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1/9/21

(NCERT Selected).

Magnetism & Matter

③ Magnetic field strength, $B = 0.25\,T$.
Torque on the bar magnet, $T = 4.5 \times 10^{-2}\,J$.
Angle between the bar magnet & external magnetic field, $\theta = 30°$

Torque is related to magnetic moment (M) as:
$T = MB \sin\theta$.

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

$$= \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30°} = 0.36\,J/T.$$

Hence, the magnetic moment of the magnet is $0.36\,J/T$.

④ Moment of the bar magnet, $M = 0.32\,J/T$.
External magnetic field, $B = 0.15\,T$.

a) The barmagnet is aligned along the magnetic field. This system is considered as being in stable equilibrium. Hence, the angle θ, between the bar magnet & the magnetic field is $0°$

Potential energy of the system $= -MB\cos\theta$.
$= -0.32 \times 0.15 \cos 0°$
$= -4.8 \times 10^{-2}\,J$.

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

$\theta = 180°$, Potential Energy $= -MB\cos\theta$

~~$= -0.32 \times 0.15 \cos 180°$~~

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

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

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

(5) No. of turns in the solenoid, $n = 800$.
Area of cross-section, $A = 2.5 \times 10^{-4}\ m^2$.
Current in the solenoid, $I = 3.0$ A.

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

The magnetic moment associated with the given current-carrying solenoid is calculated as:
$M = nIA$.
$M = 800 \times 3 \times 2.5 \times 10^{-4}$
$= 0.6$ J/T.

(8) No. of turns on the solenoid, $n = 2000$
Area of cross-section of solenoid, $A = 1.6 \times 10^{-4}\ m^2$
Current in the solenoid, $I = 4$ A.

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a) The magnetic moment along the axis of the solenoid is calculated as

$M = nAI$.

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

$= 1.28\ Am^2$

b) Magnetic field, $B = 7.5 \times 10^{-2}\ T$.
Angle between the magnetic field and the axis of the solenoid, $\theta = 30^{\circ}$.

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

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

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

Since the magnetic field is uniform, the force on the solenoid is 0. The torque on the solenoid is $4.8 \times 10^{-2}\ Nm$.

9) No. of turns in the circular 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 in the coil, $I = 0.75\ A$.
magnetic field strength, $B = 5.0 \times 10^{-2}\ T$
Frequency of oscillations of the coil, $v = 2.0/s$.

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

$= 16 \times 0.75 \times \pi \times (0.1)^2$

$= 0.377\ J/T$.

Frequency is given by the relation:-

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

where,

I = Moment of Inertia of the coil.

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

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

$$= 1.19 \times 10^{-4}\ kg/m^2$$

$\therefore$ the moment of inertia of the coil about its axis of rotation is $1.19 \times 10^{-4}\ kg/m^2$.

(11) Angle of declination, $\theta = 12°$

Angle of dip, $\delta = 60°$

Horizontal component of earth's magnetic field,

$B_H = 0.16\ G$.

Earth's magnetic field at the given location = B.

We can relate B and B_H as:-

$B_H = B \cos\delta$.

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

$$= \frac{0.16}{\cos 60°} = 0.32\ G.$$

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

(13) Earth's magnetic field at the given place
$H = 0.36$ G.

The magnetic field at a distance d, on the axis of the magnet is given as

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

where,
μ_0 = permeability of free space
M = magnetic moment

The magnetic field at the same distance d, on the equatorial line of the magnet is given as:-

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

Total magnetic field, $B = B_1 + B_2$

$$= H + \frac{H}{2} = 0.36 + 0.18 = 0.54 \text{ G.}$$

∴ the magnetic field is 0.54 in the direction of earth's magnetic field

(18) Current in the wire, $I = 2.5\,A$.

Angle of dip at the given location on earth, $\delta = 0^\circ$

Earth's magnetic field, $H = 0.33\,G = 0.33 \times 10^{-4}\,T$

The horizontal component of earth's magnetic field is given as.

$$H_H = H\cos\delta.$$

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

The magnetic field at the neutral point at a distance R from the cable is given by the relation:

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

where,

μ_0 = Permeability of the free space $= 4\pi \times 10^{-7}\,T\,m/A$

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

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

Hence, a set of neutral points parallel to & above the cable are located at a normal distance of 1.51 cm.