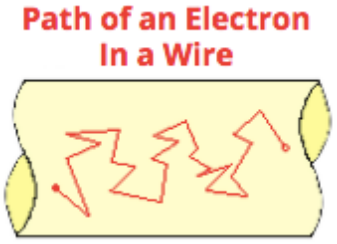
Electrical Resistance
Lesson Notes

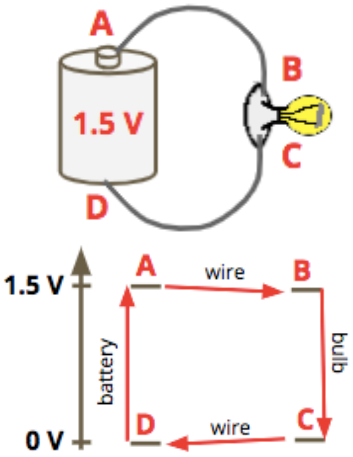
Learning Outcomes
- What is resistance?
- What variables affect resistance and in what manner do they affect it?

What is Resistance



- Because of collisions of mobile electrons with the atoms and ions of a wire, the path of an electron is anything but straight; it is a *zig-zag* journey.
- **Resistance** is the general hindrance to the flow of charge through a wire or a device.
- The amount of wire resistance depends on the wire's length, diameter, and the types of atoms it's composed of.
- While the electric potential difference encourages the flow of mobile charge carriers in a circuit, electrical resistance discourages charge flow.

Energy and Potential Changes



- Charge gains energy as it passes through the cell. This increases its electric potential or voltage.

$$V_A >>>> V_D$$

- Because of collisions of mobile charge carriers with atoms and ions of a wire, a **very small amount** of energy and potential is lost in the wire.

$$V_A > V_B \text{ and } V_C > V_D$$

- But most of the **voltage drop** occurs in the load (light bulb, heater, motor, etc.).

$$V_B >>>> V_C$$

Variables Affecting Resistance

Length:
Resistance is directly proportional to the wire's length. Longer wires offer a greater resistance to charge flow.

Cross-Sectional Area:
Resistance is inversely proportional to the wire's cross-sectional area. Wider wires offer less resistance to charge flow.

Material
Different materials contribute differently to the wire's resistance. Silver and copper are better *conductors* and offer less resistance than nickel or iron.

Mathematics of Resistance

The mathematical equation relating wire resistance (R) to the variables that affect it is …

$$R = \frac{\rho \bullet L}{A}$$

Unit of resistance is the **ohm** (symbolized by the Greek letter **Ω**),

ρ = resistivity of material (Ω•m)

L = length of wire (m)

A = cross-sectional area of wire (m^2)

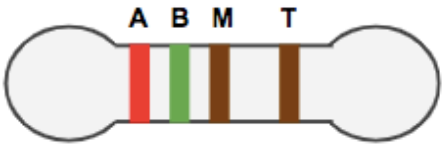
The cross-sectional area is usually calculated assuming a circular cross-section - as $\pi \cdot R^2$ - where **R** is the wire radius.

Material	Resistivity (Ω•m)
Silver	1.59×10^{-8}
Copper	1.68×10^{-8}
Gold	2.44×10^{-8}
Nickel	6.99×10^{-8}
Iron	1.0×10^{-7}
Nichrome	1.10×10^{-6}
Graphite	$\sim 2.5 \times 10^{-6}$

Resistors

Resistors are small (usually) components that are included in circuits for the sole purpose of offering resistance to charge flow and thus controlling the amount of current in the circuit.

Many resistors utilize a **color band system** comprised of a series of four colored bands.



Resistance = $(10 \bullet A + B) \times 10^{M} \pm T\%$

Resistance = $(10 \bullet 2 + 5) \times 10^{1}$ = **250 Ω ± 1%**

(ranges from 247.5 Ω to 252.5 Ω)

Color	Value	Multiplier
Black	0	x 1
Brown	1	x 10
Red	2	x 10^2
Orange	3	x 10^3
Yellow	4	x 10^2
Green	5	x 10^5
Blue	6	x 10^6
Violet	7	x 10^7
Grey	8	x 10^8
White	9	x 10^9