

NCERT Exercise

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

$$\tau = mB \sin \theta$$

$$\Rightarrow m = \frac{\tau}{B \sin \theta} = \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30^\circ} = 0.36 \text{ JT}^{-1}$$

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

a. 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

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

b. 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 then ~~minimum~~ ^{maximum} and is given by

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

5.5 Here $N = 800$, $A = 2.5 \times 10^{-4} \text{ m}^2$, $I = 3.0 \text{ A}$

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

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

a) Given $\theta_1 = 0^\circ$, $\theta_2 = 90^\circ$

$$\begin{aligned}
 W &= -mB (\cos \theta_2 - \cos \theta_1) \\
 &= -1.5 \times 0.22 (\cos 90^\circ - \cos 0^\circ) \\
 &= -0.33 \times (0 - 1) = 0.33 \text{ J}
 \end{aligned}$$

$$\text{Torque, } \tau = mB \sin 90^\circ = 1.5 \times 0.22 \times 1 = 0.33 \text{ Nm}$$

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

$$\begin{aligned}
 W &= -1.5 \times 0.22 (\cos 180^\circ - \cos 0^\circ) \\
 &= -0.33 \times (-1 - 1) = 0.66 \text{ J}
 \end{aligned}$$

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

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

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

$$m = NIA = 2000 \times 4 \times 1.6 \times 10^{-4} = 1.28 \text{ Am}^2$$

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

$$\tau = mB \sin \theta = 1.28 \times 7.5 \times 10^{-2} \times \sin 30^\circ = 0.048 \text{ Nm}$$

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 $N = 16$, $\mu = 10 \text{ cm} = 0.10 \text{ m}$, $I = 0.75 \text{ A}$, $B = 5.0 \times 10^{-2} \text{ T}$
 $v = 2.0 \text{ s}^{-1}$

Magnetic moment of the coil is $m = NIA = N\pi r^2 I$

frequency of oscillation, $v = \frac{1}{2\pi} \sqrt{\frac{mB}{I}}$

\therefore Moment of inertia is

$$\frac{I}{4\pi^2 v^2} = \frac{N^2 \pi^2 r^2 \cdot B}{4\pi^2 v^2} = \frac{16 \times 0.75 \times (0.1)^2 \times 5 \times 10^{-2}}{4 \times 3.14 \times 4} = 1.2 \times 10^{-4} \text{ kg m}^2$$

5.11 Here $B_H = 0.16 \text{ G}$, $\delta = 60^\circ$

$$\therefore B = \frac{B_H}{\cos \delta} = \frac{0.16}{\cos 60^\circ} = \frac{0.16}{0.5} = 0.32 \text{ G}$$

Thus the earth's magnetic field has a magnitude of 0.32 G 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

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

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

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

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

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

5.18 Suppose the neutral point lies at a distance x from the cable. Then at the neutral point,

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

$$\text{or } x = \frac{\mu_0 I}{2\pi B_H} = \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}} = 1.5 \times 10^{-2} \text{ m} = 1.5 \text{ cm}$$

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.