Pearson Edexcel · International A-Level · Physics

Practical Skills ·

Units 3 and 6 are written papers about experiments: you are asked how to measure, what could go wrong, how to process data and how sure you can be. The questions are set around the sixteen core practicals, so for each one know the measurement that limits it and the graph that tests it. 3 6 : 16 、

Measuring – instruments and technique :

Metre rule – resolution 1 mm. Read at eye level, perpendicular to the scale, or use a set square to transfer a position to it

Vernier calipers – resolution 0.1 mm (some 0.02 mm); check the zero with the jaws closed before use

Micrometer screw gauge – resolution 0.01 mm; turn with the ratchet, check the zero error, and measure a wire's diameter at several places and orientations, then average

Light gate and data logger – removes reaction time from a timing; the card's length must be measured to find a speed

Oscilloscope – measure across several divisions – several cycles for a period – and multiply by the time-base or volts-per-division setting

For any repeating motion, time many cycles and divide. For a small length, measure many together (a stack of coins, ten wire turns side by side) and divide.

Uncertainty in one reading: half the resolution of the instrument, or half the range of repeated readings if that is larger. For a length read at both ends, use the full resolution.

Processing and uncertainty

Percentage uncertainty = uncertainty ÷ mean value × 100%. For a product or quotient, ADD the percentage uncertainties; for a quantity raised to a power n, multiply its percentage uncertainty by n – area from a diameter, $\pi d^2/4$, doubles the diameter's.

Percentage difference = |experimental − accepted| ÷ accepted × 100%. If it is less than the percentage uncertainty, the result agrees with the accepted value within the uncertainty of the experiment.

Unit 6: draw error bars, a best-fit line and a worst line (the steepest or shallowest through all the bars). Percentage uncertainty in the gradient = |best − worst| ÷ best × 100%.

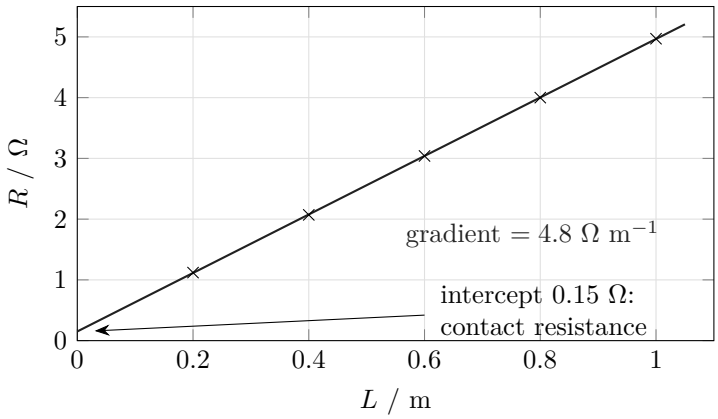
Prefer a gradient to a single calculation. A gradient is unaffected by a constant offset – a zero error, the resistance of contacts, a length measured from the wrong mark – which shows up only in the intercept.

Significant figures: give a final answer to the number of figures of the least precise data, usually 2 or 3, with its unit.

Worked analysis: resistivity of a wire (CP7) :

The diameter of a constantan wire was measured with a micrometer at six places: mean 0.36 mm ± 0.01 mm. Its resistance R was found from V and I for lengths L between the crocodile clips, at a low current so the wire stayed cool. $R = \rho L/A$, so a graph of R against L has gradient ρ/A.

L / m	0.200	0.400	0.600	0.800	1.000
R / Ω	1.12	2.07	3.04	4.00	4.97



The line misses the origin by the resistance of the clips and leads; the gradient does not include it.

1. $A = \pi d^2/4 = \pi \times (0.36 \times 10^{-3}\ m)^2 \div 4 = 1.02 \times 10^{-7}\ m^2$.

2. ρ = gradient × A = $4.8\ \Omega\ m^{-1} \times 1.02 \times 10^{-7}\ m^2 = 4.9 \times 10^{-7}\ \Omega$ m.

3. Uncertainty: diameter 0.01 ÷ 0.36 = 2.8%, so area 5.6%; gradient (from the worst line) about 2%. Total about 8%, so $\rho = (4.9 \pm 0.4) \times 10^{-7}\ \Omega$ m.

The diameter dominates the uncertainty because it is squared. Improvement: measure it at more places with the micrometer and use a thicker wire – but not so thick that the resistance becomes too small to measure.

The sixteen core practicals – what each one tests 16

CP1 Free fall – a light gate, or an electromagnet and trapdoor timer. $2h/t^2 = g$, or plot h against t^2 (gradient g/2). Air resistance and the release delay are the errors to name

CP2 Viscosity by falling ball – time the ball between two marks low enough that it has reached terminal speed (check equal times for equal distances); Stokes' law $\eta = 2r^2g(\rho_s - \rho_f)/9v$. Keep the tube wide so the walls do not slow the ball, and record the temperature

CP3 Young modulus – a long thin wire, a vernier or marker against a fixed scale, masses added and removed. Plot stress against strain in the linear region; the gradient is E. Wear eye protection and keep feet clear of the masses

CP4 Speed of sound – move a microphone away from the speaker until the oscilloscope traces come back into phase; that distance is one wavelength. Measure across several wavelengths, then $v = f\lambda$

CP5 Vibrating string – change ONE of length, tension or mass per unit length at a time, and compare the same harmonic. $f = (1/2l)\sqrt{(T/\mu)}$, so f against 1/l, or f^2 against T, is a straight line

CP6 Diffraction grating – measure the angle of each order from the straight-through position; $d \sin\theta = n\lambda$, with d = 1 ÷ lines per metre. Use the highest order you can see, and never look into the laser

CP7 Resistivity – as worked above: R against L, gradient ρ/A; low current, diameter measured with a micrometer in several places

CP8 E.m.f. and internal resistance – $V = \varepsilon - Ir$: plot terminal p.d. V against current I; the y-intercept is ε and the gradient is $-r$. Switch off between readings so the cell does not run down

CP9 Force and momentum change – a trolley pulled by a known force, its velocity from light gates before and after; compare $F\Delta t$ with $m\Delta v$

CP10 Collisions by video – film from directly above with a scale in the frame and a known frame rate; measure velocity components from successive frames and compare total momentum before and after, in two dimensions

CP11 Capacitor charge and discharge – $V = V_0 e^{-t/RC}$: plot ln V against t, gradient $-1/RC$. Start the time exactly when the switch moves, and discharge the capacitor before handling

CP12 Thermistor calibration – the thermistor in a potential divider, in a water bath with a thermometer; stir and wait for steady readings at each temperature. The calibration graph is a curve: read values from it, do not assume a line

CP13 Specific latent heat – a heater in ice (or boiling water) with a control funnel without the heater, to measure how much melts from the room alone; subtract it. L = energy ÷ mass changed

CP14 Pressure and volume – pump slowly and wait for the gas to return to room temperature before each reading; p against 1/V is a straight line through the origin for a fixed mass at fixed temperature. The tubing's volume adds a constant to V

CP15 Gamma absorption γ – measure the background count first and subtract it; count for long enough to reduce the random variation; ln(count rate) against thickness gives $-\mu$. Only the teacher handles the source, with tongs

CP16 Unknown mass by resonance – for a mass–spring system, $T^2 = 4\pi^2 m/k$: plot T^2 (or $1/f^2$) against m for known masses, then read the unknown mass from its period on the same graph

What examiners keep reporting

'Repeat and average' given as the answer to everything. It reduces random error only; a zero error, heat loss or the wrong time zero needs its own fix.

Instruments named without what they measure or their resolution. 'A micrometer, resolution 0.01 mm, to measure the diameter at several points' scores; 'a micrometer' does not.

Uncertainty in a calculated quantity that forgets the power: the diameter's percentage uncertainty is doubled in the area.

A safety precaution that does not match a hazard of THIS experiment: goggles because a stretched wire can snap, not 'be careful'.