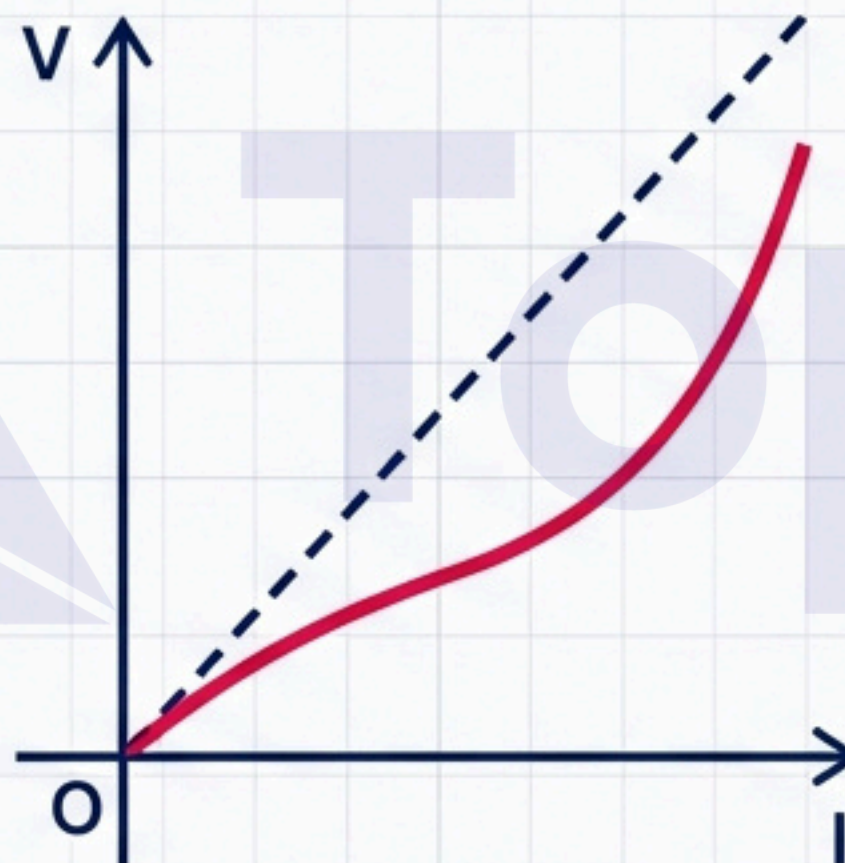
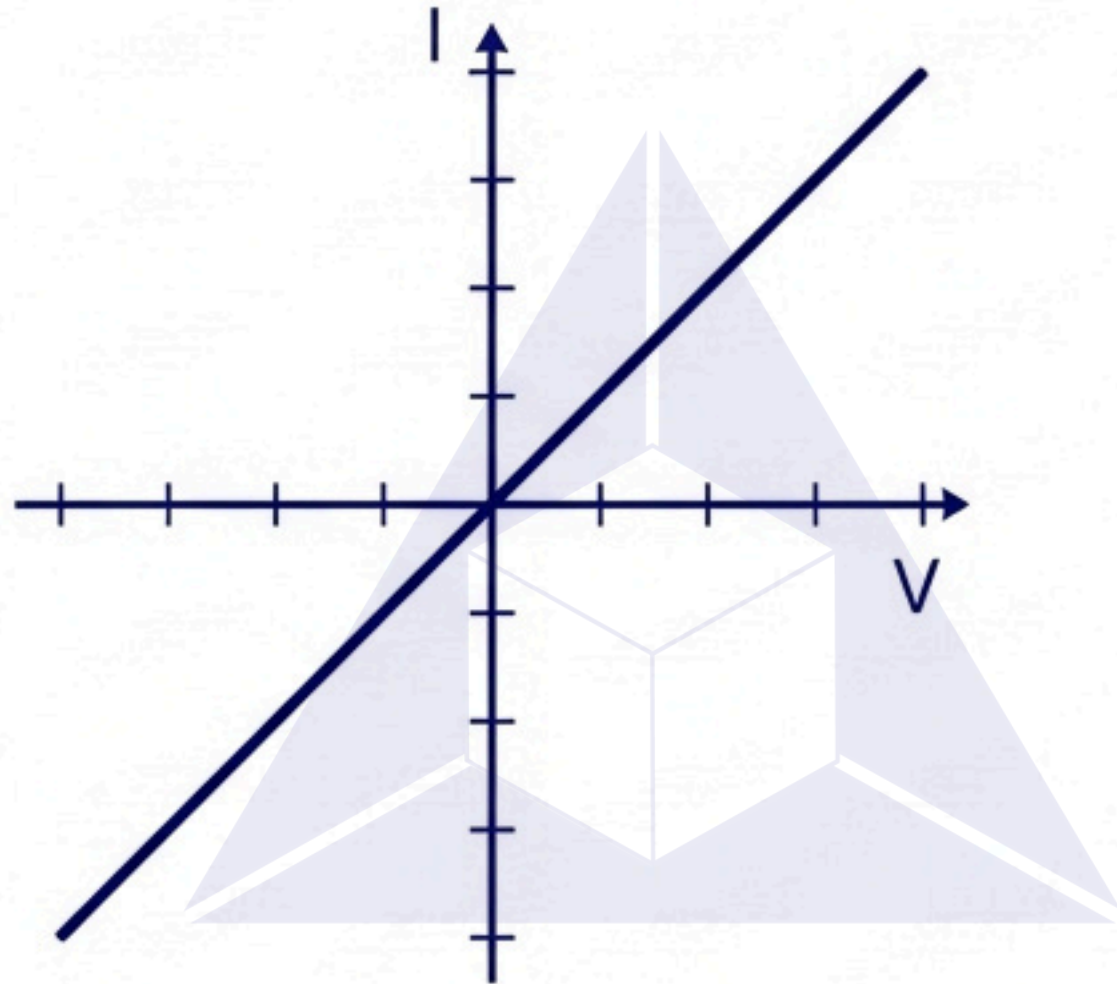


Limitations of Ohm's Law

When $V = IR$ breaks down: A visual guide to non-ohmic conductors and modern electronic devices.



OHMIC BEHAVIOR



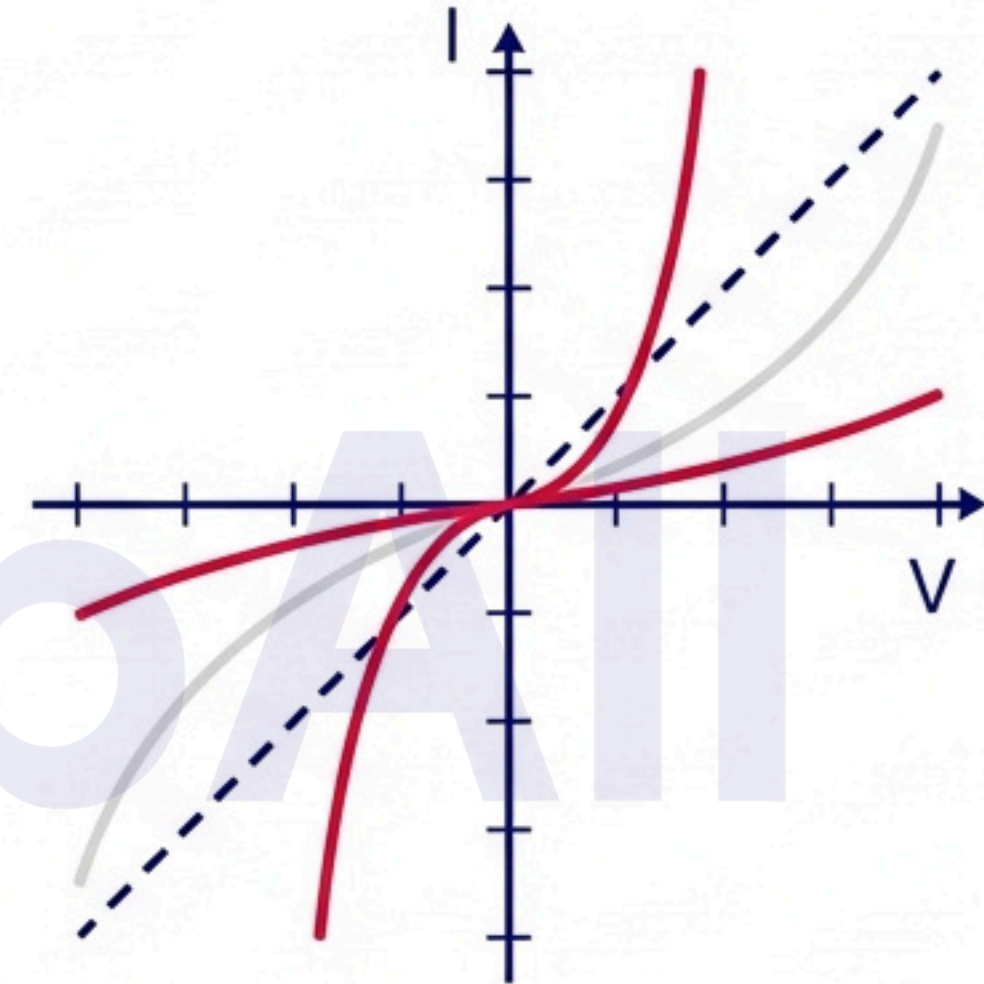
$$V \propto I \text{ (Constant } R\text{)}$$

Exam Focus Metals at constant temperature



Modern electronics rely on materials that break the proportional rule.

NON-OHMIC BEHAVIOR



$$V \neq IR \text{ (Variable } R\text{)}$$

Exam Focus Semiconductors, Diodes, GaAs

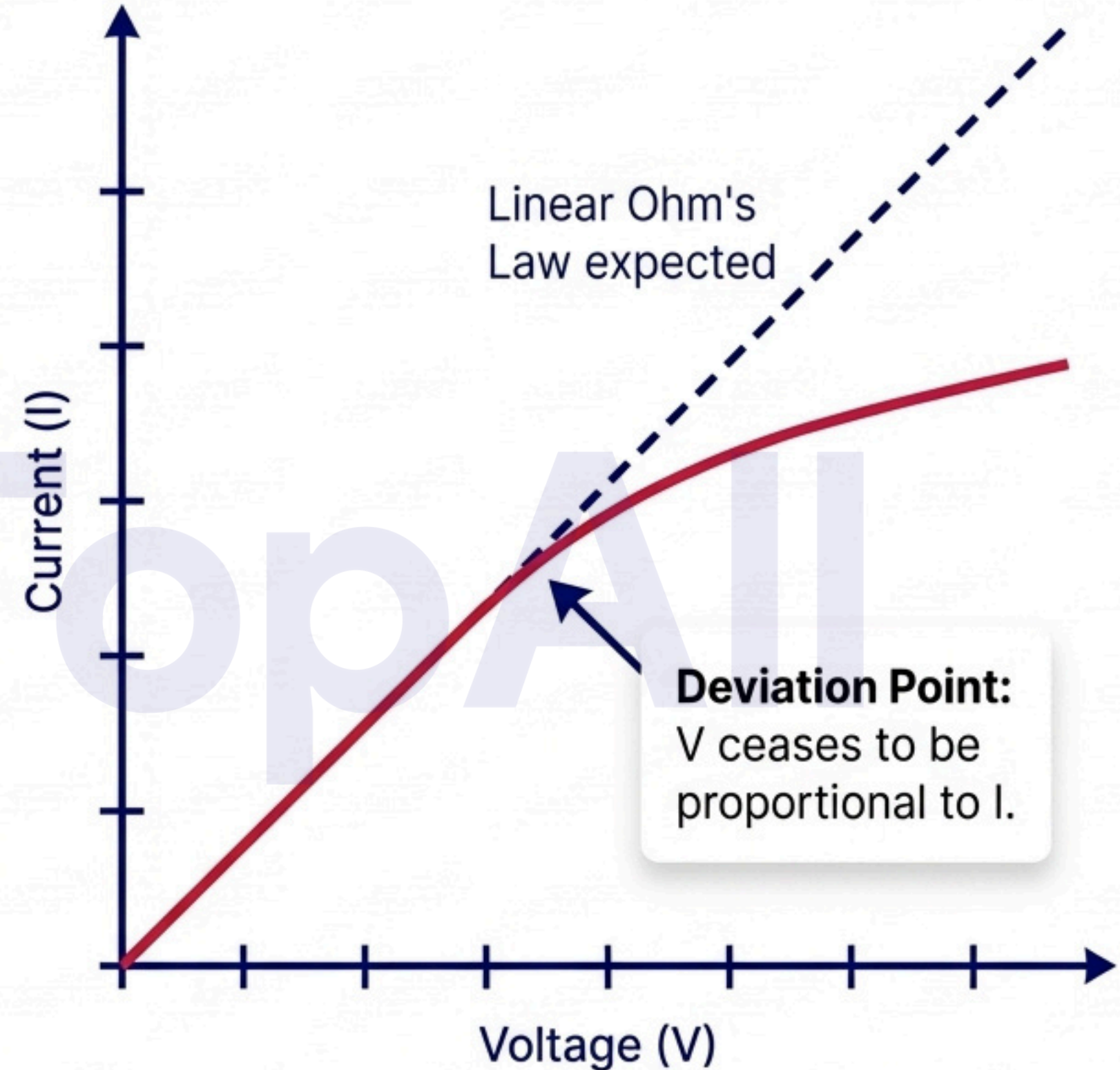
DEVIATION 1

Non-Linear V-I Relation

Proportionality breaks down at higher voltages or currents. The resistance R is no longer constant, meaning the slope of the graph changes.

Exam Focus: Good Conductors (Due to heating)

Diagnostic Note: As current increases, temperature rises, increasing atomic vibrations and collision frequency, thereby altering resistance.

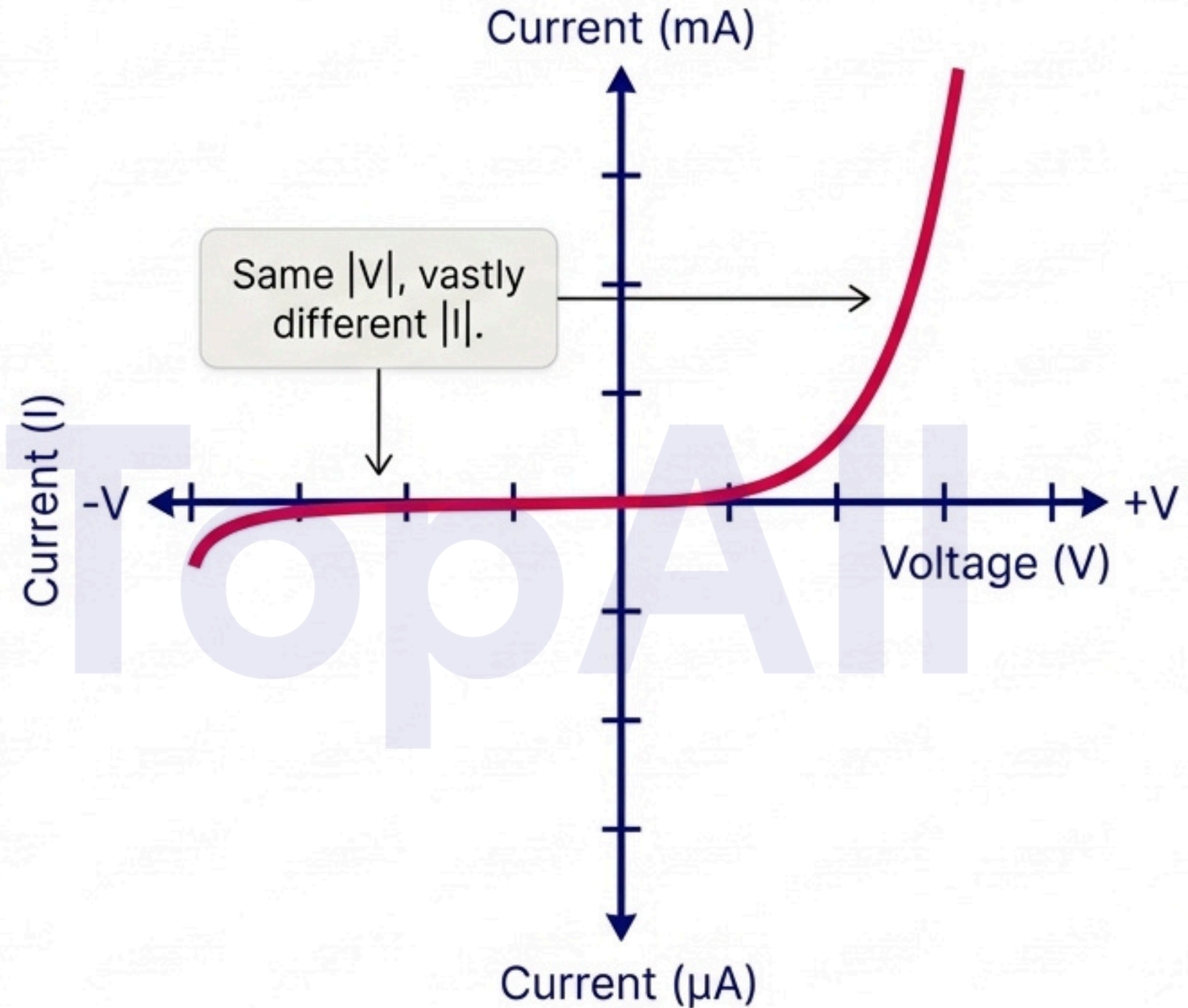


DEVIATION 2

Sign-Dependent Behavior

The relation between V and I depends on the voltage V . It depends strictly on the polarity of V . Reversing the voltage direction does not produce a proportional opposite current.

Exam Focus: P-N Junction Diodes

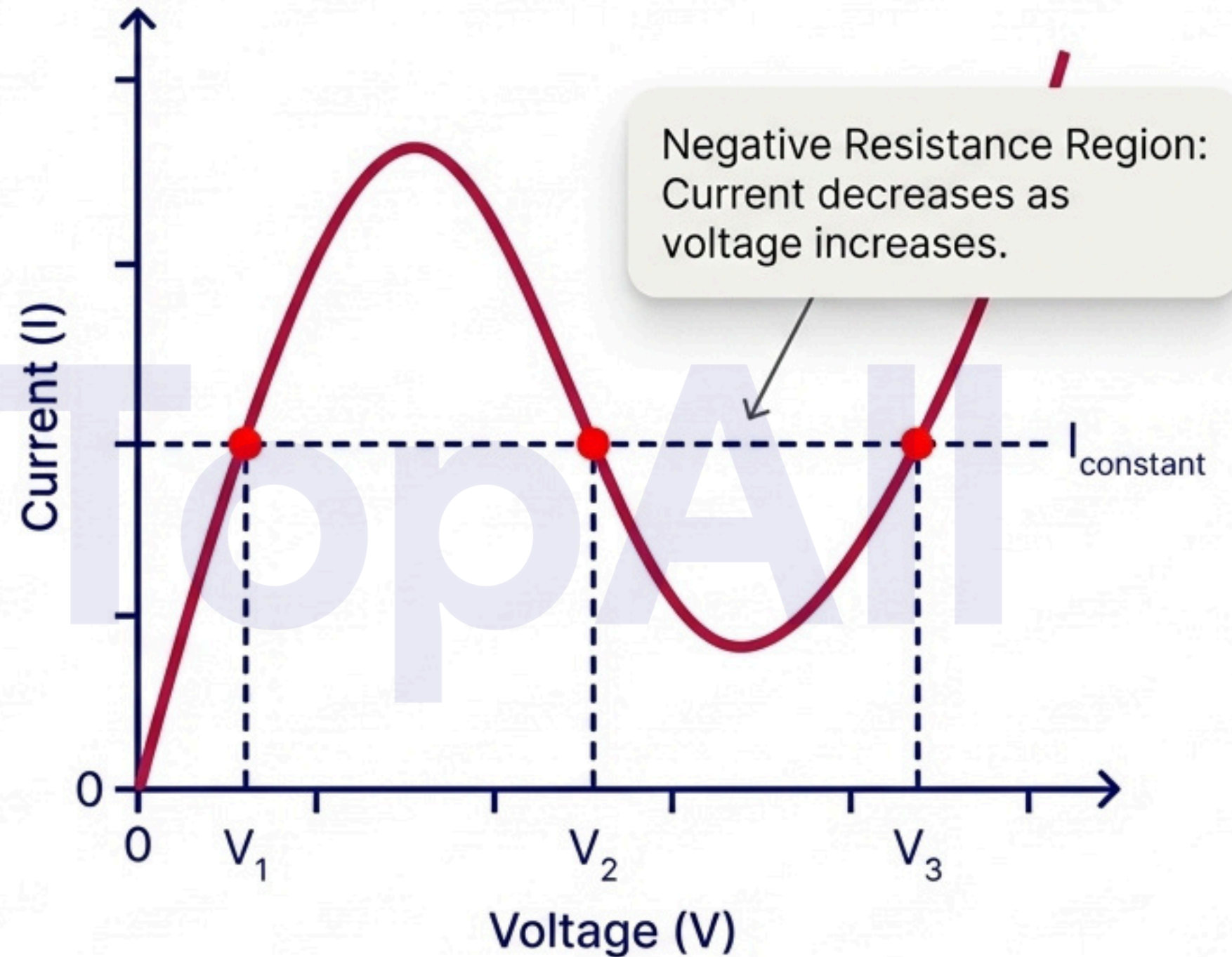


DEVIATION 3

Non-Unique Relation

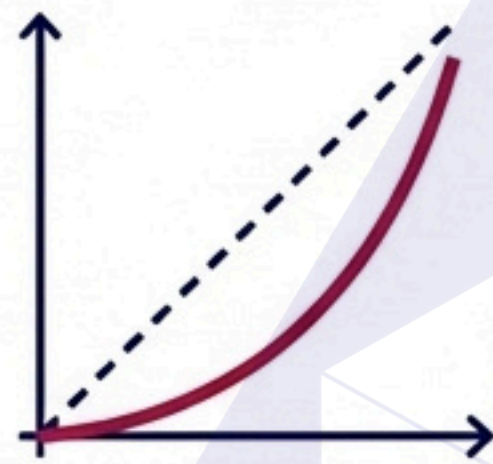
The mathematical relation completely breaks down. There is more than one value of Voltage (V) for the exact same magnitude of Current (I).

Exam Focus: Gallium Arsenide (GaAs)



KEY TAKEAWAYS: LIMITATIONS OF OHM'S LAW

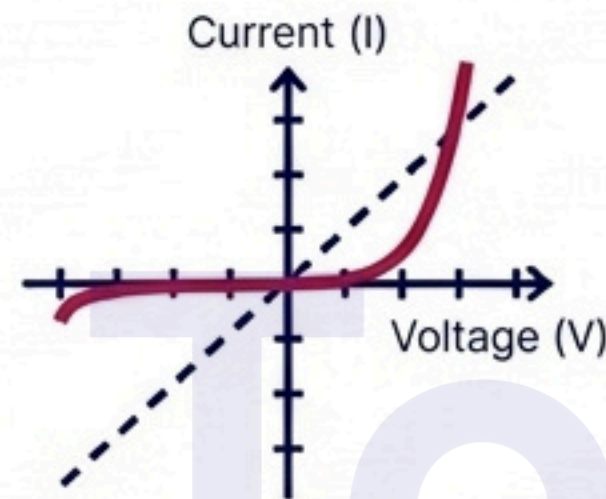
Non-Linear



Core Rule:
 $V \not\propto I$

Exam Focus:
Heated Good Conductors

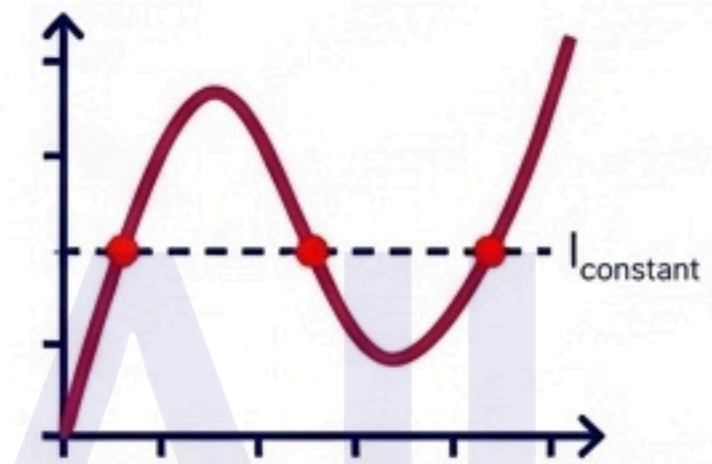
Sign-Dependent



Core Rule:
 $I(+V) \neq -I(-V)$

Exam Focus:
Diodes

Non-Unique



Core Rule:
One $I \rightarrow$ Multiple V 's

Exam Focus:
GaAs

While Ohm's law fails in these scenarios, these exact deviations form the foundation of modern semiconductor electronics.