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PHY102 17/MHS01/061 MBBS

1) $F = 1.0\,N$; $r = 2.0\,m$, $q_1 q_2 = 5.0\times10^{-5}\,C$; $q_1 = (5.0\times10^{-5} - q_2)\,C$

$F = \frac{Kq_1q_2}{r^2}$; $1.0 = \frac{9\times10^9 \times (5.0\times10^{-5} - q_2)\times q_2}{(2.0)^2}$; $4500000q_2 - 9.0\times10^9 q_2^2 = 4$

$-9.0\times10^9 q_2^2 + 4500000q_2 - 4 = 0$ [By comparism with $ax^2+bx+c=0$] $q_2 = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$q_2 = \frac{-4500000 \pm \sqrt{(4500000)^2 - 4(-9.0\times10^9)(-4)}}{2(-9.0\times10^9)}$; $\frac{-4500000 \pm \sqrt{2.025\times10^{13} - 1.44\times10^{11}}}{-1.8\times10^{10}}$

$q_2 = \frac{-4500000 + 2418767.8524}{-1.8\times10^{10}}$; OR $\frac{-4500000 - 2418767.8524}{-1.8\times10^{10}}$

$q_2 = 1.1563\times10^{-5}\,C$ OR $3.8437\times10^{-6}\,C$

Recall that $q_1 = (5.0\times10^{-5} - q_2)\,C$ $\therefore q_1 = (5.0\times10^{-5} - 1.1563\times10^{-5})\,C$

$q_1 = 3.8437\times10^{-5}\,C$ or $q_1 = (5.0\times10^{-5} - 3.8437\times10^{-6})\,C = 1.1563\times10^{-5}\,C$

$\therefore q_1 = 3.8437\times10^{-5}\,C$ and $q_2 = 1.1563\times10^{-5}\,C$ OR $q_1 = 1.1563\times10^{-5}\,C$

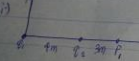
and $q_2 = 3.8437\times10^{-6}\,C$

a)

2a) Electric field is the region of space in which an electric charge will experience an electric force while electric field intensity is the force experienced by a test charge or when a test charge experiences a force. It is the force per unit charge.

b) $q_1 = +8\times10^{-9}\,C$; $q_2 = 12\times10^{-9}\,C$

(i)



$E_1 = \frac{(9\times10^9)(8\times10^{-9})}{4^2} = 1.45\,N/C$

$E_2 = \frac{(9\times10^9)(12\times10^{-9})}{3^2} = 12\,N/C$

	x-comp	y-comp
1	1.45cos0	1.45sin90
2	12cos0	12sin0

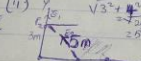
$\Sigma x = 12$ $\Sigma y = 1.45$

$E = \sqrt{\Sigma x^2 + \Sigma y^2}$

$E = \sqrt{12^2 + 1.45}$

$E = 12.1\,N/C$

(ii)



$E = \frac{kq_1}{r^2} = \frac{(9\times10^9)(8\times10^{-9})}{3^2}$

$E_1 = 8\,N/C$

$E_2 = \frac{(9\times10^9)(12\times10^{-9})}{5^2} = 4.32\,N/C$

	x-comp	y-comp
1	8cos0	8sin90
2	4.32cos36.86	4.32sin36.86
Σ	11.456	9.592

$E = \sqrt{\Sigma x^2 + \Sigma y^2} = \sqrt{11.456^2 + 9.592^2} = 14.94\,N/C$

3) (a) $d\vec{B} = \frac{\mu_0 I}{4\pi} \frac{d\vec{l}\times\hat{r}}{r^2}$

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

(b)

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

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

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

$r^2 = x^2 + y^2$; $B = \frac{\mu_0 I}{4\pi} \int_{-a}^{a} \frac{dl\sin(\pi-\varphi)}{x^2+y^2}$

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

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

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

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

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

$B = \frac{\mu_0 I}{2\pi x}\left(\frac{2a}{(x^2+a^2)^{1/2}}\right)$, when the length $2a$ of the conductor is very great in comparison to its distance, or from point P we consider it ∞ long.

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

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

4a) A magnetic flux can be defined as the strength of a magnetic field represented by lines of force.

b) $\omega = \frac{qB}{m_p} = \frac{1.60\times10^{-19}\times5.6\times10^{-1}}{1.11\times10^{-31}} = 6.147\times10^{10}\,rad/s$

$v = \frac{qBr}{m_p}$

$q = \frac{vm_p}{Br}$ = $6.149\times10^{10}\,rad/s$

This means that the electron of rest mass $9.11\times10^{-31}\,kg$ circulates at $6.149\times10^{10}\,rad/s$ in a cyclotron.