PHY102

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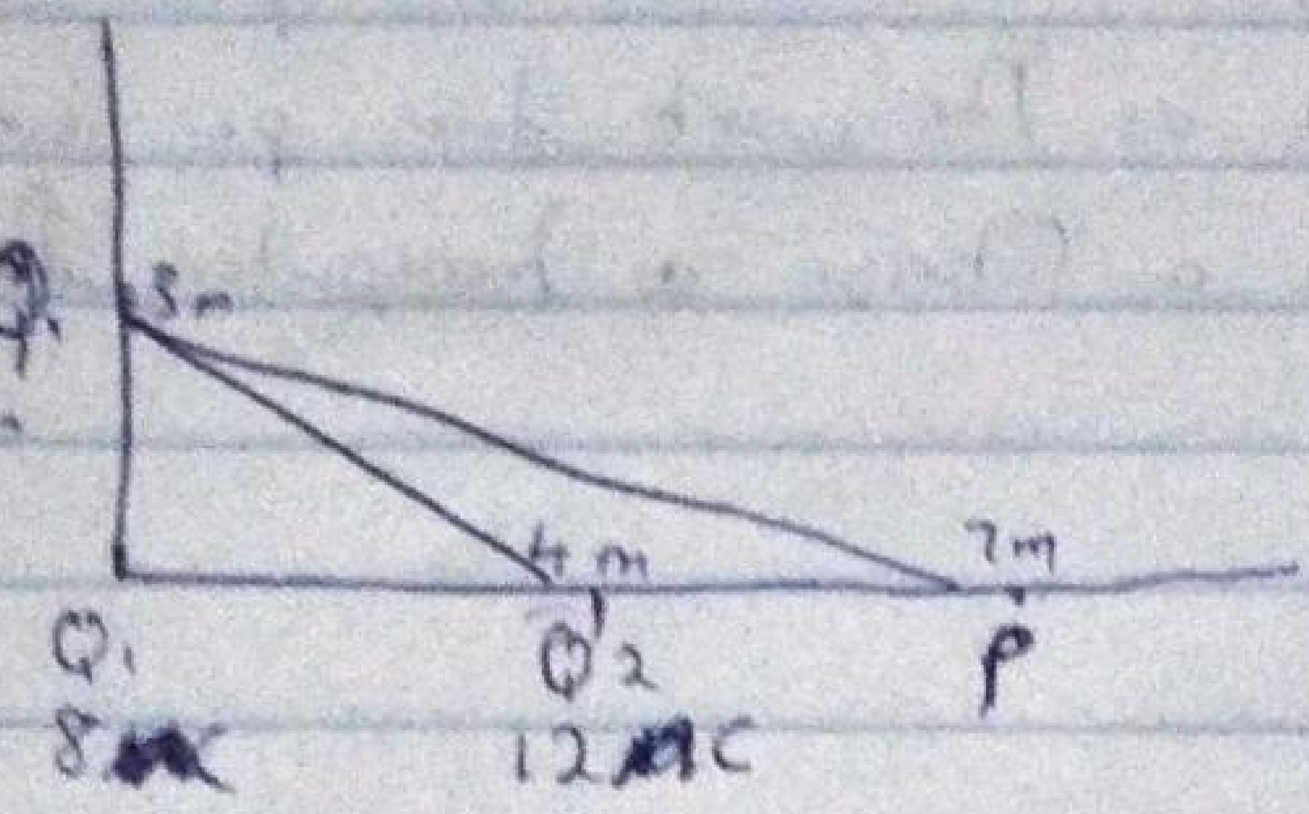
2a An electric field is the region or space in which an electric charge will experience an electric force while electric field intensity is the force per unit charge.

$Q_1 = 3\,nC$, $Q_2 = 12\,nC$ $x = 4\,m$



$E_1 = \frac{kq_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.47\ N/C$

$E_2 = \frac{kq_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{3^2} = 0.12\ N/C$

$E_{net} = 1.47 + 0.12 = 1.59\ N/C$

$\cancel{E = \frac{kq}{r^2}}$

(B) $E_1 = \frac{9\times10^9 \times 8\times10^{-4}}{3^2} = 8\ N/C$

$E_2 = \frac{9\times10^9 \times 12\times10^{-4}}{.25} = 4.32\ N/C$

$E_x = -3.46$ $\qquad E_x = 10.55\ N/C$

$|E| = \sqrt{(-3.46)^2 + (10.55)^2}$ $\qquad |E| = 11.14\ N/C$

3 (5) Volume Charge density is $(\rho) = \frac{dQ}{dV}$

Surface Charge density is $(\sigma) = \frac{dQ}{dA}$

Linear Charge density, $(\lambda) = \frac{dQ}{dl}$

(3) 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 another

$$dW = F \cdot dl$$

$$F = -q_0 E$$

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

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

$$V_B - V_A = \frac{W(A \to B)_{Ag}}{q_0} = \int_A^B E\, dl$$

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4a) Magnetic Flux
Magnetic flux is defined as the number of magnetic field lines passing through a given closed Surface. It gives the measurement of the total magnetic field that passes through a given Surface are

4b $m = 9.11 \times 10^{-31} kg$
$B = 3.5 \times 10^{-1}$ weber/meter
$r = 1.4 \times 10^{-7} m$
q of an electron $= 1.6 \times 10^{-19} C$

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

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

Cyclotron frequency $= 6.15 \times 10^{10}$ rad/s

c Discuss your answer above

Cyclotron frequency which is also known as angular Speed is obtained by the following Steps.

$$\text{Velocity} = \frac{qBr}{m}$$

q = Charge
B = magnetic ~~intensity~~ field magnitude
r = radius
m = mass

$$\omega = \frac{V}{r} = \frac{qBr}{m} \times \frac{1}{r}$$

$\therefore$ Cyclotron frequency ω is $= \dfrac{qB}{m}$

What it means is the electron circulates at 6.15×10^{10} rad per Second

State Bio-Savart Law

This is based on the observation for the magnetic field $\vec{dB}$ at a point P associated with a length element dl of a wire carrying a steady current

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

where μ_0 = Permeability of free space = $4\pi \times 10^{-7}$

I = Current

dl = change in length element

r = distance from dl to the point

The vector dB is perpendicular to dl and unit vector r

magnitude of dB is inversely to r^2

" " " is directly proportional to I

" " " is directly proportional to θ

Bio-Savart's law is an equation that describes the magnetic field created by a current wire and allows you to calculate its strength at various points

Using Bio Savart's law

$$\vec{dB} = \frac{\mu_0 I}{4\pi} \frac{dl \times \hat{r}}{r^2} \qquad db = \frac{\mu_0 I}{4\pi} \frac{\sin\theta \, dl}{r^2}$$

$$B = \int \frac{\mu_0 I \sin\theta \, dl}{4\pi r^2}$$

Sub $\theta = x/r$

$$= \int \frac{\mu_0 I y}{4\pi \sqrt{y^2 + x^2}} \frac{dl}{(y^2 + x^2)}$$

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

$$dl = dy$$

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

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

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

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

$$\int_c^b f x \, dx = \int^b f x \, dx - \int_a f x \, dx$$

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

take x to be negligible

$$B = \frac{\mu_0 I x}{4\pi x^2} \left[\frac{2a}{a} \right]$$

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