Ch-5: Magnetism and Matter

Exercises

(3) Magnetic field strength, $B = 0.25T$
Torque of magnet, $\tau = 4.5 \times 10^{-2} J$

Angle b/w magnet and external field, $\theta = 30°$

$\tau = MB\sin\theta$

$$\therefore M = \frac{\tau}{B\sin\theta} = \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30°} = 0.36\ J/T$$

$\therefore$ The magnetic moment is $0.36\ J/T$

(4) moment of bar magnet, $M = 0.32\ J/T$
External field, $B = 0.15T$

(a) The bar magnet is aligned along the magnetic field. This system is considered as being in stable equilibrium. $\therefore$ the angle θ, b/w the bar magnet and the magnetic field is $0°$

$U = -MB\sin\theta = -0.32 \times 0.15 \cos 0°$
$= -4.8 \times 10^{-2} J$

(b) The bar magnet is oriented $180°$.
$\therefore$ It's unstable equilibrium.

$\theta = 180°$

$U = -MB\cos\theta, = -0.32 \times 0.15 \cos 180°$
$= 4.8 \times 10^{-2} J$

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(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, $I = 3.0A$

A current carrying solenoid behaves as a bar magnet because a magnetic field develops along its axis.

M (Magnetic moment) = nIA
$= 800 \times 3 \times 2.5 \times 10^{-4} = 0.6 J/T$

(7) (a) Magnetic moment, $M = 1.5 J/T$
magnetic field, $B = 0.22T$

(i) initial angle, $\theta_1 = 0°$
Final angle, $\theta_2 = 90°$
The work required to make (M) ⊥ to direction of magnetic field:
$W = -MB(\cos\theta_2 - \cos\theta_1)$
$= -1.5 \times 0.22 (\cos 90° - \cos 0°)$
$= -0.33 (0-1) = 0.33 J$

(ii) initial angle; $\theta_1 = 0°$
final angle; $\theta_2 = 180°$
The W required to make (M) opposite to direction of field:
$W = -MB(\cos\theta_2 - \cos\theta_1)$
$= -1.5 \times 0.22 (\cos 180° - \cos 0°)$
$= -0.33(-1-1) = 0.66 J$

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(b) For case (i), $\theta = \theta_1 = 90°$
$\tau = MB\sin\theta = 1.5 \times 0.22 \sin 90°$
$= 0.33\ J$

For case (ii), $\theta = \theta_2 = 180°$
$\tau = MB\sin\theta = MB\sin 180°$
$= 0\ J$

(8) no. of turns of the solenoid, $n = 2000$
Area of cross-section, $A = 1.6 \times 10^{-4}\ m^2$
current in solenoid, $I = 4A$

(a) The magnetic moment along the axis:
$M = nAI = 2000 \times 1.6 \times 10^{-4} \times 4$
$= 1.28\ Am^2$

(b) Magnetic field, $B = 7.5 \times 10^{-2}\ T$
Angle b/w the magnetic field and the axis of solenoid, $\theta = 30°$
$\tau = MB\sin\theta = 1.28 \times 7.5 \times 10^{-2} \sin 30°$
$= \underline{4.8 \times 10^{-2}\ N\text{-}m}$.

(9) no. of turns in the circular coil, $N = 16$
Radius of the coil, $r = 10cm = 0.1m$
Cross-section of the coil, $A = \pi r^2 = \pi \times (0.1)^2\ m^2$
current, $I = 0.75A$
Magnetic field strength, $B = 5.0 \times 10^{-2}\ T$
Freq. of oscillations of coil, $\nu = 2.0\ s^{-1}$

$M = NIA = NI\pi r^2$
$= 16 \times 0.75 \times \pi \times (0.1)^2$
$= 0.377\ J/T$

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$$V = \frac{1}{2\pi}\sqrt{\frac{MB}{I}}$$

where, I = moment of Inertia

$$\therefore I = \frac{MB}{4\pi^2 V^2} = \frac{0.379 \times 5 \times 10^{-2}}{4\pi^2 \times (2)^2}$$

$$= \underline{1.19 \times 10^{-4}\ kg/m^2}$$

(11) Angle of declination, $\theta = 12^\circ$
Angle of dip, $\delta = 60^\circ$

Horizontal component of earth's magnetic
$B_H = 0.16\ G$
Earth's magnetic field at the given location $= B$

We can relate B and B_H as:

$$B_H = B\cos\delta$$

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

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

The magnetic field at dist d,

$$B_1 = \frac{\mu_0}{4\pi} \cdot \frac{2M}{d^3} = H$$

where,
μ_0 = permeability of free space
M = magnetic moment

$$B_2 = \frac{\mu_0 M}{4\pi d^3} = H/2$$

Total magnetic field, $B = B_1 + B_2$

$= H + H/_2 = 0.36 + 0.18 = 0.54 G$

$\therefore$ The magnetic field is 0.54 G in direction of earth's magnetic field.

(14) The magnetic field on the axis of the magnetic at a dist $d_1 = 14$ cm

$$B_1 = \frac{\mu_0 2M}{4\pi (d_1)^3} = H \quad \text{---} \text{(i)}$$

where,

M = magnetic moment

μ_0 = permeability of free space

$\therefore$ The magnetic field at a distance d_2, on the equitorial line

$$B_2 = \frac{\mu_0 M}{4\pi (d_2)^3} = H \quad \text{---} \text{(ii)}$$

$$\frac{2}{(d_1)^3} = \frac{1}{(d_2)^3}, \quad \left(\frac{d_2}{d_1}\right)^3 = 1/2$$

$$\therefore d_2 = d_1 \times (1/2)^{1/3}$$
$$= 14 \times 0.794 = 11.1 cm$$

The new null point is at 11.1 cm.

(18) Current in wire; $I = 2.5 A$

Angle of dip at given location, $\delta = 0°$

Earth's magnetic field, $H = 0.33 G = 0.33 \times 10^{-4} T$

$$H_H = H \cos\delta$$
$$= 0.33 \times 10^{-4} \times \cos 0° = 0.33 \times 10^{-4} T$$

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The mag field at neutral point from distance R'

$$H_H = \frac{\mu_0 I}{2\pi R}$$

Where,

$\mu_0 = 4\pi \times 10^{-7}$ Tm/A

$$\therefore R = \frac{\mu_0 I}{4\pi H_H} = \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}} = 15.15 \times 10^{-3}\ m$$

$= 1.51$ cm