LESSON 3.2.1

Precision, Accuracy and Resolution

Three different questions: how closely do readings agree, how close is the result to the true value, and how small a change can the instrument show?

PRECISION

How closely do repeated readings agree?

A small spread means high precision under those measurement conditions. It does not establish closeness to the true value.

ACCURACY

How close is the result to the true value?

Assess accuracy using a suitable reference or accepted value, allowing for uncertainty. Both scatter and systematic bias can affect the result.

RESOLUTION

What is the smallest distinguishable change?

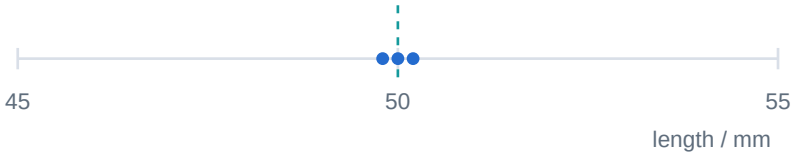
Usually the smallest scale division or last displayed increment. A finer resolution can reveal smaller changes, but cannot guarantee accuracy.

More decimal places are not evidence that a measurement is more accurate.

1 See spread and bias separately

Illustrative calibration measurements: the reference length is 50.0 mm (dashed marker).

A. TIGHT CLUSTER NEAR THE REFERENCE



High precision; the mean is close to the reference.

B. TIGHT CLUSTER SHIFTED TO ONE SIDE



High precision, but a biased result: check calibration.

C. WIDE SPREAD AROUND THE REFERENCE



Lower precision. The mean can still be near the reference.

RANDOM SCATTER

Unpredictable variation changes readings in either direction. Improve technique and take suitable repeats; averaging reduces its effect on the mean.

SYSTEMATIC BIAS

An offset or calibration error shifts readings consistently. Check zero and known standards; more repeats alone do not correct the bias.

IDENTICAL READINGS DO NOT MEAN ZERO UNCERTAINTY

A coarse instrument may round different values to the same display. Its resolution can hide real variation, and a systematic error may still be present.

2 Read what the instrument can show

Resolution is a property of the measuring system; total uncertainty also depends on how it is used.

WORKED EXAMPLE: A DIGITAL BALANCE

Display: 25.6 g Next increment: 25.7 g

Resolution = 0.1 g

$$\text{Half-resolution estimate} = \pm\frac{0.1}{2}\ \text{g} = \pm 0.05\ \text{g}$$

For the IAL single-reading convention, use half the resolution when no other uncertainty is specified. A stated instrument uncertainty takes precedence.

RECORD READINGS WITHOUT INVENTING DETAIL

Raw readings: 25.6 g, 25.7 g, 25.6 g

Keep the decimal places supported by this display. Writing 25.600 g as a raw reading would imply detail the balance did not measure. Keep extra calculator digits during processing, then round the final result appropriately.

RANGE IS NOT RESOLUTION

A balance may measure up to 2 kg while changing in 0.1 g steps. Range describes the values it can cover; resolution describes the smallest visible change.

FIX THE DOMINANT LIMITATION

A stopwatch showing 0.01 s does not remove human reaction delay. For a short transit, an automatic timing method may help more than extra display digits.

Source alignment: Pearson IAL Physics (YPH11), practical measurements.

Specification Appendix 10, pp. 77-78 | Student Practical Guide p. 13

Lesson numbering follows the Jimlaoshi course sequence.