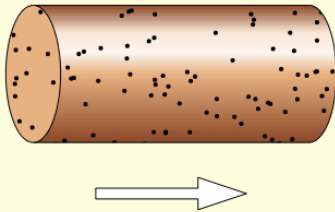# Resistivity

IB PHYSICS | ELECTRICITY

Resistance

What factors affect the resistance of a wire?

- Cross-sectional Area
- Length
- Material

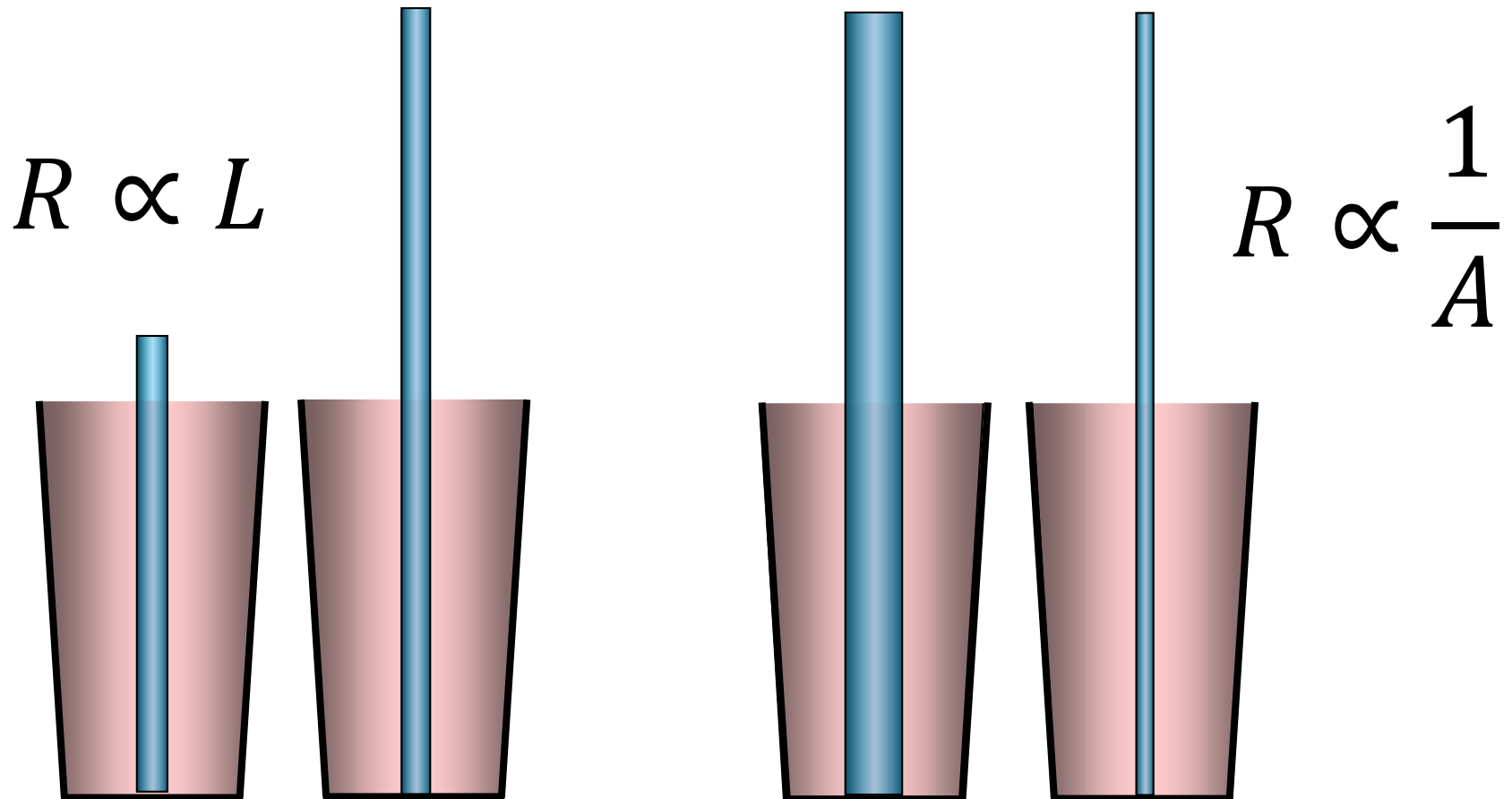$$R = \frac{\rho\, L}{A}$$

resistance = 0.653 ohms

ρ	L	A
resistivity	length	area
0.49	10.00	7.50
Ωcm	cm	cm^2

Resistance

Imagine that you are testing the resistance of a straw while drinking a milkshake...
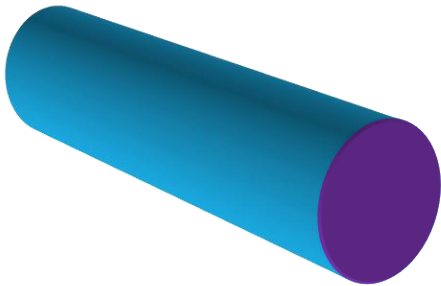
$$R \propto L$$

$$R \propto \frac{1}{A}$$

Calculating Resistance

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

$$A = \pi r^2$$

R → Resistance [Ω]

L → Length [m]

A → Area [m²]

ρ → Resistivity [Ωm]

IB Physics Data Booklet

Sub-topic 5.1 – Electric fields	Sub-topic 5.2 – Heating effect of electric currents
$I = \dfrac{\Delta q}{\Delta t}$ $F = k\dfrac{q_1 q_2}{r^2}$ $k = \dfrac{1}{4\pi\varepsilon_0}$ $V = \dfrac{W}{q}$ $E = \dfrac{F}{q}$ $I = nAvq$	Kirchhoff's circuit laws: $\Sigma V = 0$ (loop) $\Sigma I = 0$ (junction) $R = \dfrac{V}{I}$ $P = VI = I^2 R = \dfrac{V^2}{R}$ $R_{\text{total}} = R_1 + R_2 + \cdots$ $\dfrac{1}{R_{\text{total}}} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \cdots$ $\rho = \dfrac{RA}{L}$
Sub-topic 5.3 – Electric cells	Sub-topic 5.4 – Magnetic effects of electric currents
$\varepsilon = I(R + r)$	$F = qvB \sin\theta$ $F = BIL \sin\theta$

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

Resistivity

Resistivity ρ changes depending on the material used.

Conductor Material	Resistivity (Ohm meters @ 20 °C)
Silver	1.64×10^{-8}
Copper	1.72×10^{-8}
Aluminum	2.83×10^{-8}
Tungsten	5.50×10^{-8}
Nickel	7.80×10^{-8}
Iron	12.0×10^{-8}
Constantan	49.0×10^{-8}
Nichrome II	110×10^{-8}

Lower Resistivity → Better Conductor

Resistivity – Try This #1

Conductor Material	Resistivity (Ohm meters @ 20 °C)
Silver	1.64×10^{-8}
Copper	1.72×10^{-8}
Aluminum	2.83×10^{-8}
Tungsten	5.50×10^{-8}
Nickel	7.80×10^{-8}
Iron	12.0×10^{-8}
Constantan	49.0×10^{-8}
Nichrome II	110×10^{-8}

Calculate the resistance of a 1.8 m length of iron wire of with a diameter of 3 mm

$$R = (12.0 \times 10^{-8}) \frac{(1.8)}{(7.07 \times 10^{-6})}$$

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

L = 1.8 m

ρ = 12.0 × 10⁻⁸ Ωm

A = π(0.003/2)² = 7.07 × 10⁻⁶ m²

$$R = 0.0306 \ \Omega$$

Resistivity – Try This #2

A current of 4 A flowed through a 75 m length of metal alloy wire of area 2.4 mm² when a p.d. of 12 V was applied across its ends. What was the resistivity of the alloy?

$$\rho = \frac{RA}{L}$$

$$R = \frac{V}{I} = \frac{12}{4} = 3 \ \Omega$$
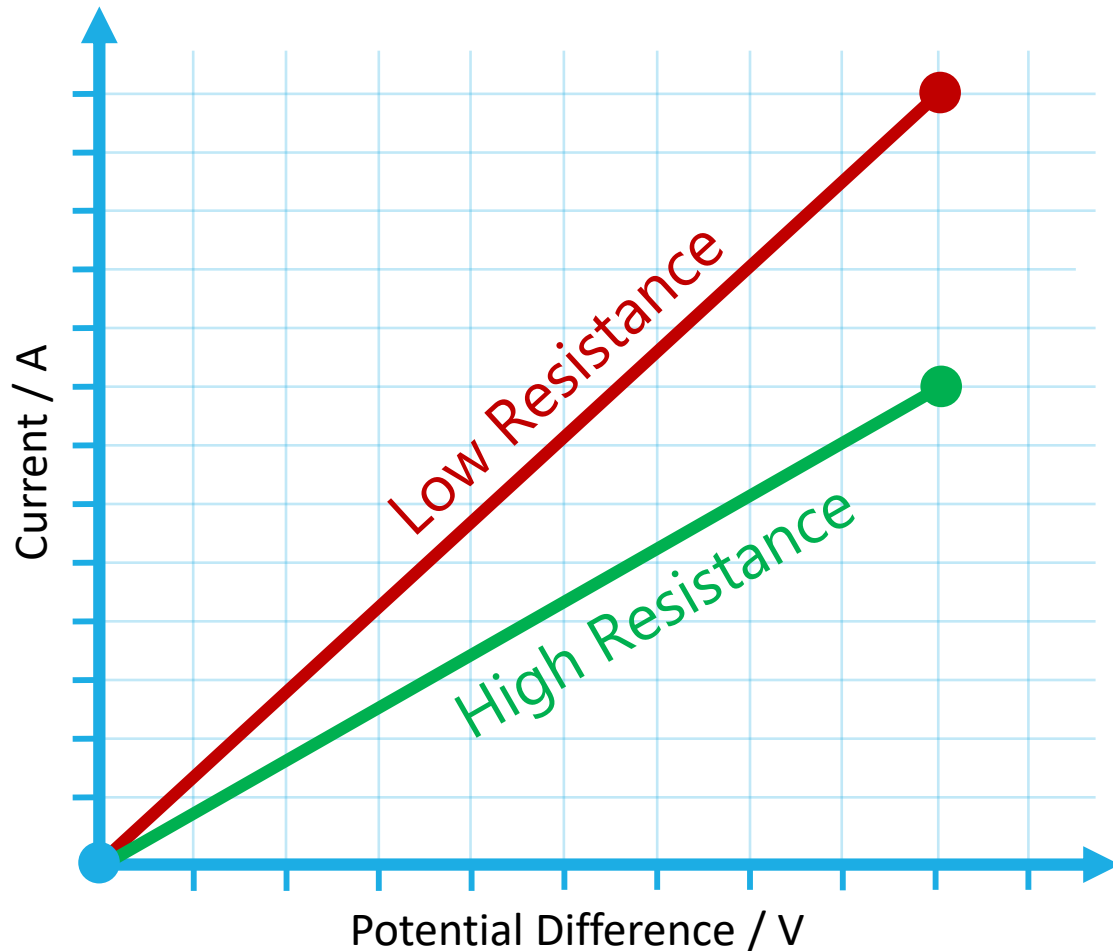
$$L = 75 \text{ m}$$

$$\rho = \frac{(3)(2.4 \times 10^{-6})}{(75)}$$

$$A = 2.4 \ \text{mm}^2 \times \left(\frac{1 \text{ m}}{1000 \text{ mm}}\right)^2$$

$$= \mathbf{9.6 \times 10^{-8} \ \Omega m}$$

$$A = 2.4 \times 10^{-6} \ \text{m}^2$$
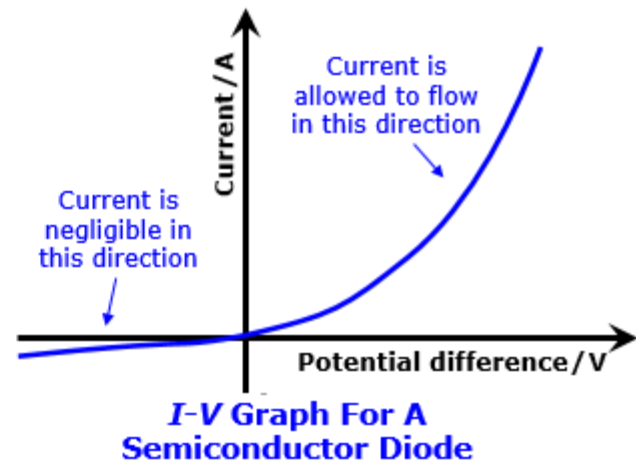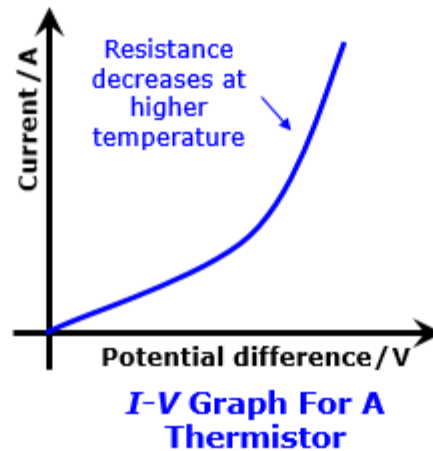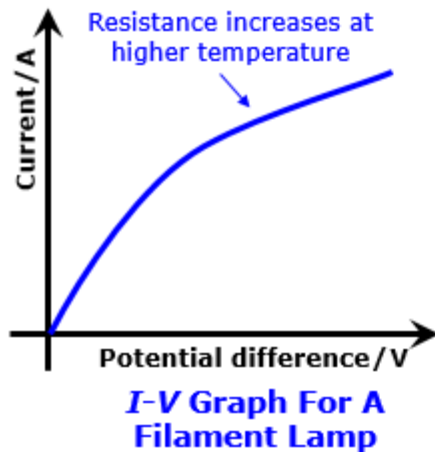
Graphing Ohm's Law

Linear Relationship means that our component is

___Ohmic___

Resistance
is constant

Graphing Ohm's Law

Many/most electrical resistors don't follow Ohm's Law all of the time… For example, incandescent light bulbs have much more resistance as they heat up

I-V Graph For A Filament Lamp

Resistance increases at higher temperature

Current / A

Potential difference / V

I-V Graph For A Thermistor

Resistance decreases at higher temperature

Current / A

Potential difference / V

I-V Graph For A Semiconductor Diode

Current is allowed to flow in this direction

Current is negligible in this direction

Current / A

Potential difference / V

Non-linear Relationship means that our component is __Non-ohmic__

Graphing Ohm's Law

Find V and R for the resistors X and Y when the current is 2A

X		
V	4 V
I	2 A
R	2 Ω

$$R = \frac{V}{I}$$

$$R = \frac{4 \text{ V}}{2 \text{ A}}$$

Y		
V	10 V
I	2 A
R	5 Ω

$$R = \frac{V}{I}$$

$$R = \frac{10 \text{ V}}{2 \text{ A}}$$
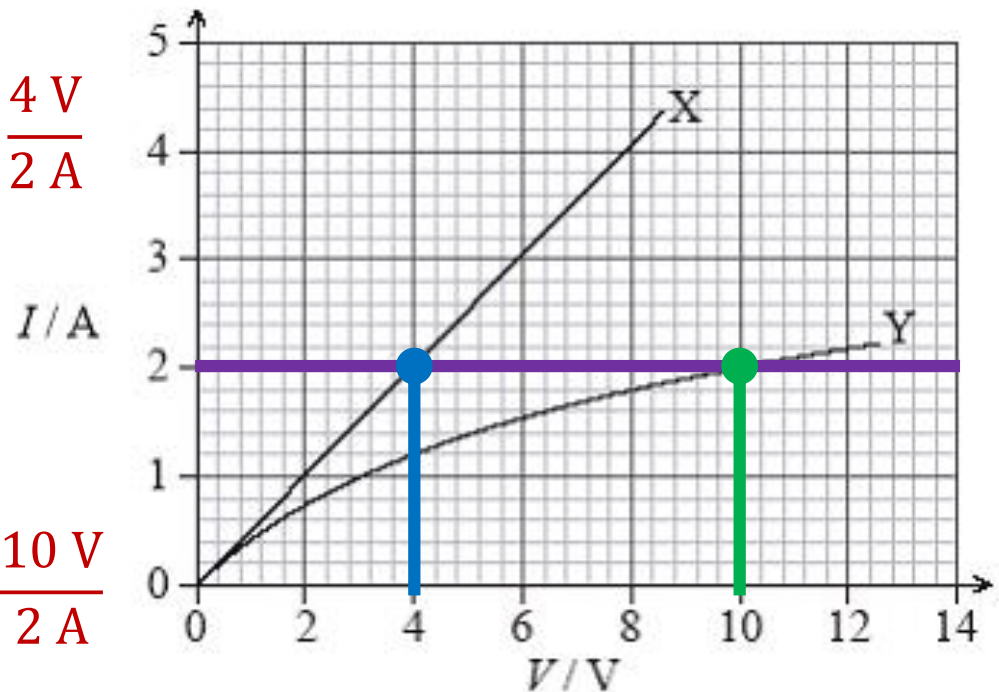
Lesson Takeaways

❑ I can describe the different factors the affect resistance

❑ I can define resistivity as a property of a material

❑ I can compare ohmic and non-ohmic resistors