

There is no practical exam: the required practicals are examined in the written papers, where at least 15% of the marks are about doing experiments. The questions ask for the method, the variables, the measuring instrument, the error and the improvement – so for each practical, know those five things.

Working scientifically – the words the questions use

Independent variable	– the one you change on purpose; it goes on the x-axis
Dependent variable	– the one you measure; it goes on the y-axis
Control variable	– one you keep the same so that it cannot affect the result. Say HOW you keep it the same
Resolution	– the smallest change an instrument can show – 1 mm on a metre rule, 0.01 g on a top-pan balance
Repeatable	– the same person, with the same method and equipment, gets similar results
Reproducible	– a different person, or a different method or equipment, gets similar results
Accurate	– close to the true value
Precise	– repeat readings are close to each other – little spread about the mean
Random error	– readings scatter unpredictably either side of the true value; repeating and taking a mean reduces its effect
Systematic error	– every reading is wrong by the same amount or in the same direction; repeating cannot remove it
Zero error	– an instrument that does not read zero when it should – a systematic error. Subtract the zero reading from every value
Uncertainty:	estimate it as half the range of the repeat readings. Readings 2.3 s, 2.5 s and 2.4 s have a mean of 2.4 s and an uncertainty of ± 0.1 s.

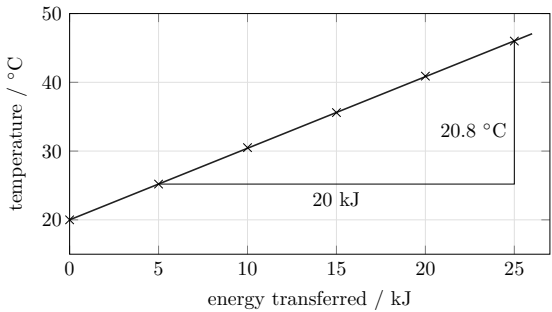
An anomaly is a result that does not fit the pattern. Leave it out of the mean, and say you would repeat that reading.

RP1 – Specific heat capacity

Aim: find the specific heat capacity of a metal block by heating it electrically and measuring its temperature rise.

1. Measure the mass of the block (a 1 kg aluminium block) on a balance.
2. Put the immersion heater and the thermometer into the holes in the block; add a drop of water to the thermometer hole so it is in good thermal contact. Wrap the block in insulation.
3. Connect the heater to a joulemeter (or to an ammeter and a voltmeter) and record the starting temperature.

4. Switch on and start the stopwatch. Record the temperature and the energy every minute for ten minutes. (Energy = potential difference $\times$ current $\times$ time if you used meters.)



Typical results for a 1.00 kg block. Gradient = $20.8\text{ }^{\circ}\text{C} \div 20\text{ }000\text{ J}$, so $c = 1 \div (\text{m} \times \text{gradient}) = 960\text{ J/kg }^{\circ}\text{C}$; the accepted value for aluminium is about $900\text{ J/kg }^{\circ}\text{C}$.

Why the value comes out too HIGH: energy is lost to the surroundings, so more energy is supplied for each degree of rise than the block actually absorbs. Insulating the block reduces this.

The first readings may lag behind: the heater has to warm up before the block does. Use the straight part of the graph.

RP2 – Thermal insulation (physics only)

Aim: compare how well different materials, or different thicknesses of one material, insulate a beaker of hot water.

1. Put the same volume of hot water, at the same starting temperature (about $80\text{ }^{\circ}\text{C}$), into a beaker wrapped in the material. Use a kettle and a measuring cylinder.
2. Put a lid on the beaker with a hole for the thermometer.
3. Record the temperature every minute for 10 minutes, or record the temperature drop after a fixed time.
4. Repeat with each material (or with 1, 2, 3, 4 layers), keeping the volume, starting temperature, beaker and lid the same.

The best insulator gives the SMALLEST temperature drop in the same time. A cooling curve that is shallower shows the slower rate of energy transfer.

Hazard: hot water scalds. Stand the beaker on the bench, not in your hand, and pour carefully.

RP3 – Resistance

Aim (a): find how the resistance of a wire depends on its length. Aim (b): find the total resistance of resistors in series and in parallel.

1. Tape a length of constantan wire along a metre rule. Connect a crocodile clip at the 0 cm mark and a second one on the wire.
2. Put an ammeter in series with the wire and a voltmeter in parallel across the length between the clips.
3. For lengths of 10 cm to 100 cm, close the switch, read the current and the potential difference, then open the switch again. Resistance = potential difference $\div$ current.
4. Plot resistance against length. Expect a straight line through the origin: resistance is directly proportional to length.

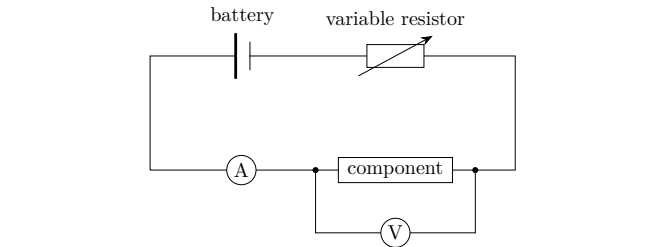
Keep the current LOW and switch off between readings. A warm wire has a higher resistance, which would change the variable you are not studying.

If the line does not pass through the origin, the crocodile clips are not at the true zero, or the contacts have resistance of their own – a systematic error.

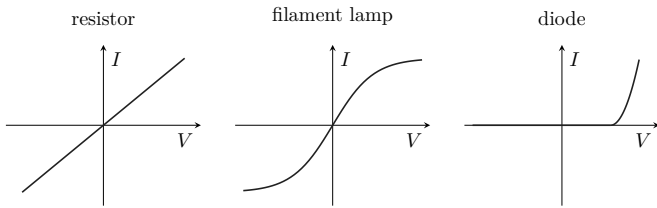
(b) Adding a resistor in series increases the total resistance; adding one in parallel DECREASES it, because the current gains another path.

RP4 – I–V characteristics

Aim: plot current against potential difference for a resistor, a filament lamp and a diode.



Ammeter in series, voltmeter in parallel across the component. The variable resistor changes the current; swap the battery’s connections to take negative readings.



The three characteristics. Only the resistor (at constant temperature) is ohmic: a straight line through the origin.

Filament lamp: as the current rises the filament gets hotter and its resistance increases, so the graph curves towards the V-axis.

Diode: current flows in one direction only, and only above about 0.6 V; in the reverse direction its resistance is very high.

RP5 – Density

Aim: find the density of regular and irregular solids and of a liquid, using density = mass ÷ volume.

Regular solid – measure length, width and height with a ruler (or vernier calipers for a small object); volume = $l \times w \times h$; mass on a balance

Irregular solid – fill a eureka (displacement) can to the spout, lower the object in on a thread, and collect the water that overflows in a measuring cylinder: its volume is the object’s volume

Liquid – zero (tare) a balance with an empty measuring cylinder on it, pour in, say, 50 cm³ of liquid, and read the mass

Read the measuring cylinder at the bottom of the meniscus, at eye level. Wait for the eureka can to stop dripping before you start, and again before you read.

RP6 – Force and extension

Aim: find how the extension of a spring depends on the force applied to it.

1. Hang the spring from a clamp, with a metre rule clamped vertically beside it and a pointer fixed to the bottom of the spring.
2. Record the pointer’s position with no mass on the spring – the original length.
3. Add 100 g masses (each about 1 N) one at a time, recording the pointer’s position each time with your eye level with the pointer.
4. Extension = new length – original length. Plot force (y) against extension (x).

Force / N	Length / cm	Extension / cm
0.0	20.0	0.0
1.0	22.4	2.4
2.0	24.9	4.9
3.0	27.3	7.3
4.0	29.8	9.8
5.0	32.2	12.2
6.0	35.4	15.4

Up to 5.0 N the extension rises by about 2.4 cm for each newton. The 6.0 N reading stretches further than that: the spring has passed its limit of proportionality.

Spring constant k = force ÷ extension, in metres: $5.0 \text{ N} \div 0.122 \text{ m} = 41 \text{ N/m}$. On the force–extension graph it is the gradient of the straight part.

Plot EXTENSION, not length. Length does not start at zero, so a length graph never passes through the origin and cannot show proportionality.

RP7 – Acceleration

Aim: find how the acceleration of a trolley depends on the force on it (and, separately, on its mass).

1. Attach a string to the trolley, run it over a pulley at the end of the bench, and hang a mass hanger from it. The hanging weight is the accelerating force.
2. Mark two lines on the bench; time the trolley between them with light gates (or record its motion with a ticker timer), and calculate the acceleration.
3. To change the force without changing the mass being accelerated, move masses from the trolley to the hanger one at a time.
4. Plot acceleration against force: a straight line through the origin shows that acceleration is proportional to force.

Friction acts against the force. Tilt the runway slightly until the trolley rolls at a steady speed when pushed: friction is then compensated for.

To study mass, keep the hanging force the same and add masses to the trolley: acceleration is inversely proportional to mass.

RP8 – Waves

Aim: measure the frequency, wavelength and speed of waves in a ripple tank and on a stretched string.

Ripple tank – a lamp above the tank casts the waves’ shadows on paper below. Measure across ten wavelengths with a ruler and divide by ten; count the waves passing a point in 10 s for the frequency; $v = f \lambda$

Stretched string – a vibration generator drives the string; adjust the frequency until a clear standing wave forms. Measure across several half-wavelengths (loops) to find λ ; read f from the signal generator; $v = f \lambda$

Measuring across many waves and dividing reduces the uncertainty in one wavelength – a single wavelength is too small to measure accurately.

Hazard: water near the mains lamp. Keep it on a dry bench and do not touch the lamp with wet hands.

RP9 – Infrared radiation

Aim: find how the colour and texture of a surface affect the infrared radiation it emits.

1. Fill a Leslie cube with hot water from a kettle. Its four faces are matt black, shiny black, matt white and shiny silver.
2. Hold an infrared detector (or thermometer) the SAME distance from each face, and record the reading.
3. Compare the faces quickly, before the water cools.

Matt black emits the most infrared, shiny silver the least. Good emitters are also good absorbers.

Control: the same distance from each face, and the same detector. The water cools while you work, which is why the readings should be taken in quick succession.

RP10 – Reflection and refraction (physics only)

Aim: investigate the reflection of light by different surfaces and the refraction of light by different substances.

1. Draw round a glass or Perspex block on paper and draw a normal (a line at 90° to the surface) where the ray will enter.
2. Shine a narrow ray from a ray box at the block along a line at a measured angle to the normal.
3. Mark the ray where it enters and leaves the block with small crosses, then remove the block and join them with a ruler.
4. Measure the angles of incidence and refraction FROM THE NORMAL with a protractor. Repeat for several angles, and for other materials.

The ray bends TOWARDS the normal entering the glass and away from it leaving. For a mirror, the angle of reflection equals the angle of incidence.

A narrow ray and a darkened room make the angles easier to measure. The ray box gets hot: let it cool before you move it.

Questions examiners ask about every practical

‘Name a control variable’ – name it AND say how it was kept the same: ‘the same volume of water, measured with a measuring cylinder’.

‘Why repeat the readings?’ – to identify anomalies and to calculate a mean, which reduces the effect of random error. Repeating does not make the results more accurate if there is a systematic error.

‘Suggest an improvement’ – name something specific: insulation for heat loss, light gates for timing, a pointer for parallax, a narrower ray for angles. ‘Be more careful’ scores nothing.

‘Describe the pattern’ – use numbers from the data: ‘when the force doubled from 2.0 N to 4.0 N the extension doubled from 4.9 cm to 9.8 cm, so they are directly proportional’.

‘Give a hazard and a precaution’ – the hazard must belong to THIS practical (hot water, a hot ray box, a falling mass) and the precaution must match it.