CLASS 12 PHYSICS — FORMULA SHEET

Chapter 5 : Magnetism and Matter (NCERT)

5.1 Bar Magnet & Magnetic Dipole

Concept	Formula
Magnetic dipole moment	$m = m_p \times 2l$ (pole strength × magnetic length) ; unit $A \cdot m^2$
Field on axial line	$B = (\mu_0/4\pi) \times (2m \div r^3)$
Field on equatorial line	$B = (\mu_0/4\pi) \times (m \div r^3)$
Axial : equatorial ratio	$B_{axial} = 2 \times B_{equatorial}$
Torque on dipole	$\tau = m \times B = mB \sin\theta$
PE of dipole	$U = -m \cdot B = -mB \cos\theta$
Magnetic length	$2l = (5/6) \times$ geometric length (approx)

5.2 Magnetic Field Intensity & Oscillation

Concept	Formula
Work done rotating dipole	$W = mB(\cos\theta_1 - \cos\theta_2)$
Work (0° to θ)	$W = mB(1 - \cos\theta)$
Oscillation time period	$T = 2\pi \sqrt{(I \div mB)}$ (I = moment of inertia)
Frequency of oscillation	$f = (1/2\pi) \sqrt{(mB \div I)}$
Stable equilibrium	$\theta = 0°$ (m parallel to B, U minimum)
Unstable equilibrium	$\theta = 180°$ (m anti-parallel to B, U maximum)

5.3 Magnetisation & Magnetic Intensity

Quantity	Formula / Definition
Magnetisation (M)	$M = m_{net} \div V$ (net magnetic moment per unit volume) ; unit A/m
Magnetic intensity (H)	$H = B \div \mu_0 - M$; unit A/m
Relation B, H, M	$B = \mu_0(H + M)$
Magnetic susceptibility	$\chi = M \div H$ (dimensionless)
Relative permeability	$\mu_r = 1 + \chi$
Permeability	$\mu = \mu_0 \mu_r$; $B = \mu H$

5.4 Classification of Magnetic Materials

Property	Diamagnetic	Paramagnetic	Ferromagnetic
Susceptibility χ	Small, negative	Small, positive	Large, positive
Relative perm. μ_r	Slightly < 1	Slightly > 1	Much > 1
In external field	Weakly repelled	Weakly attracted	Strongly attracted

Property	Diamagnetic	Paramagnetic	Ferromagnetic
Examples	Bi, Cu, water	Al, Na, O_2	Fe, Co, Ni
Effect of temperature	No effect	$\chi \propto 1/T$ (Curie)	Loses above Curie T

5.5 Curie's Law & Hysteresis

Concept	Formula / Detail
Curie's law (paramagnetic)	$\chi = C \div T$ (C = Curie constant)
Curie temperature (T_c)	Above it, ferromagnetic → paramagnetic
Curie–Weiss law	$\chi = C \div (T - T_c)$ for $T > T_c$
Hysteresis	Lag of B behind H when H is varied cyclically
Retentivity	Residual magnetism when H = 0
Coercivity	Reverse H needed to make B = 0
Hysteresis loss	Energy lost per cycle = area of B–H loop
Soft vs hard material	Soft (small loop, electromagnet) ; Hard (large loop, permanent magnet)

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Bar magnet fields	Axial = $2km/r^3$; Equatorial = km/r^3. Axial is TWICE — same as electric dipole.
Torque & PE	$\tau = mB \sin\theta$; $U = -mB \cos\theta$. Stable at 0°, unstable at 180°.
Oscillation period	$T = 2\pi\sqrt{(I/mB)}$. Stronger field → faster oscillation.
B, H, M link	$B = \mu_0(H + M)$; $\chi = M/H$; $\mu_r = 1 + \chi$.
Three materials	Dia: χ small −ve ; Para: χ small +ve ; Ferro: χ large +ve.
Curie's law	Paramagnetic $\chi \propto 1/T$. Heating reduces magnetisation.
Soft vs hard	Soft iron → electromagnets ; Steel/Alnico → permanent magnets.
Hysteresis loss	= area of the B–H loop. Soft material → thin loop → low loss.