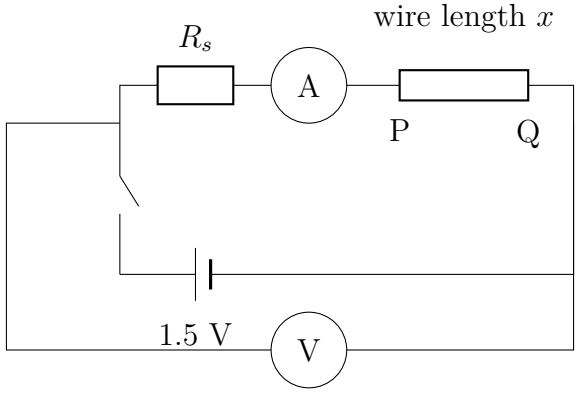
Resistivity from a series circuit

Name: _____ Class: _____ Date: _____

Aim Determine wire **resistivity** using a straight-line graph. Allow 60–75 minutes.

Key ideas $R_{\text{wire}} = \rho x/A$ and $A = \pi d^2/4$. At each reading, $V/I = R_s + \rho x/A$ in the ideal series circuit. Paired V, I readings allow V to change.

Apparatus 1.5 V cell, switch, ammeter, voltmeter, 10 Ω resistor, leads and clips, about 1.1 m of constantan wire taped to a metre rule, micrometer.



The voltmeter is across the *whole resistor-and-wire series branch*, not only the wire. Its current is assumed negligible. x is the distance along the wire between P and Q.

Safety Use low voltage only. Open the switch between readings and before moving clips. Do not short the cell or touch a hot wire. Have the circuit checked before closing the switch.

1 Measure and build

1. Check the micrometer zero. Measure diameter at three positions, in two directions. Use the ratchet gently and correct any zero error.
2. Calculate mean diameter d in metres, then area A. Avoid squeezing the wire.
3. Connect the circuit. Start near $x = 0.50$ m. Close the switch briefly and record I and terminal voltage V.
4. Open the switch. Increase x and repeat for at least six well-spread lengths. Repeat paired V, I readings after resetting a clip.
5. Record V at every length. Process each pair as $R = V/I$; this also allows for changing cell voltage.

Processing check (synthetic data) For $d = 0.230 \pm 0.005$ mm and $s = 11.8 \pm 0.6\,\Omega\,\text{m}^{-1}$, calculate $\rho = s\pi d^2/4$ and its approximate percentage uncertainty. Convert diameter before squaring.

2 Record measurements

Micrometer zero error: _____ mm Resolution: _____ mm.

Position	d_1/mm	d_2/mm

Corrected mean $d =$ _____ m $A =$ _____ m^2.

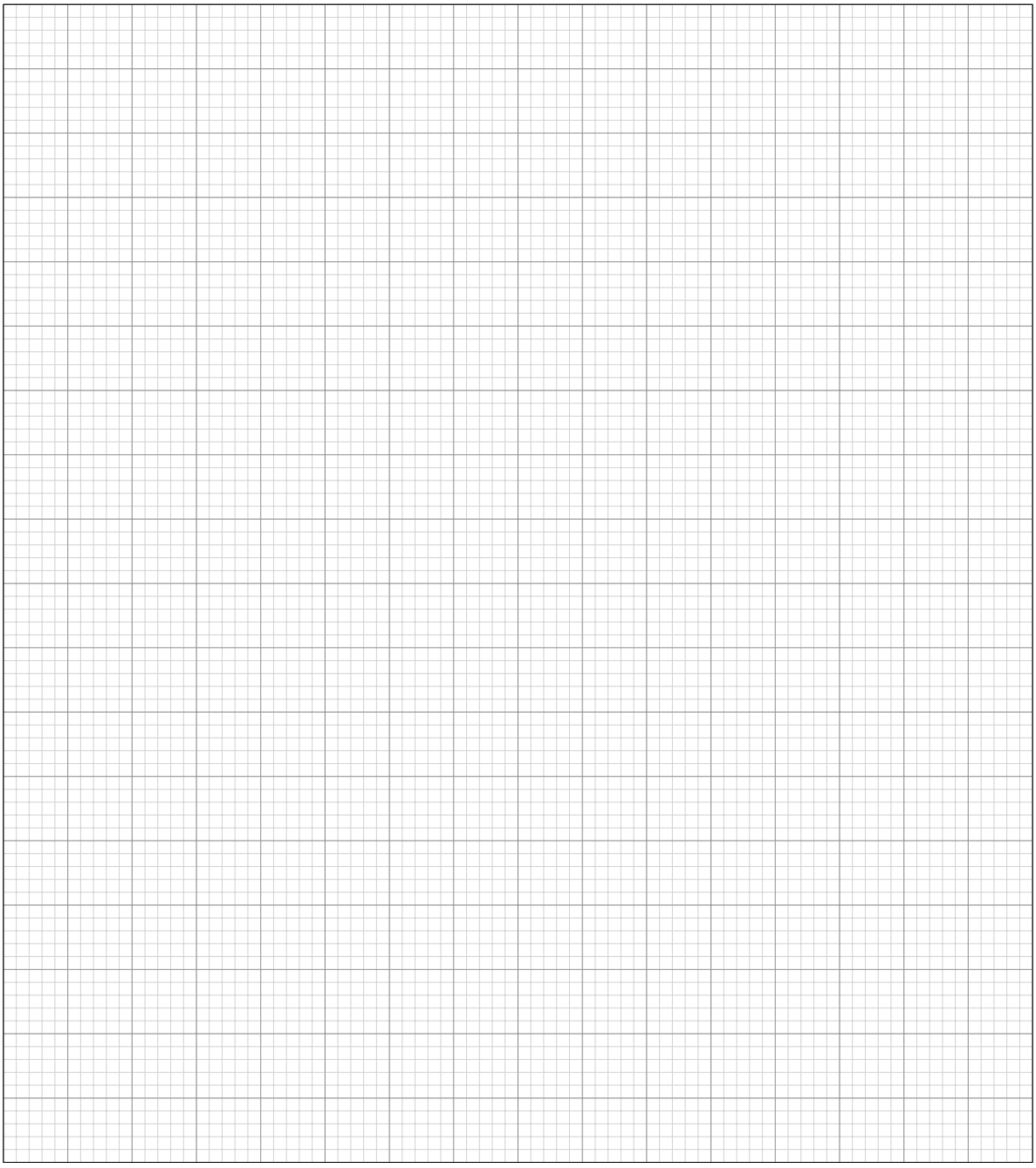
x/m	V_1, V_2/V	I_1/A	I_2/A	$\bar{I}$/A	$\bar{R}$/ Ω

Pilot and controls State the usable length range. How did you limit heating and keep clip contact consistent?

Uncertainty Estimate Δd. Explain why a diameter error matters strongly to the area.

3 Graph

For each length calculate $R_1 = V_1/I_1$, $R_2 = V_2/I_2$ and their mean $\bar{R}$. Plot $\bar{R}$ against x. Draw a best-fit line. Extension beyond Paper 3: add justified uncertainty bars in both variables and a defensible extreme line; use the gradient difference as an estimate of Δs. If no straight line fits the bars, discuss the model or underestimated errors.



Choose scales and label both axes with quantities and units. Mark a large gradient triangle on the best-fit line where appropriate.

4 Analyse the straight line

Using paired voltage and current readings,

$$\bar{R} = \underbrace{\frac{\rho}{A}}_{s} x + b, \qquad \rho = sA.$$

The intercept includes R_s and approximately constant lead, contact and ammeter resistance. For verified constant V, a $1/I$–x graph is an optional alternative.

1. Explain why paired V/I readings account for changing cell voltage. Use your own data.

2. Find gradient and intercept, including units. Calculate ρ in $\Omega\,\mathrm{m}$ and the intercept resistance in Ω. Show substitutions with SI units.

3. Estimate $\Delta\rho/\rho \approx \Delta s/|s| + 2\Delta d/d$. State how you estimated each term. If no gradient uncertainty is available, identify what is missing rather than inventing it.

4. Compare the intercept with 10 Ω and, for constantan, ρ with approximately $4.9 \times 10^{-7}\,\Omega\,\mathrm{m}$. Explain why material and temperature matter.

5. Discuss two specific limitations and matching improvements. Consider clip resistance, heating or diameter variation.

Conclusion State your resistivity with justified precision and the evidence for or against a linear model.

Before you leave Return the apparatus, clear the bench and submit your recorded data.