CHAPTER

13 Practical investigations

KEY IDEAS

At the end of this chapter you should be able to:

- explain why we do investigations
- consider and select a topic to investigate
- submit a research proposal to your teacher
- keep a logbook
- investigate different types of variables, such as independent, continuous and discrete variables
- select suitable measuring instruments to use in an investigation
- find patterns in the relationships between quantities under investigation
- use software programs
- handle difficulties
- work safely
- write a report.

As part of Unit 2, you will do a practical investigation on an aspect of the Motion Area of Study or one of the 12 options.

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What is the benefit to you?

The practical investigation lets you follow your own interests. Enjoy creating solutions to questions that are important to you, managing your work and telling others about what you have done. Your study of Physics should help you to be more scientific.

Reflect on what it means to be 'scientific', and the characteristics of scientific ways of doing things compared to non-scientific ways. You will improve your ability to solve problems, use resources and communicate ideas. These attributes are useful in everyday life and highly valued in the workplace.

Being scientific means making use of observations, experiments and logical thinking to test ideas.

What is involved?

Many of the experiments you have done as part of this course were designed with clear instructions and specific questions to answer. In this investigation, there is more responsibility on you to plan and carry out the task. It gives you the opportunity to show your skill and imagination in experimental design, commitment to a task and your communication ability in explaining your results.

The topic can be one of your choosing and you can work individually or with another student. It is a rare topic that requires three pairs of hands and eyes.

The investigation will require a significant amount of class time. Your teacher will set aside two to three weeks for the activity, so some planning and organisation on your part will be needed to achieve a personally satisfying outcome. The table below will assist with your planning.

TABLE 13.1 Investigation planning with sample schedule

Task	Due date
Your teacher spends some class time to: • introduce the task • explain what is expected of you • suggest some possible topics or brainstorm others with the class • outline the timeline • distribute a form for you write down one or more topics you would like to investigate.	Fri. 25 Aug
Return your list of possible topics for approval.	Wed. 30 Aug
Submit a detailed research proposal for your approved topic.	Mon. 5 Sept
Requested equipment is assembled by the teacher and lab technician.	Fri. 9 Sept
Investigation begins.	Mon. 12 Sept
Cycle of measurements and data analysis leading to a review of progress and further, more detailed measurements.	Tues. 13 Sept
Use some holiday time to refine graphs and plan write-up of report, etc.	Fri. 30 Sept
Cycle continues.	Mon. 3 Oct
Pack up equipment.	Tues. 11 Oct
Write sections of report and place them into a poster template.	Wed. 12 Oct
Submit finished report.	Fri. 14 Oct

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Selecting a topic

Coming up with a topic is not something that happens straight away. You need to take some time to consider it. You want to investigate a topic that interests you, that provides opportunity for some challenge, yet can be done in the time available and with the resources available within the school.

Brainstorming a list of possible topics is a good way to start:

- Form a group of three to five and appoint a leader.
- Draw a grid on a large sheet of paper with headings across the top such as: Hobbies and interests, Sports, Science in the news, Investigations you did in previous years, and Course topics. Down the side have types of investigations such as: Investigating the operation of a device or technology, Solving a technological problem, Investigating a physical phenomenon.
- Pick a box from the grid and brainstorm some topics for that box, then move onto another one.
- If other groups have done the same task, combine your entries with theirs.

Hints for brainstorming:

- Concentrate on quantity, not quality. Get down as many ideas as you can, as fast as you can. Resist the temptation to evaluate as you go — do that later.
- Be prepared to be outlandish. Humour is creative. Ideas that are preposterous might trigger ideas that are not.

Practical investigations have been a popular feature of physics courses in many countries for several decades, so there are thousands of possible topics if you search around. Some are listed below, and a document that contains weblinks and many more additional topics can be found in your eBookPLUS. You should check through these lists and see what sparks your interest because choosing a topic that intrigues you will ensure a high level of commitment and a sense of pride in the finished work. Avoid seemingly sophisticated topics, everyday topics are not only readily accessible and initially straightforward to investigate, but they often have hidden subtleties.

Turning the topic into a good question

Turning the topic into a question focuses your mind on what you want to find out. The question needs to be:

- one that experimenting can answer
- one worth investigating to you
- practicable, given your knowledge, time and the school resources
- asked in a way that indicates what you will do.

Submitting a research proposal

Once your teacher has approved your topic, the real work begins. On the next page is a typical proposal sheet that you could be asked to complete.

Keep a log

Use a separate, bound exercise book. Use it for thinking, calculating, drawing, leaving messages and preparing your report. You can use it to record your data if you don't want to use a computer. You can use the logbook to show your teacher how your work is progressing. Your logbook will also be assessed by your teacher.

Your logbook can include:

- your initial ideas
- notes from brainstorming
- notes from background reading
- equipment set up and plan
- your observations, measurements, data analysis and graphs
- difficulties you experience.

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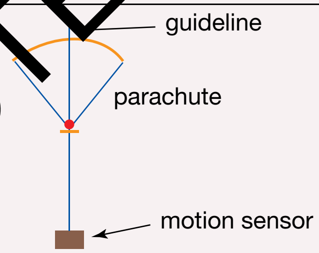
Practical investigation protocol

Name:	Jac
Partner's name (optional):	Jill
Title of your investigation:	Performance of a parachute
Investigation's purpose: (A brief sentence, but needs to be precise)	To investigate how the initial acceleration and terminal velocity of a parachute depend on the falling mass and the diameter of the air vent
Write down three starting questions you want to answer. (These are to help focus your planning.)	How quickly does a parachute reach terminal velocity? Does the air vent make a difference? Is the mass on the end a significant factor in determining the terminal velocity?
List independent variables; indicate which are continuous and which are discrete; list dependent variables. (Shows if you have thought of all the obvious variables)	Independent: falling mass, diameter of air vent, diameter of open canopy, number of strings supporting the mass, mass and type of canopy material Dependent: final terminal velocity, initial acceleration, distance and time to reach terminal velocity.
List the physics concepts and relationships you expect to use in your investigation. (Gives an indication of the extent of your understanding of the topic)	Air resistance increases with speed until the upward force balances the downward weight force, at which point the net force is zero and the parachute does not accelerate. The raw data is position of the parachute against time. From this, the speed in each interval can be calculated using $v = \frac{\Delta x}{\Delta t}$, and the acceleration between intervals can be calculated from $a = \frac{\Delta v}{\Delta t}$.
List the equipment and measuring instruments that you plan to use. (For your teacher to see whether you have the right tools for the task.)	Parachute: cloth, light string, scissors, plasticine, cardboard to reflect ultrasound, small disc with holes to attach strings, mass and cardboard Ruler, light cotton or fishing line to prevent swaying and parachute going off line Ultrasound motion sensor connected to computer, top-loading balance, protection for motion sensor from falling parachute
Sketch your experimental set up. (This will make your first day of investigating smoother and your teacher may be able to suggest refinements.)	
List the steps in your experimental design. (An important stage in your planning that gets your teacher to see if you have forgotten anything.)	1. Assemble parachute, set up equipment and do trial run. Release parachute in open position. 2. Start with a small air vent of 1 cm diameter. 3. Do at least three drops with each mass. Look at graph each time to see if the drop should be retained and if five good drops are needed. 4. Increase the mass and repeat drops. Do this for at least seven masses. Check graphs to see if pattern suggests more smaller, larger or in between mass values are needed. 5. Increase (possibly double) diameter of air vent and repeat drops for same mass values at least initially, but may need to use other values. 6. Repeat for another much larger air vent diameter. Do a fourth diameter if we have the time.
Any special requests (e.g. equipment may need to be left set up between classes, or access needed outside class time)	It would be handy if we could leave the guideline attached to the ceiling between classes or possibly stay on at lunchtime on Wednesdays.

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Variables

Variables are the physical quantities that you measure. You set the value of some variables at the start of each experiment; other variables are determined by your experiment, and sometimes there are variables that you calculate using your measurements.

Independent variables are changed in an investigation to observe their effect on another variable.

Continuous variables take a numerical value. They can be represented as a line graph.

Discrete variables may include different types of categories such as colour. They can only be presented as a column graph, not as line graphs.

Dependent variables are determined by the independent variables.

Independent variables are variables whose value you determine. You would not investigate all independent variables, you would choose just two that interest you. Your report should still mention all independent variables to show your deep understanding of the problem you are investigating. The variables you don't investigate will have constant values during your experiment, so they could be called *fixed* or *controlled variables*.

There are two types of independent variables:

1. **Continuous variables** are variables that can take any numerical value, such as the release height of a parachute. This means they can be graphed using *x*–*y* axes. A graph can reveal a relationship between two quantities.
2. **Discrete variables** are variables that allow for different types, like different material for parachutes, rather than different numbers. These can only be presented as a column graph that enables comparison.

Dependent variables are variables that come from your experiment. Their values are determined by the independent variables. You would not analyse all dependent variables; normally just one would suffice.

Sample problem 13.1

Jac and Jill were considering investigating the impact and rebound of a bouncing basketball. The variables they considered were: drop height, air pressure in the ball, temperature of the ball, different surfaces, different brands of basketball, the age of the basketball and the height the ball achieved on first bounce. Which of these are dependent variables?

Solution: The height the ball achieved on first bounce is the dependent variable, all the other variables are independent as they can be changed to alter the outcome of the experiment.

Sample problem 13.2

Which of the examples below are continuous variables?

(a) Weight of a basketball
(b) Number of basketballs used in an investigation
(c) Type of material of which the basketball is constructed
(d) Age of students in a class

Solution: (a) and (d). The continuous variables are the weight of a basketball and the age of students in a class.

Revision question 13.1

Consider the variables that Jac and Jill were considering in sample problem 13.1. Classify these variables into the two categories: continuous and discrete.

Revision question 13.2

A student wishes to investigate the impact and rebound height of a bouncing basketball. List as many dependent variables as you can think of, including ones that can be calculated from others.

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Selecting your measuring instruments

Your school will have a range of measuring instruments. They will vary in precision and ease of use.

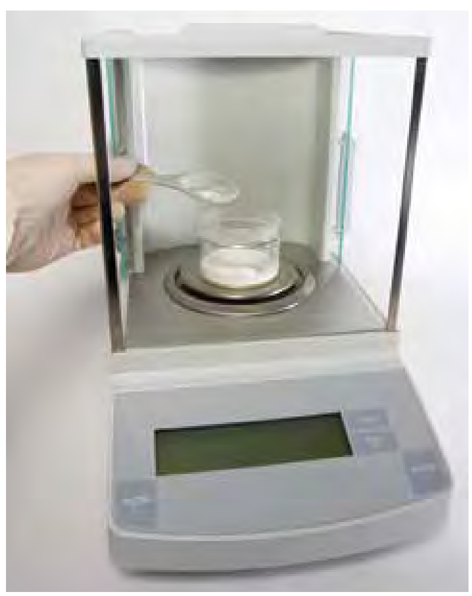
You won't always need to use the most accurate instrument. A simple instrument that allows for quick measurements will be enough more often than not. Sometimes a simple stopwatch is just as good as an electronic timer, and a beam balance may compare well to a very accurate top loading balance.

Some instruments that you might to consider are listed below based on what they measure.

Mass

- Slotted masses of known mass. Simple to use; accurate; comes only in multiples of a set weight, e.g. 50 g.
- Beam balance. Accurate with a large range of values; can be time consuming to measure several masses.

- Spring balance. Quick to use; covers a large range of masses; not very accurate.
- Top loading balance. Very accurate; very good for small masses; simple to use.



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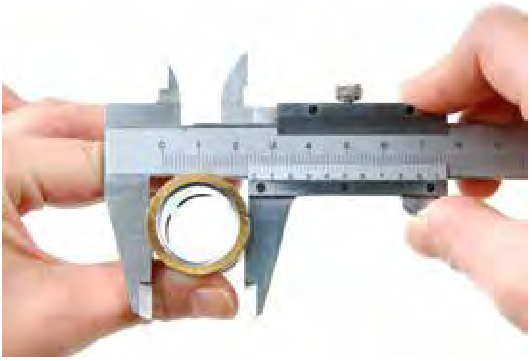

Length

- Metre ruler. Accurate; good for a range of distances; can be read to about 0.5 mm.
- Vernier calliper. For precision measurement of short distances; takes some time to learn how to use.
- Micrometer. For precision measurement of thicknesses; takes some time to learn how to use and can be easily damaged.

Time

- Stopwatch. Simple to use; accurate down to your response time; not reliable for short time intervals.
- Electronic timer. Requires some instruction; very accurate; best suited for short time intervals; can be used with electrical contacts and photogates.

Motion

- Ticker timer. Simple to use; limited in accuracy; best with objects moving over a short distance; can be time consuming to analyse.
- Air track. Very accurate, particularly if used with photogates; very effective in studying collisions; takes some time to set up, but data collection is very efficient once done.

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- Ultrasound motion detector. Quite accurate; useful with real motions; lots of data which means data analysis in Excel can be time consuming.
- Video with analysis software. Quite accurate; requires some setting up; data obtained from software; data analysis in Excel can be time consuming. Free video motion analysis software are Tracker and PhysMo. Digital cameras with high-speed video are useful for measurement of short, fast events.

Electrical

- Meters: Voltmeters, ammeters, galvanometers. Easy to set up, but care is needed to ensure the meter is wired into the circuit correctly, otherwise the meter can be damaged; large range of values; usually analogue displays.
- Multimeters. Easy to set up; more tolerant of incorrect use, but can be damaged if incorrectly connected to a high current; large range of values; usually digital displays.

Specialist equipment

- Cathode-ray oscilloscope (CRO). Even though the CRO is basically a visual voltmeter, it is a versatile instrument. It can measure both constant and varying voltages. The sweep of the trace across the screen can be used to measure time intervals of the order of millionths of a second. Many transducers, such as microphones, produce a voltage that can be displayed on the screen, either for analysis or measurement of very short time intervals. There are also computer versions of CROs that can be freely downloaded.
- Data loggers. There are sensors now available for most physical quantities, such as temperature, pressure, light intensity, motion, force, voltage, current, magnetic field, ionising radiation. The recording of data by these sensors for later analysis greatly facilitates practical investigations.
- Apps. There are increasing numbers of apps that perform measurement functions. The accuracy of each needs to be confirmed before being used in a formal investigation, but it is an area worth exploring. Some sources include Physics Toolbox and Sensor Kinetics

Making the most of a measurement

Limits to precision and uncertainty

Every instrument has a limit to how precisely it measures. The scale or digital display imposes a constraint on how many digits you can record. The scale or display also reveals the tolerance of the measurement.

A metre ruler has lines to mark each millimetre, but there is space between these lines. You could measure a length to the nearest millimetre, but because of the space between the lines, if you look carefully, you can measure to a higher precision. You can measure to the nearest 0.5 mm.

The best estimate for the length of the red line in the figure above is 2.35 cm. The actual length is closer to 2.35 cm than it is to either 2.30 cm or 2.40 cm. The measurement of 2.35 cm says the actual length is somewhere between 2.325 cm and 2.375 cm.

The way to write this is:

The length of the red line = 2.35 ± 0.025 cm

The 0.025 represents the tolerance or uncertainty in the measurement.

In this case, with well-spaced millimetre lines, the tolerance is $\frac{1}{4}$ of the smallest division. For a dense scale where measurement lines are close together, the tolerance would be $\frac{1}{2}$ of the smallest division.

The reading on a digital scale is 8.94 grams. This means the mass is not 8.93 g nor 8.95 g. The actual mass is somewhere between 8.935 and 8.945 grams. The way to write this is:

The mass = 8.94 ± 0.005 g.

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Sample problem 13.3

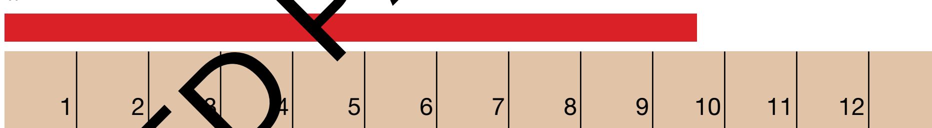
Record the reading on the scales below, including the tolerance.

Solution: The scale shows 0.250 g, so the actual weight may be between 0.2495 g and 0.2505 g. The mass is written as 0.250 ± 0.0005 g.

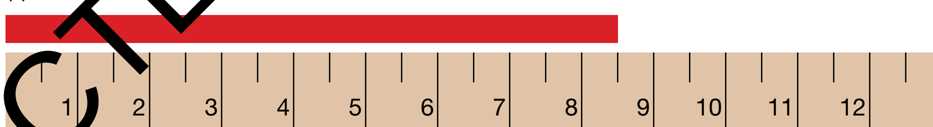
Revision question 13.3

(a) **Determine the length of each line in the diagram below, showing the tolerance in each case.**

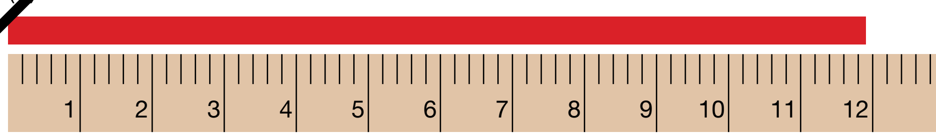
(i)

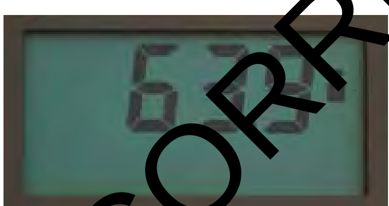


(ii)



(iii)





(b) **Record the reading on the scales at left, including the tolerance.**

Repeated measurements

Measurements of independent variables are usually precise and careful, so one measurement should be enough. However, measurements of the dependent variables are often prone to some variation.

Whether the variation is caused by the human reaction time when using a stopwatch, judging the rebound height of a basketball or in the case of the parachute, the unpredictable way the canopy will open each time, each reading may be different. So it is sensible to take several readings to obtain an average. You would expect that at least three measurements would be needed, and possibly five, but more than five is generally unnecessary.

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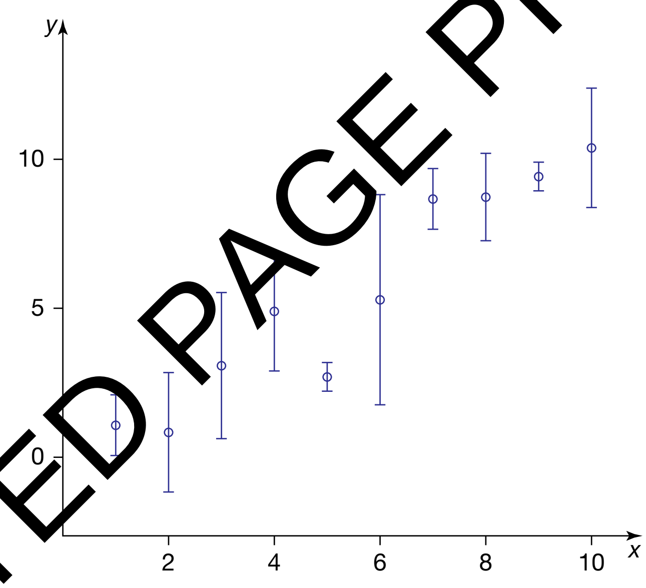
In some instances the variation between different readings will exceed the precision of the instrument. To determine which value you plot, you would use the average as well as the spread of the readings. For example, if your partner dropped the basketball from a height of 80.0 cm, and you judged the rebound height of the ball for five trials as: 68 cm, 69.5 cm, 68.5 cm, 68.5 cm and 69.5 cm. The average is 68.8 cm, which you would round to the nearest 0.5 cm because of the difficulty of judging a moving ball, giving an average of 69 cm. The full range of your measurements is from 68 cm to 69.5 cm, so your uncertainty would need to be 1 cm to cover the full range. This set of measurements would then be written as 69 ± 1 cm.

This format is useful in two ways: graphing and calculating.

When you graph your results, the number you will plot is 69 cm. To represent the '±1 cm', you can draw a line through the point, up 1 cm and down 1 cm, with a short line across the top and bottom of the line to make the ends evident.



Example of error bars

Rather than graphing rebound height against drop height, it is more revealing of the physics of the situation to calculate and graph the ratio of the rebound height to drop height against drop height. The ratio is a measure of how much of the original gravitational potential energy is restored.

In this case the ratio would be $\frac{69}{80.0} = 0.8625$, but how many digits are we entitled to use and how big should the error bar be? The first question is reasonably straightforward. The number of digits in your answer should equal the smallest number of digits in the data you used in the calculation. In this instance the average height has two digits, so the answer would be written as 0.86. You are not justified in including more digits because you don't know the original data accurately enough.

Working out the size of an error bar takes more effort. If the two pieces of data are 69 ± 1 cm and 80.0 ± 0.3 cm, we can just add the uncertainties to get ±1.3 cm, but that doesn't make sense when the calculated value is 0.86. Dividing the uncertainties would produce another unusual result.

The method used is to first express the uncertainty for each data value as a percentage. For example:

$$\text{Percentage error of } 69 \pm 1 \text{ cm} = \left(\frac{1}{69}\right) \times 100 = 1.4\%$$

$$\text{Percentage error of } 80.0 \pm 0.3 \text{ cm} = \left(\frac{0.3}{80}\right) \times 100 = 0.4\%$$

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Now add the two percentage errors together:

Total percentage error = 1.4% + 0.4% = 1.8%

Next use this total percentage error to find the error in the calculated answer.

Error = 0.86 × 1.8% = 0.016, which would be rounded to one digit as 0.02.

The full calculated answer would now be 0.86 ± 0.02.

The percentage errors are added together regardless of whether the data values are divided, multiplied, added or subtracted. For example:

- Calculating speed using $v = \frac{\Delta x}{\Delta t}$, the percentage errors of displacement and time would be added together.
- Calculating momentum using $p = mv$, the percentage errors of mass and velocity would be added together.
- Calculating the change in momentum using $\Delta p = p_{final} - p_{initial}$, the actual uncertainties of each are added together.

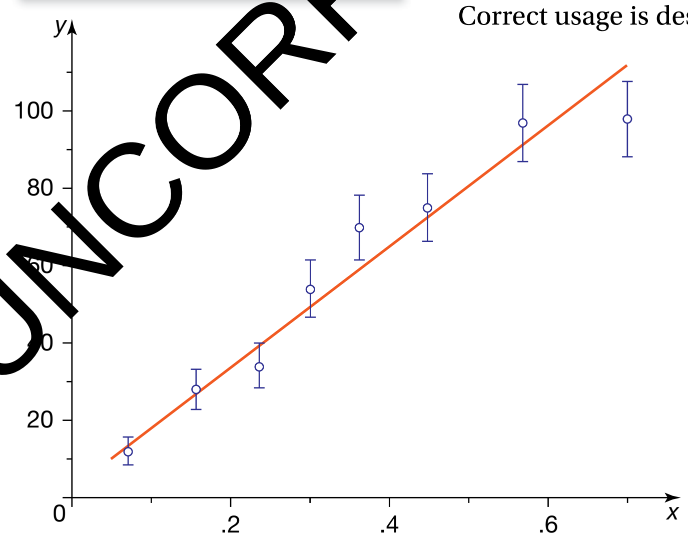
Finding patterns

Graphs are an effective way of summarising your data and looking for a physical relationship between the quantities you are investigating.

To present your data clearly, your graph should have the following features:

- Each axis labelled with the physical quantity it represents. It is convention to put the independent variable on the *x*-axis and the dependent variable on the *y*-axis. You want to find out how '*y*' depends on '*x*'. So, you might graph terminal velocity on the *y*-axis and mass on the *x*-axis.
- A scale with the units displayed.
- Include the origin, the zero value for the variables, on both axes. Sometimes the origin is a data point, even though you did not technically measure it. For example, if the drop height is zero, the rebound height would also be zero and so the origin is a data point, but the energy lost cannot be determined and is not a data point. The inclusion of the origin on the axes makes any relationship more apparent. Truncating the values on either the *y*- or *x*-axis exaggerates the variation in the data, and may disguise any relationship between the variables.
- Error bar for each data point. Sometimes, given your scale, the error bars will be too small to be seen and so would not be worth including. If you are using Excel to generate your graphs, be careful when using the error bar facility. Correct usage is described below.

Graph showing a line of best fit



Drawing a line of best fit

A line of best fit summarises your graph. The line can be used to find the gradient of your graph and also a *y*-intercept.

The line of best fit doesn't need to pass through each data point, although you should try to draw the line through each error bar if possible, but you may not be able to go through all of them. As a general rule, try to have as many data points above your line as you have below. Don't assume your line must pass through the origin.

Of course, not all graphs can be summarised by a straight line. A gentle curve may be more appropriate, which can be analysed further.

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Using Microsoft Excel

The Excel spreadsheet is a very useful tool to the experimenter. It can:

- store your measurements. Make sure you save your data every few minutes and do a backup every day.
- calculate any derived physical quantities, such as speed and acceleration of a parachute or the percentage of energy lost by a bouncing ball. The 'Fill down' command is a time saver.
- be a powerful graphing tool, but it must be used wisely. Because you are looking for a relationship between the variables, you must choose 'X Y (Scatter)' as your type of graph. This has the key scientific features of a proper scale and the presence of the origin. It is also preferable to choose a graph of unconnected data points as your sub-type. You don't want a line, straight or curved, going from data point to data point; some of your data points may be a touch out. A better choice is a 'line of best fit', which Excel can do for you.
- generate a line of best fit. If you right-click on any data point, a window pops up with the option 'Add Trendline'. This is the Excel command to create a line of best fit. Once selected, you have several choices. If your graph looks like a straight line, choose 'Linear'. If the graph looks like a curve passing through the origin, choose 'Power'. Students often think any curve is exponential, but unless the phenomenon involves growth or decay, it is very unlikely that a graph from a physics experiment would generate an exponential graph.
- create error bars. Excel can add in errors bars, but this is best avoided in most instances. It is likely that the size of your error bars will vary from data point to data point. Excel can't handle that. It assigns a fixed-size error bar to each data point. Error bars can be added by clicking on any part of the chart and going to the 'Layout' tab.

Note: These instructions may vary depending on the version of Excel you are using.

Note: In the 'Add Trendline' window, you can select to display the equation of the line of best fit on your graph. Care needs to be shown with numbers in the equation. The numbers of digits may not be justified by your data.

Handling difficulties

There will be times when:

- your results show no pattern
- your results aren't what you expected
- the equipment doesn't work
- you don't know what to do next
- you don't understand the references you have been reading.

How you handle such problems is important.

- Go back to basics. Check your logic, understanding and planning. Clarify the issue. Draw diagrams and concept maps if they help. Look for options. Go to a textbook.
- Talk to other students or members of your family. Sometimes just talking through a situation can help you see a solution.
- Seek help from your teacher.

Record in your logbook how you tackled the problem, what solution you found and where you got it from. This is good science and good management.

Safety

Part of the enjoyment of a practical investigation is that the topic may be unconventional or use an innovative method. Such situations, however, can present some risk, so special care needs to be taken to ensure yourself and others are safe.

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Some simple rules to follow are:

- Do the investigation as outlined in your approved plan. Don't vary your plan without approval from your teacher.
- Don't do experimental work unsupervised unless you have prior approval from your teacher.
- Investigations can take up more space than usual experiments, so be sensitive to the needs of other students in the classroom.
- When first setting up electrical experiments, ask your teacher to check the circuit.
- Don't interfere with the equipment set-up of others.

Writing a report

The report should have an obvious and logical structure. There is no single prescriptive format, but your report should include the sections listed in table 13.2.

TABLE 13.2 Aspects of a written report

Section	Description
Title	A precise and complete description of what you investigated
Physics concepts and relationships	A short paragraph explaining the relevant concepts and relationships and how they apply to this investigation
Aim or purpose	Why are you doing this investigation? What do you hope to find?
Procedure	This is a major section. It describes what you measured, your selection of equipment and measuring instruments, and your step-by-step method. Include diagrams and photos. Refer to how you controlled variables; achieved the desired accuracy; and overcame, avoided or anticipated difficulties.
Observations and measurements	Include your data and graphs. If there is too much data, then refer to your logbook for the full set. Show how calculations were done using actual data. Also include illustrations of how uncertainties were calculated.
Analysis of results	How does your data support your initial intentions? How much is your analysis limited by uncertainties? Identify strengths and weaknesses in the investigation, indicating how you would do it differently if you repeated it, and what your next steps in the investigation would be if you had more time.
Conclusion	A short summary related to the initial purpose, summarising the meaning of your results

Presenting as a digital poster

A written report would be read in depth by your teacher, who will often spend more than 20 minutes going through it in detail. A poster has a different intent and a different audience. The structure of your investigation should be apparent and give the viewer a good sense of the investigation within several minutes' perusal. If presenting as a poster, your teacher would also need access to your logbook to get a fuller appreciation of your work.

A poster addresses the sections outlined in table 13.2 above, without going into too much detail. For example, you would display only a subset of the data to convey your findings and accuracy. Similarly, not all your graphs need appear.

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PowerPoint templates can assist with designing posters and make it much easier than putting together a hard copy on a large sheet of card. Check out the websites on JacPlus for templates as well as examples of science posters.

Advice on assembling a poster

Layout

- Set up a clearly visible structure for your poster.
- Include a photo, diagram or graphs in each section, if possible.
- Have a short title.
- Start with an engaging statement about the topic you investigated.
- Give a quick overview of your approach, with images of experimental set-up and equipment used. A flow chart is an effective way of conveying your procedure.
- Present results in graphical form with commentary; this will be the largest section of the poster.
- Discuss your results with perceptive comments.
- Decide on font size and line spacing to achieve the best impact for your poster.

Language

- Restrict the text to 800–1000 words.
- Adopt a more personal tone in the writing; use the active voice.
- Avoid large blocks of text and long sentences.
- Don't plagiarise; if you must quote, then acknowledge your sources.
- Use sentence case; that is, no all upper case sentences and avoid italicised sentences.
- Use serif fonts such as Times New Roman and Palatino.
- Use italics for emphasis, rather than underlining or bold.
- Check spelling and grammar as well as whether the correct word has been chosen, e.g. affect or effect, it's or its etc.

Graphs

- Avoid grid lines on graphs, they complicate the picture.
- Ensure scales are readable.
- Use informative titles to support the communication message of the poster.

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Investigation topics
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Topics

Here are some sample topics to get you thinking.

Motion

- The performance of a CD hovercraft
- The performance of a firework rocket or a water-driven rocket
- The impact force on and the energy loss by a bouncing ball
- Motion of a yoyo
- Flight of a table-tennis ball
- The energy delivered by a catapult
- Energy changes on a trampoline
- Dry sand is soft; wet sand is hard; wetter sand is soft again; investigate this phenomenon
- The energy stored in a spiral clock spring
- Maximising the adhesion of blu-tack
- Factors affecting the design of a good paddlewheel

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Astronomy
- The resolution of close-spaced objects by the eye
- The field of view of a simple telescope
- The depth of focus of a simple telescope

Forces and the human body
- Effect of force on a bone (beam, cantilever)
- Effect of a twisting force on a bone
- The physics of a bicep curl
- The strength of girders of different construction (using balsa wood)
- The strength of human hair

AC to DC
- The design of an AC ammeter
- The value of fins for regulator heat sinks

Flight
- The thrust of a propeller (in air or in water)
- The drag on spheres in an airstream
- The resistance to water flow of various plumbers' fittings (pipe, bends, etc.)
- The effect of changing the size or shape of the wings of a glider
- The flight of a Magnus glider
- The supporting of a ball on a jet of air
- Paper plane design

Nuclear energy and Medical physics
- Variation in range of alpha particles with air pressure
- Variation in range of beta particles in different metals
- How many beta particles are scattered back from various substances?
- The natural radioactivity of potassium salts
- Can background radiation be reduced by screening?

Light and vision
- Do people vary in the range of wavelengths they can see?
- How quickly does the iris of the eye contract when the light is made brighter?
- Does the resolution of the eye depend on the illumination?
- The adaptation to dark of the human eye
- The depth of focus of a microscope
- The resolution of a microscope
- Moiré fringes

Sound and music
- How long does a sound last in a large hall?
- Frequency range of a microphone
- The behaviour of a loudspeaker cabinet at low frequencies
- The frequencies of a stretched wire
- Diffraction of sound waves

Ball games
- The sweet spot of a tennis racquet
- Effect of the mass of a cricket bat on ball speed after impact
- The changeover from sliding to rolling
- Compare static and kinetic friction of running shoes

Bioelectricity
- How does the resistance between two points on a conducting sheet vary with distance?
- How does the resistance between two flat plates in a tank of conducting liquid vary with their spacing?

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