

where A is the test Area.

B: magnetic field vector (magnitude B)

The S.I unit of magnetic flux is the weber and the unit is Wb.

b. Solution

$m = 9.11 \times 10^{-31}$ kg.

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

$B = 3.5 \times 10^{-11}$ T

$w = ?$

$w = \frac{qB}{m_p} = \frac{1.60 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}} = 6.1471 \times 10^{10}$ rad/s

c. It is because the charge particle circulates at this angular frequency or angular speed in the type of accelerator.

. State the Biot-Savart law.

. Using the Biot-Savart law, show the magnitude of the magnetic

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DEPARTMENT: MECHATRONICS

MATRIC NO: 19/ENG06/001

Assignment

2a. Distinguish between the terms; electric field and electric field intensity.

b. A positive charge $Q_1 = 8nC$ is at the origin and a second positive charge $Q_2 = 12nC$ is on the x-axis at $x = 4m$. Find

i. The net electric field at a point P on the x-axis at $x = 7m$

ii. The electric field at a point Q on the y-axis at $y = 3m$ due to the charges.

Solution

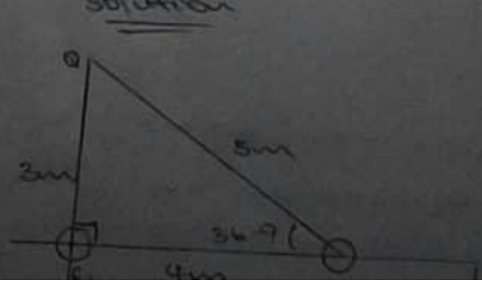
1. Electric field is a region of space in which an electric charge will experience an electric force.

ii. The electric field strength (intensity) E, can be defined as the force per unit charge. Mathematically, the magnitude of the field is given by

$$E = \frac{F[N]}{q_0[C]}$$

It is measured in Newton per Coulomb (N/C). The direction of the electric field intensity E at a point in space is the same as the direction of the force a positive test charge would experience if it was placed at that point.

b. Solution



$dW = F \cdot dl$

$F = -q_0 E$

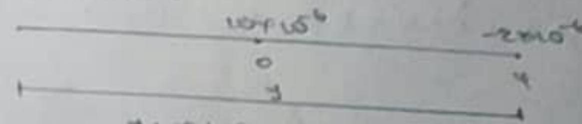
$dW = -q_0 E \, dl$

$W(A \to B)_{avg} = -q_0 \int_A^B E \, dl$

$V_B - V_A = \frac{W(A \to B)_{avg}}{q_0}$

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

c. Solution



$y = x + 4$.

$r_1 = x \qquad r_2 = x + 4$

Potential is $\frac{KQ}{r}$

$V_B - V_A = k\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$

$k\left[\frac{10}{x} + \left[\frac{-2}{x+4}\right]\right]$

At $V = 0$.

$k\left[\frac{10(x+4) - 2x}{x(x+4)}\right] = 0$.

$k[10(x+4) - 2x] = 0$.

$10(x+4) - 2x = 0$

$10x + 40 - 2x = 0$.

$\frac{\cancel{8}x}{\cancel{8}} = \frac{40}{8}$

$x = \underline{\underline{5m}}$

b. 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). It is a scalar quantity.

$$dW = F \cdot dl$$

$$F = -q_0 E$$

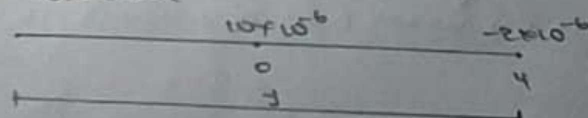
$$dW = -q_0 E\, dl$$

$$W(A \rightarrow B)_{Avg} = -q_0 \int_A^B E\, dl$$

$$V_B - V_A = \frac{W(A \rightarrow B)_{Avg}}{q_0}$$

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

c. Solution



$y = x + 4$.

$r_1 = x \qquad r_2 = x + 4$

Potential is $\frac{kQ}{r}$

$$V_B - V_A = k\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$

$$k\left[\frac{10}{x} + \left[\frac{-2}{x+4}\right]\right]$$

At $V = 0$.

$$k\left[\frac{10(x+4) - 2x}{x(x+4)}\right] = 0.$$

90°	8	$= 8\cos 90° = 0$	$8\sin 90° = 8$
36.9°	4.32	$4.32\cos 36.9 = 3.456$ $= -3.455$	$4.32\sin 36.9° = 2.594$ $10.5932 = 10.594$

$$E = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} = 8\,N/C$$

$$E_2 = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32\,N/C$$

$$= \sqrt{E_x^2 + E_y^2}$$

$$= \sqrt{(-3.455)^2 + (10.594)^2}$$

$$= 11.1\,N/C$$

$$\theta = \tan^{-1}\left[\frac{y}{x}\right] = \frac{10.594}{3.455}$$

$$= 71.9° \simeq 72°$$

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 $Q_1 = 10\mu C$ and $Q_2 = -2\mu C$ are arranged along the x-axis at $x = 0$ and $x = 4m$ respectively find the position along the x-axis where $V = 0$.

<u>Solution</u>

3a. 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, $\lambda = \frac{dQ}{dl} \rightarrow dQ = \lambda dl$

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 (* * *) becomes.

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

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

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

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

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

$$B = \frac{\mu_0 I}{2\pi r}$$