CHAPTER - 5

3. Magnetic field strength, $B = 0.25\ T$

Torque on the bar magnet, $T = 4.5 \times 10^{-2}\ J$

The angle between the bar magnet and the external magnetic field, $\theta = 30^\circ$

Torque is related to magnetic moment (M) as:

$T = MB \sin\theta$

$\therefore\ M = \dfrac{T}{B \sin\theta}$

$= \dfrac{4.5 \times 10^{-2}}{0.25 \times \sin 30^\circ} = 0.36\ J\,T^{-1}$

Hence, the magnetic moment of the magnet is $0.36\ J\,T^{-1}$

4. (a) The bar magnet is aligned along the magnetic field. This system is considered as being in stable equilibrium. Hence, the angle θ, between the bar magnet and the magnetic field is 0°,

Potential energy of the system = $-MB\cos\theta$

$= -0.32 \times 0.15 \cos 0^\circ$

$= -4.8 \times 10^{-2}\ J$

(b) The bar magnet is oriented 180° to the magnetic field. Hence, it is in unstable equilibrium. $\theta = 180^\circ$

Potential energy $= -MB\cos\theta$

$= -0.32 \times 0.15 \cos 180^\circ$

$= 4.8 \times 10^{-2}\ J$

5. No. of turns in the solenoid, $n = 800$
Area of cross-section, $A = 2.5 \times 10^{-4}\ m^2$
Current in the solenoid, $I = 3.0\ A$

A current carrying solenoid behaves like a bar magnet because a magnetic field develops along its axis, i.e., along with its length.

The magnetic moment associated with the given current carrying solenoid is calculated as:

$M = nIA$

$= 800 \times 3 \times 2.5 \times 10^{-4}$

$= 0.6\ JT^{-1}$

7. (a) Magnetic moment, $M = 1.5\ JT^{-1}$
Magnetic field strength, $B = 0.22\ T$

(i) Initial angle between the axis and the magnetic field.

$\theta_1 = 0°$

Final angle between the axis and the magnetic field,

$\theta_2 = 90°$

The work required to make the magnetic moment normal to the direction of the magnetic field is given as:

$W = -MB(\cos\theta_2 - \cos\theta_1)$

$= -1.5 \times 0.22 (\cos 90° - \cos 0°)$

$= -0.33(0-1)$

$= 0.33 J$

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(ii) Initial angle between the axis and the magnetic field,

$\theta_1 = 0^\circ$

Final angle between the axis and the magnetic field.

$\theta_2 = 180^\circ$

The work required to make the magnetic moment opposite to the direction of the magnetic field is given as:

$W = -MB(\cos\theta_2 - \cos\theta_1)$

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

$= -0.33(-1-1)$

$= 0.66 J$

(b) For case (i):

$\theta = \theta_2 = 90^\circ$

$\therefore$ Torque, $T = MB \sin\theta$

$= MB \sin 90^\circ$

$= 1.5 \times 0.22 \sin 90^\circ$

$= 0.33 J$

The torque tends to allign the magnitude moment vector along B.

for case (ii)

$\theta = \theta_2 = 180^\circ$

$\therefore$ Torque, $T = MB \sin\theta$

$= MB \sin 180^\circ$

$= 0 J$

8 (a) The magnetic moment along the axis of the solenoid is calculated as:

$M = nAI$

$= 2000 \times 4 \times 1.6 \times 10^{-4}$

$= 1.28 Am^2$

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(b) Magnetic field, $B = 7.5 \times 10^{-2}$ T
The angle between the magnetic field and the axis of the solenoid, $\theta = 30°$
Torque, $\tau = MB\sin\theta$
$= 1.28 \times 7.5 \times 10^{-2} \sin 30°$
$= 0.048$ J
Since the magnetic field is uniform, the force on the solenoid is zero. The torque on the solenoid is 0.048 J.

9 $N = 16$
$r = 10$ cm $= 0.1$ m
cross section of the coil $= \pi \times (0.1)^2$ m^2
Current in the coil, $I = 0.75$ A
Magnetic field strength, $B = 5.0 \times 10^{-2}$ T
Frequency of oscillations of the coil, $\nu = 2.0 s^{-1}$
$\therefore$ Magnetic moment, $M = NIA = NI\pi r^2$
$= 16 \times 0.75 \times \pi \times (0.1)^2$
$= 0.377$ JT^{-1}
Frequency is given by the relation:
$$\nu = \frac{1}{2\pi}\sqrt{\frac{MB}{I}}$$
where,
$$I = \frac{MB}{4\pi^2\nu^2}$$
$$= \frac{0.377 \times 5 \times 10^{-2}}{4\pi^2 \times (2)^2}$$
$= 1.2 \times 10^{-4}$ Kg m^2
Hence, the moment of inertia of the coil ~~abo~~ about its axis of rotation is 1.19×10^{-4} Kg m^2

11. $\theta = 12^\circ$

$\delta = 60^\circ$

$B_H = 0.16\,G$

Earth's magnetic field at the given ~~locapt~~ location = B

We can relate B and B_H as,

$B_H = B\cos\delta$

$\therefore B = \frac{B_H}{\cos\delta}$

$= \frac{0.16}{\cos 60^\circ} = 0.32\,G$

Earth's magnetic field ~~lines~~ lies in the vertical plane, 12° west of the geographic meridian, making an angle of 60° (upward) with the horizontal direction. Its magnitude is 0.32 G.

13. Earth's magnetic field at the given place, $H = 0.36\,G$

The magnetic field at a distance d, on the axis of the magnet, is given as:

$B_1 = \frac{\mu_0 2M}{4\pi d^3} = H$ —— (i)

Where,

μ_0 = Permeability of free space.

M = Magnetic moment.

The magnetic field at the same distance d, on the equatorial line of the magnet, is given as:

$B_2 = \frac{\mu_0 M}{4\pi d^3} = \frac{H}{2}$ [Using equation (i)]

Total magnetic field, $B = B_1 + B_2$

$= H + \frac{H}{2}$

$= 0.36 + 0.18 = 0.54\,G$

Hence, the magnetic field is 0.54 G in the direction of earth's magnetic field.

18. Current in the wire = 2.5 A

The earth's magnetic field at a location, $R = 0.33$

$R = 0.33 \times 10^{-4}$ T

Angle of dip is zero, $\delta = 0$

Horizontal component of earth's magnetic field,

$B_H = R\cos\delta = 0.33 \times 10^{-4} \cos 0$

$= 0.33 \times 10^{-4}$ T

Magnetic field due to a current carrying conductor,

$B_c = (\mu_0 / 2\pi) \times (I/r)$

$B_c = (4\pi \times 10^{-7} / 2\pi) \times (2.5/r)$

$= (5 \times 10^{-7}/r)$

$B_H = B_c$

$\Rightarrow 0.33 \times 10^{-4} = 5 \times 10^{-7}/r$

$\Rightarrow r = \dfrac{5 \times 10^{-7}}{0.33 \times 10^{-4}}$

$= 0.015$ m $= 1.5$ cm

Hence neutral point lie on a straight line parallel to the cable at a perpendicular distance of 1.5 cm