

Unit 3: Practical Skills in Physics I

WPH13 · Issue 3 · planning, measurement and processing · sheets 3.1–3.3

Which measurement would you trust?

- A result needs a method, a unit and an uncertainty.
- WPH13 tests practical skills from Units 1–2.
- Use sheets 3.1–3.3 alongside real laboratory work.

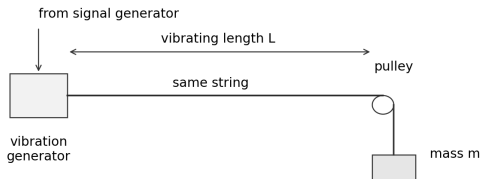
Name the variable and how it is controlled

- Independent: what you deliberately change.
- Dependent: what you measure in response.
- Control: another cause that must stay steady.

A method another student could follow

- Name apparatus, range and resolution.
- Define measurement positions and start/end events.
- Choose a useful range, repeats and a processing route.

Turn the model into a test



- 1 **Model** $f = \frac{1}{2L} \sqrt{T/\mu}$
- 2 **Linearise** $f^2 = T/(4L^2\mu)$
- 3 **Plot** f^2 vertically against T horizontally

Zero check and calibration are different

- A zero check finds an offset at zero.
- Calibration compares readings with known references.
- Repeating cannot remove a fixed zero offset.

Your turn: a changing cell is not random scatter

- Repeated voltage readings steadily decrease under a large load.
- Explain why the mean alone is inadequate.
- Suggest two changes that restore comparable conditions.

Restore conditions before averaging

- A steady trend signals changing conditions.
- Reduce current and limit heating or discharge.
- Open the switch between readings; allow stabilisation.

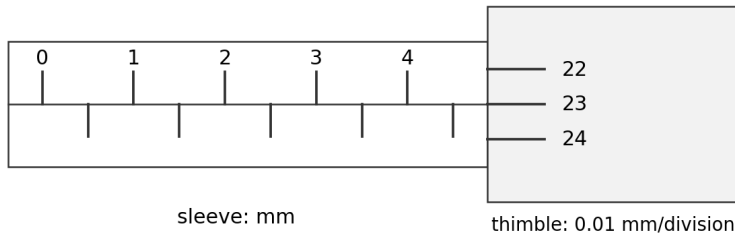
Clustered values can all be wrong

- Accuracy: closeness to the true value.
- Precision: clustering of repeated values.
- A systematic offset can coexist with high precision.

Two different checks on consistency

- Repeatability: same operator and method over a short time.
- Reproducibility: different operators, apparatus or methods.
- Investigate disagreement; do not delete it for convenience.

Read the scale that is actually shown



- Add the visible sleeve and aligned thimble reading.
- Include a visible half-millimetre sleeve mark.
- Check the stated resolution and zero condition.

Correct the indicated diameter

1 **Indicated** $d = 4.5 + 23(0.01) = 4.73 \text{ mm}$

2 **Corrected** $d = 4.73 - 0.02 = 4.71 \text{ mm}$

Measure the quantity the model needs

- A light gate gives blocking time for a known length.
- $v = l/t$ gives passage speed.
- Acceleration needs a change in speed over time.

Record only the digits the instrument resolves

- Put quantity and unit in the column heading.
- Raw readings should match instrument resolution.
- Check anomalies; record any justified exclusion.

Resolution is a starting uncertainty estimate

- For one reading: half the resolution in this specification.
- Method limitations may make uncertainty larger.
- Percentage uncertainty compares uncertainty with size.

A balance reading with units

1 **Absolute** $\Delta m = 0.1/2 = 0.05 \text{ g}$

2 **Percentage** $100\Delta m/m = 100(0.05/135.0) = 0.037\%$

Your turn: use the repeat spread

- Times: 5.12, 5.24, 5.18, 5.20 s.
- Find mean, half range and percentage uncertainty.
- Would half the display resolution describe this spread?

The observed spread is larger than resolution

- 1 **Mean** $\bar{t} = 20.74/4 = 5.185 \text{ s}$
- 2 **Half range** $\Delta t = (5.24 - 5.12)/2 = 0.06 \text{ s}$
- 3 **Percentage** $100(0.06/5.185) = 1.2\%$

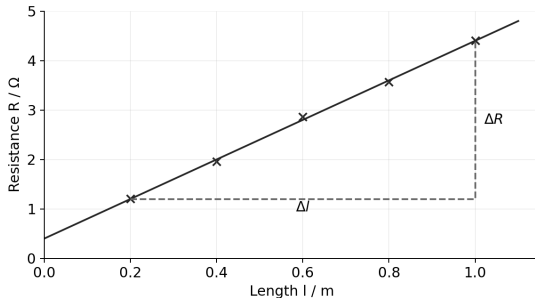
Stay within the stated Unit 3 demand

- Unit 3 does not require compounding percentage uncertainties.
- Use a supplied uncertainty in a calculated value directly.
- Do not confuse uncertainty with a known error.

Choose a graph that answers the investigation

- Use clear quantity/unit labels and regular scales.
- Plot accurate small crosses; fit the relationship.
- A straight line alone does not prove proportionality.

Read distant points on the fitted line



- The large triangle reduces relative coordinate-reading uncertainty.
- Use fitted-line points, not adjacent noisy measurements.

Match the graph to the physical equation

1 **Slope** $m = (4.40 - 1.20)/(1.00 - 0.20) = 4.00 \, \Omega \, \text{m}^{-1}$

2 **Intercept** $R_0 = 1.20 - 4.00(0.20) = 0.40 \, \Omega$

3 **Resistivity** $\rho = mA = 4.00(1.0 \times 10^{-7}) = 4.0 \times 10^{-7} \, \Omega \, \text{m}$

Axis scale factors change the numerical gradient

- Read f/MHz as frequency values in megahertz.
- Convert to hertz before substituting SI quantities.
- Rearrange the supplied model to identify the constant.

Locate a maximum and name the limitation

- Survey a broad range, then use finer settings near the peak.
- Maintain conditions and inspect scatter.
- Link each improvement to a specific measurement problem.

Turn a percentage into a comparison interval

- 1 **Absolute** $\Delta\rho = 0.009(8.90) = 0.080 \text{ g cm}^{-3}$
- 2 **Interval** 8.82 to 8.98 g cm^{-3}
- 3 **Conclusion** 8.94 is inside: consistent, without unique identification.

Check yourself

- Explain why repeats cannot remove a zero offset.
- Describe a valid graph and a large gradient triangle.
- State a conclusion that uncertainty can support.