

Chapter 5 · Magnetism and Matter

CBSE Class 12 Physics (042) · Unit III · Unit III + IV = 17 marks · Ultimate Revision Sheet

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS

This chapter has been cut hard. **Qualitative treatment only** for: bar magnet as an equivalent solenoid, the field of a magnetic dipole along its axis and perpendicular to it, and the torque on a bar magnet in a uniform field.

What remains examinable in full: magnetic field lines, and the **magnetic properties of materials** — dia-, para- and ferromagnetism, magnetisation, and the effect of temperature. Spend your time there.

60-SECOND RECALL

Bar magnet $\approx$ solenoid	Both have a dipole field; $\mathbf{m} = \mathbf{NIA}$ (qualitative)
Dipole field	Axial $\mu_0 2\mathbf{m}/4\pi r^3$ · Equatorial $\mu_0 \mathbf{m}/4\pi r^3$ (qualitative)
Torque / PE	$\tau = mB \sin\theta$ · $U = -mB \cos\theta$
Magnetisation	$\mathbf{M} = \mathbf{m}_{\text{net}}/V$ · $\chi = M/H$ · $\mu_r = 1 + \chi$
Diamagnetic	χ small negative · repelled · water, bismuth, copper
Paramagnetic	χ small positive · weakly attracted · aluminium, oxygen
Ferromagnetic	χ large positive · strongly attracted · iron, cobalt, nickel
Curie law	$\chi \propto 1/T$ · above Curie temperature ferro $\rightarrow$ para

1. Bar Magnet and Magnetic Field Lines

FIELD LINES — the properties asked

1. They form **continuous closed loops** — outside the magnet $N \rightarrow S$, inside the magnet $S \rightarrow N$.
2. They **never intersect**.
3. Their density indicates field strength.
4. The tangent at any point gives the field direction.

WHY MAGNETIC MONOPOLES DO NOT EXIST

Because the lines are **closed loops**, the net flux through any closed surface is **zero**: $\oint \mathbf{B} \cdot d\mathbf{A} = 0$. Cutting a bar magnet in half simply produces **two shorter magnets**, each with its own N and S pole.

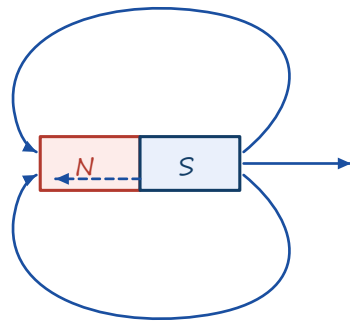
QUALITATIVE RESULTS — know the form, not the derivation

Bar magnet as a solenoid: a solenoid of N turns carrying current I behaves like a bar magnet of moment $\mathbf{m} = \mathbf{NIA}$.

Axial field: $B = \mu_0 2m / 4\pi r^3$ · **Equatorial field:** $B = \mu_0 m / 4\pi r^3$ — axial is twice equatorial, exactly as for an electric dipole.

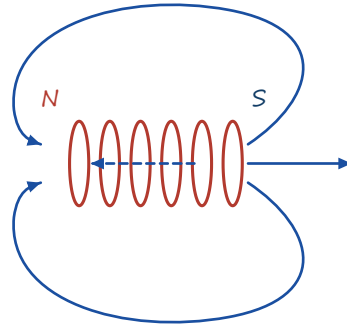
Torque: $\tau = \mathbf{m} \times \mathbf{B}$ · **Potential energy:** $U = -\mathbf{m} \cdot \mathbf{B} = -mB \cos\theta$.

(a) bar magnet



outside $N \rightarrow S$, inside $S \rightarrow N$ (dashed)
so the lines form CLOSED loops

(b) the same field, from a solenoid



identical pattern — this is WHY a magnet
behaves as a dipole, $m = NIA$

A bar magnet is equivalent to a solenoid. Because the lines close on themselves, Φ_B through any closed surface is zero — there is no magnetic monopole.

2. Magnetisation and the Three Quantities

FORMULAS

Magnetisation M = net magnetic moment / volume unit $A\ m^{-1}$

Magnetic susceptibility $\chi = M / H$ a pure number

Relative permeability $\mu_r = 1 + \chi$ · $\mu = \mu_0 \mu_r$

$B = \mu_0(H + M)$

3. The Three Magnetic Materials

THE COMPARISON TABLE — this is the 3-marker

Property	DIAMAGNETIC	PARAMAGNETIC	FERROMAGNETIC
Susceptibility χ	Small and NEGATIVE ($-1 \leq \chi < 0$)	Small and positive	Large and positive (thousands)
μ_r	Slightly less than 1	Slightly more than 1	Very much greater than 1
In a non-uniform field	Moves to the weaker field	Moves to the stronger field	Strongly to the stronger field
Atomic moment	Zero without a field	Permanent, but randomly oriented	Permanent, aligned in domains
Effect of heating	No effect	χ falls as $1/T$ (Curie law)	Becomes paramagnetic above the Curie temperature
Examples	Bismuth, copper, water, gold, all superconductors	Aluminium, oxygen, platinum, sodium	Iron, cobalt, nickel, gadolinium

TRAP Only the *diamagnetic* susceptibility is *negative*, and only diamagnetism is *unaffected by temperature*.

A *superconductor* is a *perfect diamagnet* ($\chi = -1$) — it expels the field completely. This is the Meissner effect and is a favourite one-marker.

Above its Curie temperature a ferromagnet does *not* become non-magnetic; it becomes *paramagnetic*.

4. Question Triggers what the wording is really asking

If the question says...	The answer is...
"repelled by a magnet" / "moves to the weaker field"	Diamagnetic
"susceptibility falls as temperature rises"	Paramagnetic , Curie law $\chi \propto 1/T$
"loses its magnetism above a certain temperature"	Ferromagnetic , above the Curie temperature
" μ_r slightly less than 1"	Diamagnetic
"field lines inside the magnet"	S to N — loops are closed
"a bar magnet is cut in half"	Two magnets , each with N and S; moment halves

MOST-ASKED BOARD QUESTIONS

1. [3M] Compare *dia-*, *para-* and *ferromagnetic* substances on susceptibility, behaviour in a non-uniform field, and effect of temperature.
2. [2M] Define *magnetisation* and *magnetic susceptibility*, and relate μ_r to χ .
3. [2M] Why do magnetic field lines form *closed loops*, unlike electric field lines?
4. [2M] State and explain *Curie's law*.
5. [1M] Why is a *superconductor* called a perfect diamagnet?
6. [1M] What happens to a ferromagnet above its Curie temperature? → *It becomes paramagnetic*

THE HABIT THAT SCORES — This is the lightest chapter in the unit, and almost every mark sits in one table. Learn the three materials row by row — sign of χ , direction of motion in a non-uniform field, effect of heat, one example each — and you have the chapter.