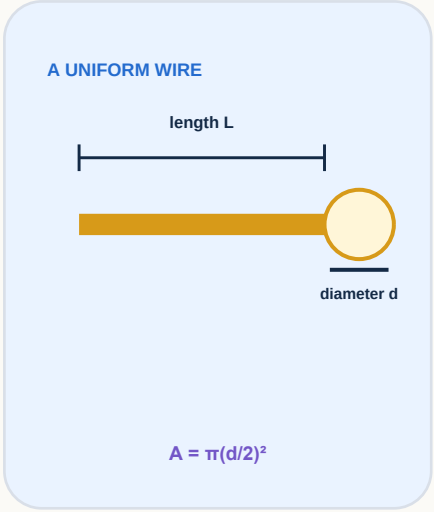
# LESSON 2.2.3

## Resistivity

## and Factors Affecting Resistance

Resistance depends on a sample's geometry. Resistivity describes the material itself at a stated temperature.




### THE DEFINING RELATIONSHIP

$$R = \rho L/A$$

ρ = resistivity (Ω m) | L = length (m) | A = cross-sectional area (m²)

### THREE FACTORS

**L** LENGTH

L ↑ → R ↑

Longer path gives carriers more collisions.

**A** AREA

A ↑ → R ↓

More parallel paths allow greater current.

**ρ** MATERIAL

ρ ↑ → R ↑

Carrier density and mobility differ by material.

### RESISTIVITY IS NOT RESISTANCE

**R changes with L and A**

unit: ohm (Ω)

**ρ identifies the material**

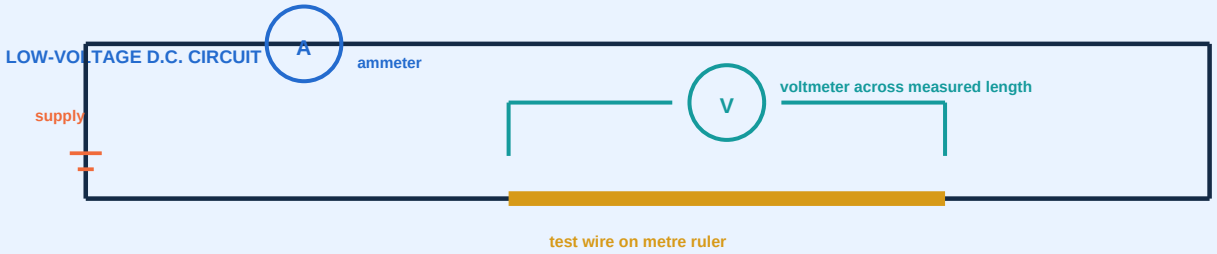
unit: ohm metre (Ω m)

**Use radius in metres when calculating $A = \pi r^2$; do not substitute the diameter for r.**

# 1 Core Practical 7: determine resistivity

Measure resistance for different lengths of the same uniform wire, then use the graph gradient.

## APPARATUS AND CONNECTIONS




## METHOD

**1 MEASURE DIAMETER**

Use a micrometer at several positions and directions; calculate mean d and $A = \pi(d/2)^2$.

**2 SET A LENGTH**

Choose L on the ruler and connect the voltmeter across exactly that section.

**3 TAKE V AND I**

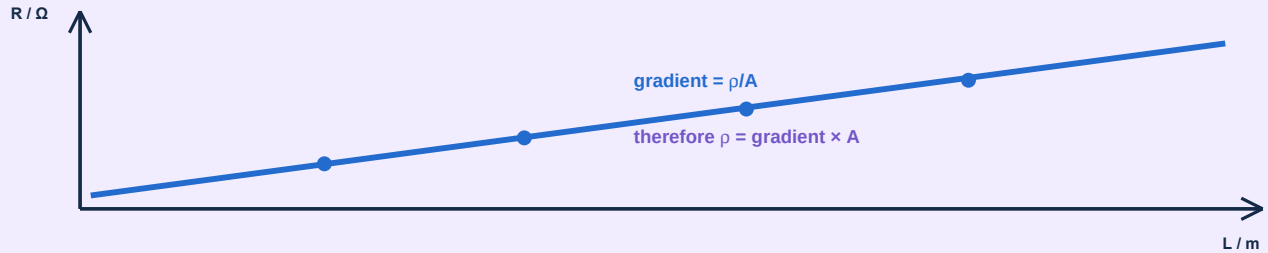
Close the switch briefly, record V and I, then calculate $R = V/I$.

**4 REPEAT**

Use several lengths, repeat readings and keep the wire temperature constant.

## ANALYSE THE DATA

PLOT R AGAINST L




Keep current low and switch off between readings: heating changes the wire's resistivity.

# 2 Calculate and explain resistivity

Use geometry carefully, then connect the macroscopic resistance to moving charge carriers.

## WORKED EXAMPLE

A wire has length 1.50 m, diameter 0.40 mm and resistance 2.4 Ω. Calculate its resistivity.

**1** RADIUS IN METRES

$r = 0.20\ \text{mm} = 2.0 \times 10^{-4}\ \text{m}$

**2** CROSS-SECTIONAL AREA

$A = \pi r^2 = \pi(2.0 \times 10^{-4})^2 = 1.26 \times 10^{-7}\ \text{m}^2$

**3** REARRANGE AND SUBSTITUTE

$\rho = RA/L = 2.4(1.26 \times 10^{-7})/1.50 = 2.0 \times 10^{-7}\ \Omega\ \text{m}$

## THE MICROSCOPIC MODEL

$$I = nqv_dA$$

n = carrier number density | q = carrier charge | v_d = drift speed | A = area

## WHY TEMPERATURE CHANGES RESISTANCE

### METAL

temperature ↑ → lattice vibration ↑ → R ↑

Collisions become more frequent, so drift response falls and resistivity increases.

### NTC THERMISTOR

temperature ↑ → carrier number n ↑ → R ↓

The rise in available charge carriers dominates, so resistivity decreases.

**Large n and an easy drift response give low resistivity; few or less mobile carriers give high resistivity.**