Magnetism and Matter

3. Here $\theta = 30°$, $B = 0.25T$

$\tau = 4.5 \times 10^{-2} J$

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

$\Rightarrow M = \dfrac{\tau}{B\sin\theta}$

$= \dfrac{4.5 \times 10^{-2}}{0.25 \sin 30°}$

$= 0.36 JT^{-1}$

4. Here $M = 0.32 JT^{-1}$

$B = 0.15 T$

(i) In Stable equilibrium the bar magnet is aligned along the magnetic field, i.e., $\theta = 0°$

Potential Energy $= -MB\cos 0°$

$= -0.32 \times 0.15(-1)$

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

In unstable equilibrium the magnet is so oriented that magnetic moment is at 180° to the magnetic field, $\theta = 180°$

Potential Energy $= -MB\cos 180°$

$= -0.32 \times 0.15(-1)$

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

5- Here, $n = 800$

$A = 2.5 \times 10^{-4} m^2$

$I = 3.0A$

A magnetic field develops along the axis of the solenoid. Therefore, the current carrying solenoid behaves like a bar magnet.

7- Here, $M = 1.5 JT^{-1}$

$B = 0.22T$

(a) (i) Here, $\theta_1 = 0°$ (along the field)

$\theta_2 = 90°$ ($\perp$ to the field)

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

$W = -1.5 \times 0.22(\cos 90° - \cos 0°)$

$= -0.33(0-1)$

$= 0.33 J$

ii) Here, $\theta_1 = 0°$

$\theta_2 = 180°$

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

$= -0.33(-1-1)$

$= 0.66 J$

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b. Torque $\tau = MB \sin\theta$

(i) Here, $\theta = 90°$

$\tau = 1.5 \times 0.22 \sin 90°$

$= 0.33 \, Nm$

ii- Here, $\theta = 180°$

$\tau = 1.5 \times 0.22 \sin 180°$

$= 0$

8- (a) $N = 2000$, $A = 1.6 \times 10^{-4} m^2$,

$I = 4 \, amp$, $B = 7.5 \times 10^{-2} T$

As, $M = NIA$

$\therefore M = 2000 \times 4 \times 1.6 \times 10^{-4}$

$= 1.28 \, JT^{-1}$

b- Net force on the solenoid $= 0$

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

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

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

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

9- Here, $n = 16$, $d = 10 cm = 0.1 m$

$I = 0.75 A$, $B = 5.0 \times 10^{-2} T$

$V = 2.0 s^{-1}$

$M = niA = ni\pi r^2$

$= 16 \times 0.75 \times \frac{22}{7} (0.1)^2$

$= 0.377 \, JT^{-1}$

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As, $\nu = \frac{1}{2\pi}\sqrt{\frac{MB}{I}}$ (where I is the moment of inertia of the coil.)

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

$I = \frac{MB}{4\pi^2\nu^2} = \frac{0.327 \times 5.0 \times 10^{-2}}{4 \times \left(\frac{22}{7}\right)^2 \times 2^2}$

$= 1.2 \times 10^{-4}\ kg\ m^2$

11- Here, declination, $\theta = 12°$ west, dip, $\delta = 60°$

$H = 0.16$ gauss $= 0.16 \times 10^{-4}$ tesla

As, $H = R\cos\delta$

$R = \frac{H}{\cos\delta} = \frac{0.16 \times 10^{-4}}{\cos 60°}$

$= \frac{0.16 \times 10^{-4}}{1/2}$

$= 0.32 \times 10^{-4} T$

13- As null points are on the axis of the magnet, therefore

$B_1 = \frac{\mu_0}{4\pi} \times \frac{2m}{d^3} = H$

On the equatorial line of magnet at same distance (d),

field due to the magnet is $B_2 = \frac{\mu_0}{4\pi} \times \frac{m}{d^3} = \frac{B_1}{2} = \frac{H}{2}$

$\therefore$ Total Magnetic field at the point on equatorial line is

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

$= \frac{3}{2}H = \frac{3}{2} \times 0.36$

$= 0.54 G$

18- Here, $i = 2.5$ amp ; $R = 0.33 a$

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

$\delta = 0°$

Horizontal component of earth's field

$H = R \cos\delta$

$= 0.33 \times 10^{-4} \cos 0°$

$= 0.33 \times 10^{-4}$ tesla

Cable $= \frac{\mu_0 I}{2\pi r}$

At neutral point, $\frac{\mu_0 I}{2\pi r} = H$

$r = \frac{\mu_0 I}{2\pi H} = \frac{4\pi \times 10^{-7} \times 2.5}{2\pi \times 0.33 \times 10^{-4}} = 1.5 \times 10^{-2} m$