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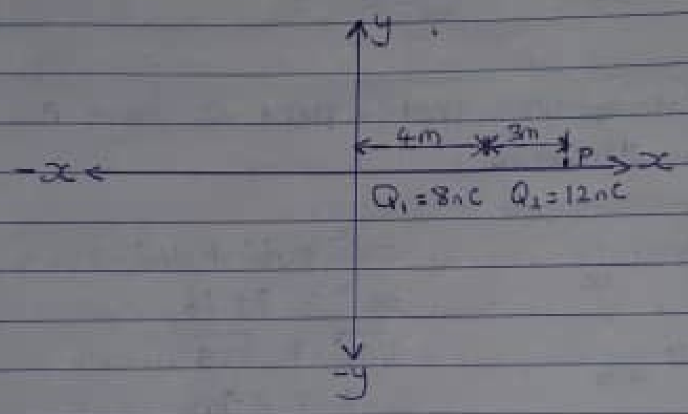
Physics 102 NO 2, 3, 4 and 5

2a) Distinguish between the terms: electric field and electric field intensity.

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

Electric field intensity E, each can be defined as the force per unit charge.

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 $x = 7m$.



$$E_1 = \frac{kq_1}{r_1^2} = 9 \times 10^9 \times 8 \times 10^{-9} = 1.4694\ N/c$$

$$E_2 = \frac{kq_2}{r_2^2} = 9 \times 10^9 \times 12 \times 10^{-9} = 12\ N/c$$

Vector	Angle	X-comp	Y-comp
$E_1 = 1.4694 N/c$	0	$1.4694 \cos 0 = 1.4694$	0
$E_2 = 12 N/c$	0	$12 \cos 0 = 12$	0
		13.4694	

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

$E = \sqrt{\Sigma E_x^2}$

$E = \sqrt{13.4694^2}$

E

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

$$E = \sqrt{3.455995^2 + 10.592^2}$$

$$E = 11.2\ N/c$$

3a) State the formulation of the following Identities of Charges:
i) volume charge density ii) Surface charge density
iii) Linear charge density

solution; 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) Explain with appropriate equations, the electric potential difference. Electric potential difference between two points in an electric field can be defined as the work done per unit charge against forces when a charge is transported from one point to another. We have different formulas for electric potential difference depending on how the case may be.

i) we have electric potential in a uniform electric field which is. $V_B - V_A = \frac{W_{(A \rightarrow B)}\,{}_{Ay}}{q_0}$

ii) We can also define potential difference as the potential energy per unit charge.

$$V_B - V_A = \frac{\Delta U}{q_0}$$

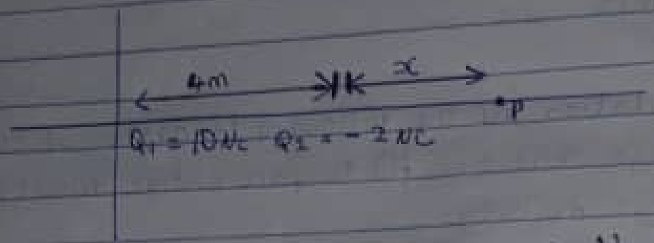
iii) We can also have electric potential due to single point charge

$$V_B - V_A = \frac{Q}{4\pi\varepsilon_0}\left[\frac{1}{r_B} - \frac{1}{r_A}\right]$$

iv) We also have electric potential due to several point charges

$$V_P = \frac{1}{4\pi\varepsilon_0} = \left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3} + \frac{Q_4}{r_4}\right]$$

c Two point charges $Q_1 = 10\mu c$ and $Q_2 = -2\mu C$ and arranged along the x-axis at $x = 0$ and $x = 4m$ respectively. Find the position along the x-axis where $V = 0$



$$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right] \quad \text{let } V_P = 0$$

$$0 = 9\times10^9\left[\frac{10\times10^{-6}}{4+x} + \frac{(-2\times10^{-6})}{x}\right]$$

$$0 = 9\times10^9\left[\frac{10\times10^{-6}}{4+x} \quad \frac{-2\times10^{-6}}{x}\right.$$

$$0 = \frac{90\,000}{4+x} - \frac{18000}{x}$$

multiply through by $(4+x)(x)$

$$(4+x)(x)0 = \frac{90\,000}{\cancel{4+x}} \times (\cancel{4+x})(x) - \frac{18\,000}{\cancel{x}}(4+x)(\cancel{x})$$

$$0 = 90\,000x - 18000(4+x)$$

$$0 = 90\,000x - 72\,000 - 18\,000x$$

$$72\,000 = 90000x - 18000x$$

$$72000 = 72000x$$

$$x = \frac{\cancel{72\,000}}{\cancel{72000}}$$

$$x = 1$$

$$4+x = 4+1 = 5m$$

So, the position along the x-axis due $V=0$ is 5m.

4a) What is magnetic flux: This is the strength of magnetic field represented by lines of force. It is usually represented by the symbol Φ.

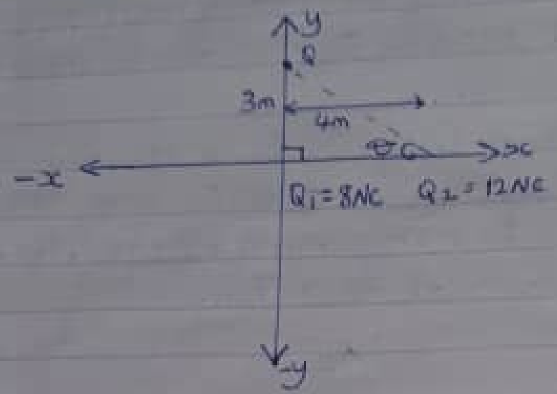
b) An electron with a rest mass of 9.11×10^{-31} kg moves on a circular orbit of radius 1.4×10^{-7}m in a uniform magnetic field of 3.5×10^{-1}. Weber/meter square,

Perpendicular to th
Cyclotron frequency
$\omega = \frac{qb}{m_p}$
$F_B = qVB\sin\theta$
$F_B = qVB$
$F_c = qvB$
$V = \frac{qBr}{m}$
$V = \frac{-1.6\times10^{-19}}{9}$
$V = -8$
Hence, the a
$= \frac{-1.6\times10^{-19}}{9.11}$
c) We were t
angular speed -
values were slot
5) State Bio - Sa
i) The vector d
in the direction o
$\hat{r}$ directed fro
ii) The magnitu
to r^2, where
iii) The magnitud
and to the magn
iv) The magnitud
θ is the angle
Therefore
dB

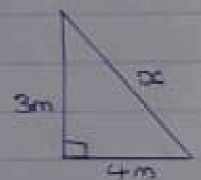
$E = 13.4694$

$E = 13.5 \ N/C$

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



To find the distance b/w electric field at point P and Q_2 use Pythagoras theorem.



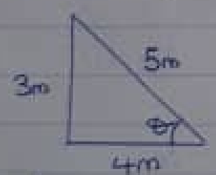
$x^2 = 3^2 + 4^2$

$x^2 = 9 + 16$

$\sqrt{x^2} = \sqrt{25}$

$\therefore x = 5m.$

To find the angle between the horizontal and E_2, do this



$\sin\theta = 3/5$

$\theta = \sin^{-1} 3/5$

$\theta = 36.87°$

$E_1 = \frac{kq_1}{r_1^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{3^2} = 8 N/C$

$E_2 = \frac{kq_2}{r_2^2} = 9 \times 10^9 \times 12 \times 10^{-9} = 4.32 \ N/c$

Vector	Angle	x-component	Y-component
$E_1 = 8 N/c$	$90°$	$8\cos 90 = 0$	$8\sin 90 = 8$
$E_2 = 4.32 N/c$	$36.87°$	$4.32 \cos 36.87 = 3.455995$	$4.32 \sin 36.87 = 2.592$
		3.455995	10.592

$E = \sqrt{\Sigma Ex^2 +$

$E = \sqrt{3.4559$

$E = 11.2 N/c$

3a) State the formula

i) volume charge

iii) Linear charge

solution; i) volu

ii) Surface ch

iii) Linear charg

b) Explain with appro

difference. Elect

in an electric field

charge against forc

to another. We hav

difference depending

i) we have electric

is. $V_B - V_A =$

ii) We can also

energy per unit ch

$V_B - V$

iii) We can also

$V_B - V_A = \frac{Q}{4}$

iv) We also have

$V_P = \frac{1}{4\pi\varepsilon}$

c. Two point charge

along the x-a

perpendicular to the speed with which electron moves. Find the cyclotron frequency of the moving electron.

$$\omega = \frac{qb}{m_p}$$

$F_B = qVB\sin\theta$ where $\theta = 90°$

$F_B = qvB$

$F_B : qvB = \frac{mv^2}{r}$

$$V = \frac{qBr}{m}$$

$$V = \frac{-1.6\times10^{-19}\times 3.5\times10^{-1}\times 1.4\times10^{-7}}{9.11\times10^{-31}}$$

$V = -8.60593$ m/s

Hence, the angular speed $= \omega = \frac{qB}{m_p}$

$$= \frac{-1.6\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}} = -6.147\times10^{10} \text{ rad/s}$$

c) We were told to find the cyclotron frequency in the angular speed. The formula was provided above and the values were slotted into the formula.

5) state Bio - Savart Law

i) The vector dB is perpendicular both to dl (which points in the direction of the current and to the unit vector $\hat{r}$ directed from dl toward P.

ii) The magnitude of $\vec{dB}$ is inversely proportional to r^2, where r is the distance from $\vec{dl}$ to P.

iii) The magnitude of dB is proportional to the current I and to the magnitude of the length element $\vec{dl}$.

iv) The magnitude of $\vec{dB}$ is proportional to $\sin\theta$, where θ is the angle between of and $\vec{dl}$.

Therefore

$$\vec{dB} = \frac{\mu_0}{4\pi} \cdot \frac{I\vec{dl}\times r^2}{r^2}$$

$$B = \frac{N_0 I x}{4\pi}\int_{-a}^{a}\frac{1}{(x^2+y^2)^{3/2}}\,dy$$

$$\cancel{B = \frac{\mu_0 I x}{4\pi}\int_{-a}^{a}}$$

Using special Integrals:

$$\int\frac{dy}{(x^2+y^2)^{3/2}} = \frac{1}{x^2} = \frac{y}{x^2(x^2+y^2)^{1/2}}$$

Equation (***) becomes

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

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

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

when the length 2a of the conductor is very great in comparison to it's distance x from point P, we consider it infinitely long. That is, when a is much longer than x

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

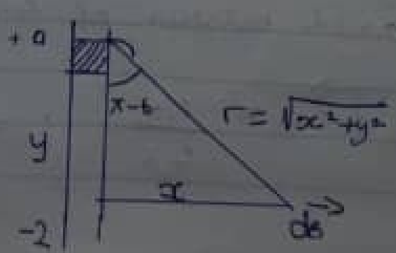
$$\therefore B = \frac{\mu_0 I}{2\pi x}$$

$$\cancel{(x^2+a^2)^{1/2}}$$

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

$$B = \frac{N_0 I}{2\pi r}$$

$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a}\frac{dl\sin\theta}{r^2}$$



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

$$\therefore \quad B = \frac{N_0 I}{4\pi}\int_{-a}^{a} \frac{dl \sin(\pi - 6)}{r^2}$$

from the diagram, $r^2 = x^2 + y^2$ (Pythagoras Theorem)

$$B = \frac{N_0 I}{4\pi}\int^{a} \frac{dl \sin(\pi - 6)}{x^2+y^2} \quad \text{-----} (*)$$

But $\sin(\pi - 6) = \dfrac{x}{\sqrt{x^2+y^2}} = \dfrac{x}{(x^2+y^2)^{1/2}}$ --- $(**)$

Substitute $(**)$ into $(*)$ we have:

$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a} dl \, \frac{x}{(x^2+y^2)(x^2+y^2)^{1/2}}$$

$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a} dl \, \frac{x}{(x^2+y^2)^{3/2}}$$

Recall $dl = dy$

$$B = \frac{N_0 I}{4\pi}\int_{-a}^{a} \frac{x}{(x^2+y^2)^{3/2}} \, dy.$$