Sosanya Ayoola Elizabeth
M/ts
Pharmacy
PHY 102
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SECTION A

3) Electric field and electric field intensity.

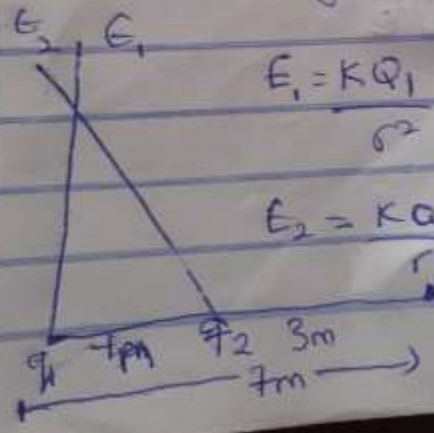
electric field	electric field intensity
• It is a region of space in which an electric charge will experience an electric force	It is the force per unit charge

2b) $q_1 = 8nC$ at origin, $q_2 = 12nC$ on x axis at $x = 4m$

(i) net electric field at point P on the x axis at $x = 7m$

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

(i)



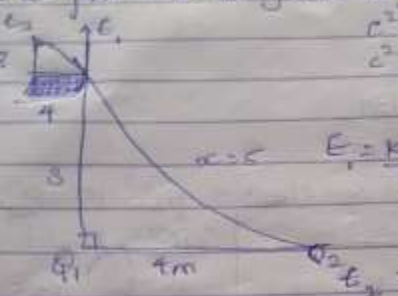
$$E_1 = \frac{KQ_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = 1.469\ N/C$$

$$= 1.5\ N/C$$

$$E_2 = \frac{KQ_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{7^2} = 12\ N/C$$

$E_{net} = \vec{E_1} + \vec{E_2} = 1.5 + 12\ N/C = 13.5\ N/C$

iii) $\vec{E}$ at point Q on the y axis at y = 3m due to charge.



$c^2 = a^2 + b^2$

$c^2 = 4^2 + 3^2$

$= 5$

$E_1 = \frac{KQ_1}{r^2} = \frac{9\times10^9 \times 8\times10^{-7}}{3^2} = 8\ N/C$

$E_{y1} = \frac{KQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-7}}{5^2}$

$= 4.32\ N/C$

vector	angle	x-comp	y-comp
$E_1 = 8\ N/C$	$90°$	0 N/C	8 N/C
$E_2 = 4.32$	$36.87°$	$-3.45\ N/C$	$2.57\ N/C$

$E_{fx} = -3.45\ N/C$ $E_{fy} = 10.57\ N/C$

$E_{net} = \sqrt{E_{fx}^2 + E_{fy}^2}$

$= 11.12\ N/C$

3. Formulation of identities of charges

a) volume charge density $\rho = \frac{dQ}{dv} = dQ = \rho dv$

b) surface charge density $\sigma = \frac{dQ}{dA} = dQ = \sigma dA$

c) linear charge density $\lambda = \frac{dQ}{dL} = dQ = \lambda dL$

5) electric potential difference equation.

- due to a single point charge.

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

where Q = point charge

r_B = distance of Q to point B

r_A = distance of Q to point A

- due to several point charges

$$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1}\right] + \left(\frac{Q_2}{r_2}\right)$$

where V = electric potential

Q = point charge

r = distance of Q

3) Point charge $Q_1 = 10\mu C$, $Q_2 = -2\mu C$ along x axis $x = 0$, x is 4m find the position along x-axis where $V = 0$.

q_1 q_2 P $V=0$

$$V_p = \frac{1}{4\pi\varepsilon_0}\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right) \quad \text{recall } \frac{1}{4\pi\varepsilon_0} = 9\times10^9 \, k$$

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

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

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

$$0 = \frac{10\times10^{-6}}{4+x} + \frac{-2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4+x} - \frac{2\times10^{-6}}{x}$$

$$10\times10^{-6}x = (4+x)(2\times10^{-6})$$

$$10\times10^{-6}x = 8\times10^{-6} + 2\times10^{-6}x$$

$$8\times10^{-6} = 10\times10^{-6}x - 2\times10^{-6}x$$

$$8\times10^{-6} = 8\times10^{-6}x$$

$$x = \frac{8\times10^{-6}}{8\times10^{-6}}$$

$$x = 1$$

Position along x-axis is 1m.

where $v = 0$

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

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

$$\frac{2\times10^{-6}}{x} = \frac{10\times10^{-6}}{4-x}$$

$$(4-x)(2\times10^{-6}) = x(10\times10^{-6})$$

$$8\times10^{-6} - 2\times10^{-6}x = 10\times10^{-6}x$$

$$8\times10^{-6} = 10\times10^{-6}x + 2\times10^{-6}x$$

$$8\times10^{-6} = 12\times10^{-6}x$$

$$x = \frac{8\times10^{-6}}{12\times10^{-6}}$$

$$x = 0.67\,m$$

$\therefore$ Position of $v=0$ is $0.67\,m$.

SECTION B.

4a) Magnetic flux is defined as the strength of the magnetic field which can be represented by line of force. It is denoted as Φ

$\Phi = B \cdot dA$

4b) $m_e = 9.11 \times 10^{-31}$ kg, $r = 1.4 \times 10^{-7}$ m, $B = 3.5 \times 10^{-1}$ Wb/m^2

Cyclotron frequency = angular speed. $q = 1.6 \times 10^{-19}$

$F_B = qvB = \frac{m_e v^2}{r}$

$m_e v = qBr$

$v = \frac{qBr}{m_e} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1} \times 1.4 \times 10^{-7}}{9.11 \times 10^{-31}}$

$v = 8.61 \times 10^{-3}$ m/s.

$\omega = \frac{v}{r} = \frac{qB}{m_e} = \frac{1.6 \times 10^{-19} \times 3.5 \times 10^{-1}}{9.11 \times 10^{-31}}$

$\omega = 6.14 \times 10^{10} s^{-1}$

4c) In 4b we were given some parameters mass of electron $= 9.11 \times 10^{-31}$ kg radius $= 1.4 \times 10^{-7}$ m $B = 3.5 \times 10^{-1}$ wb

we were asked to find the cyclotron frequency which is the same thing as angular speed. It is called cyclotron frequency because it is a

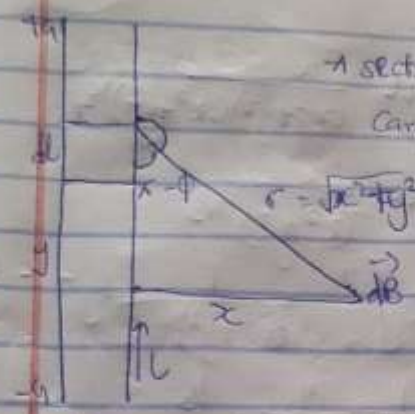
frequency of an accelerator called cyclotron.
Recall ω = angular speed.
$\omega = \frac{qB}{m_p}$. Since cyclotron frequency = angular speed
The cyclotron frequency = $6.14 \times 10^{-10} C^{-1}$
having a unit of $\frac{1}{T}$ which is the unit of frequency dimensionally.

5a) Bio-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 lenght, the radius and inversely proportional to square of radius (r^2). mathematically,

$$\vec{dB} = \frac{\mu_0 I \, dL \times \hat{r}}{4\pi r^2}$$

where μ_0 (permeability of free space) = $4\pi \times 10^{-7}$ T.m/A
r = radius $\vec{dB}$ = magnetic field I = steady current,
dL = lenght of wire unit is W/m^2.

5b Magnetic field of a straight current carrying conductor:



Applying Bio-Savart law, we find the magnitude of the field ($\vec{dB}$) from the diagram.

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

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

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

from the diagram $r^2 = x^2 + y^2$

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

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

Substitute (II) into (1)

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

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

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

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

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

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