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CHAPTER - 5

Exercise (Magnetism and Matter)

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 the external magnetic field, $\theta = 30°$.
Torque is related to magnetic moment:

$$T = MB\sin\theta$$

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

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

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

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

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

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

$$= -0.32 \times 0.15\cos 0°$$

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

b) The bar magnet is oriented $180°$ to the magnet field. Hence, it is in unstable equillibrium.
$\theta = 180°$

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

$$= -0.32 \times 0.15\cos 180°$$

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

⑤ Number of turns in the solenoid, $n = 800$
Area of cross, $A = 2.5 \times 10^{-4} m^2$.
Current in the solenoid, $I = 3.0A$.
A current-carrying solenoid behaves as a bar magnet because a magnetic field develops along its axis.

$$M = nIA$$
$$= 800 \times 3 \times 2.5 \times 10^{-4}$$
$$= 0.6\ JT^{-1}$$

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, $\theta_1 = 0^\circ$
Final angle between the axis and the magnetic field, $\theta_2 = 180^\circ$

$$W = -MB(\cos\theta_2 - \cos\theta_1)$$
$$= -1.5 \times 0.22(\cos 180^\circ - \cos 0^\circ)$$
$$= -0.33\ (-1-1)$$
$$= 0.66J$$

b) For case(i): $\theta = \theta_2 = 90^\circ$
∴ Torque, $\tau = MB\sin\theta$
$$= 1.5 \times 0.22 \sin 90^\circ$$
$$= 0.33J$$

For case(ii): $\theta = \theta_2 = 180^\circ$
∴ torque, $\tau = MB\sin\theta$
$$= MB\sin 180^\circ = 0J$$

8) Number of turns on the solenoid, $n = 2000$
Area of cross section of the solenoid, $A = 1.6 \times 10^{-4} m^2$
current in the solenoid, $I = 4A$.
a) Magnetic moment along the axis of the solenoid.

$M = nAI$
$= 2000 \times 1.6 \times 10^{-4} \times 4$
$= 1.28 \, Am^2$

b) Magnetic field, $B = 7.5 \times 10^{-2} T$
Angle between the magnetic field and the axis of solenoid, $\theta = 30°$
Torque, $\tau = MB\sin\theta$
$= 1.28 \times 7.5 \times 10^{-2} \sin 30°$
$= 4.8 \times 10^{-2} Nm$
Since the magnetic field is uniform, the force on the solenoid is zero. The torque on the solenoid is 4.8×10^{-2} Nm.

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 in the coil, $I = 0.75A$.
Magnetic field strength, $B = 5.0 \times 10^{-2} T$
Frequency of oscillations, $\nu = 2.0 s^{-1}$
$\therefore$ Magnetic moment, $M = NIA = NI\pi r^2$
$= 16 \times 0.75 \times \pi \times (0.1)^2$
$= 0.377 \, JT^{-1}$

$\nu = \frac{1}{2\pi}\sqrt{\frac{MB}{I}}$ where I is moment of inertia

$I = \frac{0.377 \times 5 \times 10^{-2}}{4\pi^2 \times (2)^2} = 1.19 \times 10^{-4} kgm^2$

11) Angle of declination, $\theta = 12^\circ$
Angle of dip, $\delta = 60^\circ$
Horizontal component of earth's magnetic field, $B_H = 0.16\,G$.
Earth's magnetic field $= B$.

$$B_H = B\cos\delta$$

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

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

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

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

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

On the equatorial line,

$$B_2 = \frac{\mu_0 M}{4\pi d^3} = \frac{H}{2} \text{ — from (i)}$$

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, $I = 2.5A$
Angle of dip, $\delta = 0°$
Earth's magnetic field, $H = 0.33G = 0.33 \times 10^{-4} T$

Horizontal component of magnetic field:
$H_H = H \cos \delta$
$= 0.33 \times 10^{-4} \times \cos 0° = 0.33 \times 10^{-4} T$

At neutral point at a distance R.
$$H_H = \frac{\mu_0 I}{2\pi R}$$
$$\therefore R = \frac{\mu_0 I}{2\pi H_H}$$
$$= \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}} = 15.15 \times 10^{-3} m = 1.51 cm$$

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