# Magnetism and Matter Class 12 Formula Sheet

CBSE Class 12 Physics · NCERT · for boards, NEET and JEE revision

ChapterNotes

## Bar Magnet as a Magnetic Dipole

$$m = m_{pole} \cdot 2l \text{ (unit: A·m}^2\text{)}$$

2l is the magnetic length (~0.84 of geometric length); moment points S → N.

- Pole strength m_pole has unit A·m; moment m has unit A·m$^2$
- No magnetic monopoles - cutting a magnet gives two smaller dipoles
- Equivalent to a solenoid: m = N I A; field lines are closed loops

## Field of a Magnetic Dipole

$$B_{axial} = (\mu_0/4\pi)\cdot 2m/r^3 \text{ , } B_{equator} = (\mu_0/4\pi)\cdot m/r^3$$

Valid for a short magnet (r ≫ size); $\mu_0/4\pi = 10^{-7}$ T·m/A.

- Axial field is twice the equatorial: B_axial = 2 B_equator
- Axial B is along m; equatorial B is opposite to m
- Both fall off as 1/r$^3$ - the dipole signature

## Torque on a Dipole

$$\tau = m\ B \sin\theta \text{ (vector: } \tau = m \times B)$$

Net force is zero in a uniform field - only torque acts.

- Maximum τ = mB at θ = 90°
- τ = 0 at θ = 0° (stable) and θ = 180° (unstable)
- A net translational force needs a non-uniform field

## Potential Energy of a Dipole

$$U = -m\ B \cos\theta \text{ (vector: } U = -m\cdot B)$$

Work to rotate $\theta_1 \to \theta_2$ is $W = mB(\cos\theta_1 - \cos\theta_2)$.

- Minimum U = −mB at θ = 0° (stable equilibrium)
- Maximum U = +mB at θ = 180° (unstable)
- U = 0 at θ = 90° (dipole perpendicular to field)

## Oscillations in a Field

$$T = 2\pi \sqrt{(I / m B)}$$

I is the moment of inertia; used to compare B or m experimentally.

- Period depends on inertia I, moment m and field B
- Stronger field or larger moment → faster oscillation
- Standard NEET method to find m or compare field strengths

## Earth's Magnetism

$$B_H = B_E \cos I \text{ , } B_V = B_E \sin I \text{ , } \tan I = B_V / B_H$$

Magnetic S-pole lies near geographic North; axis tilted ~11.3°.

- Three elements: Declination D, Dip/Inclination I, Horizontal component B_H
- Magnetic equator: I = 0° → field horizontal, B_V = 0
- Magnetic poles: I = 90° → field vertical, B_H = 0; B_E = √(B_H$^2$ + B_V$^2$)

## Magnetisation, H & Susceptibility

$$B = \mu_0(H + M) \text{ , } M = \chi\ H \text{ , } \mu_r = 1 + \chi$$

H and M share the unit A/m; χ and $\mu_r$ are dimensionless; $\mu = \mu_0\mu_r$.

- H = applied magnetising field, M = magnetisation (moment per volume)
- χ small negative → dia; small positive → para; large positive → ferro
- $\mu_r$ < 1 (dia), slightly > 1 (para), ≫ 1 (ferro)

## Dia, Para & Ferromagnetism

$$\text{Para: } \chi = C/T \text{ ; Ferro above } T_c\text{: } \chi = C/(T - T_c)$$

Memory hook: Dia = away, Para = pulled, Ferro = fiercely pulled.

- Diamagnetic (Bi, Cu, water): χ < 0, temp-independent; superconductor χ = −1
- Paramagnetic (Al, Na, $O_2$): χ small +, obeys Curie's law χ = C/T
- Ferromagnetic (Fe, Co, Ni): χ ≫ 0, domains & hysteresis; → paramagnetic above T_c

## Quick revision

- Bar magnet ≈ magnetic dipole; m = NIA; τ = mB sin θ; U = −mB cos θ
- Earth's field: Declination (δ), Dip (I), Horizontal component BH = B cos I
- Diamagnetic: χ < 0, repelled (Cu, Bi, $H_2O$); Paramagnetic: χ > 0, weak attraction (Al, $O_2$)
- Ferromagnetic: χ >> 0, strong attraction (Fe, Co, Ni); above Curie temp → paramagnetic
- Curie's law (paramagnetic): χ ∝ 1/T
- Hysteresis: retentivity (B at H=0), coercivity (H to make B=0)
- Soft iron: easy to magnetise/demagnetise (electromagnets); Steel: permanent magnets

Full chapter notes with solved examples and practice questions: https://chapternotes.in/cbse/class-12-physics/magnetism-and-matter-class-12-notes/