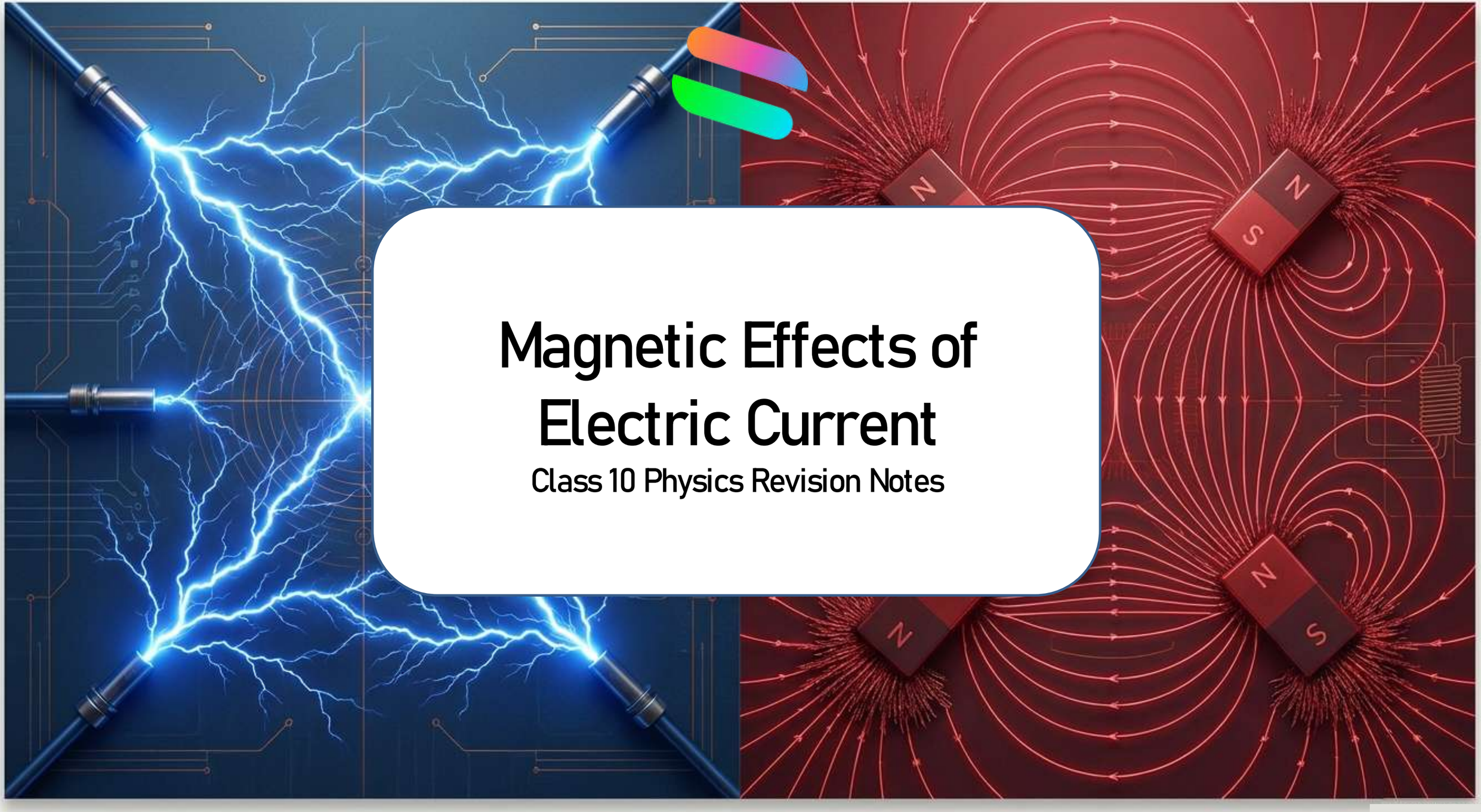


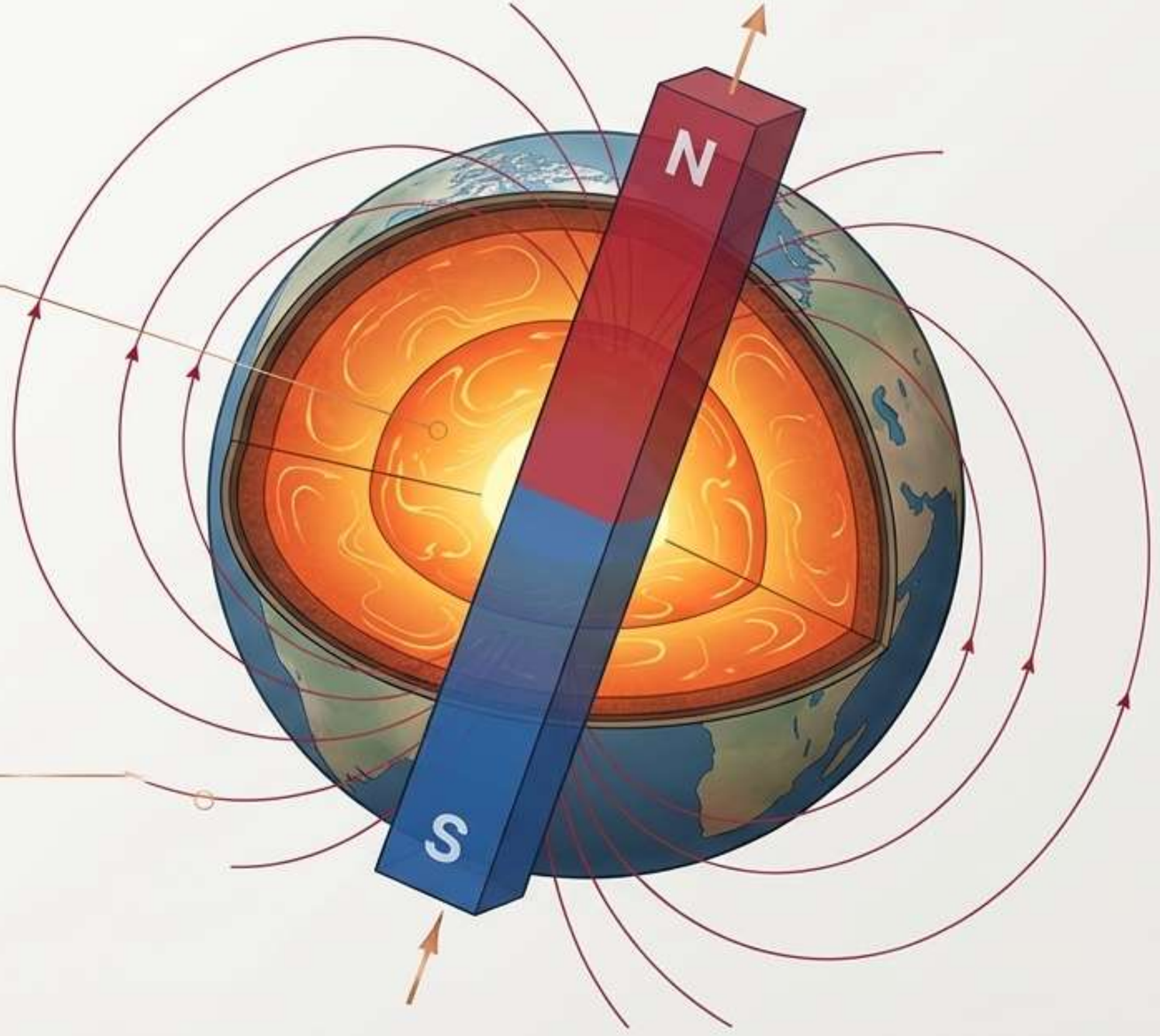
Magnetic Effects of Electric Current

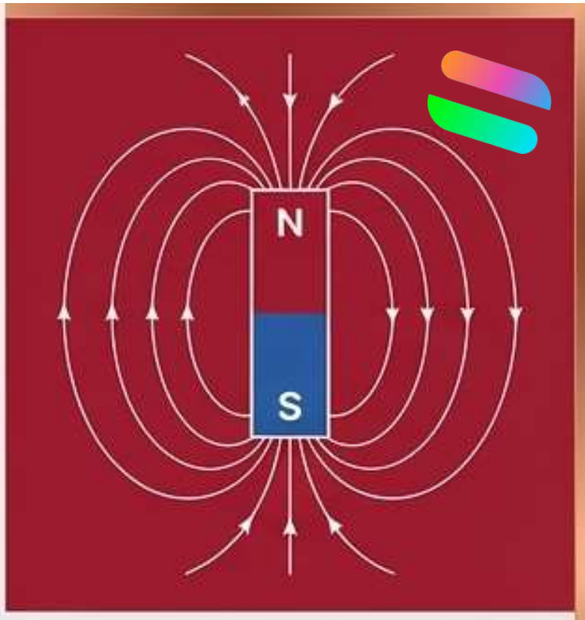
Class 10 Physics Revision Notes

Earth is a Giant Electromagnet

The Core: Molten, charged metallic fluid flows inside a core with a 3500 km radius.

The Effect: This flowing current acts as a giant solenoid, generating a magnetic field of about one gauss.



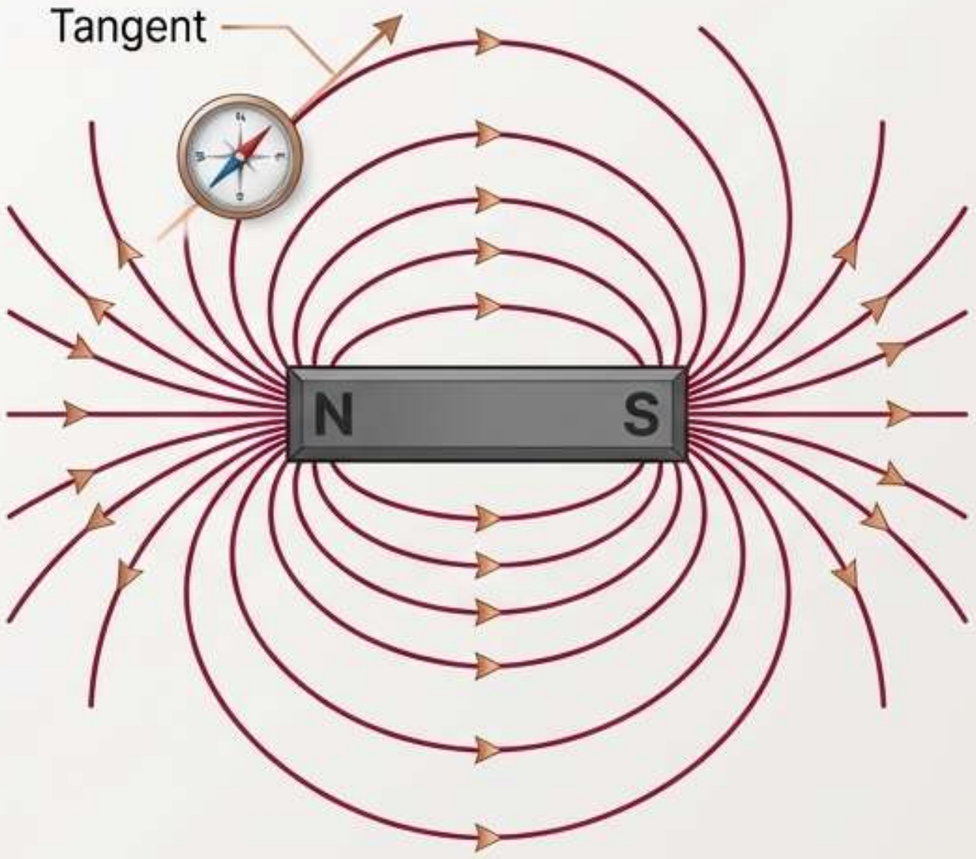


The Rules of Poles

- Centers of attraction are located near the ends (poles).
- Like poles repel. Unlike poles attract.
- A freely suspended magnet always points North-South.

Mapping the Invisible: Magnetic Field Lines

Direction: Lines travel North to South outside the magnet, and South to North inside.



Continuous: All field lines form closed curves.

No Intersections: Lines never cross. If they did, a compass at the intersection would point in two directions, which is impossible.

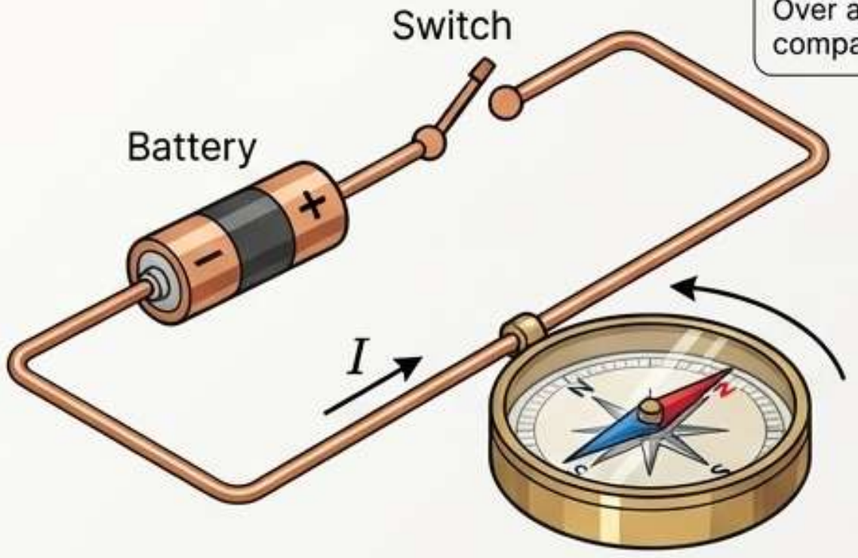
Strength: The closer the lines, the stronger the field. Intensity equals the number of lines passing normally per unit area.

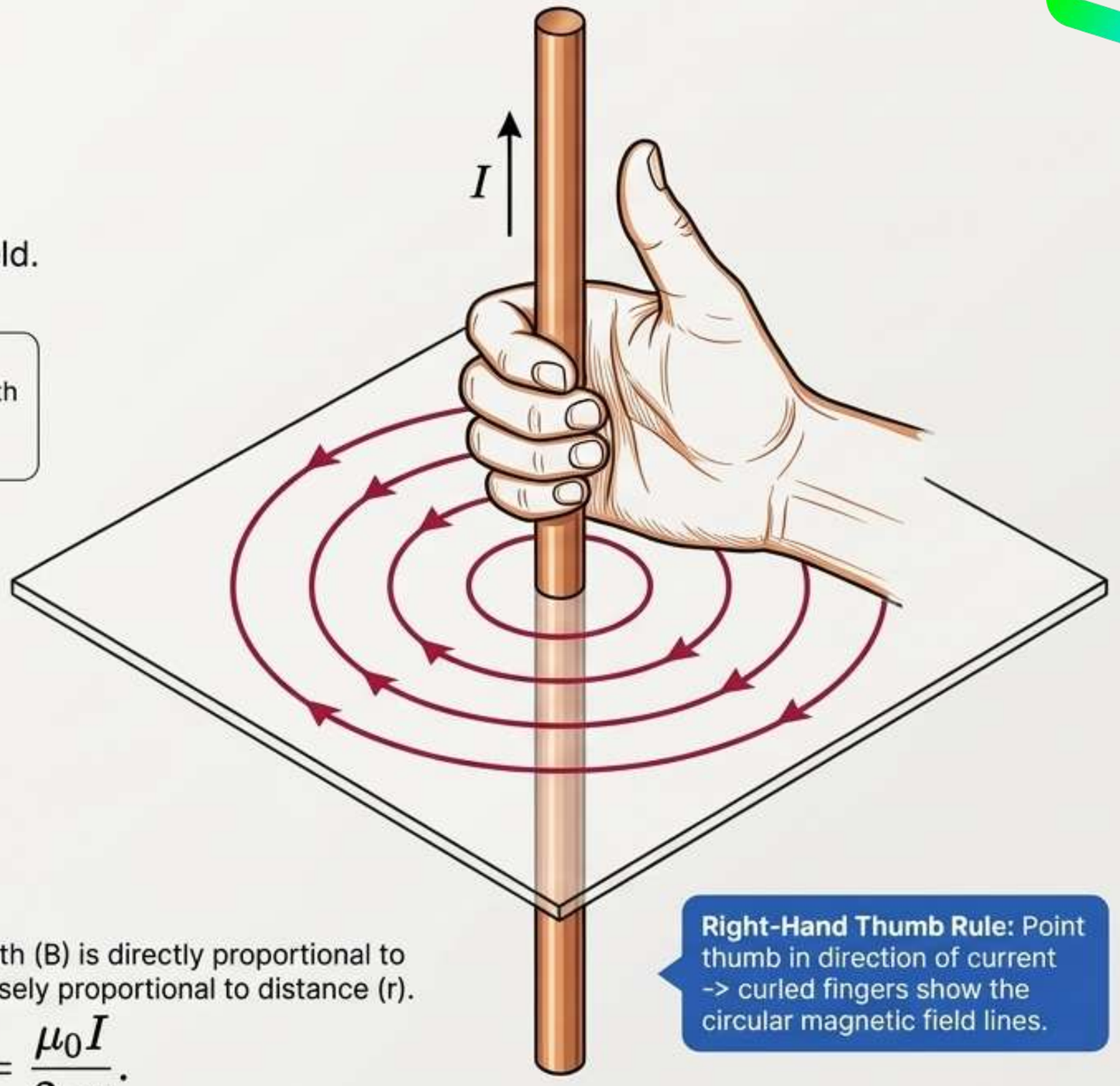
Oersted's Revelation: Wires Have Magnetic Fields

The Discovery (1820): Hans Christian Oersted noticed a compass needle deflect near a live wire.

Conclusion: A current-carrying wire produces a magnetic field.

The SNOW Rule:
Current from South to North
Over a wire deflects the
compass needle West.



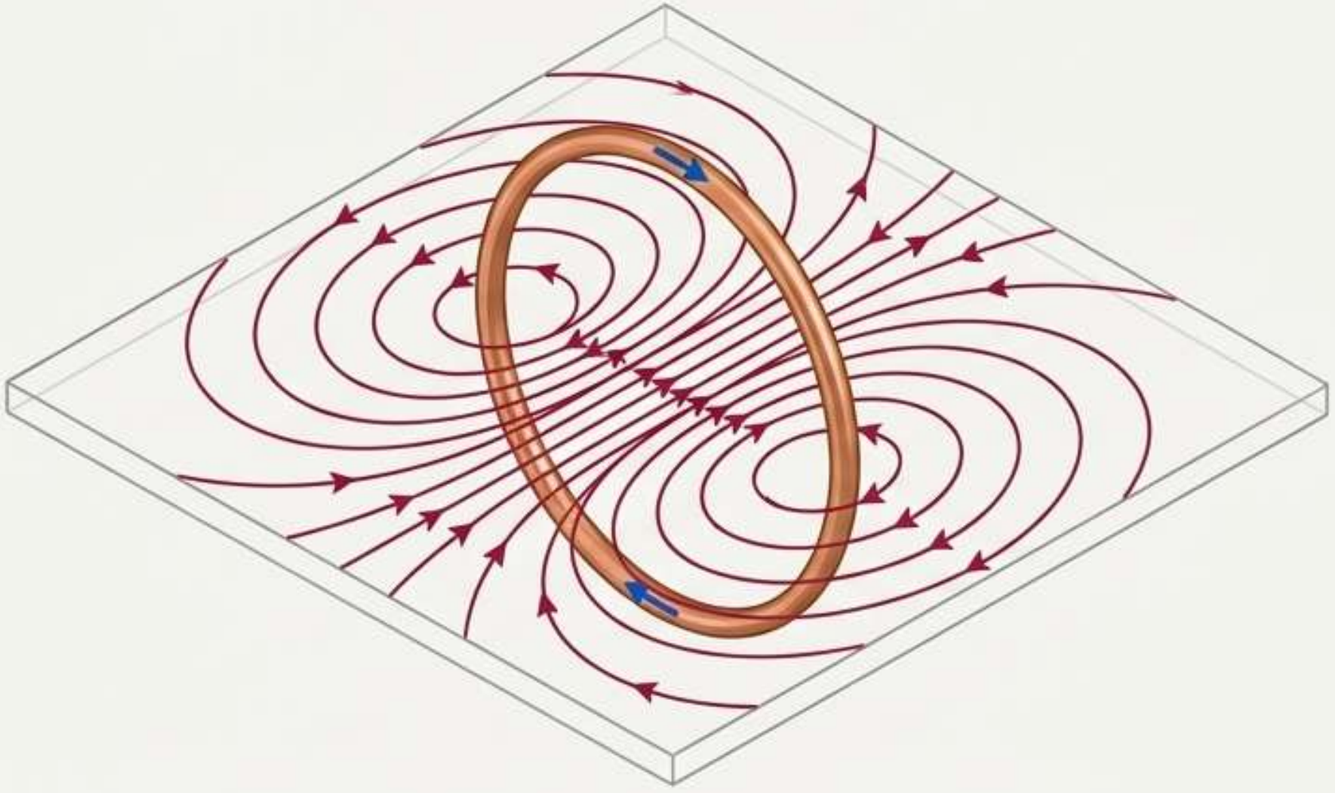


Right-Hand Thumb Rule: Point thumb in direction of current -> curled fingers show the circular magnetic field lines.

The Math: Strength (B) is directly proportional to current (I) and inversely proportional to distance (r).

Formula: $$B = \frac{\mu_0 I}{2\pi r}.$$

Shaping the Field: Bending the Wire



The Geometry Shift: When a wire is bent into a coil, the circular fields around the wire segments combine. At the dead center, the lines add together to become perfectly straight and parallel.

The Formula:

$$B = \frac{\mu_0 n I}{2r}$$

(where n = number of turns).

Visual Callout - Clock-Face Rule

Clockwise current = South Pole

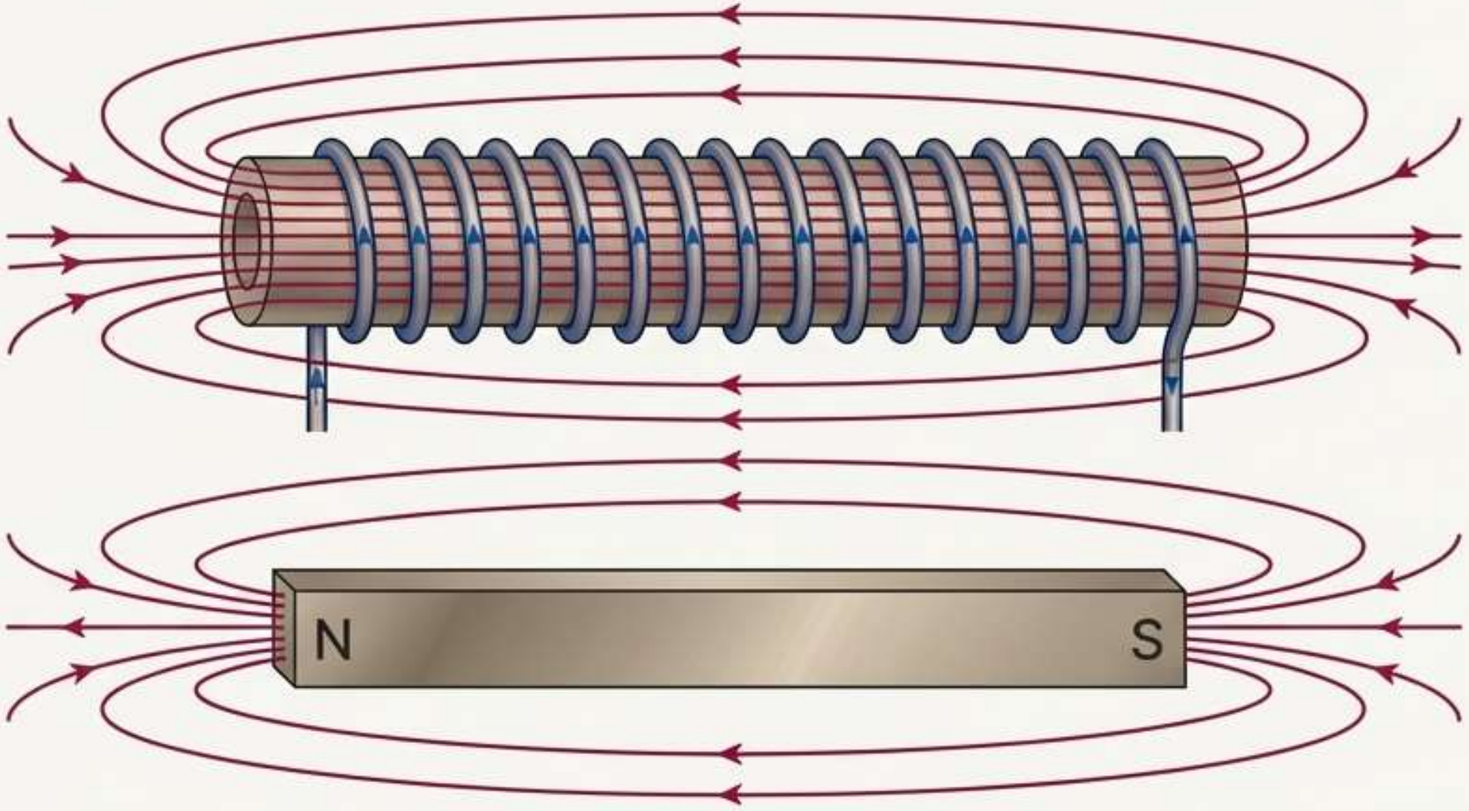
Anticlockwise current = North Pole

The Solenoid: Stacking the Coils

What is it?
A long cylindrical coil. It behaves exactly like a bar magnet, creating a uniform field inside.

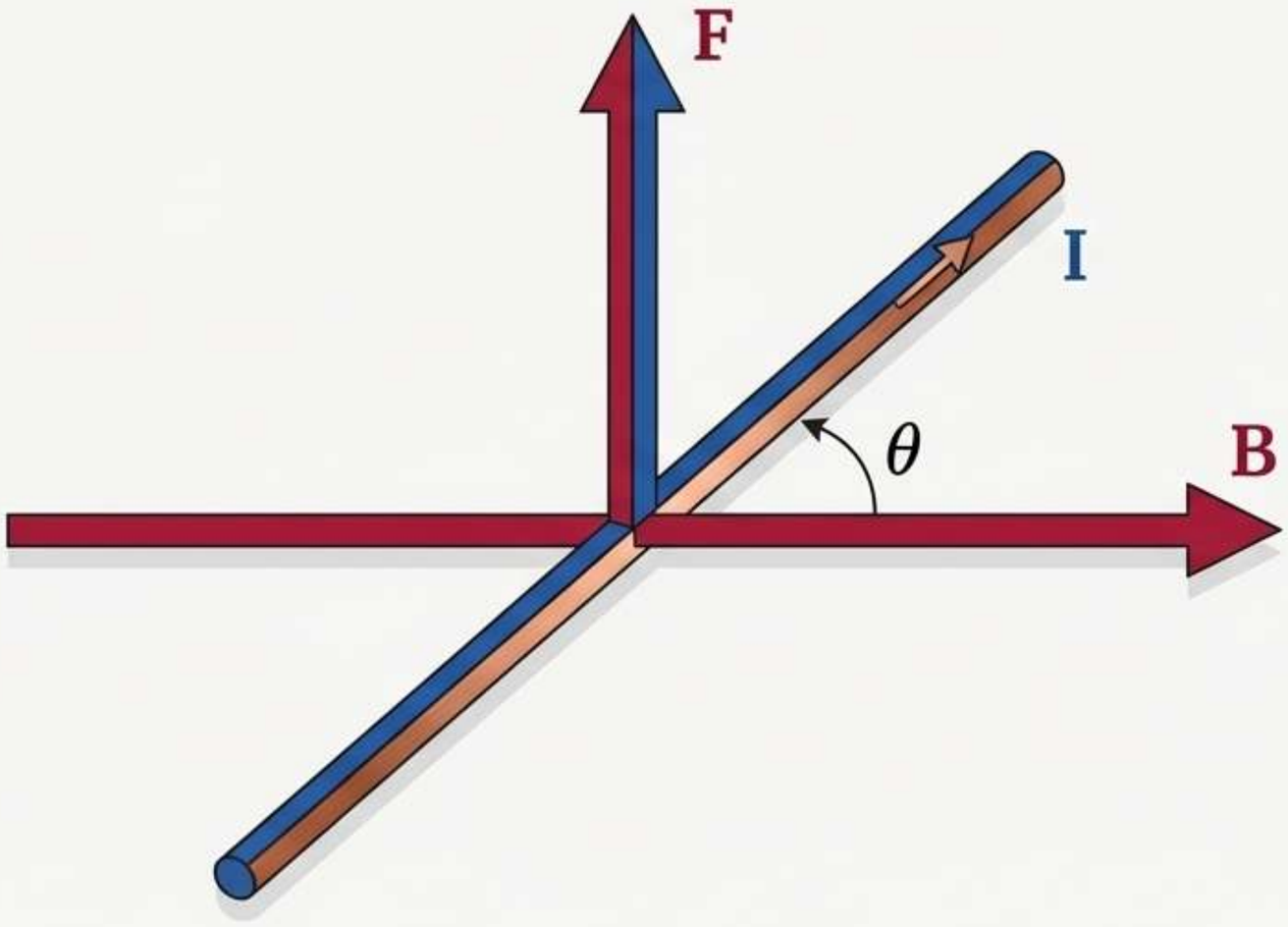
The Formula:
Field intensity depends on turns per unit length (n), current (I), and core permeability (\μ_r).

$$B = \mu_0 \mu_r n I.$$



	Electromagnet (Soft Iron Core)	Permanent Magnet (Hard Steel/Alnico)
1	Temporary (only works with current), variable strength, reversible polarity.	Cannot be easily demagnetized, fixed weak/moderate strength, fixed polarity.

When Fields Collide: Electromagnetic Force



The Interaction:

When a current-carrying conductor enters a magnetic field, the two fields interact, exerting a physical net force on the wire.

The Math:

$$F = I\ell B \sin\theta$$

The Extremes:

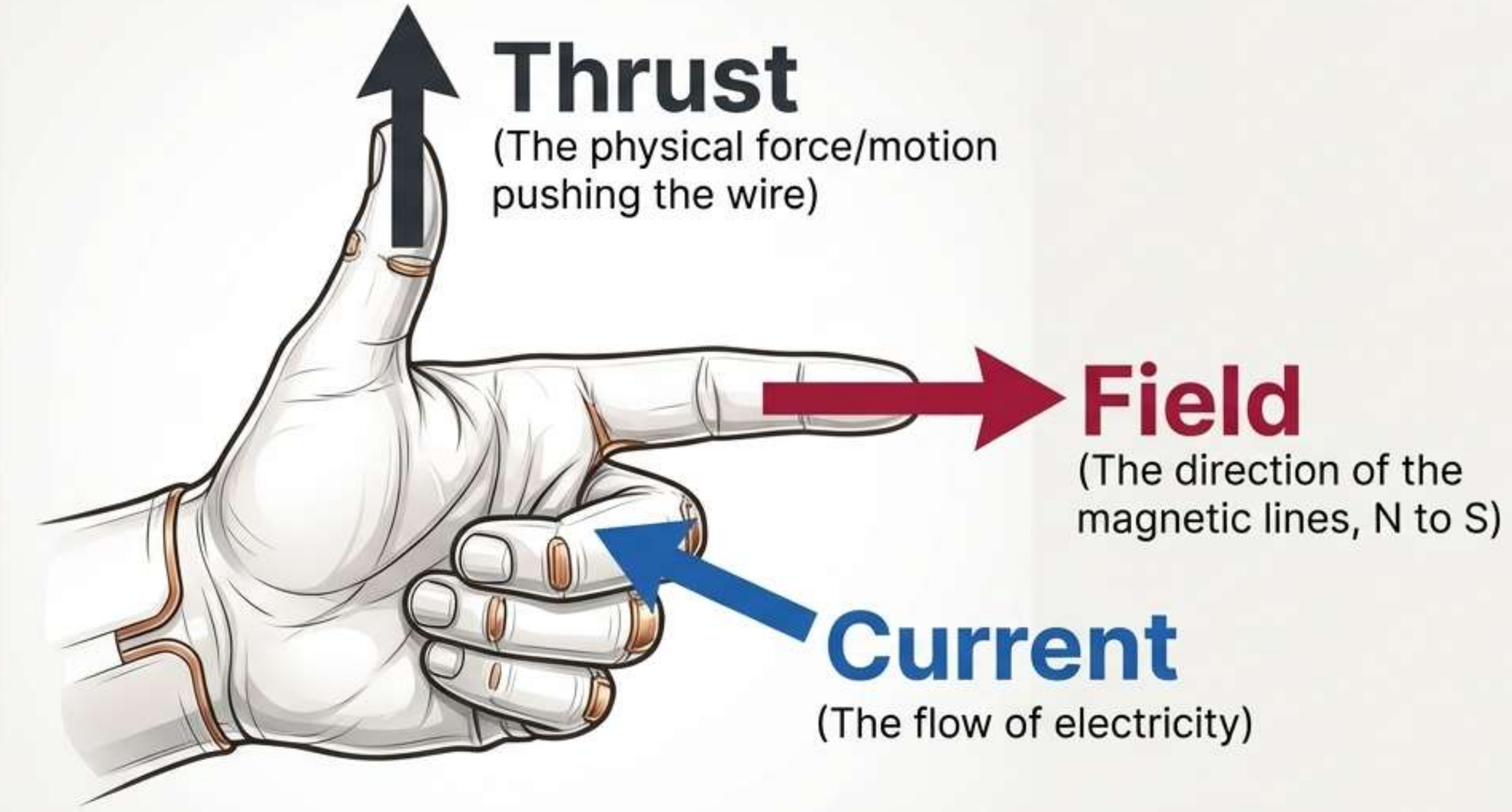
Maximum force occurs when the wire is exactly perpendicular to the field (θ = 90°). Zero force occurs if it runs parallel (θ = 0°).

Defining the Tesla

If I = 1 Amp and ℓ = 1 meter, then B = F.

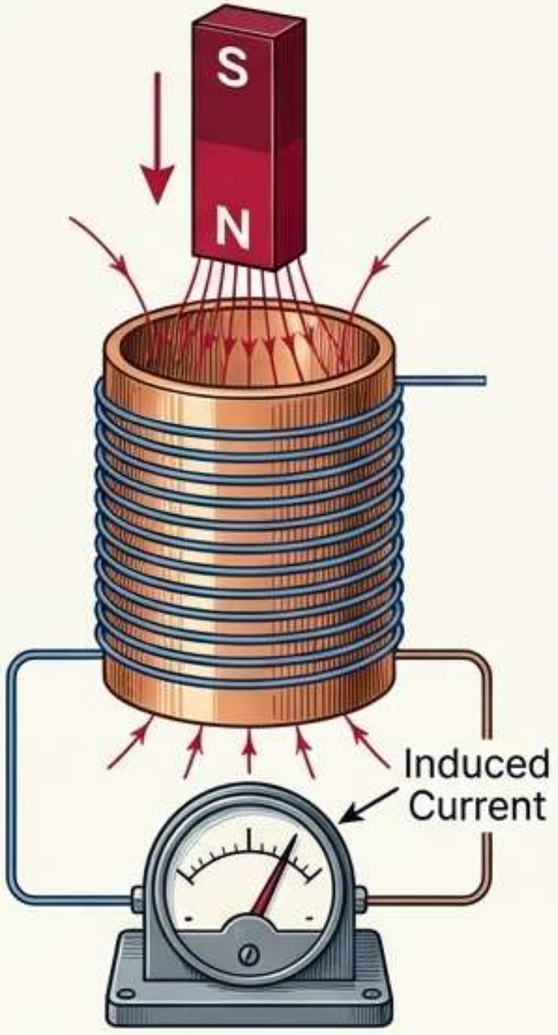
$$1\ \text{Tesla} = 1\ \text{N}\ \text{A}^{-1}\ \text{m}^{-1}$$

Fleming's Left-Hand Rule: The Motor Rule



Context: Used to determine the direction of force acting on a live conductor placed inside a magnetic field. This is the foundational physics behind all electric motors.

Faraday’s Flip: Magnetism Creates Electricity



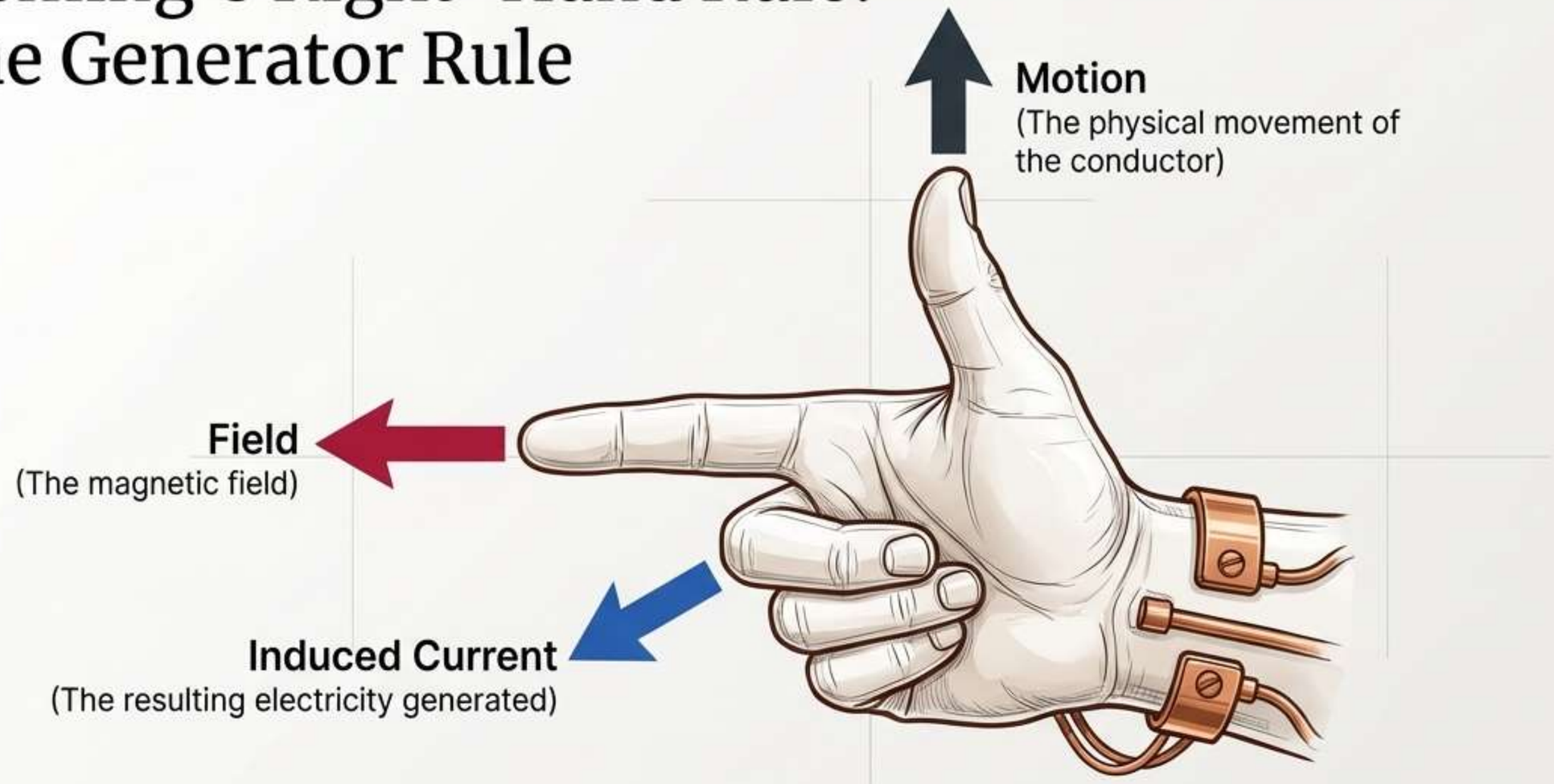
Electromagnetic Induction: Moving a magnet inside a closed coil changes the ‘magnetic flux’ (the number of field lines linking the wire).

The Result: This changing flux induces an electromotive force (e.m.f.), creating an induced current. Current only flows when the magnet is in motion.

Scaling the Power: To increase the induced current, you must increase:

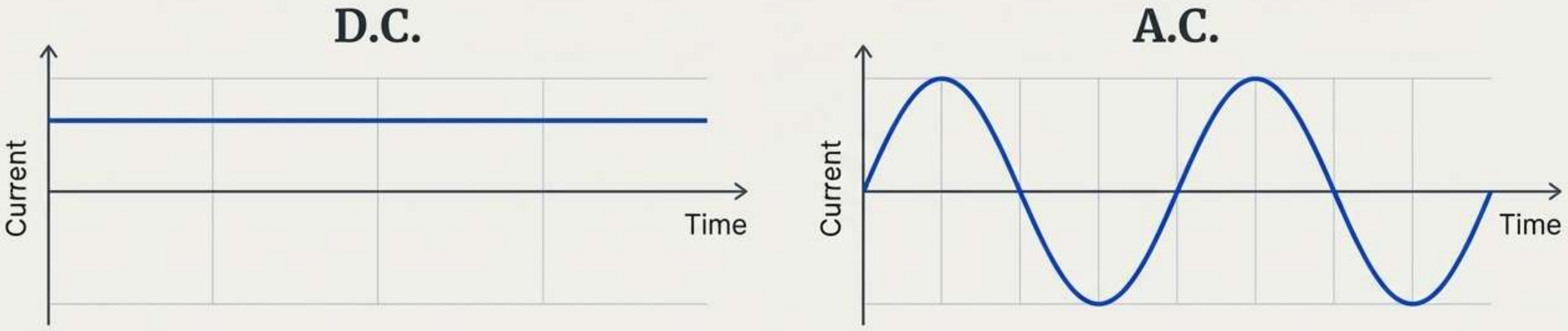
1) The number of turns in the coil,
2) The strength of the magnet, or
3) The speed of the motion.

Fleming's Right-Hand Rule: The Generator Rule



Context: Used to determine the direction of the newly created current when a wire is forced to move through a magnetic field. This is the foundational physics behind all power plant generators.

The Flow of Power: AC vs. DC



Direct Current (DC): Constant magnitude and direction. Sourced from batteries/cells.

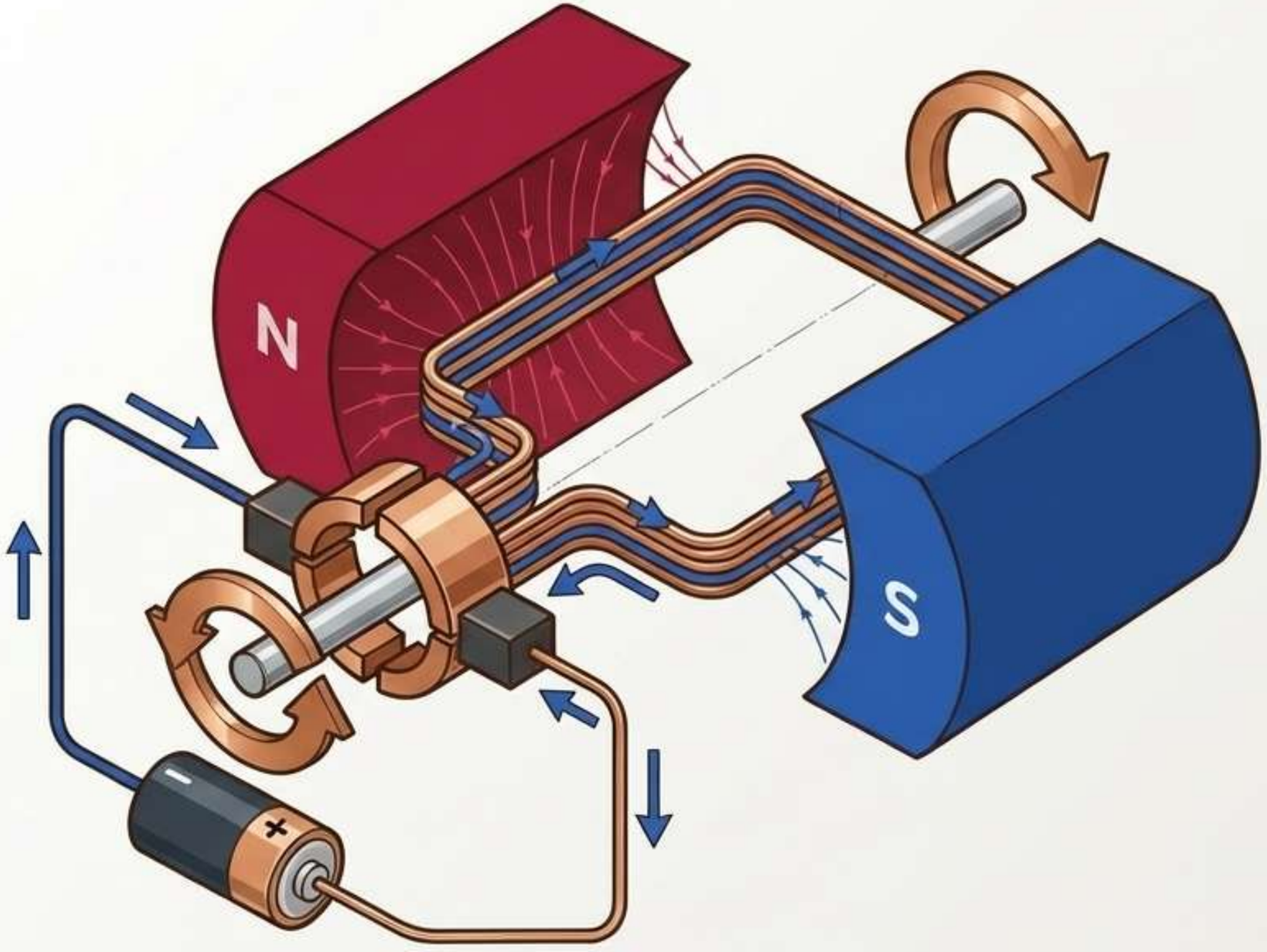
Alternating Current (AC): Reverses direction periodically.

The Standard: The household supply frequency in India is 50 Hz. It completes 50 cycles a second, meaning the current physically changes direction 100 times per second.

Why AC Wins the Grid

- Transmits over long distances with minimal energy loss.
- Cheaper to produce.
- Voltage can be easily stepped up/down using a Transformer.

The DC Motor: Electrical to Mechanical



The Physics

Current is pumped into the armature. Sitting in a magnetic field, the left and right sides of the coil experience opposing forces (Left-Hand Rule), forcing the shaft to spin.

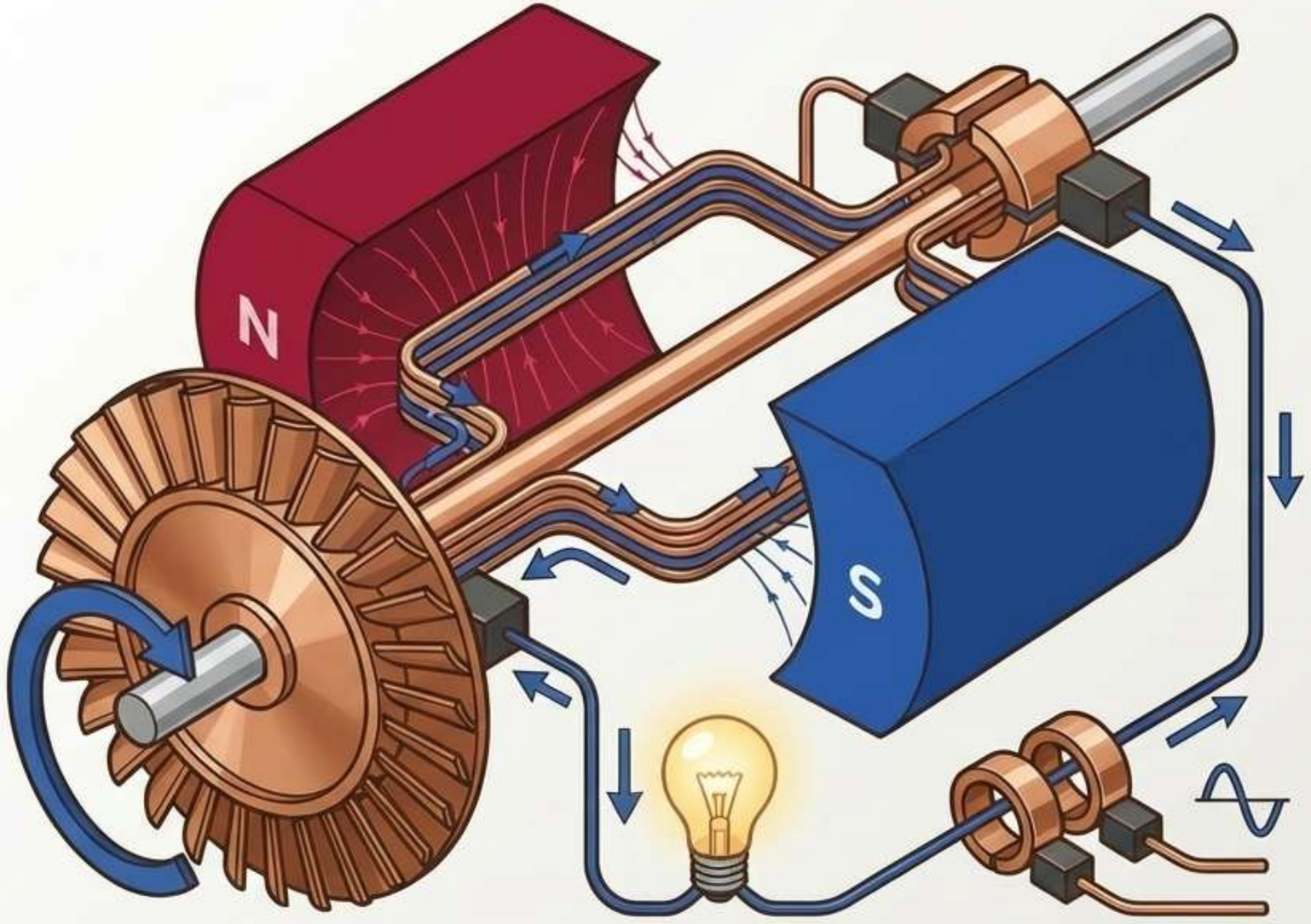
The Secret Mechanism

The Split-Ring Commutator.

Why it matters

Without it, the coil would just flip 180 degrees and get stuck. The commutator physically reverses the current direction inside the coil every half-rotation, ensuring the force always pushes in the same rotational direction.

The Generator: Mechanical to Electrical



The Physics

An outside force (steam, wind, diesel) physically rotates the armature inside a magnetic field. This changing flux induces a current in the wire (Right-Hand Rule).

DC vs. AC Generators:

- DC Generator (Dynamo): Uses a split-ring commutator (like the motor) to ensure the output current always flows in one direction to the external circuit.
- AC Generator (Alternator): Uses slip rings instead of a commutator. Because the coil flips, the resulting current naturally alternates back and forth.

The Symmetry of Electromagnetism: A Quick Reference

Row 1: The Push (Using Power)			
Input: Electricity –> **Output:** Motion	**Core Principle:** Magnetic Force on a Conductor ($F = I\ell B \sin\theta$)	**Hand Rule:** Fleming's Left-Hand Rule	**Machine:** Electric Motor
Row 2: The Pull (Creating Power)			
Input: Motion –> **Output:** Electricity	**Core Principle:** Electromagnetic Induction (Faraday)	**Hand Rule:** Fleming's Right-Hand Rule	**Machine:** Electric Generator

Electromagnetism is not two separate phenomena, but two sides of the exact same coin.