CHAPTER
5

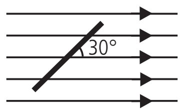
Magnetism and Matter

NCERT FOCUS

ANSWERS

Topic 1

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



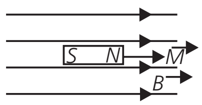
$4.5 \times 10^{-2} = M\,(0.25 \sin 30°)$

Magnetic dipole moment,

$M = 0.36\ \text{J T}^{-1}$.

2. (a) An equilibrium is stable, if on disturbing the magnet, it comes back to same initial state.

Bar magnet is in stable equilibrium at $\theta = 0°$



Potential energy

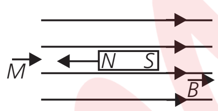
$U = -\,M\cdot B = -\,MB \cos 0°$

$= -0.32 \times 0.15 = -\,0.048$ J

(b) A bar magnet is in unstable equilibrium, if on disturbing from its position, it further gets disturb and do not come back to previous position of equilibrium.

At $\theta = 180°$, the equilibrium is unstable.

Potential energy

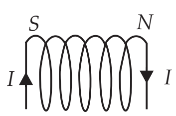


$U = -M.B$

$= -MB \cos 180°$

$= +\,MB = +0.048$ J

3.



A current carrying closely wound solenoid acts like bar magnet. Each of the turn provide a dipole moment and all turns together provides the dipole moment of the magnet.

Total magnetic moment, $M = NIA$

$= 800 \times 3 \times 2.5 \times 10^{-4} = 0.6\ \text{A m}^2$

4. The solenoid behaves as a bar magnet

so, torque, $\tau = MB \sin\theta$

$\tau = 0.6 \times 0.25 \times \sin 30° = 0.075$ N m.

5. (a) Work required to turn the dipole

$W = MB\,[\cos\theta_i - \cos\theta_f]$

(i) $\theta_i = 0°$ and $\theta_f = 90°$

$W = 1.5 \times 0.22\,[\cos 0° - \cos 90°] = 0.33$ J

(ii) $\theta_i = 0°$ and $\theta = 180°$

$W = 1.5 \times 0.22\,[\cos 0° - \cos 180°] = 0.66$ J

(b) Torque when $\theta = 90°$

$\tau_1 = MB \sin 90° = 0.33$ N m

Torque when $\theta = 180°$

$\tau_2 = MB \sin 180° = 0$

6. (a) Magnetic moment associated with solenoid

$M = NIA = 2000 \times 4 \times 1.6 \times 10^{-4} = 1.28\ \text{A m}^2$

(b) Force on the solenoid will be zero in uniform magnetic field.

Torque $\tau = MB \sin\theta$

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

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

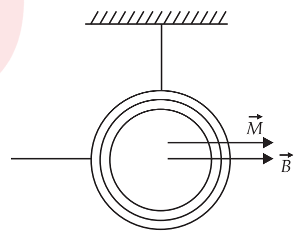
The torque tends to align the solenoid in the direction of magnetic field.

7. The circular coil carries a dipole moment

$M = NIA = 16 \times 0.75 \times \pi\,[0.1]^2$

$= 0.3768\ \text{A-m}^2$

Time period of oscillation



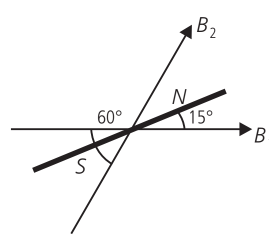
$$T = 2\pi\sqrt{\frac{I}{MB}}$$

Frequency $f = \dfrac{1}{2\pi}\sqrt{\dfrac{MB}{I}}$

So, moment of inertia $I = \dfrac{1}{4\pi^2}\dfrac{MB}{f^2}$

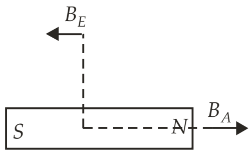
$$I = \frac{1}{4\pi^2} \times \frac{(0.3768) \times 5 \times 10^{-2}}{(2)^2} = 11.9 \times 10^{-5}\ \text{kg m}^2$$

8. The magnetic dipole experiences torque due to both the fields and is in equilibrium.



$MB_1 \sin 15° = MB_2 \sin 45°$

$1.2 \times 10^{-2} \times 0.26 = B_2\,(0.71)$ or $B_2 = 0.44 \times 10^{-2}$ T.

9. 

For short magnet

(i) $B_{\text{axial}} = \frac{\mu_0}{4\pi}\frac{2M}{r^3}$

$B_{\text{axial}} = \frac{10^{-7}\times 2\times 0.48}{(0.1)^3} = 9.6\times 10^{-5}$ T,

along S – N direction

(ii) B equatorial = $\frac{\mu_0}{4\pi}\frac{M}{r^3}$ = 4.8 × 10^{-5} T,

along N – S direction

Topic 2

1. (a) In a specimen of a ferromagnets, the atomic dipoles are grouped together in domains. All the dipoles of a domain are aligned in the same direction and have net magnetic moment. In an unmagnetised substance these domains are randomly distributed so that the resultant magnetisation is zero. When the substance is placed in an external magnetic field, these domains align themselves in the direction of the field. Some energy is spent in the process of alignment when the external field is removed, these domains do not come back into their random positions completely. The substance retains some magnetisation. The energy spent in the process of magnetisation is not fully recovered. The balance of energy is lost as heat. This is the basic cause for irreversibility of the magnetisation curve of a ferromagnetic substance.

(b) Carbon steel piece, because the heat produced in complete cycle of magnetisation is directly proportional to the area under the hysteresis loop.

(c) Magnetisation of a ferromagnet is not a single valued function of the magnetising field. Its value for a particular field depends both on the magnetising field and on the history of its magnetisation *i.e.* how many cycles of magnetisation it has gone through etc. So, the value of magnetisation is a record or memory of its cycles of magnetisation. If information bits can be made to correspond to these cycles, the system displaying such a hysteresis loop can act as a device for storing information.

(d) Ferrites or ceramics which is specially treated barium iron oxides.

(e) By surrounding the region with soft iron rings, as magnetic field lines will be drawn into the rings and the enclosed space becomes free of magnetic field.

2. Dipole moment at complete saturation

$M = 2 \times 10^{24} \times 1.5 \times 10^{-23} = 30 \text{ J T}^{-1}$

At 0.64 T and 4.2 K, 15% of sample is magnetised.

$M = C\frac{B_0}{T_0}$

$0.15\times 30 = C\frac{0.64}{4.2}$ ... (i)

At 0.98 T and 2.8 K

$M = C\frac{0.98}{2.8}$ ... (ii)

Dividing (i) by (ii), $M = 10.5 \text{ J T}^{-1}$

3. Magnetic field B in the core

$B = \mu_m nI = \frac{\mu_m NI}{2\pi r}$

$B = \frac{\mu_0\mu_r NI}{2\pi r} = \frac{4\pi\times 10^{-7}\times 800\times 3500\times 1.2}{2\pi\left(15\times 10^{-2}\right)}$ = 4.48 T

4. (a) In paramagnetics, the tendency to disrupt the alignment of molecular dipoles with the external magnetising field arising from random thermal motion is reduced at lower temperatures.

(b) In diamagnetics, the molecular dipole moments always align in direction opposite to that of external magnetising field, inspite of the internal motion of atoms.

(c) As bismuth is diamagnetic, so the field in the toroid with bismuth core will be slightly less than when the core is empty.

(d) No, the permeability of a ferromagnetic material is not independent of the magnetic field. It is more at higher fields.

(e) As the magnetic permeability m of a ferromagnetic is much larger than unity *i.e.*, $m >> 1$, so magnetic field lines are always nearly normal to the surface of a ferromagnet at every point.

(f) Yes, but for the maximum possible magnetisation of paramagnetic sample impractically very high magnetising fields are required.