Date ______
Page ______

Exercises

5.3 Magnetic field strength, $B = 0.25 T$
Torque on the bar magnet, $T = 4.5 \times 10^{-2} J$
Angle ~~between~~, $\theta = 30°$

Torque, $T = MB\sin\theta$

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

$$= \frac{4.5\times10^{-2}}{0.25 \times \sin 30} = \frac{4.5\times10^{-2}}{0.25 \times \frac{1}{2}}$$

$$= 0.36 J T^{-1}$$

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

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

a) The bar magnet aligned along the magnetic field The system is considered as being in stable equilibrium. Hence, $\theta = 0°$

Potential energy of the system $= -MB\cos\theta$

$$= -0.32 \times 0.15 \cos 0°$$

$$= -4.8\times10^{-2} J$$

b) The bar magnet is oriented 180° to the magnetic field. Hence, it is in unstable equilibrium.

$\theta = 180°$

$P.E. = -MB\cos\theta$

$= -0.32 \times 0.15 \cos 180°$

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

5.5 Turns in the solenoid, $n = 800$

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

Current in solenoid, $I = 3.0\ A$.

A current-carrying solenoid behaves as a bar magnet because a magnetic field develops along its axis, i.e., along its length.

$M = nIA$

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

$= 0.6\ JT^{-1}$

5.7 a) Magnetic moment, $M = 1.5\ JT^{-1}$

Magnetic field, $B = 0.22T$

i) $\theta_1 = 0°$

$\theta_2 = 90°$

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

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

$= -0.33(0-1)$

$= 0.33J$

ii) $\theta_1 = 0°$, $\theta_2 = 180°$

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

$= -1.5 \times 0.22 (-1-1)$

$= -0.33(-1-1)$

$= 0.66\, J$.

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

∴ Torque, $\tau = MB\sin\theta$

$= 1.5 \times 0.22 \sin 90°$

$= 0.33 J$

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

∴ Torque, $\tau = MB\sin\theta$

$= 0 J$.

5.8 No. of turns in the solenoid, $n = 2000$

Area of cross-section, $A = 1.6 \times 10^{-4}\ m^2$.

Current in the solenoid, $I = 4A$

a) Magnetic moment, $M = nAI$

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

$= 1.28\ Am^2$.

b) Magnetic field, $B = 7.5 \times 10^{-2} T$

$\theta = 30°$

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

Date
Page

5.9. No. of turns in 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, $I = 0.75A$.
Magnetic field strength, $B = 5.0 \times 10^{-2}\,T$.
Frequency, $\nu = 2.0\,s^{-1}$

$\therefore$ 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

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

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

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

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

Date
Page

5.11. ~~Ag~~ Angle of declination, $\theta = 12°$
Angle of dip, $\delta = 60°$
Horizontal component, $B_H = 0.16\,G$

$B_H = B\cos\delta$

$\therefore\ B = \frac{B_H}{\cos\delta}$

$= \frac{0.16}{\cos 60°} = 0.32\,G.$

$\boxed{B = 0.32\,G}$

5.13 Earth's magnetic field at given place, $H = 0.36\,G$

The magnetic field at a distance d,

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

The magnetic field at the same distance d, on the equatorial line,

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

Total magnetic field

$B = B_1 + B_2$

$= 0.36 + 0.18 = 0.54\,G.$

$\boxed{B = 0.54\,G}$

Date ______
Page ______

5.18 Current in the wire, $I = 2.5A$
Angle of dip, $\delta = 0°$
Earth's magnetic field, $H = 0.33 G = 0.33 \times 10^{-4} T$.
Horizontal component of earth's magnetic field, $H_H = H \cos\delta$

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

Magnetic field at the neutral point at a distance R

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

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

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