Magnetism and Matter

3) Magnetic field Strength, $B = 0.25\,T$
Torque on magnet, $T = 4.5 \times 10^{-2}\,J$
Angle between bar magnet and external magnetic field, $\theta = 30^\circ$

$\Rightarrow T = MB\sin\theta$

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

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

4) Moment on bar magnet $= M = 0.32\,JT^{-1}$
External magnetic field, $B = 0.15\,T$
(a) The bar magnet is aligned along the magnetic field. This system is considered as being in stable equilibrium. Hence angle θ, between the bar magnet and field is 0°.

Potential Energy of system $= -MB\cos\theta$
$= -0.32 \times 0.15 \cos 0^\circ$
$= -4.8 \times 10^{-2}\,J$

(b) The bar magnet is kept at 180°.
$\theta = 180^\circ$
Potential Energy $= -MB\cos\theta = -0.32 \times 0.15 \cos 180^\circ$

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

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

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

7) $M = 1.5 JT^{-1}$
$B = 0.22 T$

(i) Initial angle between the axis and magnetic field $= \theta_1 = 0°$
Final angle : $\theta_2 = 90°$

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

(ii) Initial angle $\theta_1 = 0°$
Final angle $\theta_2 = 180°$
$\Rightarrow W = -MB(\cos\theta_2 - \cos\theta_1)$
$= -1.5 \times 0.22 (\cos 180° - \cos 0°)$
$= -0.33 (-1-1)$
$= \underline{0.66 J}$

(b) For case (i) $\theta = \theta_2 = 90°$
$\therefore$ Torque $= MB\sin\theta = 1.5 \times 0.22 \sin 90°$
$= 0.33 J$

For case (ii) $\theta = \theta_2 = 180°$
Torque $= MB\sin 180° = \underline{0 J}$

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8) No of turns = 2000.
Area of cross section = $1.6 \times 10^{-4} m^2$.
Current, I = 4A.

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

(b) $B = 7.5 \times 10^{-2} T$
Angle between field and axis = $\theta = 30°$
Torque = $MB\sin\theta$
= $1.28 \times 7.5 \times 10^{-2} \sin 30°$
= 4.8×10^{-2} Nm.

9) No of turns = 16
Radius of coil = 0.1m
Cross sec of coil, $A = \pi r^2 = \pi \times (0.1)^2 m^2$
Current in the coil = 0.75 A
$B = 5.0 \times 10^{-2} T$
Frequency of oscillations = $2.0 s^{-1}$
⇒ $M = NIA = NI\pi r^2$

= $16 \times 0.75 \times \pi (0.1)^2$
= $0.377 JT^{-1}$
Frequency $\nu = \frac{1}{2\pi}\sqrt{\frac{MB}{I}}$

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

11) Angle of declination, $\theta = 12^\circ$
Angle of dip = $\delta = 60^\circ$
Horizontal component of Earth's field
$B_H = 0.16\,G$.
Magnetic field = B

$\Rightarrow B_H = B\cos\delta$

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

Earth's magnetic field lies in the vertical plane, 12° West of the Geographic Meridian making angle 60° upward.

13) Earth's Magnetic field at place
$H = 0.36\,G$.
The field at distance d on axis
$= B_1 = \frac{\mu_0}{4\pi}\frac{2M}{d^3} = H \quad (-i)$

The field at same distance on equatorial point

$\Rightarrow B_2 = \frac{\mu_0 M}{4\pi d^3} = \frac{H}{2} \quad$ [from (i)]

$\Rightarrow H + H/2 = 0.36 + 0.18 = 0.54\,G$

18) Current in the wire, $I = 2.5\,A$.
Angle of dip : $\delta = 0^\circ$

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Earth's Magnetic field, $H = 0.33 G = 0.33 \times 10^{-4} T$

Horizontal component of Earth $= H_H = H \cos \delta$

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

The magnetic field at the neutral point at distance R

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

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

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