

Resistance, Kirchhoff's rules and steady-state RC circuits

AP Physics 2 (algebra-based) · Lab

Name: _____ Date: _____ Class: _____

How does the resistance of a metal wire depend on its length, and can a straight-line graph give the resistivity of the metal? In this lab you collect voltage and current data, plot resistance against length and use the gradient to find a property of the material itself.

Level: AP Physics 2 (algebra-based) · **Curriculum:** AP P2 Unit 11

Aim

Measure the resistivity of a constantan wire by finding how its resistance depends on its length.

Equipment

- constantan wire, about 1.2 m, diameter near 0.28 mm
- metre rule and tape
- power supply set to 3 V d.c. (or two 1.5 V cells) with a switch
- ammeter (0–1 A) and voltmeter (0–3 V)
- two crocodile clips and connecting leads
- micrometer screw gauge

Safety

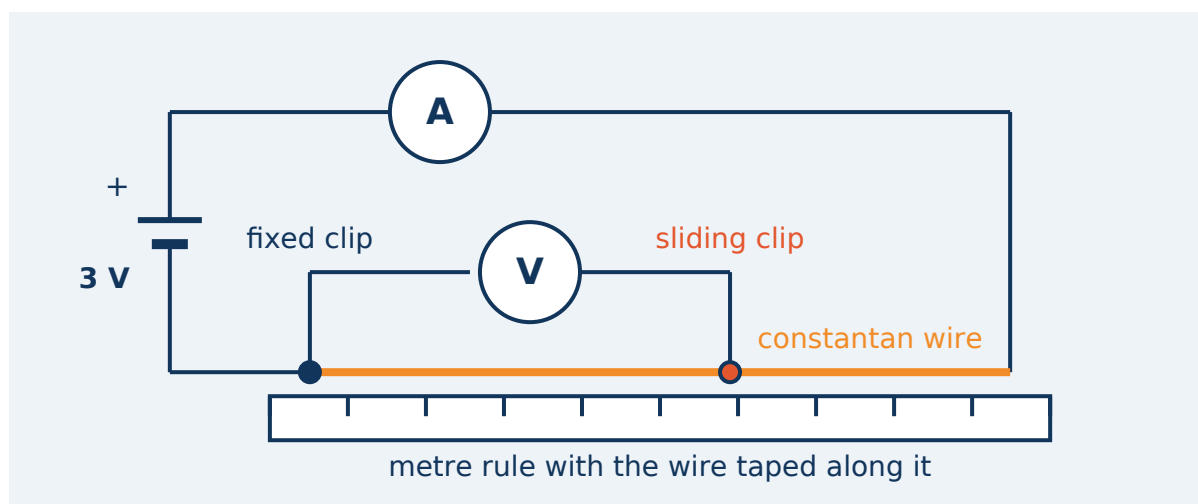
Safety

The wire warms up when current flows. Keep the switch open except when taking a reading, and do not touch the wire while the current is on.

Method

1. Measure the diameter of the wire at three places with the micrometer. Calculate the mean and the area $A = \pi(d/2)^2$.
2. Tape the wire straight along the metre rule and build the circuit shown.
3. Place the sliding clip at $L = 0.20$ m from the fixed clip. Close the switch, read V and I at once, then open the switch.
4. Repeat for $L = 0.40, 0.60, 0.80$ and 1.00 m.

5. Calculate $R = V/I$ for each length.



The voltmeter measures the voltage across the part of the wire between the two clips.

Results

Sample data, mean diameter 0.28 mm, $A = 6.2 \times 10^{-8} \text{ m}^2$:

Length L (m)	Voltage V (V)	Current I (A)	$R = V/I$ (Ω)
0.20	0.40	0.250	1.60
0.40	0.78	0.245	3.18
0.60	1.12	0.235	4.77
0.80	1.42	0.225	6.31
1.00	1.72	0.215	8.00

Analysis questions

Question 1 Resistance values

Check the table. Calculate R for $L = 0.60 \text{ m}$ and describe the trend of R with L .

Question 2 Graph

Plot R (y-axis) against L (x-axis), draw the best-fit line and state its shape. Explain why the line should pass through the origin.

Question 3 Gradient

Calculate the gradient of the line using the first and last points of the table. Give its unit.

Question 4 Resistivity

Use the gradient and the area A to calculate the resistivity of the wire. The accepted value for constantan is about $4.9 \times 10^{-7} \Omega \cdot \text{m}$. Comment.

Question 5 Uncertainty in the area

The micrometer reads to $\pm 0.01 \text{ mm}$ on a diameter of 0.28 mm . Calculate the percentage uncertainty in A and the resulting uncertainty in ρ .

Question 6 Why open the switch

Explain why the switch is opened between readings, and what would happen to the readings if the wire heated up.

Question 7 Improving the method

A student finds that the best-fit line has a small positive intercept on the R axis. Suggest a cause and one improvement.