

3.12 CURRENT ELECTRICITY

Kirchhoff's Rules

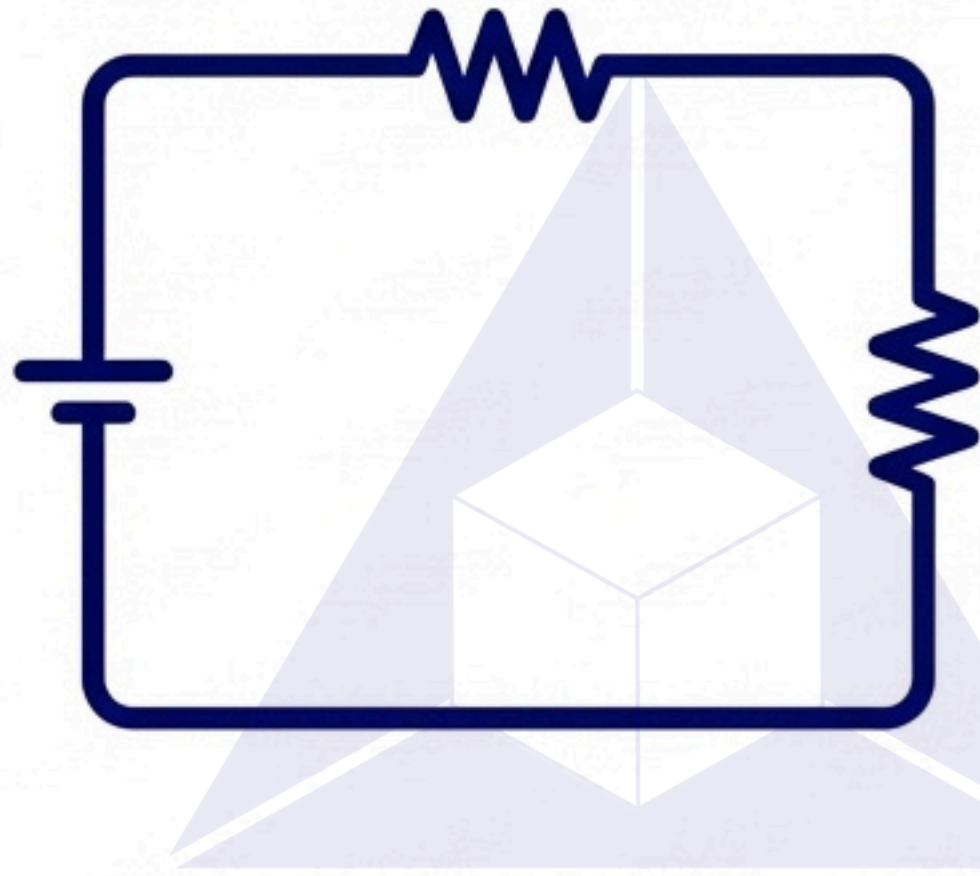
Mastering complex circuit analysis.

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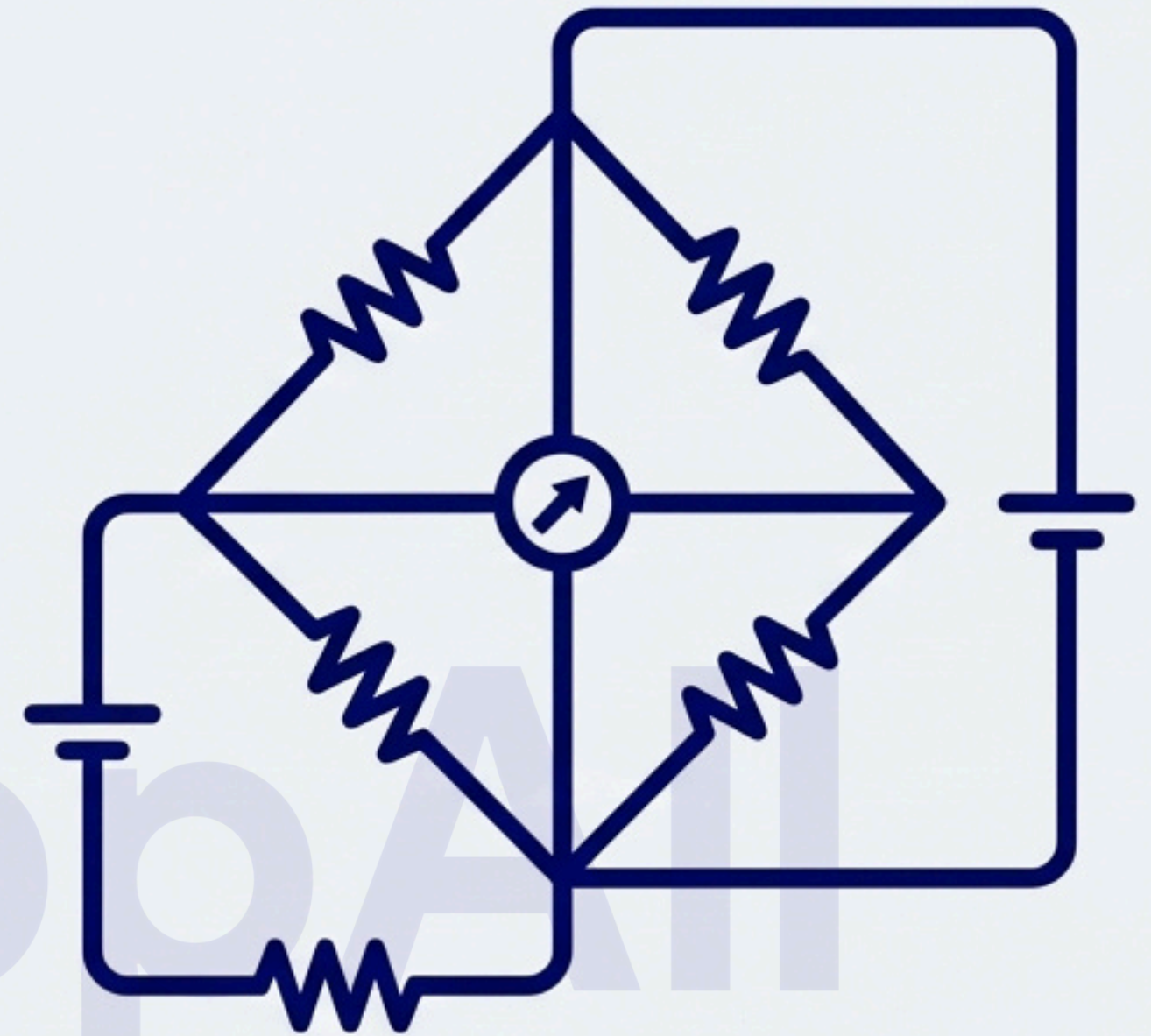
THE LIMITS OF OHM'S LAW

Why We Need These Rules



Basic Circuits

Solved by $V=IR$ & Series/Parallel rules.



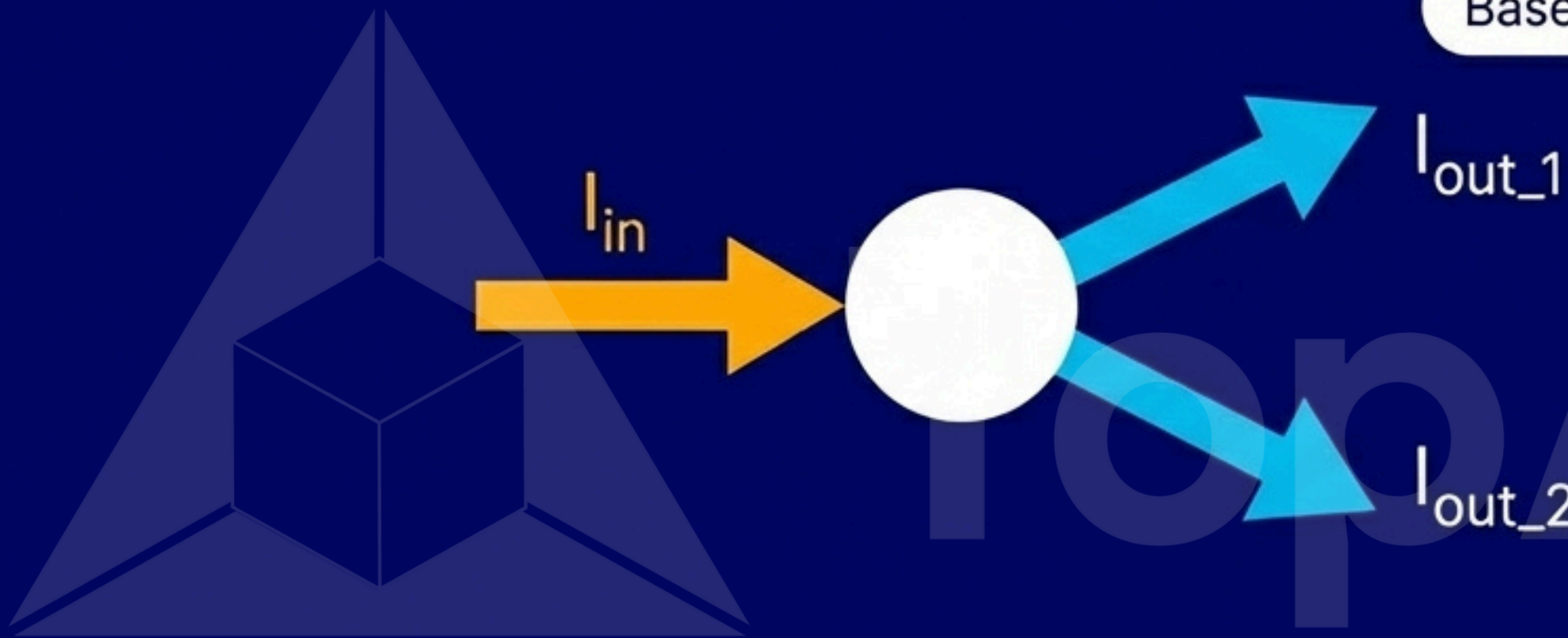
Complex Networks

Requires Kirchhoff's Rules.

When a circuit contains multiple power sources or interconnected branches, basic series and parallel reduction fails. Kirchhoff's Rules provide a universal, mathematical framework to solve any circuit network.

The Junction Rule (KCL)

Based on: Conservation of Charge

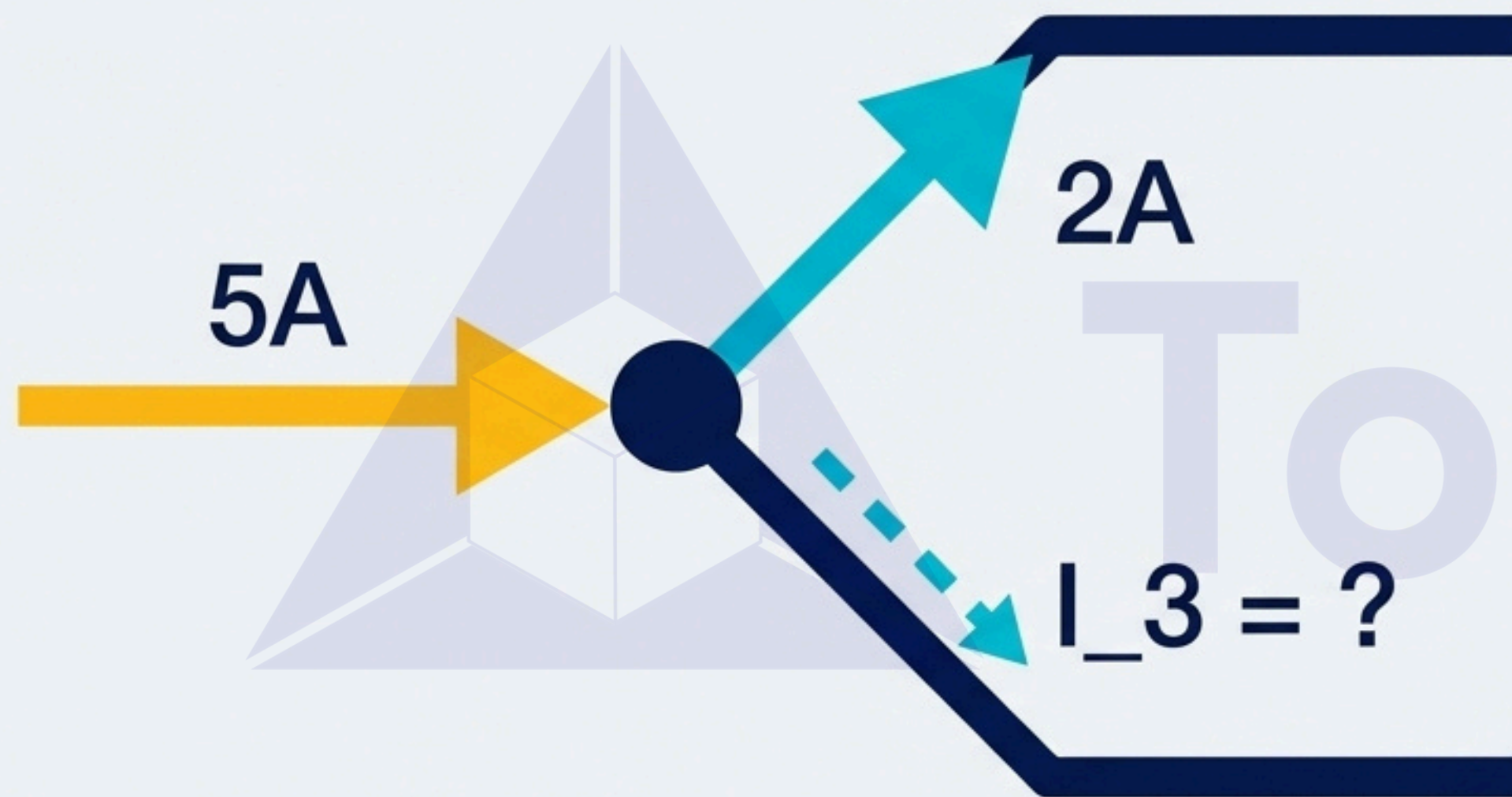


Definition: At any junction, the sum of currents entering is equal to the sum of currents leaving.

Formula: $\sum I = 0$

Core Logic: Steady currents mean there is no accumulation of charges at any junction or point in a line. What flows in must flow out.

Applying the Junction Rule



Step 1:	$\sum I_{\text{in}} = \sum I_{\text{out}}$
Step 2:	$5A = 2A + I_3$
Step 3:	$I_3 = 3A$

Mental Model: Think of water flowing through a branching pipe—current cannot pool at the intersection.

The Loop Rule (KVL)



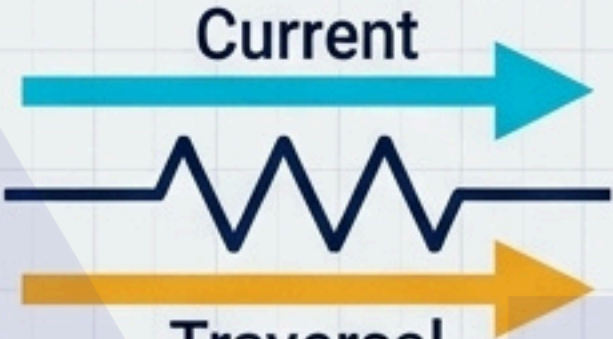
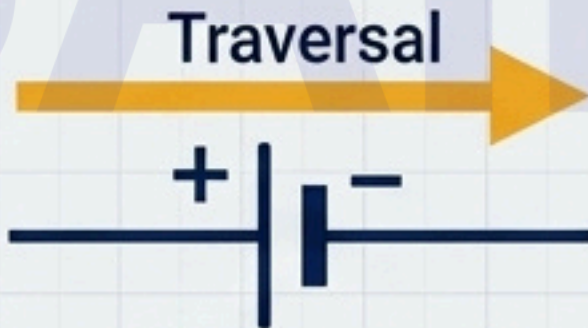
Based on: Conservation of Energy

Definition: The algebraic sum of changes in potential around any closed loop involving resistors and cells is zero.

Formula: $\sum \Delta V = 0$

Core Logic: Electric potential depends on location. If you traverse a closed loop and return to your starting point, the total change in potential must be exactly zero.

Sign Convention Matrix

	Traversal WITH Current / NEG to POS	Traversal AGAINST Current / POS to NEG
Component: Resistor	 Current Traversal $\Delta V = -IR$ (Potential Drop)	 Current Traversal $\Delta V = +IR$ (Potential Gain)
Component: Battery	 Traversal $\Delta V = +\varepsilon$ (Potential Gain)	 Traversal $\Delta V = -\varepsilon$ (Potential Drop)

Golden Rule: The sign is determined by comparing your chosen traversal direction against the current's direction or the battery's polarity.

Synthesis: Kirchhoff's Rules

	Junction Rule (KCL)	Loop Rule (KVL)
Physics Principle	Conservation of Charge	Conservation of Energy
Mathematical Formula	$\sum I = 0$	$\sum \Delta V = 0$
Primary Application	Finding missing currents at nodes	Finding voltage drops and currents in closed paths

Exam Strategy: Isolate nodes for current. Trace loops for voltage. Always strictly follow your sign convention.