Magnetism And Matter

3. Given, uniform magnetic field
$B = 0.25\,T$
The magnitude of torque $\tau = 4.5 \times 10^{-2}\,J$
Angle between magnetic moment and magnetic field
$\theta = 30°$
Torque experienced on a magnet placed in external magnetic field.

$$\tau = M \times B$$
$$\tau = MB\sin\theta$$
$$4.5 \times 10^{-2} = M \times 0.25 \times \sin 30°$$
$$M = \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30}$$
$$= \frac{4.5 \times 10^{-2} \times 2}{0.25 \times 1} = 0.36\,J/T$$

4. Given, magnetic moment of magnet $m = 0.32\,J/T$
The magnitude of magnetic field $B = 0.15\,T$

a) For stable equilibrium the angle between magnetic moment (M) and magnetic field (B) is $\theta = 0°$
The potential energy of the magnet

$$U = -M \cdot B$$
$$= -MB\cos\theta$$
$$= -0.32 \times 0.15 \cos 0°$$
$$= -4.8 \times 10^{-2}\,J.$$

Thus for the stable equilibrium the potential energy is $-4.8 \times 10^{-2}\,J$.

b. For unstable equilibrium the angle betn the magnetic moment and magnetic field is 180°. $\theta = 180°$

Potential energy of the magnet

$U = -MB\cos 180^\circ$

$= -0.32 \times 0.15 (-1) = 4.8 \times 10^{-2}$ J

5. Given, number of turns $n = 800$.

Area of cross section of solenoid $A = 2.5 \times 10^{-4}$ m²

Current through solenoid $I = 3A$.

As a current passes through a solenoid, a magnetic field is produced. By the use of Maxwell right hand grip rule, the magnetic field is along the axis of the solenoid, using the formula of magnetic moment:

$M = nIA$

$= 800 \times 3 \times 2.5 \times 10^{-4}$

$= 0.6$ J/T along the axis of the solenoid

8. Given, numbers of turns $n = 2000$

Area of cross-section $A = 1.6 \times 10^{-4}$ m²

$I = 4A$.

a. magnetic moment associated with solenoid

$M = nIA = 2000 \times 4 \times 1.6 \times 10^{-4} = 1.28$ J/T

b. The force (net) on the solenoid is zero, because two equal and opp. forces (on each of its poles) are acting, but their lines of action are parallel so they form a couple thus a torque (no force) is applied on it

Torque on the solenoid $\tau = MB\sin\alpha$

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

$= 1.28 \times 7.5 \times 10^{-2} \times \frac{1}{2}$

$= 4.8 \times 10^{-2}$ N-m

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9. Given, number of turns of circular coil $n = 16$.
Radius of circular coil $r = 10 cm = 0.1 m$.
Current $I = 0.75 A$.
Magnetic field $B = 5.0 \times 10^{-2} T$
Frequency $f = 2s$
magnetic moment of the coil $M = nIA$
$= 16 \times 0.75 \times \pi (0.1)^2$
$= 16 \times 0.75 \times 3.14 \times 0.1 \times 0.1$
$= 0.377 J/T$.
Frequency of oscillation of the coil.
$$f = \frac{1}{2\pi}\sqrt{\frac{M \times B}{I}}$$ I - Moment of inertia of the coil.
Squaring on both the sides, we get.
$$f^2 = \frac{1}{4\pi^2} \cdot \frac{MB}{I}$$
$$I = \frac{MB}{4\pi^2 f^2} = \frac{0.377 \times 5 \times 10^{-2}}{4 \times 3.14 \times 3.14 \times 2 \times 2}$$
$$= 1.2 \times 10^{-4} \; kg\,m^2.$$

11. Given, angle of deflection $\theta = 12°$ west
Angle of dip $\delta = 60°$
Horizontal component of earth magnetic field $H = 0.16 G$
Let the magnitude of earth's magnetic field at that place is R.
$$R = \frac{H}{\cos\delta} = \frac{0.16}{\cos 60°} = \frac{0.16 \times 2}{1} = 0.32 G = 0.32 \times 10^{-4} T$$

13. Distance of the null point from the centre of magnet $d = 14 cm = 0.14 m$.
The earth's magnetic field where the angle of dip

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zero, i.e. the horizontal component of earth's magnetic field.

$H = 0.36\,G$

Initially, the null point are on the axis of the magnet.

$$B_1 = \frac{\mu_0}{4\pi}\frac{2m}{d^3} \quad \text{---(i)}$$

The magnetic field is equal to the horizontal component of earth's magnetic field

$$B_2 = \frac{\mu_0}{4\pi}\cdot\frac{m}{d^3} = \frac{B_1}{2} = \frac{H}{2} \quad \text{---(ii)}$$

The total magnetic field on equitorial line at this point

$$B = B_2 + H = \frac{H}{2} + H$$

$$= \frac{3H}{2} = \frac{3}{2} \times 0.36 = 0.54\,G.$$

13. Given, current in the cable I = 2.5A.
Magnetic meridian $M_N M_S$ is 10° west of geographical meridian $G_N G_S$ earth's magnetic field

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

Angle of dip $\delta = 0°$
The neutral point is the point where the magnetic field due to the current carrying cable is equal to the horizontal compound of earth's magnetic field.
Horizontal component of earth's magnetic field

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

$$B = \frac{\mu_0}{4\pi}\cdot\frac{2I}{r} \quad \text{--- (i)}$$

At neutral point $H = B$

$$0.33 \times 10^{-4} = \frac{\mu_0}{4\pi} \cdot \frac{2I}{r}$$

$$0.33 \times 10^{-4} = \frac{10^{-7} \times 2 \times 2.5}{r}$$

$$r = \frac{5 \times 10^{-7}}{0.33 \times 10^{-4}}$$

$$r = 1.5 \times 10^{-2}\ m = 1.5 cm$$