CLASS 12 PHYSICS — FORMULA SHEET

Chapter 4 : Moving Charges and Magnetism (NCERT)

4.1 Force on a Moving Charge

Concept	Formula
Lorentz force	F = q(E + v × B) (electric + magnetic)
Magnetic force only	F = q(v × B) ; |F| = qvB sin θ
Direction	Fleming's left-hand rule (or v × B for positive charge)
Force is zero when	v parallel to B (θ = 0° or 180°)
Force maximum when	v perpendicular to B (θ = 90°): F = qvB
Work done by magnetic force	Zero (force always ⊥ to velocity)

4.2 Circular & Helical Motion of Charge

Concept	Formula
Radius of circular path	r = mv ÷ (qB)
Time period	T = 2πm ÷ (qB) (independent of speed & radius)
Frequency (cyclotron)	f = qB ÷ (2πm)
Angular frequency	ω = qB ÷ m
Helical path	When v has components both parallel & perpendicular to B
Pitch of helix	$p = v_{parallel} \times T = (2\pi m\, v \cos\theta) \div (qB)$

4.3 Cyclotron

Concept	Formula
Cyclotron frequency	f = qB ÷ (2πm)
Maximum velocity	$v_{max} = qBR \div m$ (R = radius of dees)
Maximum kinetic energy	$KE_{max} = (q^2B^2R^2) \div (2m)$
Principle	Accelerates ions using high-frequency AC + magnetic field
Limitation	Cannot accelerate electrons (relativistic) or neutral particles

4.4 Biot–Savart Law & Magnetic Fields

Source	Magnetic Field Formula
Biot–Savart law	$dB = (\mu_0/4\pi) \times (I\, dl \times \hat{r}) \div r^2$
μ_0 value	$\mu_0 = 4\pi \times 10^{-7}$ T·m/A
Straight infinite wire	$B = \mu_0 I \div (2\pi r)$
Centre of circular loop	$B = \mu_0 I \div (2R)$
Axis of circular loop	$B = (\mu_0 I R^2) \div [2(R^2 + x^2)^{3/2}]$

Source	Magnetic Field Formula
N-turn coil (centre)	$B = \mu_0 NI \div (2R)$

4.5 Ampere's Circuital Law & Solenoid/Toroid

Concept	Formula
Ampere's law	$\oint B \cdot dl = \mu_0 I_{enclosed}$
Solenoid (inside)	$B = \mu_0 n I$ (n = turns per unit length)
Solenoid (at end)	$B = \mu_0 n I \div 2$
Toroid (inside)	$B = \mu_0 N I \div (2\pi r)$
Outside solenoid/toroid	B = 0 (ideal case)

4.6 Force on Current & Between Wires

Concept	Formula
Force on current-carrying wire	$F = I(L \times B)$; $\lvert F \rvert = BIL \sin\theta$
Force between parallel wires	$F/L = (\mu_0 I_1 I_2) \div (2\pi d)$
Nature of force	Same direction currents ATTRACT ; opposite REPEL
Definition of ampere	1 A: wires 1 m apart with force 2×10^{-7} N/m

4.7 Current Loop, Torque & Moving Coil Galvanometer

Concept	Formula
Magnetic moment of loop	$m = N I A$; unit $A \cdot m^2$
Torque on a loop	$\tau = m \times B = NIAB \sin\theta$
Maximum torque	$\tau_{max} = NIAB$ ($\theta = 90°$)
PE of magnetic dipole	$U = -m \cdot B = -mB \cos\theta$
Galvanometer current	$I = (k \div NAB)\,\theta$ (k = torsional constant)
Current sensitivity	$= \theta \div I = NAB \div k$
Voltage sensitivity	$= \theta \div V = NAB \div (kR)$
Ammeter (shunt)	Low resistance in PARALLEL ; $S = (I_g G)/(I - I_g)$
Voltmeter (series R)	High resistance in SERIES ; $R = (V/I_g) - G$

★ QUICK MEMORY AIDS & TRICKS

Lorentz force	$F = q(E + v \times B)$. Magnetic part does NO work (always ⊥ to v).
Radius & period	$r = mv/qB$; $T = 2\pi m/qB$. Period is INDEPENDENT of speed.
Straight wire	$B = \mu_0 I/2\pi r$ (falls as 1/r). Loop centre: $B = \mu_0 I/2R$.
Solenoid	$B = \mu_0 nI$ inside (uniform) ; half that at the open end.

Parallel wires	Same direction → attract ; opposite → repel. $F/L = \mu_0 I_1 I_2 / 2\pi d$.
Torque on loop	$\tau = NIAB \sin\theta$; magnetic moment $m = NIA$.
Ammeter vs voltmeter	Ammeter: low R shunt in parallel. Voltmeter: high R in series.
μ_0 value	$\mu_0 = 4\pi \times 10^{-7}$ T·m/A — memorise it.