Magnetism and Matter :-

Q3. Magnetic field strength, $B = 0.25\ T$
Torque on the bar magnet, $T = 4.5 \times 10^{-2}\ J$
Angle between the bar magnet & the external magnetic field, $\theta = 30°$.

Torque is related to magnetic moment (M) as:
$T = MB \sin\theta$

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

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

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

Q4. Moment of the bar magnet, $M = 0.32\ J T^{-1}$
External magnetic field, $B = 0.15\ T$.

(a) The bar magnet is alligned along the magnetic field. This system is considered as being in stable eq^m^. Hence, the angle θ, between the bar magnet and the magnetic field is $0°$.

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

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

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

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

$= -0.33(0-1)$

$= 0.33\ J$

(ii) Initial angle betn the axis and the magnetic field, $\theta_1 = 0^\circ$

Final angle betn the axis and the magnetic field, $\theta_2 = 180^\circ$

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

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

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

$= -0.33(-1-1)$

$= 0.66\ J.$

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(b) For case (i): $\theta = \theta_2 = 90^\circ$

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

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

$= 0.33\ J$

For case (ii): $\theta = \theta_2 = 180^\circ$

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

$= MB \sin 180^\circ$.

$= 0\ J.$

Q8. 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) The magnetic moment along the axis of the solenoid is calculated as:

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

(b) Magnetic field, $B = 7.5 \times 10^{-2}$ T
Angle betn the magnetic field & the axis of the 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

Q9. Number of turns in the circular coil, $N = 16$
Radius of the coil, $r = 10\,cm = 0.1\,m$
Cross-section of the 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 the coil, $\nu = 2.0\ s^{-1}$
∴ 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 = Moment of inertia of the coil.

Q13. 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:

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

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:

$$B_2 = \frac{\mu_0 M}{4\pi d^3} = \frac{H}{2} \quad \left(\text{using eq}^n \text{ (i)}\right)$$

Total magnetic field, $B = B_1 + B_2$

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

$$= 0.36 + 0.18 = 0.54 \text{ G}$$

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

Q18. Current in the wire, I = 2.5 A
Angle of dip at the given location on earth, $\delta = 0^\circ$
The horizontal component of earth's magnetic field is given as:

$$H_H = H \cos \delta$$

$$= 0.33 \times 10^{-4} \times \cos 0^\circ = 0.33 \times 10^{-4} \text{ T}$$

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

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

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

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

Hence, the moment of inertia of the coil about its axis of rotation is 1.19×10^{-4} kg m^2.

Q11. Angle of deflection, $\theta = 12°$

Angle of dip, $\delta = 60°$

Horizontal component of earth's magnetic field, $B_H = 0.16$ G

Earth's magnetic field at the given location = B.

We can relate B and B_H as:

$$B_H = B \cos \delta$$

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

$$= \frac{0.16}{\cos 60°} = 0.32 \text{ G}.$$

Earth's magnetic field lines 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.

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

$\theta = 180°$.

Potential energy = $-MB\cos\theta$

$= -0.32 \times 0.15 \cos\theta$

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

Q5. Number of turns in the solenoid, $n = 800$

Area of cross-section, $A = 25 \times 10^{-4}\ m^2$

Current in the solenoid, $I = 3.0$ A.

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

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

$M = nIA$

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

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

Q7. (a) Magnetic moment, $M = 1.5\ J\ T^{-1}$

Magnetic field strength, $B = 0.22$ T

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

Final angle between the axis and the magnetic field, $\theta_2 = 90°$

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

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

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

$$= \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}}$$

$$\Rightarrow 15.15 \times 10^{-3} m = 1.51\ cm$$

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

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