Moving on from GCSE

Three knowledges:
1. Mathematical skills
2. Linguistical skills
3. Practical skills

Practical skills

risk of harm to a person

- safety consideration of hazards and how to reduce risk
- group work everybody must participate in all aspects
- planning variables?
  - independent variable ← imposition of will to change
  - dependant variable ← changes as a consequence of indep. variable
  - control variable ← imposition of will to keep the same

  state how to manage variables.
  decide methodology, decide instruments
  decide the outcome ← how do you measure sucess?
- record results

  Single measurements, such as wire diameter
  diameter of wire, d/mm = 1.00, 1.01, 1.00 at least three times
  Draw table
  independent → dependent → processing
  Example:

wire length, l/m	resistance, R/Ω			Average resistance, $\langle R \rangle$/Ω
	1st set	2nd set	3rd set	
				± uncertainty

wire diameter, d/mm =
average wire diameter $\langle d \rangle$/mm = ± uncertainty

Making careful measurements

instruments: ruler, vernier calipers, micrometers, balance, protractors, stop watches, oscilloscope, thermometer, ammeters, voltmeters

Measurements must be valid (useful for the investigation)
Repeatable results (same results within experimental error when measured with same apparatus in the same way)
Reproducible results (same results with different instrumentation or methodology)

Errors are not mistakes

systematic errors — usually caused by instrumentation or methodology; if systematic error can be measured it can be removed - same bias for each measurement

random errors — spread of values for a single measurement

uncertainty — must be recorded for every measurement; ± uncertainty calculated as ½ range of values

$\langle d \rangle / \mathrm{mm} = 1.01 \pm 0.10$

Zero error — instrument shows non-zero value when should show zero; subtract zero error

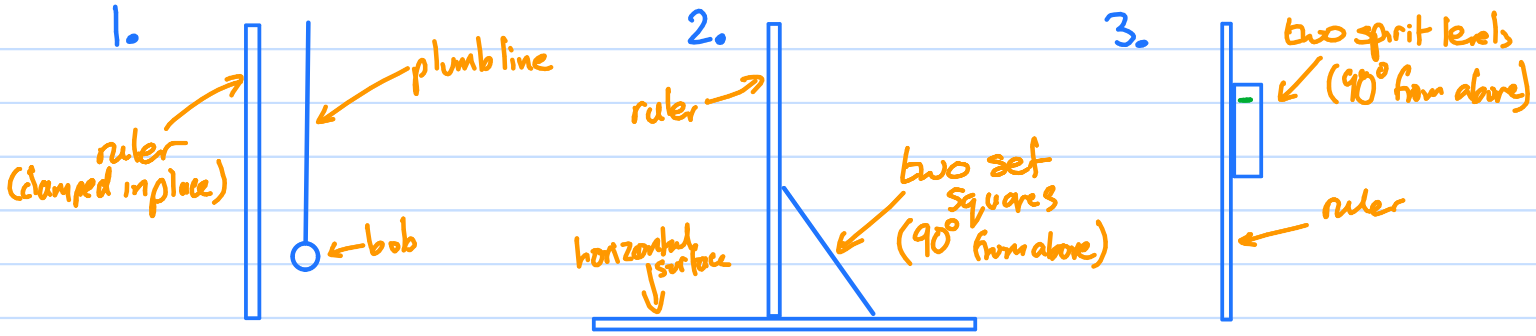
Accuracy — how close a measured value is to the true value

Precision — spread of reading — smaller spread means more precise

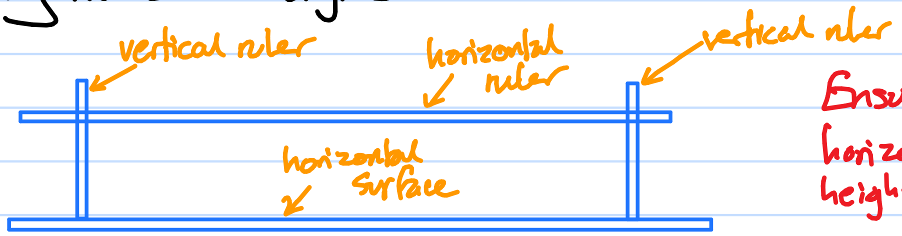
Resolution — the smallest measurable interval

Everyday physics instruments

Measuring heights – ruler must be vertical.

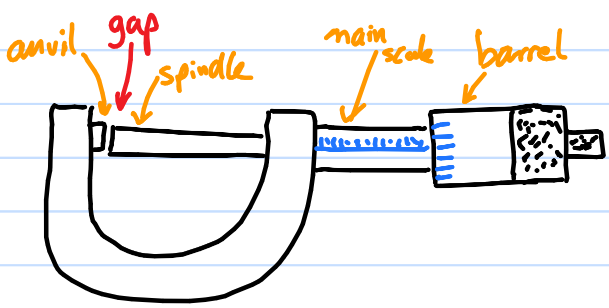


Measuring horizontal lengths –



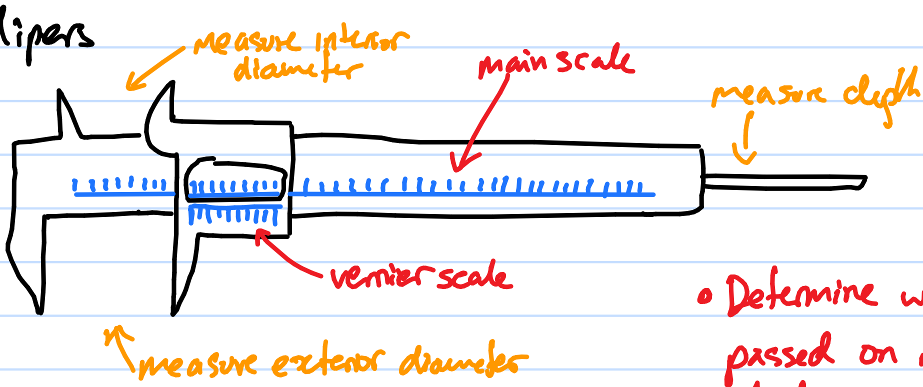
Ensure both ends of horizontal ruler are at same height

Micrometers



- When barrel rotated one full turn, gap increases 0.50mm
- Read off main scale (0.5mm resolution)
- read 100th of mm from barrel

Vernier calipers



- Determine where 0 on vernier has passed on main scale
- which vernier (0.1mm) line lines up with a main scale line

Timers when timing oscillations, DON'T start from first oscillation, start counting from zero, at least 10 oscillations, 40 is better

Balances Ensure zeroed at start, Ensure level.

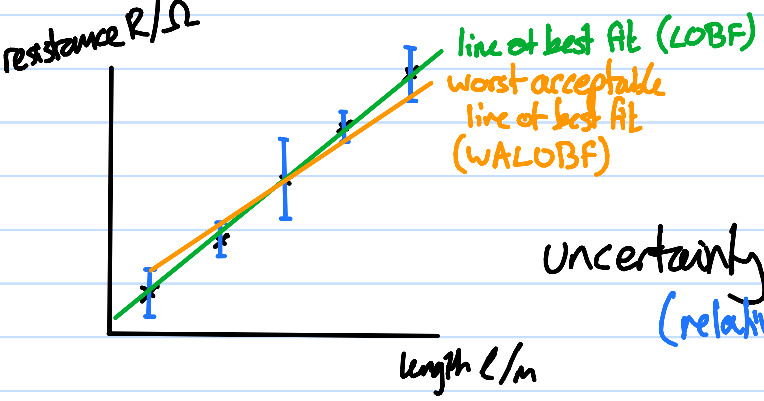
Analysis and evaluation

We must know the resolution of our instruments
smallest measurement interval

- uncertainty in a reading is ½ resolution
- Most measurements require two readings
- For digital instruments where first reading is zero, and you can set it to zero, uncertainty in first reading is zero.
- For analogue instruments each measurement has uncertainty equal to resolution
- for some digital instruments each measurement has uncertainty equal to ½ resolution

Repeat measurements can reduce uncertainty
- uncertainty of repeated measurement is ½ range

Processing with uncertainties



Difference between gradients is absolute uncertainty in gradient

$$\text{uncertainty in gradient} = \frac{\text{Gradient of LOBF} - \text{Gradient of WALOBF}}{\text{Gradient of LOBF}}$$

(relative uncertainty) (×100% for percentage uncertainty)

$$R = \frac{\rho}{A} l$$ should pass through origin

$$y = mx + c$$

$$\text{gradient} = \frac{\rho}{A} \qquad A = \frac{1}{4}\pi d^2$$

$$\rho = \text{gradient} \times \frac{1}{4}\pi d^2$$

- When quantities are multiplied or divided, we add relative uncertainties
- if quantity raised to a power, multiply relative uncertainty by the power

$$\text{relative uncertainty } \varepsilon x = \frac{\Delta x}{\langle x \rangle}$$ absolute uncertainty

- When quantities are summed or subtracted, we add absolute uncertainties

$$\text{absolute uncertainty } \Delta x = \langle x \rangle \varepsilon x$$

- Always present final answer in practical work with uncertainty

$$x = (\langle x \rangle \pm \Delta x) \text{ unit}$$

fill in numbers