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MAGNETISM & MATTER

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NCERT Exercise

5.3) Magnetic field strength, $B = 0.25\ T$
Torque on the bar magnet, $T = 4.5 \times 10^{-2}\ J$
Angle between the bar magnet and external magnetic field, $\theta = 30°$
Torque is related to magnetic moment (M) as:

$$T = MB \sin\theta$$

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

$$= \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30°} = 0.36\ J\ T^{-1}$$

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

5.4) Moment of bar magnet, $M = 0.32\ J\ T^{-1}$
External magnetic field, $B = 0.15\ T$

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

Potential energy of the system $= -MB\cos\theta$
$= -0.32 \times 0.15 \cos 0°$
$= -4.8 \times 10^{-2}\ J$.

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b) The bar magnet is oriented 180° to the magnetic field. Hence, it is in unstable equilibrium.

$\theta = 180°$

Potential energy $= -MB\cos\theta$

$= -0.32 \times 0.15 \cos 180°$

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

5.5) Number 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. The magnetic moment is calculated as :

$M = nIA$

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

$= 0.6 \, J T^{-1}$.

5.7) a) Magnetic moment, $M = 1.5 \, JT^{-1}$

Magnetic field strength, $B = 0.22T$

(i) Initial angle between axis & magnetic field, $\theta_1 = 0°$

Final angle " " " " " , $\theta_2 = 90°$

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

$$W = -MB(\cos\theta_2 - \cos\theta_1)$$
$$= -1.5 \times 0.22(\cos 90° - \cos 0°)$$
$$= -0.33(0-1)$$
$$= 0.33 \text{ J}$$

(ii) Initial angle between axis & magnetic field, $\theta_1 = 0°$
Final angle " " " " ", $\theta_2 = 180°$

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

$$W = -MB(\cos\theta_2 - \cos\theta_1)$$
$$= -1.5 \times 0.22(\cos 180° - \cos 0°)$$
$$= -0.33(-1-1)$$
$$= 0.66 \text{ J}$$

(b) For case (i), $\theta = \theta_2 = 90°$
$\therefore$ Torque, $\tau = MB\sin\theta = 1.5 \times 0.22 \sin 90° = \underline{0.33 \text{ J}}$

For case (ii), $\theta = \theta_2 = 180°$
$\therefore$ Torque, $\tau = MB\sin\theta = MB\sin 180° = \underline{0 \text{ J}}$.

5.8) Number of turns on 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 axis of solenoid is :
$M = nAI$
$= 2000 \times 1.6 \times 10^{-4} \times 4$
$= 1.28 \ Am^2$.

(b) Magnetic field, $B = 7.5 \times 10^{-2} \ T$
Angle between magnetic field & axis of solenoid, $\theta = 30°$
Torque, $\tau = MB \sin \theta$
$= 1.28 \times 7.5 \times 10^{-2} \sin 30°$
$= 4.8 \times 10^{-2} \ Nm$.

5.9) Number of turns in circular coil, $N = 16$
Radius of the coil, $r = 10 \ cm = 0.1 m$
Cross-section of coil, $A = \pi r^2 = \pi \times (0.1)^2 m^2$
Current in the coil, $I = 0.75 \ A$
Magnetic field strength, $B = 5.0 \times 10^{-2} \ T$
Frequency of oscillations of coil, $v = 2.0 s^{-1}$

∴ Magnetic moment, $M = NIA$
$= 16 \times 0.75 \times \pi \times (0.1)^2$
$= 0.377 \ J T^{-1}$

Frequency is given by the relation :

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

Where, I = Moment of Inertia of the coil.

$$\therefore I = \frac{MB}{4\pi^2 v^2}$$

$$= \frac{0.377 \times 5 \times 10^{-2}}{4\pi^2 \times (2)^2}$$

$$= 1.19 \times 10^{-4} \text{ kg m}^2. \text{ (Ans).}$$

5.11) Angle of declination, $\theta = 12°$
Angle of dip, $\delta = 60°$
Horizontal component of earth's magnetic field, $B_H = 0.16$ G
Earth's magnetic field at given location = B

$$B_H = B \cos \delta$$

$$\therefore B = \frac{B_H}{\cos 60°} = \frac{0.16}{\cos 60°} = 0.32 \text{ G. (Ans).}$$

5.13) 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 :

$$B_1 = \frac{\mu_0}{4\pi}\frac{2M}{d^3} = H \quad \text{—— (1)}$$

Where,

μ_0 = Permeability of free space
M = Magnetic moment

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

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

Total magnetic field,

$$B = B_1 + B_2$$
$$= H + \frac{H}{2}$$
$$= 0.36 + 0.18 = 0.54\ G \text{ (Ans)}.$$

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

5.18) Current in wire, $I = 2.5\ A$
Angle of dip at given location on earth, $\delta = 0°$
Earth's magnetic field, $H = 0.33\ G = 0.33 \times 10^{-4}\ T$
The horizontal component of earth's magnetic field is :

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

The magnetic field at neutral point at a distance R from the cable is given by relation :

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

Where,

μ_0 = Permeability of free space = $4\pi \times 10^{-7}\ TmA^{-1}$

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

$$= \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}} = 15.15 \times 10^{-3}\ m = \underline{1.51\ cm}$$

Hence, a set of neutral points parallel to and above the cable are located at a normal distance of 1.51cm.