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Chapter : 4 Moving charges and Magnetism

1) $N = 100$

$r = 8cm = 0.08m$

$I = 0.40A$

B at Centre: $\frac{\mu_0 IN}{2r} = \frac{4\pi \times 10^{-7} \times 0.4 \times 100}{2 \times 0.08}$

$= 3.14 \times 10^{-4} T$

2) $I = 35A$

$r = 20cm = 0.2m$

$B = \frac{\mu_0 I}{2r} = \frac{4\pi \times 10^{-7} \times 35}{2 \times 0.2} = 3.5 \times 10^{-5} T$

6) $l = 3cm = 0.03m$

$I = 10A$

$B = 0.27T$

$\theta = 90^\circ$

$F = BIl\sin\theta$

$= 0.27 \times 10 \times 0.03 \times \sin 90$

$= 8.1 \times 10^{-2} N$

7) $I_A = 8A$

$I_B = 5A$

$r = 4cm = 0.04m$

$l_A = 10cm = 0.1m$

$B = \frac{\mu_0 2 I_A I_B l_A}{4\pi r} = \frac{4\pi \times 10^{-7} \times 8 \times 5 \times 0.1}{2\pi \times 0.04}$

$= 2 \times 10^{-5} N$

8) $l = 80cm = 0.8m$

$N = 5 \times 400 = 2000$

$D = 1.8cm = 0.018m$

$I = 8A$

$B = \frac{\mu_0 NI}{l} = \frac{4\pi \times 10^{-7} \times 2000 \times 8}{0.8}$

$= 8\pi \times 10^{-3} = 2.5 \times 10^{-2} T$

11) $B = 6.5\ G = 6.5 \times 10^{-4}\ T$
$v = 4.8 \times 10^{6}$
$\theta = 90^\circ$
$m_e = 9.1 \times 10^{-31}\ kg$
$e = 1.6 \times 10^{-19}\ C$

Magnetic force exerted on the electron is
$f = evB \sin\theta$.
Centripetal force $F_c = \frac{mv^2}{r}$

$F_c = f$
$\Rightarrow \frac{mv^2}{r} = evB\sin\theta \Rightarrow r = \frac{mv}{Be\sin\theta} = \frac{9.1 \times 10^{-31} \times 4.8 \times 10^{6}}{6.5 \times 10^{-4} \times 1.6 \times 10^{-19} \times \sin 90^\circ}$

$= 4.2 \times 10^{-2}\ m = 4.2\ cm.$

12) $B = 6.5 \times 10^{-4}\ T$
$v = 4.8 \times 10^{6}$
$\theta = 90^\circ$
$m_e = 9.1 \times 10^{-31}$
$e = 1.6 \times 10^{-19}$
$r = 4.2\ cm = 0.042\ m$

Let frequency of the electron be f
Angular frequency $= \omega = 2\pi f$
Velocity is related to angular frequency as: $v = r\omega$.

$= evB = \frac{mv^2}{r} \Rightarrow eB = \frac{m}{r}(r\omega) = \frac{m}{r} r 2\pi f$
$\Rightarrow f = \frac{Be}{2\pi m}$

$\therefore$ Frequency is independent of the speed of electron.
$f = \frac{Be}{2\pi m} \Rightarrow \frac{6.5 \times 10^{-4} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}} = 18\ MHz$

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13) a) $N = 30$, $r = 8\ cm = 0.08\ m$, $I = 6A$, $B = 1T$, $\theta = 60°$

$A = \pi r^2 = 3.14 \times (0.08)^2 = 0.0201$

$\tau = nIBA\sin\theta$

$= 30 \times 6 \times 1 \times 0.0201 \times \sin 60°$

$= 3.133\ Nm$

b) As τ doesn't depend on shape so it will not change.

Additional Exercise:

14) $r_1 = 16\ cm = 0.16\ m$

$n_1 = 20$, $I_1 = 16A$, $r_2 = 0.1\ m$, $I_2 = 18A$.

$B_{centre_1} = \frac{\mu_0 I N}{2r} = \frac{4\pi \times 10^{-7} \times 20 \times 16}{2 \times 0.16} = 4\pi \times 10^{-4}\ T$ (towards east)

$B_2 = \frac{\mu_0 N_2 I_2}{2 r_2} = \frac{4\pi \times 10^{-7} \times 25 \times 18}{2 \times 0.10} = 9\pi \times 10^{-4}\ T$ (towards west)

$B_{net} = B_2 - B_1$

$= 9\pi \times 10^{-4} - 4\pi \times 10^{-4}$

$= 5\pi \times 10^{-4}\ T$ (towards west)

15) $B = 100G = 100 \times 10^{-4}\ T$, $N = 1000$ turns/m, $I = 15A$

$B = \frac{\mu_0 N I}{l} \Rightarrow \frac{NI}{l} = \frac{B}{\mu_0} \Rightarrow \frac{NI}{l} = \frac{100 \times 10^{-4}}{4\pi \times 10^{-7}} \Rightarrow \frac{NI}{l} = 7961$

Let the current $= 10A$ & $l = 0.6\ m$

So we get $= \frac{N \times 10}{0.6} = 7961 \Rightarrow N = \frac{7961 \times 6}{100} \Rightarrow N = 477.6$

17) $r_1 = 25\ cm = 0.25\ cm$, $r_2 = 26\ cm = 0.26\ m$, $N_1 = 3500$, $I = 11A$

a) Outside the toroid, magnetic field is zero.

b) $B = \frac{\mu_0 N I}{l} \Rightarrow l = 2\pi \left(\frac{r_1 + r_2}{2}\right) = \pi \times 0.51$

$B = \frac{\mu_0 N I}{l} = \frac{4\pi \times 10^{-7} \times 3500 \times 11}{\pi \times 0.51} = 3.02 \times 10^{-2}\ T$

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18a) Intial velocity is either parallel or anti parallel to the magnetic field. Their is no magnetic force acting on the particle when it is parallel or anti-parallel and it moves undeflected.

b) Yes, as magnetic force can change the direction of velocity but not it's magnitude.

c) Magnitude field should be in a vertically downward direction.

19) $B = 0.15T$, $V = 2KV$, gain in KE of an $e^- \Rightarrow E = (1/2) mv^2$

$\Rightarrow eV = (1/2) mv^2$

$\Rightarrow u = \sqrt{2eV/m}$

$= \sqrt{2 \times 1.6 \times 10^{-19} \times 2 \times 10^3 / 9.1 \times 10^{-31}}$

$= 2.65 \times 10^7 \ m/s$

a) $F_1 = F_2$, $F_1 = eVB$, $F_2 = mV^2/2 \Rightarrow eVB = mv^2/2 \Rightarrow r = mv/eB$

$\Rightarrow r = mv/eB \Rightarrow r = 9.1 \times 10^{-31} \times 2.65 \times 10^7 / 1.6 \times 10^{-19} \times 0.15$

$\Rightarrow 10^{-3} m = 1 mm$

b) $r = mv \sin\theta / Be$, $r = 9.1 \times 10^{-31} \times 2.65 \times 10^7 \times \sin 30^\circ / 0.15 \times 1.6 \times 10^{-19}$

$= 50.2 \times 10^{-5} m$, $r = 0.5 mm$.

20) $B = 0.75T$, $V = 15KV = 15 \times 10^3 V$, $E = 9.0 \times 10^{-5} \times Vm^{-1}$

$K = 1/2 mv^2$, $\Rightarrow eV = 1/2 mv^2$

$\Rightarrow e/m = v^2/2V$

$\therefore$ The particular particles are not defeated by $\vec{E}$ & $\vec{B}$

$\Rightarrow eE = evB$

$\Rightarrow v = E/B$

$1/2 m (E/B)^2 = eV \Rightarrow e/m = E^2/2VB^2 \Rightarrow (9.0 \times 10^5)^2 / 2 \times 15000 \times (0.75)^2$

$\Rightarrow 4.8 \times 10^7 \ C/kg$.

$\therefore$ The answer is not unique as only ratio of charge to mass is determined. The beam contains electrons.

24) $B = 3000\,G = 0.3\,T$, $A = 10 \times 5 = 50 \times 10^{-4}\,m^2$, $I = 12A$.

a) $\tau = I\vec{A} \times \vec{B}$

$\vec{A} = 50 \times 10^{-4}\,\hat{i}$ (y-z plane)

$\vec{B} = 0.3\,\hat{k}$ (along z axis)

$\tau = 12 \times (50 \times 10^{-4})\hat{i} \times 0.3\hat{k}$

$= -1.8 \times 10^{-2}\,\hat{j}\ Nm$ (towards -ve y-direction)

b) It is same as a) in the -ve y direction $F_{net} = 0$

c) $\vec{A} = -50 \times 10^{-4}\,\hat{j}$ (x-z plane)

$\vec{B} = 0.3\,\hat{k}$

$\vec{\tau} = 12 \times (-50 \times 10^{-4})\hat{j} \times 0.3\hat{k}$

$= -1.8 \times 10^{-2}\,\hat{j}\ Nm$

∴ Net force is zero.

d) $\tau = 12 \times 50 \times 10^{-4} \times 0.3$

$= 1.8 \times 10^{-2}\ Nm.$

∴ Net force is zero.

e) $\vec{A} = 50 \times 10^{-4}\,\hat{k}$

$\vec{B} = 0.3\,\hat{k}$

$\vec{\tau} = 12 \times (50 \times 10^{-4})\,\hat{k} \times 0.3\hat{k}$

∴ $F_{net} = 0$

f) $\vec{A} = -50 \times 10^{-4}\,\hat{k}$

$\vec{B} = 0.3\,\hat{k}$

$\vec{\tau} = 12\,(-50 \times 10^{-4})\,\hat{k} \times 0.3\hat{k}$

∴ $F = 0$

∴ Case (e) & (f)

27) $G = 12\,\Omega$

$I = 3\,mA$

$R = (V/I_g) - G \Rightarrow (18/3\times10^{-3}) - 12 \Rightarrow 6000 - 12 = 5988\,\Omega$

28) $G = 15\,\Omega$, $I_g = 4\,mA = 4 \times 10^{-3}\,A$.

Ammeter range $= 0$ to $6A$

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$S = I_g G / I - I_g$

$= \frac{4 \times 10^{-3} \times 15}{6 - 0.004}$

$= 10 \times 10^{-3} A$

$S = 10 \, mA$

$\therefore$ 10 mA resistor must be connected in parallel

—x—