SCIENCE

Level

F	1	2	3	**4**	5	6	B6

Fair tests

Strand
Science and Society

Key concept
Science as a 'way of knowing' is shaped by the ways that humans construct their understandings.

Purpose

Activities in this module are designed to help students understand what makes a fair test. Students have opportunities to:

- identify whether or not a test is fair;
- design and perform investigations that incorporate the elements of a fair test;
- identify and control variables in investigations;
- judge the credibility of results;
- communicate their understandings of fair tests.

Overview of activities

The following table shows the activities in this module and the way in which these are organised in **introductory**, **developmental** and **culminating** phases.

Introductory ►	Developmental ►	Culminating
The jumping grasshopper	A controlled experiment	Pendulum experiment
	Graphing	Module summary
	'Blind' tests	

QUEENSLAND SCHOOL CURRICULUM COUNCIL

Core learning outcome

This module focuses on the following core learning outcome from the Years 1 to 10 Science Syllabus:

Science and Society

4.2 Students use the elements of a fair test when considering the design of their investigations.

Core content

This module incorporates the following core content from the syllabus:

Science and Society

Investigations

- controlled — fair testing
- justification of decisions and conclusions

Assessment strategy

Suggestions for gathering information about student learning are provided in each of the activities in this module. Once sufficient information has been collected, judgments can be made about students' demonstrations of outcomes. Typical demonstrations of this module's intended outcome are provided here to indicate the pattern of behaviour to look for when making judgments.

Science and Society

4.2 Students use the elements of a fair test when considering the design of their investigations.

Students may:

- analyse an investigation to decide whether or not it is a fair test;
- identify the reasons why a test is or is not fair;
- use the elements of a fair test when designing investigations.

Background information

Current scientific conceptions

To achieve a fair test:

- the question being dealt with must be answerable through experiment;
- the experiment must deal with the question being studied;
- all the variables in an experiment must be considered and controlled;
- only one variable may be altered at a time;
- the experiment must be able to be replicated;
- the experimenters must not be biased;
- the results from which conclusions are drawn must be better than those from chance.

Students' prior understandings

Students' prior understandings may differ from current scientific conceptions in a range of ways.

Some students may think that:

- controls in experiments are unnecessary;
- more than one variable can be changed at a time;
- scientific tests, as seen on television advertisements, are always fair tests.

Teachers can enhance students' understandings by emphasising the importance of considering the elements of a fair test when designing investigations and judging the credibility of results.

Students may be unaware of the most appropriate ways to collect, record and display data. Teachers can help students in these activities by sharing exemplary models and encouraging discussion about the best ways to collect, record and display data.

Terminology

Terms associated with fair tests are essential to the activities in this module — for example:

bias	controlled variables	variables
'blind' tests	replication	

Students may already be familiar with some of these terms and understand their meanings and use in scientific contexts. If so, the activities in this module will provide opportunities for them to evaluate current usage. If not, these activities will provide opportunities for students to develop their understandings.

School authority policies

Teachers need to be aware of and observe school authority policies that may be relevant to this module.

Safety policies are of particular relevance to the activities that follow. It is essential that demonstrations and student activities are conducted according to procedures developed through appropriate risk assessments at the school.

In this module, teachers need to consider safety issues relating to the use of fertilisers.

ACTIVITY

The jumping grasshopper

Introductory

Focus

This activity provides opportunities for students to explore their ideas of what constitutes a fair test.

Students participate in a role-play that involves applying the principles of a fair test.

Materials

- Resource Sheet 1, 'The jumping grasshopper: A one-act play'
- cardboard — cut and coloured to resemble grasshopper legs, which can be fastened onto a student's legs to represent the grasshopper

Teaching considerations

For a test to be fair, only one variable should be changed. When the professor in the play removes the grasshopper's legs, he changes two variables — the ability to hear (he thinks grasshoppers hear through their legs) and the ability of the grasshopper to jump.

Some students may think that the testing process described in the play is not fair because it is not 'morally right' to pull legs off an insect. The ethical aspects of this could be discussed but should not overshadow the point of the activity, which is about the characteristics of a 'fair test'.

Working scientifically

Time: 30 minutes

Seeking reasons
Formulating and elaborating ideas
Discussing thinking
Expressing points of view

Resource Sheet 1

▶ Students discuss the meaning of the word 'entomologist' and compare their ideas with a dictionary definition.

▶ Students read and act out their parts in the play on Resource Sheet 1.

▶ Students discuss their thinking about the following ideas:

- whether Professor Know was correct in saying the experiment proved grasshoppers hear through their legs;
- whether you can now be certain that grasshoppers do not hear through their legs;
- how Professor Know's experiment could be changed to determine whether or not grasshoppers hear through their legs.

▶ As a class, students discuss their understanding of fair tests.

▶ Students write down what they now know about fair tests.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' ideas about fair tests.

ACTIVITY

A controlled experiment

Developmental

Focus

This activity provides opportunities for students to identify the factors that should be controlled in an experiment.

Students design and perform experiments to determine the optimum amount of fertiliser to be added to sand for growth of plants.

Materials

For each group:

- 10 identical containers (milk cartons with the top cut off or yoghurt containers)
- river sand or washed sand
- 30–50 tomato seeds (dried seeds from tomatoes, or commercially produced seeds)
- 250 mL measuring cylinder or jug
- fertiliser
- materials to protect plants from insects (e.g. frame with shadecloth), optional

Teaching considerations

Give students about 30 seeds and 10 identical pots per group.

Sand has been suggested as the growing medium rather than potting mix. Potting mix usually has nutrients added to it to ensure the healthy growth of plants, at least in the short term. Washed sand has few nutrients. The effects of the different amounts of fertiliser should, therefore, be more evident. Sand from the beach contains salt and would not be suitable unless it has been washed thoroughly.

All groups could test one type of fertiliser. Alternatively, each group could test a variety of fertilisers.

Controlling variables

Factor to control	How controlled
Fertiliser	Measure the amount of fertiliser added to each container. If possible, mix the fertiliser evenly through the sand. One container, the control, should get no fertiliser.
Pots	Use identical pots or containers.
Sand — quality and quantity	Make sure the sand has uniform texture. Add equal quantities to each container.
Water	Decide on a watering regime. Add equal amounts of water to each container.
Seed quality	If the seeds have come from a variety of sources, mix them thoroughly before giving them to the different groups.
Drainage	The number, size and placement of holes should be similar in each container.
Sunlight	Put all the containers where they will get equal amounts of sunlight.
Insects	Cover all plants with shadecloth, if possible, to keep out leaf-eating insects.
Seed placement	Plant seeds at the same depth and the same distance apart. Tomato seeds should be planted just under the surface of the sand.

(continued)

Factor to control	How controlled
Temperature	Place containers where the variations in temperature throughout the day will be the same for all.
Measurement	Agree on the starting and finishing points for any measurements. Use the same instruments to do the measuring.
Observations	Agree on the criteria for describing observations. Use the same instruments to make observations.

The planning and reporting worksheets in appendix 3 of the sourcebook guidelines could be used to support students as they plan their experiments.

Safety

Inform students about safe practices for using fertilisers. For example, since some fertilisers cause irritation to skin and eyes, students should:

- protect their eyes;
- wash their hands after use.

Working scientifically

Time: 60 minutes of class time; four weeks for observation

Collecting information
Designing and performing experiments
Handling materials
Identifying and controlling variables
Measuring
Drawing conclusions
Inferring from data
Making comparisons
Discussing thinking
Explaining ideas and decisions

▶ Students discuss why fertilisers are used. They also discuss differences they could expect to see between plants that have had adequate amounts of fertiliser and those that have had too little or too much.

▶ Students consider the question:

- What amount of fertiliser causes tomato plants to grow best?

▶ In small groups, students design an experiment to answer the question. They discuss:

- factors that need to be controlled to ensure a fair test;
- how these factors could be controlled;
- aspects of plant growth that could be measured;
- other observations that could provide information to help answer the question.

▶ Students share their ideas with the rest of the class. A retrieval chart like the one shown in 'Teaching considerations' could be developed and displayed for reference purposes.

▶ Students may wish to modify the designs of their experiments based on the discussion.

▶ They then perform their experiments and record the results. They interpret data and draw conclusions about which plants grew best.

▶ Students present reports of their experiments emphasising what they did to ensure that tests were fair.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' designs for experiments;
- students' reports and notes about fair tests.

ACTIVITY

Graphing

Developmental

Focus

This activity provides opportunities for students to develop an understanding of the usefulness of various graphs to display data.

Materials

- Resource Sheet 2, 'Graphs'
- Resource Sheet 3, 'Comments on graphs A–F'
- graph paper
- results from the activity 'A controlled experiment'

Teaching considerations

Graphing

Although graphing skills are not a necessary consideration when one designs a fair test, they are an important aspect of communicating information gathered during a test.

Most spreadsheet programs have a graphing facility. Such software could be used if access to computers is available.

Independent and dependent variables

Independent variables are controlled in an experiment — for example, the amount of fertiliser added. The dependent variable is the one that is measured or monitored throughout the experiment — for example, growth of seedlings. When graphing variables, the independent variable should be represented on the horizontal axis and the dependent variable on the vertical axis.

Analysing
Assessing
Examining and evaluating
Creating tables and graphs
Expressing points of view

Resource Sheets 2, 3

Working scientifically

Time: 30 minutes

▶ The data below are presented in the graphs on Resource Sheet 2.

Container number	Amount of fertiliser (g)	Number of germinated seeds	Average height of seedlings (cm)
1	0	10	4.5
2	1	9	6.0
3	2	10	10.0
4	3	10	9.0
5	4	10	8.0
6	5	10	7.0
7	6	5	4.0
8	7	3	1.0
9	8	1	0.5
10	9	0	0.0

▶ Students study each graph and comment on whether it is an appropriate and accurate presentation of the data in the table. They evaluate the graphs and give each of them an overall rating in terms of their usefulness.

▶ Students share their ideas with the rest of the class. The discussion could include the ideas on Resource Sheet 3.

▶ A retrieval chart like the one on Resource Sheet 3 could be generated.

▶ Students now graph their actual results using data they obtained from the activity 'A controlled experiment' (p. 5), or some other data.

Gathering information about student learning

Sources of information could include:

- students' comments on the graphs;
- students' graphs.

ACTIVITY

'Blind' tests

Developmental

Focus

This activity provides opportunities for students to investigate how the use of 'blind' tests may contribute to the development of a fair test.

Materials

- four large packets of corn chips of the same flavour — two generic brands and two name brands (The packets should look as similar as possible.)
- one large block of generic-brand chocolate and one of brand-name chocolate (The chocolate must be the same flavour with no name on the squares.)
- brown paper bags

Teaching considerations

One packet of generic-brand corn chips should be transferred to a brand-name packet and vice versa. The other two packets should be transferred to bags marked A or B so that only the teacher knows which brand they contain.

Safety

Some students may have food intolerances. Diabetics may need to monitor the sugar content of their food.

Working scientifically

Time: 30 minutes

Identifying and controlling variables
Judging credibility
Creating tables and graphs
Discussing thinking

▶ Students eat one corn chip from each named packet and record which brand they like best. Class results are recorded in a table and displayed.

▶ Students eat one corn chip from bag A and one from bag B and record which they like the best. The results are tallied and displayed.

▶ The actual brands of the corn chips are revealed for both tests. Students discuss the results of the tests. Discussion questions could include:

- What differences were there in the results of the two tests?
- Why did these differences arise?
- To what extent did the packaging of the chips influence you?
- Why does packaging sometimes influence people's decisions on taste?
- Which of the two tests is more likely to be a fair test and why?

▶ Students discuss ways in which the test could be improved.

▶ In pairs, students use the ideas from the class discussion to design a fair test to determine which brand of chocolate is preferred. They perform the test and record results. Class results are tallied and displayed.

▶ Students write about what made the test they performed a fair test.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' designs for tests and notes about why their tests were fair.

ACTIVITY

Pendulum experiment

Culminating

Focus

This activity provides opportunities for students to use the elements of a fair test when designing an investigation.

Materials

For each group:

- four identical weights (four identical metal nuts of moderate weight are suitable)
- one piece of string, 50 cm long
- scissors
- rulers
- stopwatch or watch with a second hand
- butcher's paper and markers
- Resource Sheet 4, 'Pendulums'

Teaching considerations

Pendulums can be attached to any stable horizontal rail.

Inform students that it is easier to time ten swings than to time one swing (the average can be taken to determine the time of one swing).

The planning and reporting worksheets in appendix 3 of the sourcebook guidelines could be used in this activity.

Galileo Galilei's work

In about AD1600 at the university of Padua, Galileo Galilei investigated how long it took for pendulums to swing in a full arc — that is, the curved pathway from the highest point reached on one side of the pivot to the point reached on the other. It is reported that he started the investigation in church one Sunday when he noticed a lantern swinging in the breeze. He used his pulse to time the swing of the lantern.

Galileo discovered that the only variable that made a difference to the time taken for the pendulum to swing was the length of the pendulum. This led to the construction of clocks based on the pendulum. From the seventeenth century to the 1960s, grandfather clocks with pendulums were still the most accurate timepieces in many homes.

Working scientifically

Resource Sheet 4

Designing and performing experiments

Exploring phenomena

Identifying and controlling variables

Time: 60 minutes

▶ The students are shown a pendulum like diagram 1 on Resource Sheet 4.

▶ In small groups, students discuss what variables might influence the time it takes for a pendulum to swing one full arc. The following are variables that may be considered:

- the length of the string;
- the mass at the end of the pendulum;
- how far the pendulum swings.

Making plans
Measuring
Predicting
Drawing conclusions
Inferring from data
Creating presentations
Describing
Explaining ideas and decisions
Summarising and reporting

▶ In groups, students design an investigation to determine which variables influence the time it takes for a pendulum to swing a full arc. They perform the investigation.

▶ Each group of students makes a presentation to the class, which includes:
- a description of what they did;
- the elements of fair tests that they considered when designing their investigation;
- a description of what happened;
- a display of their results;
- their conclusions.

Additional learning

▶ Students investigate:
- Galileo Galilei and his work;
- how clocks with pendulums work.

Gathering information about student learning

Sources of information could include:
- students' contributions to discussions;
- students' planning of investigations;
- students' presentations to the class.

ACTIVITY

Module summary

Culminating

Focus

This activity provides opportunities for students to demonstrate their understandings of what makes a fair test.

Materials

No particular materials are required.

Teaching consideration

This activity can be used as a self-test or to gather information about student learning.

Working scientifically

Time: 30 minutes

Designing and performing investigations
Identifying and controlling variables
Analysing
Examining and evaluating
Judging credibility

▶ Students decide whether the following experiments are fair tests. They discuss reasons for their decisions.

- An experimenter wishes to find out which type of cola is most popular, so she asks people which one they like.
- In a television advertisement promoting dry dog food, a dog is given a choice of the dry dog food or tinned food to see which it likes the best.
- A bleach is being tested for its ability to remove stains. The bleach is added to some dirty clothes to see whether it removes stains.
- A doctor tests a drug on one person to see if it works or has any harmful effects.
- A variety of detergents is tested on different stains to see which detergent is most effective.

▶ Students choose three of the tests. For each test they describe how they would design that test to ensure it is a fair test. When describing the tests, they show clearly why they think the tests will be fair.

Gathering information about student learning

Sources could include:

- students' contributions to discussions;
- students' decisions about the fairness of tests;
- students' descriptions of tests and why they are fair.

The jumping grasshopper: A one-act play

Cast:

Professor Know-a-Lot — also called *Professor Know*

Grasshopper — a student who plays the part of the grasshopper (has cardboard grasshopper 'legs' attached)

Master of Ceremonies — also called the *MC*

Audience — a group of entomologists

Scene: A convention of entomologists. Standing at the podium is the MC. Sitting in a chair beside the podium is Professor Know-a-Lot who is holding a leash attached to a grasshopper.

MC: Order, order, ladies and gentlemen, order, please.

[Faint mumbles, then silence.]

Thank you, ladies and gentlemen. Today we have a rare treat. We have the well-known entomologist Professor Know-a-Lot here to talk about the latest research on insect hearing. So please give a warm welcome to Professor Know. *[He then sits down.]*

[Applause. Professor Know-a-Lot moves to the podium leading a hopping grasshopper on a leash.]

Professor Know: Good evening, ladies and gentlemen of science, here for the National Entomologists' Convention. I am pleased to be in the same room with such distinguished researchers as Professor Stink, the beetle expert, and Professor Bumble, the bee investigator. No doubt many of you have been wondering what I, Professor Know, have been doing. It has taken me five years of hard work to get my grasshopper to jump on command. My grasshopper will now demonstrate this training to you.

[The professor leads the grasshopper out to centre stage and looks it in the eyes.]

Jump.

[The grasshopper jumps.]

Jump.

(continued)

The jumping grasshopper *(continued)*

[The grasshopper jumps.]

Jump.

[The grasshopper jumps. Applause. Expressions of wonder and awe.]

Professor Know: As you can see, ladies and gentlemen, I have succeeded in teaching my grasshopper to jump on command. It can obviously hear me now. I would like to prove to you that grasshoppers hear through their legs. To do this, I will now remove the grasshopper's legs.

[The professor proceeds to take off the cardboard legs of the grasshopper to the gasps of amazement and outrage from the audience.]

Audience members: That's horrible!
Ghastly!

It's an outrage!

[General shouts of disapproval. The MC comes to the podium.]

MC: Order! You call yourselves people of science. Let the professor continue. I'm sure he has a good reason for treating the grasshopper this way. Order, order!

[Gradually the audience becomes quiet.]

Professor Know: As I was saying, it is obvious that the grasshopper can hear when it has legs.

[The professor looks the grasshopper in the eyes.]

Jump.

[The grasshopper just sits there.]

See, the grasshopper no longer jumps on command. I have thus proved that grasshoppers hear through their legs.

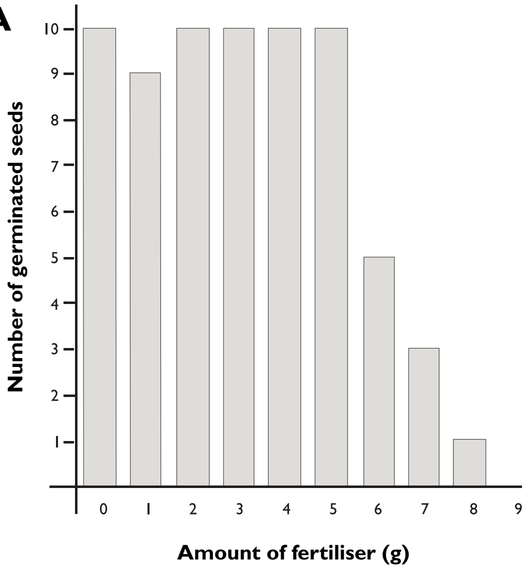
[The audience riots.]

End

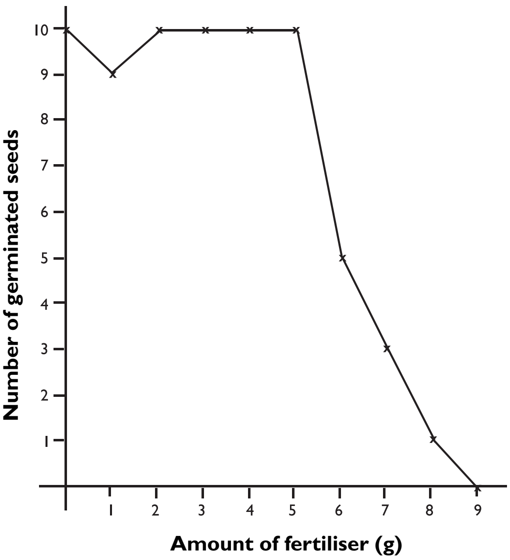
Graphs

R2 Resource Sheet 2

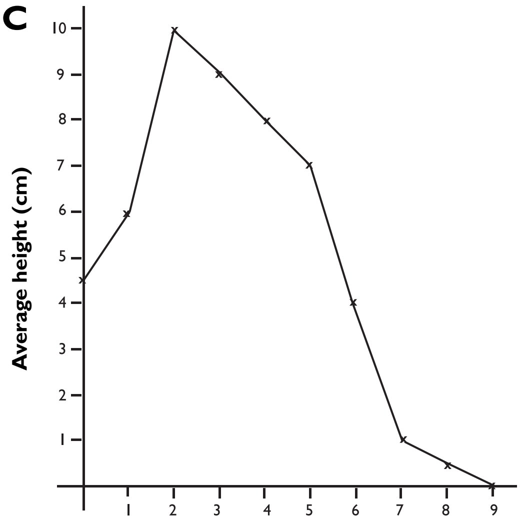
A



B



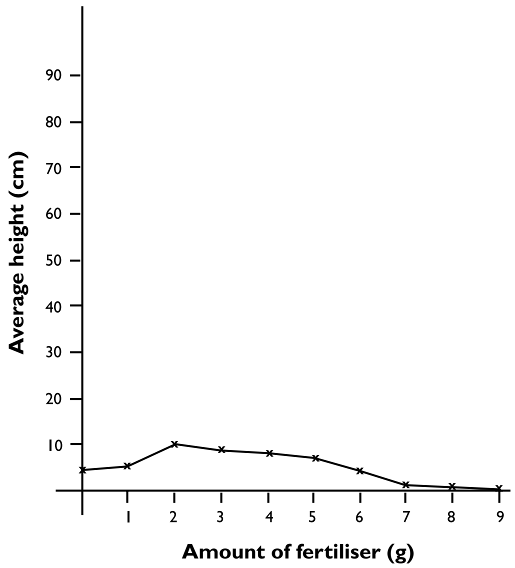
C



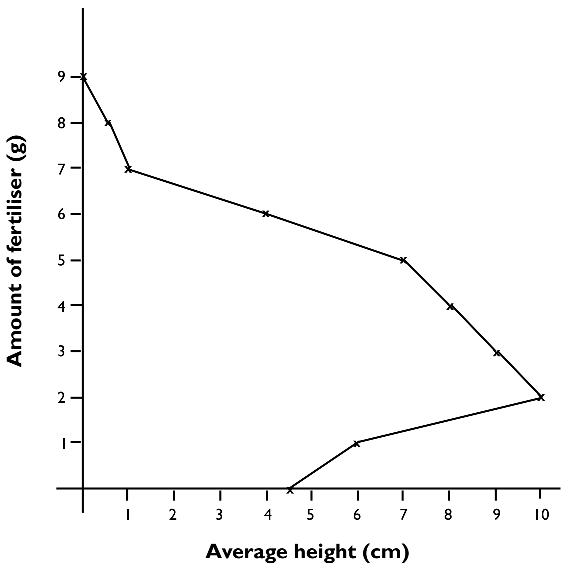
(continued)

Graphs *(continued)*

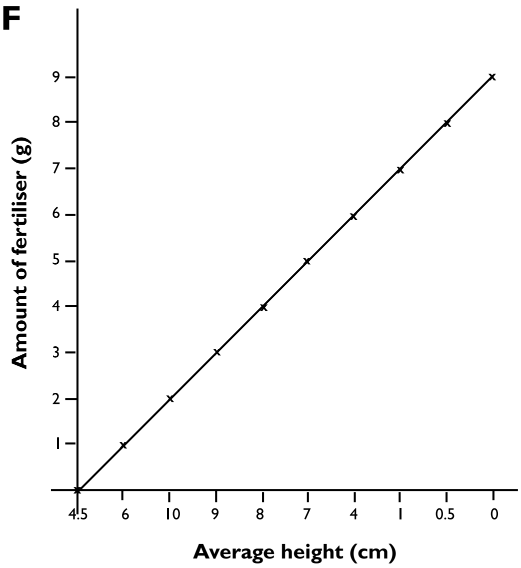
D



E



F



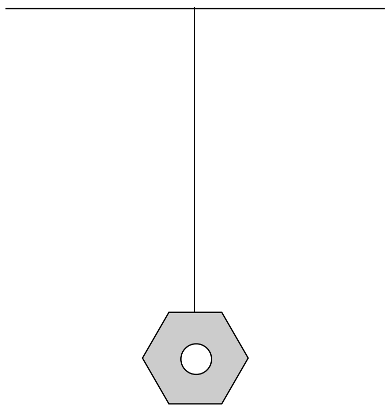
Comments on graphs A–F

Graph	Features of each graph	Overall rating of usefulness
A	A bar graph is best for these data since there cannot be a fraction of a seed germinating. These types of data are called 'discrete data' — that is, there are no in-between values.	Excellent
B	A line graph tends to suggest that there can be values in between those plotted on the graph. The information on graph B could be interpreted to suggest that adding 6.3 grams of fertiliser would result in 4.5 seeds germinating. This cannot happen. Therefore, a line graph could be seen as misleading. However, a line graph shows the trend of what is occurring in the data. This is a valid point and sometimes a line graph is used for discrete data — that is, where there are no in-between values.	Fair
C	The horizontal axis is not labelled in this graph. (The axis shows data for the amount of fertiliser used.) A line graph is good for these data as it has in-between values. For example, provided the horizontal axis is labelled correctly, it is possible to read from the graph how much growth could be expected from 6.5 grams of fertiliser.	Fair
D	The scale on the vertical axis is too small. The scale on the graphs should spread the data to highlight any trends in the data; however, the scale should not be so large that small changes are exaggerated.	Fair
E	In scientific graphs the **independent variable** (the controlled variable, in this case the amount of fertiliser added) should be placed on the horizontal axis. The **dependent variable** (the one measured as the experiment proceeds) is placed on the vertical axis. Placing the variables on the other axes makes the graph difficult to interpret.	Poor
F	The scale on the horizontal axis is incorrect. The values have simply been read from the table and placed on the axis in that order. As a result, the graph will always form a straight line. It is most important that the values increase consistently on both axes. The scale on the horizontal axis may be different from that on the vertical axis. In this graph the independent and dependent variables have been placed on the incorrect axes.	Poor

Pendulums

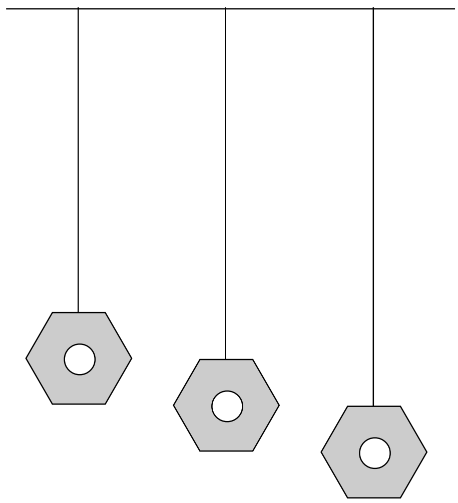
R4 Resource Sheet 4

1.



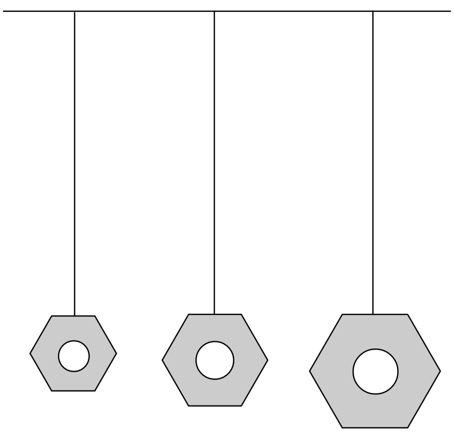
Simple pendulum

2.



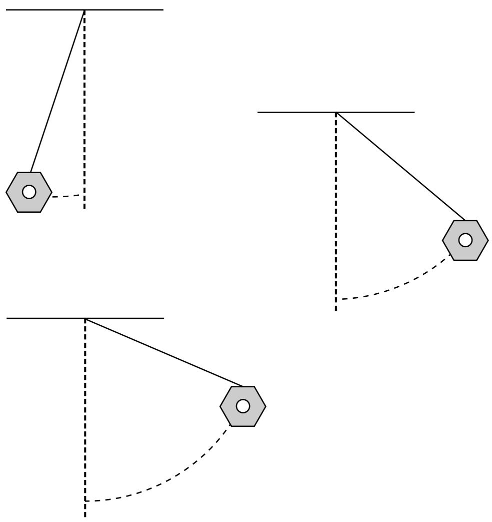
These pendulums have:
- **different lengths;**
- **the same mass.**

3.



These pendulums have:
- **different masses;**
- **the same length.**

4.



These pendulums have:
- **different starting positions;**
- **the same mass;**
- **the same length.**

Acknowledgments

This module is based on material developed by Noel Wood who attended a module writing workshop organised by the Science Teachers' Association of Queensland and the Queensland School Curriculum Council.

This sourcebook module should be read in conjunction with the following Queensland School Curriculum Council materials:

Years 1 to 10 Science Syllabus

Years 1 to 10 Science Sourcebook: Guidelines

Science Initial In-service Materials

ISBN 0 7345 2005 0

Any inquiries should be addressed to:
Queensland School Curriculum Council
PO Box 317
Brisbane Albert Street, Q 4002
Australia

Telephone: (07) 3237 0794
Facsimile: (07) 3237 1285
Website: http://www.qscc.qld.edu.au
Email: inquiries@qscc.qld.edu.au

PIP 99146