Ch-4 (NCERT Exercise)

4.1 $r = 8.0\,cm = 0.08\,m$

$n = 100$

$I = 0.40\,A$

$\mu_0 = 4\pi \times 10^{-7}\,TmA^{-1}$

$$B = \frac{\mu_0 2\pi n I}{4\pi r}$$

$$B = \frac{\cancel{4\pi} \times 10^{-7}}{\cancel{4\pi}} \times \frac{2\pi \times 100 \times 0.4}{0.08}$$

$$B = \frac{\cancel{100} \times 2\pi \times \cancel{100} \times 4}{10^{7}\,{}^{3} \times 10 \times 8\,4} = 3.14 \times 10^{-4}\,T$$

4.2 $I = 35\,A$

$r = 20\,cm = \frac{20}{100} = 0.2\,m$

$$B = \cancel{\mu_0 2\pi I} \quad \frac{\mu_0 2I}{4\pi r}$$

$$B = \frac{\cancel{4\pi} \times 10^{-7} \times 2 \times 35}{\cancel{4\pi} \times 0.2}$$

$$B = \frac{10 \times 2 \times 35}{10^{7}\,{}^{6} \times 2} = \frac{\cancel{2}^{1} \times \cancel{35}^{7}}{\cancel{10} \times 10^{5} \times \cancel{2}\,1} = 3.5 \times 10^{-5}\,T$$

4.3 $I = 10\,A$

$l = 3.0\,cm = 0.03\,m$

$B = 0.27\,T$

$F = BIl \sin\theta$

$F = 0.27 \times 10 \times 0.03 \times \sin 90^\circ = \frac{27}{100} \times 10 \times \frac{3}{100} \times 1$

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

4.7 $I_A = 8.0A$

$I_B = 5.0A$

$r = 4.0cm = 0.04m$

$l = 10cm = 0.1m$

$$B = \frac{\mu_0 2 I_A I_B l}{4\pi r}$$

$$B = \frac{4\pi \times 10^{-7} \times 2 \times 8 \times 5 \times 0.1}{4\pi \times 0.04}$$

$$B = \frac{100 \times 2 \times 8 \times 5 \times 1}{10^7 \times 4 \times 10} = 2 \times 10^{-5} N$$

4.8 $l = 80cm = 0.8m$

$n = 400$ and 5 layers so, $N = 5 \times 400 = 2000$ turns

$d = 1.8cm = 0.018m$

$I = 8.0A$

400 × 5 = 2000

3.14 × 4 = 12.56

× 2 = 25.12

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

$$B = 4 \times 3.14 \times 2 \times \frac{1}{10^3}$$

$$B = 25.12 \times 10^{-3} T$$

4.11 $B = 6.5G = 6.5 \times 10^{-4} T$

$V = 4.8 \times 10^6 m/s$

$e = 1.6 \times 10^{-19} C$

$m_e = 9.1 \times 10^{-31} kg$

$\theta = 90°$

$F = evB\sin\theta$

$$F_c = \frac{mv^2}{r}$$

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The F force provides centripetal force to the moving electron. Hence, the electron starts moving in a circular path of radius r.
In equilibrium, the centripetal force is equal to the magnetic force i.e

$$F = F_c$$

$$\Rightarrow evB\sin\theta = \frac{mv^2}{r}$$

$$\Rightarrow r = \frac{mv^2}{Be\sin\theta}$$

$$= \frac{9.1\times10^{-31}\times4.8\times10^{6}}{6.5\times10^{-4}\times1.6\times10^{-19}\times\sin 90^\circ}$$

$$= \frac{91\times48\times10^{6}\times10\times10^{4}\times10\times10^{19}}{65\times16\times1\times10\times10^{31}\times10}$$

$$= 4.48\times10^{-2}\ m$$

$$= 4.48\ cm$$

4.12 $B = 6.5\times10^{-4}\ T$

$e = 1.6\times10^{-19}\ C$

$m_e = 9.1\times10^{-31}\ kg$

$v = 4.8\times10^{6}\ m/s$

$r = 4.48\ cm = \frac{448}{100}\times\frac{1}{100} = 0.0448\ m$

frequency of revolution of the electron $= \nu$

angular frequency of the electron $= \omega = 2\pi\nu$

$v = r\omega$

$$\Rightarrow evB = \frac{mv^2}{r} \qquad \Rightarrow eB = \frac{m}{r}(r2\pi\nu)$$

$\Rightarrow v = \frac{Be}{2\pi m}$

$\Rightarrow v = \frac{6.5 \times 10^{-4} \times 1.6 \times 10^{-19}}{2 \times 3.14 \times 9.1 \times 10^{-31}}$

$\Rightarrow v = 18.2 \times 10^{6}$ Hz

$\Rightarrow v = 18$ MHz

4.13 a) $n = 30$

$r = 8.0\,cm = 0.08\,m$

$I = 6.0\,A$

$B = 1\,T$

$\theta = 60^\circ$

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

$T = nIBA\sin\theta$

$T = 30 \times 6 \times 1 \times 0.0201 \times \sin 60^\circ$

$T = 30 \times \cancel{6}^{3} \times \frac{201}{10000} \times \frac{\sqrt{3}}{\cancel{2}_{1}}$

$T = 3.133$ Nm.

b) No, the answer wouldn't change, if the circular coil were replaced by a planer coil of same irregular shape that encloses the same area as the magnitude of the applied torque is not dependent on the shape of the coil, it depends on the area of the coil.

14 $r_x = 16\,cm = 0.16\,m$

$r_y = 10\,cm = 0.1\,m$

$n_x = 20$

$n_y = 25$

$I_x = 16\,A$

$I_y = 18\,A$

$$\Rightarrow B_x = \frac{\mu_0 n_x I_x}{2r_x}$$

$$\Rightarrow B_x = \frac{4\pi \times 10^{-7} \times 20 \times 16}{2 \times 0.16}$$

$$\Rightarrow B_x = 4\pi \times 10^{-4}\ T$$

and,

$$\Rightarrow B_y = \frac{\mu_0 n_y I_y}{2r_y}$$

$$\Rightarrow B_y = \frac{4\pi \times 10^{-7} \times 25 \times 18}{2 \times 0.1}$$

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

$$\Rightarrow B = B_y - B_x$$

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

$$\Rightarrow B = 5\pi \times 10^{-4}\ T$$

$$\Rightarrow B = 5 \times 3.14 \times 10^{-4}$$

$$\Rightarrow B = 1.57 \times 10^{-3}\ T$$

4.15. $B = 100G = 100 \times 10^{-4}\ T$

$n = 1000$ turns m^{-1}

$I = 15A$

$B = \mu_0 n I$

$$nI = \frac{B}{\mu_0}$$

$$= \frac{100 \times 10^{-4}}{4\pi \times 10^{-7}}$$

$$= 7957.74$$

$$\simeq 8000\ A/m$$

If the length of the coil is taken as 50cm,

$\rightarrow$

radius is 4cm, no. of turns = 400 and current is 10A. These particulars are not unique. Some adjustment with limits is possible.

4.17 $r_1 = 25cm = 0.25m$
$r_2 = 26cm = 0.26m$
$N = 3500$
$I = 11A$

a) Magnetic field outside a toroid is zero.

b) Inside :-

$$B = \frac{\mu_0 N I}{l}$$

$$\therefore l = 2\pi\left(\frac{r_1 + r_2}{2}\right)$$
$$= \pi(0.25 + 0.26)$$
$$= 0.51\pi$$

$$= \frac{4\cancel{\pi} \times 10^{-7} \times 3500 \times 11}{0.51\cancel{\pi}}$$

$$= 3 \times 10^{-2}\,T$$

c) Magnetic field in the empty space surrounded by the toroid is zero.

4.18 a) The initial velocity of the particle is either parallel or anti parallel to the magnetic field. Therefore, it travels along a straight path without suffering any deflection in the field.

b) Yes, the final speed of the charged particle will be equal to its initial speed because magnetic force can ~~be~~ change the direction of velocity but not its magnitude.

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4.19 $B = 0.15\,T$

$e = 1.6 \times 10^{-19}\,C$

$m = 9.1 \times 10^{-31}\,kg.$

$V = 2KV = 2 \times 10^{3}\,V$

$K.E = eV$

$\Rightarrow eV = \frac{1}{2} mv^2$

$\Rightarrow v = \sqrt{\frac{2eV}{m}}$

a) $BeV = \frac{mv^2}{r}$

$r = \frac{mv}{Be}$

$r = \frac{m}{Be}\left[\frac{2eV}{m}\right]^{1/2}$

$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \left(\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9.1 \times 10^{-31}}\right)^{1/2}$

$= 100.55 \times 10^{-5}$

$= 1.01 \times 10^{-3}\,m$

$= 1\,mm$

b) $r_1 = \frac{mv_1}{Be}$ $\quad v_1 = v\sin\theta$

$= \frac{mv\sin\theta}{Be}$

$= \frac{9.1 \times 10^{-31}}{0.15 \times 1.6 \times 10^{-19}} \times \left(\frac{2 \times 1.6 \times 10^{-19} \times 2 \times 10^{3}}{9 \times 10^{-31}}\right)^{1/2} \times \sin 30^\circ$

$= 0.5 \times 10^{-3}\,m$

$= 0.5\,mm$

4.20 $B = 0.75T$

$V = 15kV = 15 \times 10^3 V$

$E = 9 \times 10^5 V m^{-1}$

$\Rightarrow \frac{1}{2} mv^2 = eV$

$\Rightarrow \frac{v^2}{2V} = \frac{e}{m}$

$\therefore \cancel{q}E = \cancel{q}vB$

$\Rightarrow v = \frac{E}{B}$

$\frac{e}{m} = \frac{1}{2} \frac{\left(\frac{E}{B}\right)^2}{V} = \frac{E^2}{2VB^2} = \frac{(9 \times 10^5)^2}{2 \times 15 \times 10^3 \times (0.75)^2} = 4.8 \times 10^7 C/kg$

4.24 $B = 3000G = 3000 \times 10^{-4} T = 0.3T$

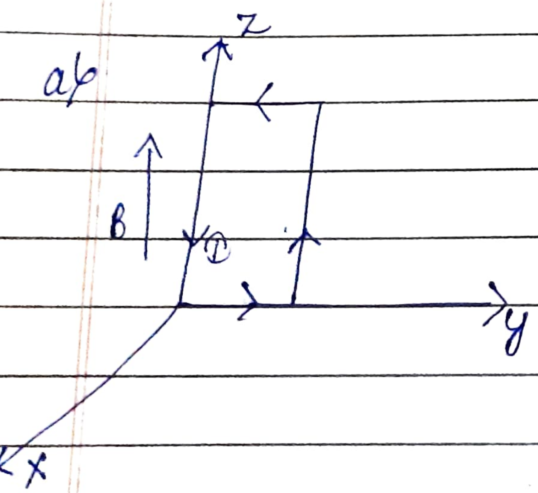
$l = 10 cm$

$b = 5 cm$

$A = l \times b = 10 \times 5 = 50 cm^2 = 50 \times 10^{-4} m^2$

$I = 12A$

a)



In this case,

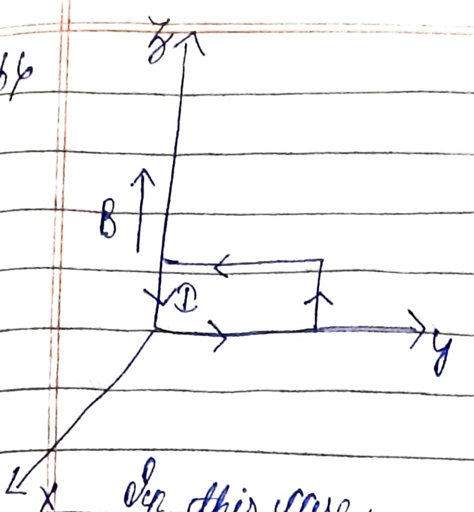
Torque $\vec{\tau} = I\vec{A} \times \vec{B}$

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

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

The force on the loop is zero because the angle between A and B is zero.

b)



In this case,

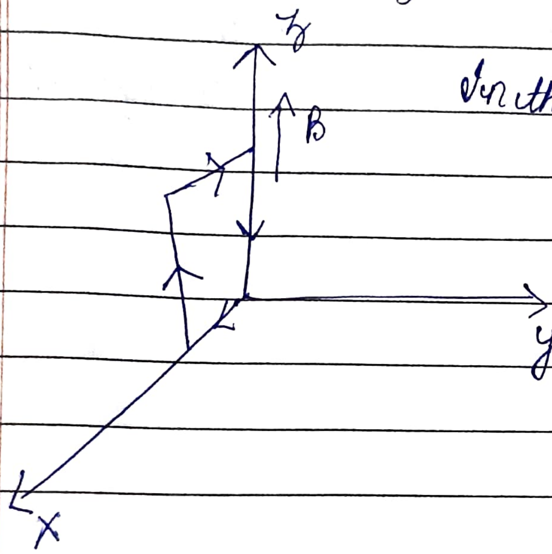
$\vec{\tau} = I\vec{A} \times \vec{B}$

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

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

The force on the loop is zero because the angle between them is zero.

c)



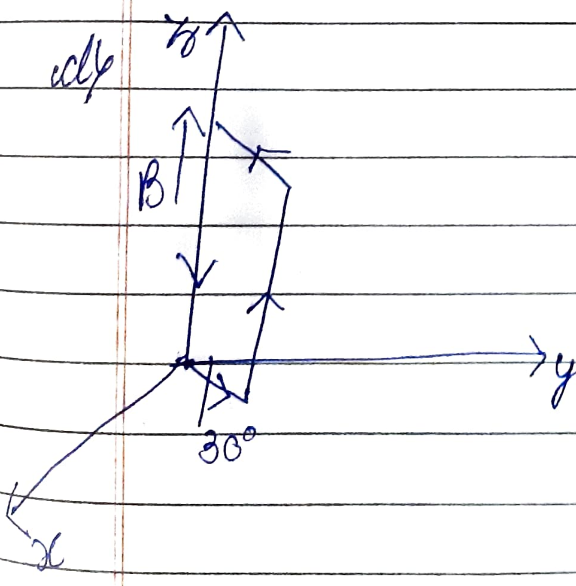
In this case, $\vec{\tau} = I\vec{A} \times \vec{B}$

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

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

Force is zero.

d)



In this case,

$\vec{\tau} = I\vec{A}\vec{B}$

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

$= 1.8 \times 10^{-2}$ Nm at an angle 240° with positive x direction

Force is zero.

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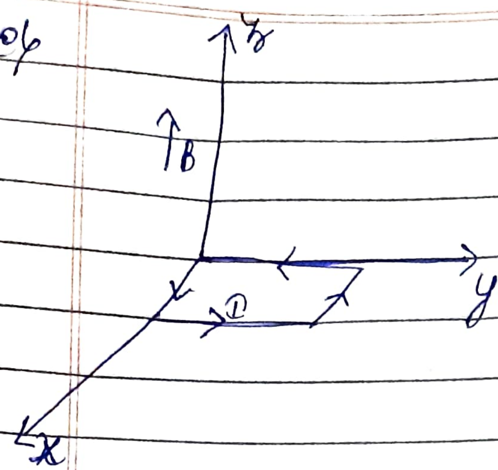
(e)



In this case,

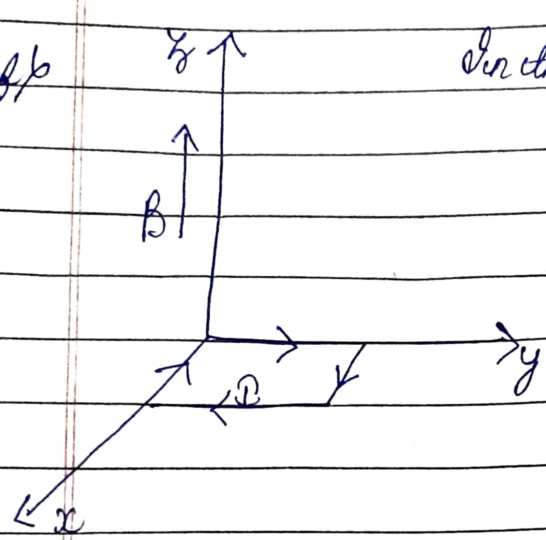
$\vec{\tau} = I\vec{A} \times \vec{B}$

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

$\vec{\tau} = 0$

Force is zero.
angle between them is zero hence has a stable equilibrium.

(f)



In this case,

$\vec{\tau} = I\vec{A} \times \vec{B}$.

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

$\vec{\tau} = 0$

Force is zero.
angle between them is 180° hence has an unstable equilibrium.

4.27 $G = 12\,\Omega$

$I_g = 3\,mA = 3 \times 10^{-3} A$

$V = 18V$

$R = \frac{V}{I_g} - G$

$R = \frac{18}{3 \times 10^{-3}} - 12$

$R = \frac{6\cancel{18} \times 10^3}{\cancel{3}_1} - 12$

$R = 6000 - 12$

$R = 5988\,\Omega$

Hence, a resistor of resistance $5988\,\Omega$ is to be connected in series with the galvanometre.

4.28 $G = 1.5\,\Omega$

$I_g = 4\,mA = 4 \times 10^{-3}\,A$

$I = 6A$

$S \rightarrow$ Shunt resistance

$$S = \frac{I_g G}{I - I_g}$$

$$S = \frac{4 \times 10^{-3} \times 1.5}{6 - 4 \times 10^{-3}}$$

$$S = \frac{6 \times 10^{-2}}{6 - 0.004} = \frac{0.06}{5.996} \approx 0.01\,\Omega = 10\,m\Omega$$

Hence, a $10\,m\Omega$ shunt resistor is to be connected in parallel with the galvanometre.