

Chapter 4 · Moving Charges and Magnetism

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

SCOPE ALERT — OFFICIAL 2026-27 SYLLABUS Biot–Savart law is applied to a *circular loop* only.

Ampere's law is applied to an *infinitely long straight wire*; the *straight solenoid* is *qualitative treatment only*. Do not memorise a solenoid derivation.

60-SECOND RECALL

Biot–Savart	$dB = (\mu_0/4\pi) I dl \sin\theta / r^2 \cdot \mu_0 = 4\pi \times 10^{-7} \text{ T m A}^{-1}$
Circular loop (centre)	$B = \mu_0 NI / 2R$ · on axis $\mu_0 NI R^2 / 2(R^2 + x^2)^{3/2}$
Long straight wire	$B = \mu_0 I / 2\pi r$
Solenoid	$B = \mu_0 nI$ (qualitative only)
Force on charge	$F = qvB \sin\theta \cdot F = q(\mathbf{v} \times \mathbf{B})$
Force on wire	$F = BIL \sin\theta$
Two parallel wires	$F/L = \mu_0 I_1 I_2 / 2\pi d$ — same direction attract
Torque on loop	$\tau = NIAB \sin\theta = mB \sin\theta, m = NIA$

1. Biot–Savart Law

WRITE THIS VERBATIM The magnetic field due to a small current element is *directly proportional to the current, the length of the element and $\sin\theta$, and inversely proportional to the square of the distance from it.*

FORMULAS

$$dB = (\mu_0/4\pi) \cdot I dl \sin\theta / r^2 \quad \mu_0/4\pi = 10^{-7} \text{ T m A}^{-1}$$

$$\text{Centre of a circular loop: } B = \mu_0 NI / 2R$$

$$\text{On the axis: } B = \mu_0 NI R^2 / 2(R^2 + x^2)^{3/2}$$

BIOT–SAVART vs COULOMB — a favourite comparison Both fall as $1/r^2$ and both obey superposition. But the electric field is along the line joining, while the magnetic field is *perpendicular to both dl and r* (a cross product), and there is **no magnetic monopole** — a current element cannot exist in isolation.

2. Ampere's Circuital Law

STATEMENT AND THE ONE DERIVATION ASKED

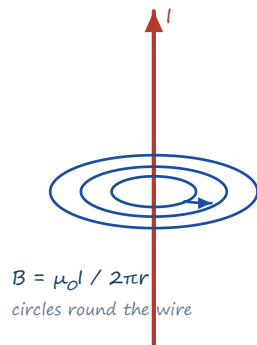
$$\oint \mathbf{B} \cdot d\mathbf{l} = \mu_0 I_{\text{enclosed}}$$

Infinitely long straight wire: choose a circular loop of radius r around the wire; B is constant and along it, so $B(2\pi r) = \mu_0 I$ giving

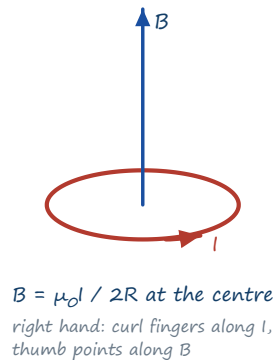
$$B = \mu_0 I / 2\pi r$$

Solenoid (qualitative): the field inside is **uniform and parallel to the axis**, $B = \mu_0 n I$, and is nearly zero outside.

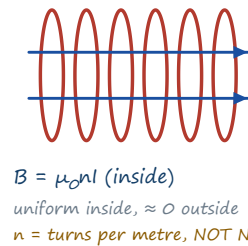
(a) straight wire



(b) circular loop



(c) solenoid



Three standard Biot-Savart / Ampère results. The syllabus wants the **solenoid qualitatively only**, so learn the field shape and the formula — not the derivation.

3. Force on a Moving Charge

FORMULAS

$$\mathbf{F} = q(\mathbf{v} \times \mathbf{B}) \rightarrow F = qvB \sin\theta$$

$$\text{Lorentz force: } \mathbf{F} = q(\mathbf{E} + \mathbf{v} \times \mathbf{B})$$

$$\text{Circular path: } r = mv/qB \cdot T = 2\pi m/qB \text{ (independent of speed)}$$

THE THREE FACTS ABOUT THE MAGNETIC FORCE 1. It is **zero** when the charge is at rest, or when v is **parallel** to B .

2. It is always **perpendicular** to v , so it does **NO work** and the **speed never changes** — only the **direction** does.

3. Velocity selector: when $qE = qvB$, the particle goes straight through $\rightarrow v = E/B$.

4. Force Between Currents — the definition of the ampere

FORMULA AND DEFINITION

$$F/L = \mu_0 I_1 I_2 / 2\pi d$$

Currents in the same direction **ATTRACT**; opposite directions **REPEL**. (The opposite of charges — worth saying aloud.)

One ampere is that current which, flowing in each of two infinitely long parallel conductors **1 m** apart in vacuum, produces a force of 2×10^{-7} N per metre between them.

5. Current Loop and the Moving Coil Galvanometer

TORQUE ON A LOOP

$$\tau = NIAB \sin\theta \cdot \text{magnetic moment } m = NIA \rightarrow \tau = m \times B$$

The **net force is zero** in a uniform field; only a torque acts. A current loop therefore behaves as a **magnetic dipole**.

GALVANOMETER — the parts that carry marks

At equilibrium the magnetic torque balances the restoring torque of the spring: $NIAB = k\phi$, so

$$\phi = (NAB/k) I \rightarrow \text{deflection is directly proportional to current}$$

Current sensitivity = $\phi/I = NAB/k$ · **Voltage sensitivity** = $\phi/V = NAB/kR$

A **radial magnetic field** (concave pole pieces + soft iron core) keeps the plane of the coil always parallel to B , so $\sin\theta = 1$ and the scale is **linear**.

CONVERSION — both formulas

To an AMMETER: shunt S in PARALLEL, $S = I_g G / (I - I_g)$ — small resistance

To a VOLTMETER: R in SERIES, $R = V/I_g - G$ — large resistance

An **ideal ammeter** has **zero** resistance and goes in **series**; an **ideal voltmeter** has **infinite** resistance and goes in **parallel**.

TRAP

Increasing N raises current sensitivity but **NOT** necessarily voltage sensitivity, because adding turns also increases the coil's resistance R . This exact reasoning is asked as a 2-marker.

WORKED EXAMPLE

A galvanometer of resistance $G = 60 \Omega$ gives full-scale deflection at $I_g = 1 \text{ mA}$. Convert it to an ammeter reading up to **1 A**.

$$S = I_g G / (I - I_g) = (0.001 \times 60) / (1 - 0.001) \\ = 0.06 / 0.999 = 0.06 \Omega \text{ approximately, connected in parallel.}$$

6. Question Triggers what the wording is really asking

If the question says...	Use
"field at the centre of a circular coil"	$\mu_0 NI/2R$
"field near a long straight wire"	$\mu_0 I/2\pi r$ (Ampere)
"charged particle enters perpendicular to B "	Circular path, $r = mv/qB$
"speed of the particle changes?"	No — magnetic force does no work
"two parallel wires carrying current"	$\mu_0 I_1 I_2 / 2\pi d$; same direction $\rightarrow$ attract
"why radial field in a galvanometer"	Keeps $\sin\theta = 1$ $\rightarrow$ linear scale
"convert galvanometer to ammeter"	Shunt in parallel, $S = I_g G / (I - I_g)$

MOST-ASKED BOARD QUESTIONS

1. [3M] State Biot–Savart law and derive the field at the *centre of a circular current loop*.
2. [3M] Using Ampere's law, find the field due to an *infinitely long straight wire*.
3. [3M] Derive the *torque* on a current loop in a uniform magnetic field, and define magnetic moment.
4. [3M] Describe a *moving coil galvanometer* and derive $\phi \propto I$. Why a radial field?
5. [2M] Derive the *force per unit length* between two parallel current-carrying wires and define the ampere.
6. [2M] Convert a galvanometer into an ammeter / voltmeter (numerical).
7. [1M] Does the magnetic force change a particle's kinetic energy? → **No**

THE HABIT THAT SCORES — Draw the direction before you calculate. Right-hand thumb rule for the field around a wire, $F = qv \times B$ for a charge — a correct magnitude with the wrong direction still loses the mark, and direction is the part that takes five seconds to check.