Magnetism and Matter

(3) $B = 0.25 T$

Torque on the bar magnet, $T = 4.5 \times 10^{-2} J$

Angle between the bar magnet and the external magnetic field, $\theta = 30^\circ$

Torque is related to magnetic moment (M) as

$$T = MB\sin\theta$$

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

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

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

(4) $M = 0.32 J T^{-1}$

$B = 0.15 T$

(a) Potential energy of system $= -MB\cos\theta$

$= 0.32 \times 0.15 \cos 0^\circ$

$= -48 \times 10^{-2} J$

(b) $\theta = 180^\circ$

Potential energy $= -MB\cos\theta$

$= -0.32 \times 0.15 \cos 180^\circ$

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

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(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, $I = 3.0 A$
A current ~~carry~~ carrying Solenoid behaves as a bar magnet because a magnetic field develops along its axis.

The magnetic moment associated with the given current carrying Solenoid is calculated as
$M = nIA$
$= 800 \times 3 \times 2.5 \times 10^{-4}$
$= 0.6\ J T^{-1}$

(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, $\theta_1 = 0°$
Final angle between the axis and the magnetic field, $\theta_2 = 90°$
The work required to make the magnetic moment normal to the direction of magnetic field is given as
$W = -MB(\cos\theta_2 - \cos\theta_1)$
$= 1.5 \times 0.22 (\cos 90° - \cos 0°)$
$= -0.33 (0-1)$
$= 0.33 J$
(ii) ~~Or~~ $\theta_1 = 0°$
$\theta_2 = 180°$
The work required to make the magnetic moment opposite to the direction of magnetic field is given as

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

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

$= -0.33\,(-1-1)$

$= 0.66\,J$

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

$= MB\sin 180^\circ = 0\,J$

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) 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 between the magnetic field and the axis of the solenoid, $\theta = 30^\circ$

$\tau = MB\sin\theta$

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

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

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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) 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, $\nu = 2.0\,s^{-1}$
$\therefore$ 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

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

$$= 1.19 \times 10^{-4}\,Kg\,m^2$$

(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

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

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13 $H = 0.36\,G$

The magnetic field at a distance d, on the axis of the magnet is given as:

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

where,
μ_0 = Permeability of free space
M = Magnetic moment.

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

$$B_2 = \frac{\mu_0 M}{4\pi d^3} = \frac{H}{2}$$

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 ~~dis~~ direction of earths magnetic field.

18 $I = 2.5\,A$.

Angle of dip at given location $= 0°$

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:

$$H_H = H \cos\delta$$

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

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The magnetic field of 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 $= 4\pi \times 10^{-7}\ TmA^{-1}$

$$R = \frac{\mu_0 I}{2\pi H_H} = \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}} = 15.15 \times 10^{-3} m$$

$$= 1.51 cm$$

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