Chapter - 5

5.3. Here $\theta = 30^\circ$, $B = 0.25\,T$, $\tau = 4.5 \times 10^{-2}\,J$, $m = ?$

As $\tau = mB\sin\theta$,

$$\therefore m = \frac{\tau}{B\sin\theta} = \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30^\circ}$$

$$= 0.36\,JT^{-1}.$$

5.4. Here $m = 0.32\,JT^{-1}$, $B = 0.15\,T$

i) The bar will be in stable equilibrium when its magnetic moment $\vec{m}$ is parallel to $\vec{B}$ ($\theta = 0^\circ$). Its potential energy is then minimum and is given by

$$U_{min} = -mB\cos 0^\circ$$
$$= -0.32 \times 0.15 \times 1$$
$$= -4.8 \times 10^{-2}\,J$$

ii) The bar will be in unstable equilibrium when its magnetic moment $\vec{m}$ is antiparallel to $\vec{B}$ ($\theta = 180^\circ$). Its potential energy is maximum and is given by:

$$U_{max} = -mB\cos 180^\circ$$
$$= -0.32 \times 0.15 \times (-1)$$
$$= +4.8 \times 10^{-2}\,J$$

5.5. Here $N = 800$, $A = 2.5 \times 10^{-4}\,m^2$, $I = 3\,A$

$m = NIA = 800 \times 3 \times 2.5 \times 10^{-4} = 0.60\,JT^{-1}$

The magnetic field of a solenoid has the same pattern as that of bar magnet. It acts along the axis of the ~~solenoid~~ solenoid. Its direction is determined by the sense of flow of current.

5.7. Here $m = 1.5\,JT^{-1}$, $B = 0.22\,T$

i) Given $\theta_1 = 0^\circ$, $\theta = 90^\circ$

$$\therefore W = -mB(\cos\theta_2 - \cos\theta_1)$$
$$= -1.5 \times 0.22\,(\cos 90^\circ - \cos 0^\circ)$$
$$= -0.33 \times (0 - 1)$$
$$= +0.33\,J$$

Torque, $\tau = mB\sin 90^\circ$

$= 15 \times 0.22 \times 1$

$= 0.33$ Nm.

ii) Given $\theta_1 = 0^\circ$, $\theta_2 = 180^\circ$

$W = -1.5 \times 0.22 \times (\cos 180^\circ - \cos 0^\circ)$

$= -0.33 \times (-1-1)$

$= 0.66$ J

Torque, $\tau = mB\sin 180^\circ = 1.5 \times 0.22 \times 0$

$= 0$.

5.8. Here $N = 2000$, $A = 1.6 \times 10^{-4}\ m^2$, $I = 4$ A

a) Magnetic moment of solenoid of turns N, area of cross-section A and carrying current I is

$m = NIA = 2000 \times 4 \times 1.6 \times 10^{-4}\ Am^2$

$= 1.28\ Am^2$.

This magnetic moment acts along the axis of the solenoid in a direction related to the sense of current via the right hand screw rule.

b) Net force experienced by the magnetic dipole in the uniform magnetic field = 0

The ~~magnetic~~ magnitude of the torque τ exerted by the magnetic field $\vec{B}$ on the solenoid is given by

$\tau = mB\sin\theta = 1.28 \times 7.5 \times 10^{-2} \times \sin 30^\circ$

$= 0.048$ Nm

This torque tends to align the axis of the solenoid (i.e., its magnetic moment vector $\vec{m}$) along the field $\vec{B}$.

5.9. Here, $N = 16$, $r = 10$ cm $= 0.10$ m, $I = 0.75$ A

$B = 5 \times 10^{-2}$ T, $\nu = 2\ s^{-1}$

Magnetic moment of the coil is $m = NIA = NI \cdot \pi r^2$

Frequency of oscillation, $\nu = \frac{1}{2\pi}\sqrt{\frac{mB}{I}}$

∴ Moment of inertia is

$$I = \frac{mB}{4\pi^2 \nu^2} = \frac{NI\pi r^2}{4\pi^2 \nu^2}$$

$$= \frac{16 \times 0.75 \times (0.1)^2 \times 5 \times 10^{-2}}{4 \times 3.14 \times 4}$$

$$= 1.2 \times 10^{-4} \text{ Kg m}^2.$$

5.11. Here, $B_H = 0.16\,G$, $\delta = 60°$

$$\therefore B = \frac{B_H}{\cos\delta} = \frac{0.16}{\cos 60°} = \frac{0.16}{0.5} = 0.32\,G.$$

Thus the earth's magnetic field has a magnitude of 0.32 and lies in a vertical plane 12° west of the geographic meridian making an angle of 60° (upwards) with the horizontal (magnetic south to magnetic north) direction.

5.13. As the null points lie on the axis of the magnet

$$\therefore B_{axial} = \frac{\mu_0}{4\pi} \cdot \frac{2m}{r^3} = B_H$$

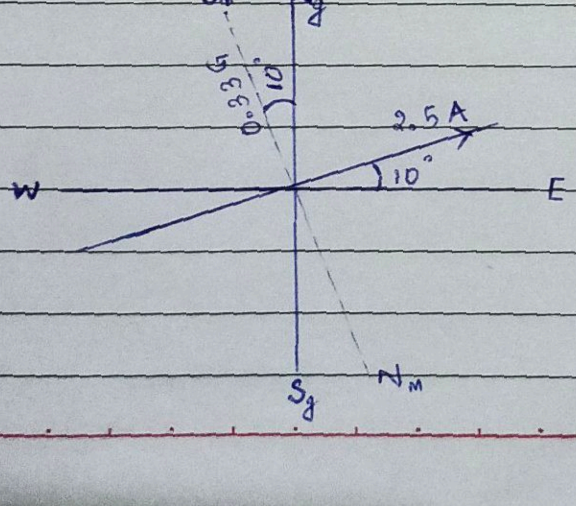
Magnetic field of the magnet on its normal bisector at the same distance will be

$$B_{equa} = \frac{\mu_0}{4\pi} \cdot \frac{m}{r^3} = \frac{B_H}{2} = \frac{0.36}{2} = 0.18\,G$$

∴ Total magnetic field at the required point on the normal bisector is

$$B_{equa} + B_H = 0.18 + 0.36 = 0.54\ G$$

5.18.



Suppose the neutral point lies at a distance r from the cable.

Then at the neutral point,

$$\frac{\mu_0 I}{2\pi r} = B_H$$

$$\Rightarrow r = \frac{\mu_0 I}{2\pi B_H} = \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}}$$

$$= 1.5 \times 10^{-2} \text{ m}$$

$$= 1.5 \text{ cm}$$

As the direction of the magnetic field of the cable is opposite to that of $\vec{B}_H$ at points above the cable, so the line of neutral points lies parallel to and above the cable at a distance of 1.5 cm from it.