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Magnetism And Matter

NCERT Exercise Questions

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, $30°$.

Torque is related to magnetic moment (M) as:

$$T = MB \sin\theta$$

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

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

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) When the bar magnet is aligned along the magnetic field, it 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 $= -MB\cos\theta$

$$= -0.32 \times 0.15 \cos 0°$$

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

b) When the bar magnet is aligned opposite to the magnetic field, it is considered as being in unstable equilibrium, $\theta = 180°$.

Potential energy $= -MB\cos\theta$

$$= -0.32 \times 0.15 \cos 180°$$

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

5. Number of turns in the solenoid, $n = 800$
Area of cross - section, $A = 2.5 \times 10 \; m^2$
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:

$M = nIA$

$= 800 \times 32.5 \times 10^{-4}$

$= 0.6 \; JT^{-1}$

8. Number of turns on the solenoid, $n = 2000$
Area of cross - section of the solenoid, $A = 1.6 \times 10^{-4} m$
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) Angle betn the magnetic field and the axis of the solenoid $\theta = 30°$

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

$= 1.28 \times 7.5 \times 10^{-2} \sin 30°$

$= 4.8 \times 10^{-2} \; Nm$

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. $N = 16$

$r = 10\text{ cm} = 0.1\text{ m}$

$A = \pi r^2 = \pi \times (0.1)^2\ m^2$

$I = 0.75\ A$

$B = 5.0 \times 10^2\ T$

$\nu = 2.0\ s^{-1}$

$M = NIA = NI\pi r^2$

$= 16 \times 0.75 \times \pi \times (0.1)^2$

$= 0.377\ JT^{-1}$

Frequency is given by the relation:

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

where,

I = moment of inertia of the coil

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

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

$$= 1.19 \times 10^{-1}\ kg\,m^2$$

Hence, the moment of inertia of the coil about its axis of rotation is $1.19 \times 10^{-1}\ kgm^2$.

11. Angle of declination, $\theta = 12°$

Angle of dip, $\delta = 60°$

$B_H = 0.16\ G$

Earth's magnetic field at the given location = B

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We can relate B and B_H as

$B_H = B \cos \delta$

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

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

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:
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 eq (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, $I = 2.5\ A$

Angle of dip at the given location on earth, $\delta = 0^\circ$
~~Earth~~ Earth's magnetic field, $H = 0.33\ G = 0.33 \times 10^{4}\ T$

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The horizonal component of earth's magnetic field is given as:

$$H_H = H \cos \delta$$

$$= 0.33 \times 10^{-4} \times \cos 0° = 0.33 \times 10^{-4}$$

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

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

Where,

μ_0 = ~~Perm~~ Permeability of free space $= 4\pi \times 10^{-7}$ $Tm A^{-1}$

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

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

Hence, a set of neutral point lie on a straight line parallel to the cable at a perpendicular distance of 1.51 cm, above the plane of the paper.