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COURSE — PHY 102

DEPARTMENT — PHARMACY

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ASSIGNMENT

Section A

2) Electric field & Electric field intensity

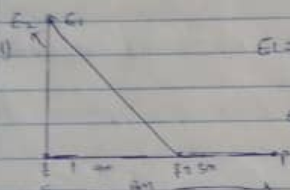
Electric field	Electric intensity
• It is a region of space in which an electric charge will experience an electric field.	It is the force per unit charge.

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)

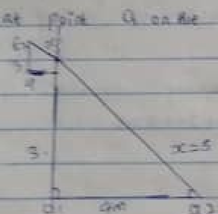


$E_1 = \frac{kq_1}{r^2} = \frac{9 \times 10^9 \times 8 \times 10^{-9}}{7^2} = 1.469 N/C$
$\approx 1.5 N/C$

$E_2 = \frac{kq_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{3^2} = 12 N/C$

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

ii) $\vec{E}$ at point Q on the y axis at $y = 3m$ due to charges



$hyp^2 = a^2 + b^2$
$c^2 = 4^2 + 3^2$
$c = 5$

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

$E_2 = \frac{kq_2}{r^2} = \frac{9 \times 10^9 \times 12 \times 10^{-9}}{5^2} = 4.32 N/C$

Vector	angle	x-comp	y-comp
$E_1 = 8 N/C$	$90°$	$0 N/C$	$8 N/C$
$E_2 = 4.32$	$36.87°$	$-3.45 N/C$	$2.59 N/C$

$E_{net} = \sqrt{E_x^2 + E_y^2}$ $E_x = -3.45 N/C$ $E_y = 10.59 N/C$

$E_{net} = 11.12 N/C$

where Q = charge
V = Volume
L = Length
A = Area

3) Formulae of densities of charge

a) Volume charge density $\rho = \frac{dq}{dv} = dq = \rho dv$.

ii) Surface charge density $\sigma = dq/dA = dq = \sigma dA$.

iii) Linear charge density $\lambda = dq/dL = dq = \lambda dL$.

b) 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

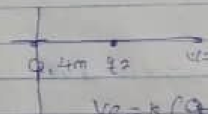
• due to several point charges.

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

where V = electric potential
Q = point charge.
r = distance of Q

3c)

point charge $Q_1 = 10\mu C$, $Q_2 = -2\mu C$ along x axis at $x = 0$, $x = 4m$ respectively. Find the position along the x axis where $V = 0$



$V_P = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1}{r_1} + \frac{q_2}{r_2}\right]$ recall $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 = k$

$V_P = k\left[\frac{q_1}{r_1} + \frac{q_2}{r_2}\right]$

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

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

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

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

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

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

$8 \times 10^{-6} = 8 \times 10^{-6} x$

$x = \frac{8 \times 10^{-6}}{8 \times 10^{-6}}$ $x = 1$.

∴ position along the x-axis is 1m.

where V = 0

$$V = k\left(\frac{q_1}{r_1} + \frac{q_2}{r_2}\right)$$

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

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

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

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

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

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

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

$x = 0.67m$

∴ position of V = 0 is 0.67m

SECTION B

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

$$\phi = B \cdot dA$$

4b) $M_e = 9.11\times10^{-31}kg$, $r = 1.4\times10^{-7}m$; $B = 3.5\times10^{-1}wb/m^2$

Cyclotron frequency = angular speed. $q = 1.6\times10^{-19}$

$$F_B = qvB = \frac{M_e V^2}{r}$$

$M_e V = qBr$

$$V = \frac{qBr}{M_e} = \frac{1.6\times10^{-19}\times3.5\times10^{-1}\times1.4\times10^{-7}}{9.11\times10^{-31}}$$

$V = 8.61\times10^{-3}m/s$.

$$w = \frac{V}{r} = \frac{qB}{m_e} = \frac{1.6\times10^{-19}\times3.5\times10^{-1}}{9.11\times10^{-31}}$$

$W = 6.14\times10^{10}s^{-1}$.

4c) In 4b we were given parameters; mass of electron $= 9.11\times10^{-31}kg$

Radius $= 1.4\times10^{-7}m$ $B = 3.5\times10^{-1}wb/m^2$

And 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 W = angular speed

$$W = \frac{qB}{M_e}$$

Since cyclotron frequency = angular speed

The cyclotron frequency $= 6.14\times10^{10}s^{-1}$ having a unit of $1/T$ which is the unit of frequency dimensionally.

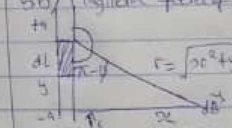
5A) Biot-Savart law states that the magnetic field is directly proportional to the product permeability of free space (μ_0) the current (I), the change in length, the radius and inversely proportional to square of radius (r^2). Mathematically;

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

where μ_0 = permeability of free space $= 4\pi\times10^{-7}T.m/A$; r = radius

$\vec{dB}$ = magnetic field I = steady current ; dl = length of wire unit wb/m^2

5B) Magnetic field of a straight current carrying conductor



A section of a straight current carrying conductor.

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

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

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

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

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

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

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

Substitute (ii) into (i)

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

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

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

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

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

$= a = \infty$