CH-5

MAGNETISM and MATTER

Q3 A short bare magnet placed with its axis at 30° with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to 4.5×10^{-2}. What is the magnitude of magnetic moment of the magnet.

Magnetic field strength, $B = 0.25$ T
Torque on bar magnet, $T = 4.5 \times 10^{-2}$ J

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

Torque is relation to magnetic moment (M)

$T = MB\sin\theta$

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

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

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

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

(a) The bar magnet is aligned along the magnetic field. This system is considered as being 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) The bar magnet is oriented 180° to the magnetic field. Hence, it is in unstable equilibrium.

$\theta = 180°$
potential energy $= -MB\cos\theta$

$= -0.32 \times 0.15 \cos 180°$
$= 4.8 \times 10^{-2} J$

5.5 Number of turns in the solenoid, $n = 80$
Area of cross section, $A = 2.5 \times 10^{-4} m^2$

Current of solenoid, $I = 3.0 A$

A current carrying solenoid is
Calculated as

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

5.7

(a) magnetic moment, $M = 1.5 J T^{-1}$
magnetic field strength, $B = 0.22 T$

(i) Initial angle between the axis and the magnetic moment normal to the direction of magnetic field is given as:

$$W = -MB(\cos\theta_2 - \cos\theta_1)$$
$$= -1.5 \times 0.22 (\cos 90° - \cos 0°)$$
$$= -0.33 (0 - 1)$$

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

Final angle between the axis and the magnetic field, $\theta_2 = 180°$

The work required to make the magnetic moment opposite to the direction of magnetic field H given as.

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

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

$= -0.33 (-1-1)$

$= 0.66 J$

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

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

$= 1.5 \times 0.22 \sin 90°$

$= 0.33 J$

For case (ii) $\theta = \theta_2 = 180°$

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

$= MB \sin 180° = 0 J$

9)

$n = 2000$
Area of cross section of solenoid, $A = 1.6 \times 10^{-4} m^2$
$I = 4A$

(a) The magnetic moment along the axis of solenoid is
$M = nAI$
$= 2000 \times 1.6 \times 10^{-4} \times 4$
$= 1.28 \; Am^2$

(b) magnetic field, $B = 7.5 \times 10^{-2} T$
Angle between the magnetic field and the axis of the solenoid, $\theta = 30°$

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 in uniform, the force on the solenoid is zero. The torque on the solenoid is $4.8 \times 10^{-2} Nm$

5.9 $N = 16$

$r = 10\ cm = 0.1\ m$

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

$I = 0.75\ A$

$B = 5.0 \times 10^{-2}\ T$

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

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

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

$= 0.377\ J T^{-1}$

Frequency

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

I = moment of inertia of the coil

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

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

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

5.11 $\theta = 120^\circ$

$\delta = 60^\circ$

$B_H = 0.16\ G$

Earth magnetic field = B

$B_H = B \cos \delta$

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

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Earth's magnetic field lies in the vertical plane, 12° west of the geographic meridian making angle 60° (upward) with the horizontal direction. Its magnitude H 0.32 G.

5.13 $H = 0.36\ G$

$$B_1 = \frac{\mu_0}{4\pi}\frac{2M}{d^2} = H \quad \ldots (i)$$

μ_0 = Permeability of free space

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

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 direction of earth's magnetic field.

5.14

$I = 2.5 A$

$\delta = 0^{\circ}$

$H = 0.33 G = 0.33 \times 10^{-4} T$

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

μ_0 = permeability of free space.

$= 4\pi \times 10^{-7} T m A^{-1}$

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

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

$= 1.51 m$

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