OBINNA BLESSING CHINONSO
19/MHS11/091
PHARMACY SECTION A

Electric field & electric field intensity

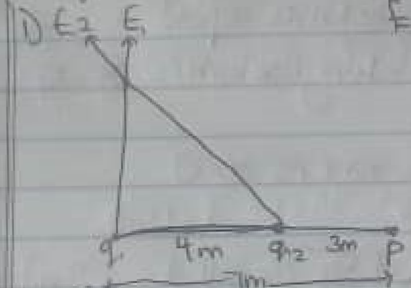
| electric field | electric field intensity |
|---|---|
| It is a region of space in which an electric charge will experience and electric force | It is the force per unit charge |

$q_1 = 8nC$ 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)

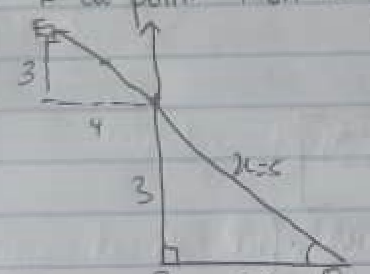


$$E_1 = \frac{kQ_1}{r_2} = \frac{9\times10^9 \times 8\times10^{-9}}{7^2} = 1.469 N/C \approx 1.5 N/C$$

$$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{7^2} = 12 N/C$$

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

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



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

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

$$c = 5$$

$$E_1 = \frac{kQ_1}{r_2} = \frac{9\times10^9 \times 8\times10^{-9}}{3^2} \quad E_1 = 8N/C$$

$$E_2 = \frac{kQ_2}{r^2} = \frac{9\times10^9 \times 12\times10^{-9}}{5^2} = 4.32 N/C$$

| Vector | Angle | x-comp | y-comp |
|---|---|---|---|
| $E_1 = 8N/C$ | 90 | 0 N/C | 8N/C |
| $E_2 = 4.32$ | 36.87° | -3.45N/C | 2.59N/C |
| | | $\Sigma F_x = -3.45N/C$ | $\Sigma F_y = 10.59 N/C$ |

$$E_{net} = \sqrt{\Sigma F_x^2 + \Sigma F_y^2}$$

$$E_{net} = 11.12 N/C$$

3 - Formulation of identities of charge

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 $\lambda = \frac{dQ}{dL} = dQ = \lambda dL$

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 $\quad V$ = electric potential

$r_B$ = distance of $Q$ to point B

$r_A$ = distance of $Q$ to point A

- due to several point charges

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{Q_1}{r_1} + \frac{Q_2}{r_2}\right]$$ 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 $x = 0$, $x = 4m$ 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 $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$

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

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

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

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

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

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

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

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

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

$$x = 1$$

$\therefore$ position along the x-axis is 1m.

where $V = 0$

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

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

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

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

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

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

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

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

$$x = 0.67m$$

$\therefore$ position of $V=0$ is $0.67m$

## SECTION B

(44) Magnetic flux is defined as the strength of the magnetic field which can be represented by line of forces. It is denoted as $\phi$

$$\phi = B.dA$$

(45) $m_e = 9.11\times10^{-31}kg$, $r = 1.4\times10^{-7}m$; $B = 3.5\times10^{-1}w/m^2$

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

$$F_B = qVB = \frac{m_eV^2}{r}$$

$$M_eV = qBr$$

$$V = \frac{qBr}{m_e} = \frac{1.6\times10^{-19}\times3.5\times10^{-1}\times1.4\times10^{-7}}{9\times11\times10^{-31}}$$

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

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

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

(46) In 45 we were given parameters, mass of electron $= 9.11\times10^{-31}kg$ radius $= 1.4\times10^{-7}m$ $B = 3.5\times10^{-1}w/m^2$ 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.

$\omega$ = angular speed

$\omega = \frac{qB}{me}$ since cyclotron frequency = angular speed

The cyclotron frequency = $1.19 \times 10^{-19} s^{-1}$ having a unit of $\frac{1}{T}$ which is the unit of frequency dimensionally.

5) Bio-Savart law states that the magnetic field is directly proportional to the product permeability of free space ($\mu_0$) the current (I), the change in length, the radius ~~or are~~ and inversely proportional to the square of radius ($r^2$). mathematically:-

$$d\vec{B} = \frac{\mu_0 I \, d\vec{l} \times \hat{r}}{4\pi r^2}$$

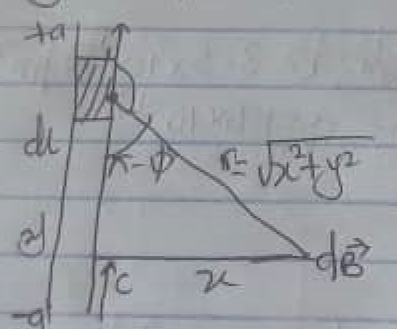
where $\mu_0$ = permeability of free space = $4\pi \times 10^{-7}$ m/A

r = radius

$d\vec{B}$ = magnetic field, I = steady current, dl = length of wire

unit is $w/m^2$

5b) magnetic field of a straight current carrying conductor




A section of a straight current carrying conductor.

Applying Bio-Savart law, we find the magnitude of the field (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 $r^2 = x^2 + y^2$

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

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

substitute (II) into (1)

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

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

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

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

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

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