Date 5·9·21

Ch-5 Magnetism and Matter

EXERCISE

5.3) Magnetic field strength, $B = 0.25T$
Torque on the bar magnet, $T = 4.5\times10^{-2}J$
Angle b/w the bar magnet and the external magnetic field, $\theta = 30°$
Torque is related to magnetic moment (M) as:
$T = MB\sin\theta$

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

$$= \frac{4.5\times10^{-2}}{0.25\times\sin30°} = 0.36\ J\,T^{-1}$$

Ans

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

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

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

$$= -0.32\times0.15\cos0°$$

$$= -4.8\times10^{-2}J$$

Ans

(b) The bar magnet is ~~obtained~~ oriented 180° to the magnetic field. Hence, it is in unstable equilibrium, $\theta = 180°$

Potential energy $= -MB\cos\theta$

$$= -0.32\times0.15\cos180°$$

$$= 4.8\times10^{-2}J$$

Ans

5.5) No. of turns in the solenoid, $n = 800$
Area of cross-section, $A = 2.5 \times 10^{-4} m^2$
Current in the solenoid, $I = 3.0 A$

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:

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

5.8) No. 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:
$M = nAI$
$= 2000 \times 1.6 \times 10^{-4} \times 4$
$= 1.28 Am^2$ Ans

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

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5.9) No. 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 oscillation of the coil, $\nu = 2.0\,s^{-1}$

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

Frequency is given by the relation:
$\nu = \frac{1}{2\pi}\sqrt{\frac{MB}{I}}$, where I = moment of inertia of the coil

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

$= \frac{0.377 \times 5 \times 10^{-2}}{4\pi^2 \times (2)^2} = 1.19 \times 10^{-4}\ kg\,m^2$

Ans

5.11) 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 at the given location $= B$

We can relate B and B_H as:
$B_H = B\cos\delta$

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

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 the magnet is given as:

$$B_2 = \frac{\mu_0 M}{4\pi d^3} = \frac{H}{2} \quad [\text{using eq. (1)}]$$

Total magnetic field, $B = B_1 + B_2$

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

$$= 0.36 + 0.18 = 0.54\ G$$ Ans

5.18) Current in the wire, I = 2.5A
Angle of dip at the 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 given as:

$$H_H = H\cos\delta$$

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

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

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

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

Ans