# Home Assignment

Shrabanee Samantaray
"XII" "DB"
School no.: 9888

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## PHYSICS

CHAPTER:5

# Magnetism and Matter...

5.3 A short bar magnet placed with its axis at 30° with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to $4.5 \times 10^{-2}$ J. What is the magnitude of magnetic moment of the magnet?

# NCERT Exercises

5.3 A short bar magnet ... axis at 30° uniform ext. magnetic field of 0.25 T experiences a torque of magnitude equal to $4.5 \times 10^{-2}$ J. What is the magnitude of magnetic moment of the magnet?

Sol^n. Magnetic field strength, $B = 0.25$ T
torque $\tau = 4.5 \times 10^{-2}$ J
$\theta = 30°$

Now $\tau = MB\sin\theta$

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

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

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

Thus, magnetic moment of the magnet :— 0.36 $JT^{-1}$

5.4. A short bar magnet of magnetic moment $m = 0.32 \ JT^{-1}$ is placed in a uniform magnetic field of 0.15 T. If the bar is free to rotate in the plane of the field, which orientation would correspond to its (a) stable, and (b) unstable equilibrium? What is the potential energy of the magnet in each case?

5.4 A short bar . . m = 0.32 J T^-1 . . . magnetic field of 0.15 T.
If bar is free to rotate . . .
a) stable and b) unstable equilibrium
What's potential energy of magnet?

$M = 0.32\ J\ T^{-1}$
$B$ (ext. mag. field) $= 0.15\ T$

a) Bar magnet aligned along magnetic field.
This system considered as being in stable equilibrium.
Hence, angle $\theta$, b/w bar magnet and magnetic field = 0°

Potential energy of system =

$$-MB\cos\theta = -0.32 \times 0.15 \cos 0°$$
$$= -4.8 \times 10^{-2}\ J$$

b) Bar magnet is oriented 180° to magnetic field
Thus, it's in unstable equilibrium.

$\theta = 180°$

Potential energy $= -MB\cos\theta$

$$= -0.32 \times 0.15 \cos 180°$$
$$= 4.8 \times 10^{-2}\ J$$

5.5 A closely wound solenoid of 800 turns and area of cross section $2.5 \times 10^{-4}$ $m^2$ carries a current of 3.0 A. Explain the sense in which the solenoid acts like a bar magnet. What is its associated magnetic moment?

5.5 A No. of turns in solenoids (n) = 800.

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

current in solenoid, $I = 3.0A$

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

∴ The magnetic moment associated with current carrying solenoid is :—

$M = nIA$

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

$= 0.6 \, JT^{-1}$

(b) What is the torque on the magnet in cases (i) and (ii)?

5.8 A closely wound solenoid of 2000 turns and area of cross-section $1.6 \times 10^{-4}\ m^2$, carrying a current of 4.0 A, is suspended through its centre allowing it to turn in a horizontal plane.

(a) What is the magnetic moment associated with the solenoid?

(b) What is the force and torque on the solenoid if a uniform horizontal magnetic field of $7.5 \times 10^{-2}$ T is set up at an angle of 30° with the axis of the solenoid?

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

Area of cross section of the solenoid,

$A = 1.6 \times 10^{-4} m^2$

Current in solenoid, $I = 4.0 A$.

a) Magnetic moment associated with solenoid :—

$M = nAI = 2000 \times 4 \times 1.6 \times 10^{-4} = 1.28 Am^2$.

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

The angle b/w magnetic field and axis of solenoid.

$\theta = 30°$

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

$= 1.28 \times 7.5 \times 10^{-2} \sin 30° = 0.048J$

∴ Magnetic field uniform, force on solenoid 0. and $\tau = 0.048J$

30° with the axis of the solenoid?

5.9 A circular coil of 16 turns and radius 10 cm carrying a current of 0.75 A rests with its plane normal to an external field of magnitude $5.0 \times 10^{-2}$ T. The coil is free to turn about an axis in its plane perpendicular to the field direction. When the coil is turned slightly and released, it oscillates about its stable equilibrium with a frequency of $2.0\ s^{-1}$. What is the moment of inertia of the coil about its axis of rotation?

5.10 A magnetic needle free to rotate in a vertical plane parallel to the

S.9 No. of turns in circular coil, $N = 16$.

Radius of coil, $r = 10\ cm$ i.e $0.1\ m$

A (cross section area of coil) $= \pi r^2$

$= \pi (0.1)^2\ m^2$

Current in coil, $I = 0.75\ A$.

Magnetic field, $B = 5.0 \times 10^{-2}\ T$

frequency of oscillations of coil, $\nu = 2.0\ s^{-1}$

$\therefore$ Magnetic moment, $M = NIA = NI\pi r^2$.

$16 \times 0.75 \times \pi \times (0.1)^2 = 0.377\ J\ T^{-1}$

Now $\nu = \frac{1}{2\pi}\sqrt{\frac{MB}{I}}$

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

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

$\therefore$ Moment of inertia of coil about its rotation

$1.2 \times 10^{-4}\ kg\ m^2$ (approx)

**5.11** At a certain location in Africa, a compass points 12° west of the geographic north. The north tip of the magnetic needle of a dip circle placed in the plane of magnetic meridian points 60° above the horizontal. The horizontal component of the earth's field is measured to be 0.16 G. Specify the direction and magnitude of the earth's field at the location.

5.11 Angle of declination, $\theta = 12°$
& Angle of dip, $\phi = 60°$

$B_H = 0.16\ G$ (Horizontal component of earth's magnetic field)

Earth's magnetic field at given location = B.

Now $B_H = B \cos\phi$

i.e. $B = \frac{B_H}{\cos\phi} = \frac{0.16}{\cos 60°} = 0.32\ G$

Earth's magnetic field lies in a vertical plane, 12° West of geographic meridian, making an angle of 60° (upward) with horizontal direction. It's magnitude is 0.32 G.

(b) the equatorial lines (normal bisector) of the magnet.

5.13 A short bar magnet placed in a horizontal plane has its axis aligned along the magnetic north-south direction. Null points are found on the axis of the magnet at 14 cm from the centre of the magnet. The earth's magnetic field at the place is 0.36 G and the angle of dip is zero. What is the total magnetic field on the normal bisector of the magnet at the same distance as the null–point (i.e., 14 cm) from the centre of the magnet? (At *null points*, field due to a magnet is equal and opposite to the horizontal component of earth's magnetic field.)

5.14 If the bar magnet in exercise 5.13 is turned around by 180°, where

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

Magnetic field at given place ~~from a~~ distance 'd', on axis of magnetic given as :-

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

Now Magnetic field at 'd' on equitorial line of magnet

$B_2 = \frac{\mu_0 M}{4\pi d^3} = \frac{H}{2}$ [∵ using (1)]

Total magnetic field, $B = B_1 + B_2 = H + \frac{H}{2}$

$= 0.36 + 0.18$

$= 0.54G$ in direction of earth's magnetic field.

Suggest a method.

**5.18** A long straight horizontal cable carries a current of 2.5 A in the direction 10° south of west to 10° north of east. The magnetic meridian of the place happens to be 10° west of the geographic meridian. The earth's magnetic field at the location is 0.33 G, and the angle of dip is zero. Locate the line of neutral points (ignore the thickness of the cable)? (At *neutral points*, magnetic field due to a current-carrying cable is equal and opposite to the horizontal component of earth's magnetic field.)

Q.7 Current in the wire = 2.5 A

The earth's magnetic field at a given place,

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

Angle of dip $= \phi = 0$

Horizontal component of earth's magnetic field,

$B_H = R\cos\phi = 0.33 \times 10^{-4} \cos 0$

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

Magnetic field due to a current carrying conductor,

$$B_c = \left(\frac{\mu_0}{2\pi}\right) \times \left(\frac{I}{r}\right)$$

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

$$= \frac{5 \times 10}{r}$$

$B_H = B_c$ i.e. $0.33 \times 10^{-4} = 5 \times 10^{-7}/r$

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

$= 0.015\,m = 1.5\,cm$

∴ Neutral points lie on straight line parallel to cable at perpendicular distance of 1.5 cm.


THANK YOU !