LESSON 3.1.2

Choosing Apparatus and Controlling Variables

Choose tools that can resolve the change you expect, then isolate the variable whose effect you want to test.

RANGE: will it fit?

The instrument must cover every expected value. A pilot reading helps you choose a useful range without overloading a meter.

RESOLUTION: is it fine enough?

Resolution is the smallest distinguishable change. Compare it with the size of the quantity being measured.

MATCH THE INSTRUMENT TO THE QUANTITY

Wire diameter 0.01 mm; use the ratchet gently.	**Micrometer**
Cylinder diameter 0.1 mm for the specified calipers.	**Vernier calipers**
Wire length 1 mm divisions; align with the wire.	**Metre rule**
Short transit time Avoid manual reaction-time delay.	**Light gate + timer**
Current and p.d. Series / parallel; choose safe ranges.	**Ammeter / voltmeter**

Check the actual instrument: digital models can have different ranges, resolutions and specified uncertainties.

A finer scale does not remove zero error, poor alignment or heating.

1 Justify the measurement

Worked example: choose an instrument for a wire whose diameter is about 0.50 mm.

COMPARE THE SAME QUANTITY

Vernier calipers

Resolution: 0.10 mm

Single-reading estimate: ±0.05 mm

$$\frac{0.05}{0.50} \times 100\% = 10\%$$

Micrometer

Resolution: 0.01 mm

Single-reading estimate: ±0.005 mm

$$\frac{0.005}{0.50} \times 100\% = 1.0\%$$

Here, use half the resolution for a single reading, as specified for IAL practical analysis. Use a stated instrument uncertainty when one is supplied.

CHECK ZERO BEFORE MEASURING

Suppose the closed micrometer reads +0.02 mm. Its reading on the wire is 0.52 mm. Subtract the signed zero reading:

$$d_{corrected} = 0.52 - 0.02 = 0.50 \text{ mm}$$

Repeating an uncorrected measurement does not remove this offset.

MAKE THE TECHNIQUE PART OF THE METHOD

DIAMETER

Measure at several positions and orientations. Avoid crushing the wire. Inspect the spread before using a mean diameter.

LENGTH AND TIME

Read a rule at eye level. Time many complete oscillations, then divide by their number; a finer timer alone cannot fix reaction delay.

Resolution limits detail; calibration checks bias; repeats reveal random scatter. These are different improvements.

2 Control the cause of a change

Example: investigate how the resistance of a uniform metal wire depends on its length.

$$R = \frac{\rho L}{A}$$

At fixed material, temperature and cross-sectional area: R is proportional to L.

INDEPENDENT: length L

Move one contact along the same wire. Measure the wire length between the electrical contact points.

DEPENDENT: resistance R

Measure V across that length and I through it. Calculate R = V/I for each chosen length.

A CONTROL NEEDS BOTH A REASON AND AN ACTION

MATERIAL

Resistivity depends on material.

Use the same wire throughout.

AREA

A thicker wire has a lower resistance.

Use uniform wire; avoid stretching it.

TEMPERATURE

Metal resistance usually rises as it warms.

Use a low current; switch off between readings.

NOT EVERY QUANTITY SHOULD BE HELD CONSTANT

Current may change when length changes: measure it at every setting. The relevant control is wire temperature, not an assumption that current stays fixed.

Source alignment: Pearson IAL Physics (YPH11), Unit 3 planning and analysis.

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Lesson numbering follows the Jimlaoshi course sequence.