Magnetism & Matter — NEET Formula Sheet

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Class XII | NEET Physics | ★ = NEET Frequently Tested

Magnetic dipole moment:

$$M = m \times 2\ell \quad [\text{A m}^2 \text{ or J T}^{-1}]$$

m = pole strength (A m), 2ℓ = magnetic length

Axial field ($r \gg \ell$):

$$\boxed{B_{\text{axial}} = \frac{\mu_0}{4\pi} \cdot \frac{2M}{r^3}} \quad \text{(direction: along } \vec{M}\text{)}$$

Equatorial field ($r \gg \ell$):

$$\boxed{B_{\text{equat}} = \frac{\mu_0}{4\pi} \cdot \frac{M}{r^3}} \quad \text{(direction: opposite to } \vec{M}\text{)}$$

Important ratio:

$$B_{\text{axial}} = 2\, B_{\text{equat}} \quad \text{(at equal distances)}$$

General point (angle θ from axis):

$$B = \frac{\mu_0 M}{4\pi r^3}\sqrt{3\cos^2\theta + 1}$$

Torque:

$$\boxed{\tau = MB\sin\theta} \quad (\text{max when } \theta = 90°)$$

Potential energy:

$$\boxed{U = -MB\cos\theta}$$

- Stable equilibrium: $\theta = 0°$, $U_{\text{min}} = -MB$
- Unstable equilibrium: $\theta = 180°$, $U_{\text{max}} = +MB$

Work done to rotate $\theta_1 \to \theta_2$:

$$W = MB(\cos\theta_1 - \cos\theta_2)$$

Time period of vibration magnetometer:

$$\boxed{T = 2\pi\sqrt{\frac{I}{MB}}}$$

Comparing magnets (same I):

$$\frac{T_1}{T_2} = \sqrt{\frac{M_2}{M_1}} \quad \Rightarrow \quad \frac{M_1}{M_2} = \frac{T_2^2}{T_1^2}$$

Tan-A & Tan-B positions (deflection magnetometer):

$$\text{Tan-A: } M = \frac{4\pi}{\mu_0} \cdot \frac{d^3}{2} \cdot H\tan\theta$$

$$\text{Tan-B: } M = \frac{4\pi}{\mu_0} \cdot d^3 \cdot H\tan\theta$$

Magnetic moment:

$$\boxed{M = NIA}$$

Circular loop (radius r):

$$M = NI\pi r^2$$

Bohr Magneton (smallest unit of magnetic moment):

$$\mu_B = \frac{eh}{4\pi m_e} = 9.27 \times 10^{-24} \text{ J T}^{-1}$$

Gyromagnetic ratio:

$$\frac{M_l}{L} = \frac{e}{2m_e} \approx 8.8 \times 10^{10} \text{ C kg}^{-1}$$

Three elements (most NEET-tested topic):

Element	**Meaning**
Magnetic Declination (δ)	Angle between true north and magnetic north (horizontal plane)
Angle of Dip (ϕ)	Angle between $\vec{B}_E$ and horizontal (vertical plane)
Horizontal Component	$H = B_E\cos\phi$
Vertical Component	$V = B_E\sin\phi$

Key relations:

$$\boxed{B_E = \sqrt{H^2 + V^2}} \qquad \boxed{\tan\phi = \frac{V}{H}}$$

Special locations:

- Magnetic poles: $\phi = 90°$, $H = 0$, $B_E = V$
- Magnetic equator: $\phi = 0°$, $V = 0$, $B_E = H$

Apparent dip (plane rotated by α from magnetic meridian):

$$\boxed{\tan\phi' = \frac{\tan\phi}{\cos\alpha}}$$

Neutral points (bar magnet horizontal, N facing north):

- Neutral points: on **equatorial line**
- N facing south: neutral points on **axial line**

Magnetisation (intensity of magnetisation):

$$I = \frac{M_{\text{net}}}{V} \quad [\text{A m}^{-1}]$$

Magnetic susceptibility:

$$\boxed{\chi_m = \frac{I}{H}}$$

Relative permeability:

$$\boxed{\mu_r = 1 + \chi_m} \qquad \mu = \mu_0 \mu_r$$

Magnetic flux density:

$$B = \mu_0(H + I) = \mu_0 \mu_r H$$

	Dia	Para	Ferro
χ_m	Small −ve	Small +ve	Large +ve
μ_r	< 1	> 1 (slight)	$\gg 1$
In field	Repelled	Weakly attracted	Strongly attracted
Temp effect	None	Decreases	Drops at T_C
Examples	Cu, Bi, Water, NaCl	Al, Mn, O_2, $CuCl_2$	Fe, Ni, Co

Superconductors: Perfect diamagnets, $\chi_m = -1$, $\mu_r = 0$

Curie's Law (paramagnetics):

$$\boxed{\chi_m = \frac{C}{T}} \quad \Rightarrow \quad \chi_m \propto \frac{1}{T}$$

Curie-Weiss Law (ferromagnetics, $T > T_C$):

$$\boxed{\chi_m = \frac{C}{T - T_C}}$$

Curie temperature T_C: Above T_C, ferromagnetic → paramagnetic.

- Fe: ≈ 1043 K   Co: ≈ 1388 K   Ni: ≈ 631 K

Diamagnetics: Susceptibility nearly **independent of temperature**.

8. Hysteresis Loop

- **Retentivity**: B when $H = 0$ (residual magnetism)
- **Coercivity**: H needed to make $B = 0$ (demagnetising force)
- **Hysteresis loss** $\propto$ area enclosed by B-H loop

Property	Perm. Magnet	Soft Iron (Electromagnet)
Retentivity	High	High
Coercivity	High	Low
Area of loop	Large	Small
Material	Steel, Alnico	Soft Fe, Mumetal

Transformer core: Soft iron (low hysteresis loss). **Permanent magnet**: Steel/Alnico (high coercivity).

$$\boxed{\oint \vec{B} \cdot d\vec{A} = 0}$$

- No magnetic monopoles exist
- Magnetic field lines are always **closed loops**
- Both inside and outside a magnet: lines are closed

1. **Earth's magnetism** (dip, H, V, B_E) — asked almost every year
2. **Vibration magnetometer** $T = 2\pi\sqrt{I/MB}$ — comparing magnets, sum/difference positions
3. **Properties of dia/para/ferro** — assertion-reason type
4. **Neutral points** of bar magnet — conceptual
5. **Curie's law** $\chi \propto 1/T$ — graph-based question
6. **Hysteresis** — identify material from B-H graph
7. $B_{\textbf{axial}} = 2B_{\textbf{equat}}$ at equal distance
8. **Retentivity vs Coercivity** for permanent vs soft magnet
9. **Bohr magneton** value: 9.27×10^{-24} J T^{-1}
10. **Apparent dip formula**: $\tan\phi' = \tan\phi / \cos\alpha$

COMMON NEET CONFUSIONS

- **Dip vs Declination**: Dip is in the *vertical* plane; declination is in the *horizontal* plane. Very commonly confused.
- **Neutral points direction**: N-pole facing geographic north ⇒ neutral points on equatorial line (perpendicular bisector), *not* axial line.
- **Magnetic equator vs geographic equator**: These are *different*. At magnetic equator, dip = 0; do not confuse with geographic equator.
- **Diamagnetic** $\chi_m < 0$: NEET often asks whether susceptibility is zero or negative. It is **negative**, not zero.
- **Curie law applies to paramagnetics only**: Ferromagnetics follow Curie-Weiss law above T_C.

Below T_C they are ferromagnetic.

- **Soft iron vs steel**: Soft iron has *high retentivity* but *low coercivity* — ideal for electromagnets. Steel has high coercivity — ideal for permanent magnets.
- **Direction of equatorial field**: Equatorial $\vec{B}$ is *antiparallel* to $\vec{M}$. Many students draw it in the same direction as axial field.
- $T \propto 1/\sqrt{M}$ **not** $1/M$: In vibration magnetometer, $T \propto 1/\sqrt{M}$ — a common calculation error.
- **Apparent dip at** $\alpha = 90°$: $\cos 90° = 0 \Rightarrow \tan\phi' \to \infty \Rightarrow \phi' = 90°$. This is the "dip at a plane perpendicular to meridian" result.
- **Ferromagnetic domains**: Below T_C, ferromagnets have *domains* (regions of aligned dipoles). Above T_C, domains break down → paramagnetic behaviour.

$$\mu_0 = 4\pi \times 10^{-7}\ \text{T m A}^{-1} \qquad \frac{\mu_0}{4\pi} = 10^{-7}\ \text{T m A}^{-1}$$

$$\mu_B = 9.27 \times 10^{-24}\ \text{J T}^{-1} \qquad B_E \approx 3.6 \times 10^{-5}\ \text{T}$$

Dip at poles $= 90°$ Dip at equator $= 0°$

Prepared by: Let's Play With Physics • **letsplaywithphysics.in** • *Understand deeply, score confidently.*