Physics

NCERT Exemplar Problems

Chapter 5

Magnetism and Matter

Answers

5.1 (c)

5.2 (a)

5.3 (c)

5.4 (b)

5.5 (b)

5.6 (a), (d)

5.7 (a), (d)

5.8 (a), (d)

5.9 (a), (c), (d)

5.10 (b), (c), (d)

5.11 $\mu_p \approx \dfrac{e\hbar}{2m_p}$ and $\mu_e \approx \dfrac{e\hbar}{2m_e}, \hbar = \dfrac{h}{2\pi}$

$\mu_e >> \mu_p$ because $m_p >> m_e$.

5.12 $Bl = \mu_0 M\,l = \mu_0(I + I_M)$ and $H = 0 = I$

$Ml = I_M = 10^6 \times 0.1 = 10^5$ A.

5.13 $x\,\alpha\,\text{density}\,\rho$. Now $\dfrac{\rho_N}{\rho_{Cu}} = \dfrac{28g/22.4Lt}{8g/cc} = \dfrac{3.5}{22.4}\times 10^{-3} = 1.6 \times 10^{-4}$.

$\dfrac{x_N}{x_{Cu}} = 5\times10^{-4}$ (from given data).

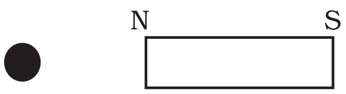
Hence major difference is accounted for by density.

5.14 Diamagnetism is due to orbital motion of electrons developing magnetic moments opposite to applied field and hence is not much affected by temperature.

Paramagnetism and ferromagnetism is due to alignments of atomic magnetic moments in the direction of the applied field. As temperature increases, this aligment is disturbed and hence susceptibilities of both decrease as temperature increases.

5.15 (i) Away from the magnet.

(ii) Magnetic moment is from left to right



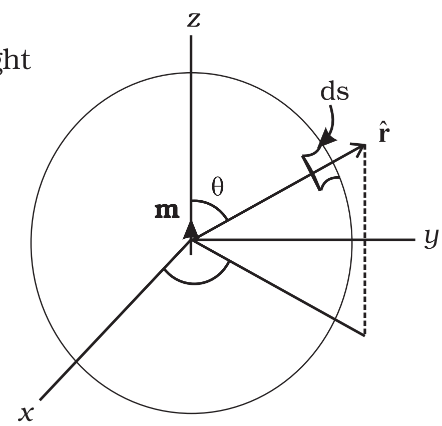
5.16 $\mathbf{B} = \dfrac{\mu_0}{4\pi}\dfrac{3\mathbf{m}.\hat{\mathbf{r}}}{r^3}, m = m\hat{\mathbf{k}}$

$d\mathbf{s} = \hat{\mathbf{r}}.\mathbf{r}^2\sin\theta d\theta c\,\phi$

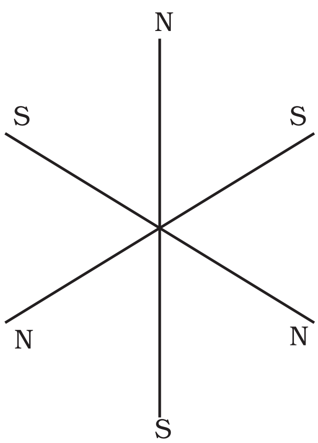
$0 \le \theta \le \pi, 0 \le \phi \le \pi$

$\oint \mathbf{B}.ds = \dfrac{\mu_0 m}{4\pi}\int \dfrac{3\cos\theta}{r^3} r^2 \sin\theta d\theta d\phi$

$= 0[\text{due to } \theta \text{ integral}]$.



5.17 Net $m = 0$. Only possibility is shown in Fig.



5.18 $E\,(r) = c\,B\,(r)$, $p = \dfrac{m}{c}$. Mass and moment of inertia of dipoles are equal.

5.19 $T = 2\pi\sqrt{\dfrac{I}{mB}}$ $\quad I' = \dfrac{1}{2}\times\dfrac{1}{4}I$ and $m' = \dfrac{m}{2}$. $\quad T' = \dfrac{1}{2}T$

5.20 Consider a line of **B** through the bar magnet. It must be closed. Let C be the amperian loop.

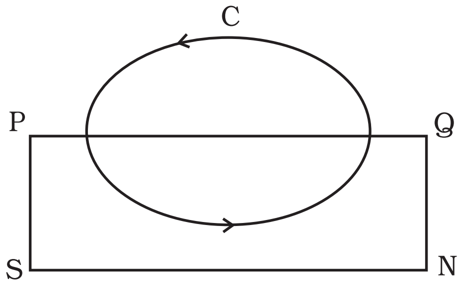
$\int_Q^P \mathbf{H}.d\mathbf{l} = \int_Q^P \dfrac{\mathbf{B}}{\mu_0}.d\mathbf{l} > 0$

$\oint_{PQP} \mathbf{H}.d\mathbf{l} = 0$

$$\int_p^Q \mathbf{H}.d\mathbf{l} < 0$$

P → Q is inside the bar.

Hence **H** is making an obtuse angle with *d***l**.

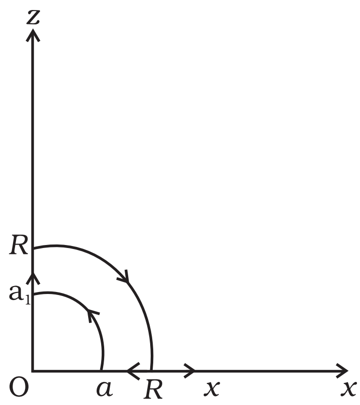


5.21 (i) Along z axis

$$\mathbf{B} = \frac{\mu_0}{4\pi}\frac{2\mathbf{m}}{r^3}$$

$$\int_a^R \mathbf{B}.d\mathbf{l} = \frac{\mu_0}{4\pi}2m\int_a^R \frac{dz}{z^3} = \frac{\mu_0 m}{2\pi}\left(-\frac{1}{2}\right)\left(\frac{1}{R^2}-\frac{1}{a^2}\right)$$

(ii) Along the quarter circle of radius R



$$B_\theta = \frac{\mu_0}{4\pi}\frac{-\mathbf{m}.\hat{\theta}}{R^3} = \frac{-\mu_0}{4\pi}\frac{m}{R^3}(-\sin\theta)$$

$$\mathbf{B}.d\mathbf{l} = \frac{\mu_0 m}{4\pi R^2}\sin\theta d\theta$$

$$\int_0^{\frac{\pi}{2}} \vec{B}.\vec{dl} = \frac{\mu_0 m}{4\pi R^2}$$

(iii) Along x-axis

$$\mathbf{B} = \frac{\mu_0}{4\pi}\left(\frac{-m}{x^3}\right)$$

$$\int \mathbf{B}.d\mathbf{l} = 0$$

(iv) Along the quarter circle of radius a

$$\mathbf{B}.d\mathbf{l} = \frac{-\mu_0 m}{4\pi a^2}\sin\theta d\theta\ ,\ \int \mathbf{B}.d\mathbf{l} = -\frac{-\mu_0 m}{4\pi a^2}\int_0^{\frac{\pi}{2}} \sin\theta d\theta = \frac{-\mu_0 m}{4\pi a^2}$$

Add $\oint_C \mathbf{B}.d\mathbf{l} = 0$

5.22 χ is dimensionless.

χ depends on magnetic moment induced when H is turned on. H couples to atomic electrons through its charge e. The effect on m is via current I which involves another factor of 'e'. The combination "$\mu_0 e^2$" does not depend on the "charge" Q dimension.

$$\chi = \mu_0 e^2 m^\alpha v^\beta R^\gamma$$

$$\mu_0 c^2 = \frac{1}{c^2}\frac{e^2}{\varepsilon_0} \sim \frac{1}{c^2}\frac{e^2}{\varepsilon_0 R}.R \sim \frac{\text{Energy length}}{c^2}$$

$$[\chi] = M^0L^0T^0Q^0 = \frac{ML^3T^{-2}}{L^2T^{-2}} M^{\alpha}\left(\frac{L}{T}\right)^{\beta} L^{\gamma}Q^0$$

$$\alpha = -1, \beta = 0, \gamma = -1$$

$$\chi = \frac{\mu_0}{} \frac{e^2}{mR} \sim \frac{10^{-6} \times 10^{-38}}{10^{-30} \times 10^{-10}} \sim 10^{-4}.$$

5.23 (i) $|\mathbf{B}| = \frac{\mu_0}{4\pi} \frac{m}{R^3} (4\cos^2\theta + \sin^2\theta)^{1/2}$

$$\frac{|\mathbf{B}|^2}{\left(\frac{\mu_0}{4\pi R^3}\right)^2 m^2} = 3\cos^2\theta + 1$$, minimum at $\theta = \frac{\pi}{2}$.

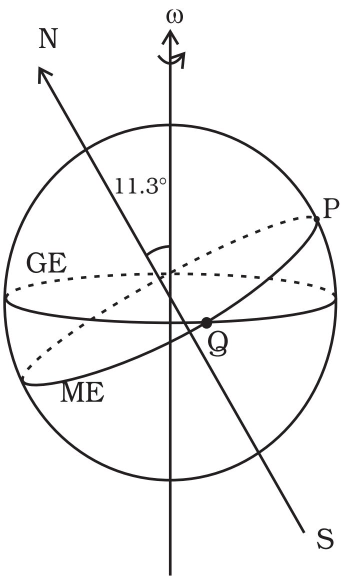
$|\mathbf{B}|$ is minimum at magnetic equator.

(ii) tan (dip angle) = $\frac{B_V}{B_H} = 2\cot$

at $\theta = \frac{\pi}{2}$ dip angle vanishes. Magnetic equator is again the locus.

(iii) Dip angle is ± 45° when $\left|\frac{B_V}{B_H}\right| = 1$

2 cot θ = 1
θ = $\tan^{-1}2$ is the locus.



5.24 Refer to the adjacent Fig.

1. P is in S (needle will point both north)

Declination = 0

P is also on magnetic equator.

∴ dip = 0

2. Q is on magnetic equator.

∴ dip = 0

but declination = 11.3°.

5.25 $n_1 = \frac{L}{2\pi R}$ $\qquad$ $n_2 = \frac{L}{4a}$

$m_1 = n_1 IA_1$ $\qquad$ $m_2 = n_2 IA_2$

$$= \frac{L}{2\pi R} I\pi R \qquad\qquad = \frac{L}{4a} Ia^2 = \frac{L}{4} Ia$$

$$I_1 = \frac{MR^2}{2} \text{ (moment of inertia about an axis through the diameter)}$$

$$I_2 = \frac{Ma^2}{12}$$

$$\omega_1^2 = \frac{m_1 B}{I_1} \qquad\qquad \omega_2^2 = \frac{m_2 B}{I_2}$$

$$\frac{m_1}{I_1} = \frac{m_2}{I_2}$$

$$\frac{LR}{2\pi} \quad \frac{I}{\frac{MR^2}{2}} = \frac{\frac{L}{4} Ia}{\frac{Ma^2}{12}} \Rightarrow a = \frac{3\pi}{4} R.$$