

## Practical Skills

### Planning

**Variables** are any quantity which might change the results in an experiment. One variable (the **independent variable**) is the one you choose to change during the experiment.

Another variable (the **dependent variable**) will change as a result of the change in the independent variable and you measure this.

Other variables must be **controlled** (kept the same) so they do not affect the result. This is necessary to ensure that the conclusions are **valid**.

You should ideally choose at least **6** different values for your independent variable (5 is usually OK at GCSE) and these should be **spread evenly over as large a range as possible**.

You should carry out **repeats** of your measurements. Any **anomalies** should be identified but not used. The **mean** should be calculated for **concordant** (similar) data.

If any quantities have to be calculated, these should have their own column in the results table (with correct heading and units) and the method should include the formula used to determine the value.

### Anomalous values in tables

An anomalous value is one which is **much further away from the mean** than the other results.

It is not concordant and should not be included when calculating a mean value.

### Measurements

You should state all the quantities that need to be measured **and** state the apparatus you will use to measure them. Common examples are:

- Measure **distance** using a metre rule/30 cm ruler/tape measure
- Measure **time** with a stopclock
- Measure **mass** with a balance
- Measure **force** with a newtonmeter or, for weight, use the mass and multiply by g (=10 N/kg)
- Measure **angles** using a protractor
- Measure **temperature** with a 0-100 degree thermometer
- Measure **potential difference** (voltage) with a voltmeter
- Measure **current** with an ammeter
- Measure **volume of a liquid** using a measuring cylinder

### Recording results

Measurements should be recorded in **tables** (without modification) to the same level of precision as the measuring equipment. This should mean that all the measurements recorded in the same column should be recorded to the same number of decimal places eg all to 1 dp. Don't forget **.0** as this shows the level of precision of your measurement.

Headings should state the quantity and give the **unit** of your measurements.

### Graphs

Choose **sensible scales** (eg don't go up in 3s!) and use **more than half** the graph space in each direction so your plotted points use up more than a quarter of the graph area.

Plot all points accurately to the nearest half small square (they will check!) and if there are any points that don't fit the general pattern, **check you have plotted them correctly** and they are genuinely anomalous.

Draw a line (could be straight or curved) of best fit. If the points do not fall on a perfect line then your line of best fit should have equal scatter of points on either side of the line.

The **gradient** of a **straight line** should be found using a large triangle. Gradient =  $\frac{\Delta y}{\Delta x}$  ('rise over run').

The **gradient** at a given point on a **curve** should be found by carefully drawing a **tangent** (a line which just touches the curve and looks 'symmetrical' to the curve at that point). The gradient is found the same way as above.

### Anomalous points on graphs

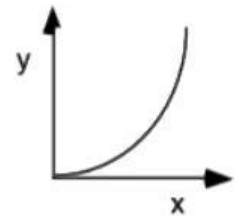
This is a point that does not follow the general pattern of the other points. It should be identified eg by drawing a circle around it and you should ignore it when choosing where to draw your line of best fit.

### Analysis of results

You should be able to identify common relationships.

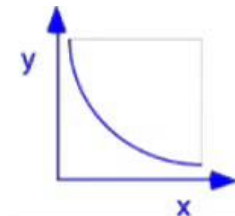
- A straight line shows a **linear** relationship. A curve shows a **non-linear** relationship.
- A general upward line or curve shows one variable increases when the other is increased.
- A general downward line or curve shows one variable decreases when the other is increased.
- A **straight line through the origin** shows that the variables are **proportional**
- If the upward curve is getting steeper from left to right,  $y$  increases as  $x$  increases and  $y$  increases more at higher values of  $x$ .

Note: Don't use the term 'exponential increase' unless this is mathematically correct as this term has a precise meaning.



- If the downward curve is getting less steep, then  $y$  decreases when  $x$  is increased but  $y$  decreases less at higher values of  $x$ .

Note: Don't use the terms 'inversely proportional' or 'exponential decrease' unless this is mathematically correct as these terms have a precise meaning. For  $x$  and  $y$  to be 'inversely proportional' a graph of  $y$  against  $1/x$  would be a straight line through the origin.



- If the graph has distinct sections, then describe the pattern for each section and quote the values at which each section starts and finishes.

Eg for the first 10 seconds velocity is constant. From 10s to 25 s the velocity is increasing with constant acceleration. From 25 s to 50 s the velocity is increasing with decreasing acceleration.

- To **compare** two graphs, remember that compare means **similarities** and **differences**. Look at the number of marks available to estimate the number of each you need to identify.

### Improvements

To improve the quality of your data you could:

- Extend the range of your data
- Carry out additional measurements using values for your independent variable which are between those already made
- Carry out repeats (if not already done)
- Get another person to repeat the experiment
- Use measuring equipment with smaller divisions. Be specific eg use a thermometer with  $0.1^{\circ}\text{C}$  divisions
- Use light gates to stop and start a stop clock without uncertainties due to human reaction time (DO NOT just refer to 'human error'!)
- Use temperature sensors connected to a data logger, to record results at smaller time intervals, over a longer period of time or remotely
- To develop the investigation, another variable could be investigated either by using a different value for that variable and repeating the existing experiment, or by making the new variable the independent variable and keeping the original independent variable constant.