SCIENCE

Level

F	1	2	3	4	5	6	B6

Obtaining and using energy efficiently

Strand
Energy and Change

Key concepts
In interactions and changes, energy is transferred and transformed but is not created or destroyed.

There are different ways of obtaining and utilising energy and these have different consequences.

Purpose

Activities in this module are designed to help students understand the relationships between laws of energy and everyday experiences; understand ways of using laws of motion and energy to explain energy transfers in the manipulation of forces; and explore and express ideas about future energy use. Students have opportunities to:

- investigate common phenomena of energy transfers and transformations;
- apply ideas and concepts about electrical energy to simple circuits;
- communicate their ideas about current and future energy use.

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
Batteries and bulbs	Electric circuit role-play	Efficient energy converters
Pendulums and bouncing balls	Ohm's law	Future consequences
Energy in the home	Electrical appliances	Electrical safety
	Exploring sound	
	Soundproofing	
	Heat and fabrics	
	Doppler effect	

QUEENSLAND SCHOOL CURRICULUM COUNCIL

Core learning outcomes

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

Energy and Change

5.2 Students explain how energy is transferred and transformed (including energy transfer by convection and conduction).

5.3 Students discuss the consequences of different ways of obtaining and using energy (including nuclear energy).

6.2 Students model and analyse applications of energy transfer and transformation.

6.3 Students evaluate the immediate and long-term consequences of different ways of obtaining and using energy.

Core content

This module incorporates the following core content from the syllabus:

Energy and Change

Transfer and transformation of energy types
- sound — vibration, pitch, frequency, travel of sound in solids, liquids and gases
- electrical — voltage, current, resistance, Ohm's law
- potential — elastic, gravitational

Energy transfers that occur in:
- the home

Consequences of energy use
- short-term and long-term effects

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 outcomes are provided here to indicate the pattern of behaviour to look for when making judgments.

Energy and Change

5.2 Students explain how energy is transferred and transformed (including energy transfer by convection and conduction).

Students may:
- identify the energy transformations that occur in simple interactions (for example, the transformation of gravitational potential energy to kinetic energy as an object is falling);
- compare the way that sound is transferred through different materials;
- design and perform investigations to identify which materials conduct electricity;
- describe the different ways that sound can be transferred.

5.3 Students discuss the consequences of different ways of obtaining and using energy (including nuclear energy).

Students may:

- describe the consequences of different ways of obtaining and using energy;
- discuss the environmental impact of different methods of generating electricity;
- argue a position about the consequences of different ways of obtaining and using energy.

6.2 Students model and analyse applications of energy transfer and transformation.

Students may:

- apply concepts of electron flow to explain the transfer of electrical energy;
- explain that sound travels as waves of vibrating particles;
- create presentations that explain heat transfer in terms of the particle model of matter.

6.3 Students evaluate the immediate and long-term consequences of different ways of obtaining and using energy.

Students may:

- compare the long-term costs and benefits of using different appliances in the home;
- envision alternative futures by analysing the possible long-term consequences of energy use;
- prepare scenarios depicting future consequences of energy use.

Background information

Current scientific conceptions

Transfer and transformation of energy

Energy is defined as the capacity to do work. Forms of energy include sound energy, light energy, heat energy, electrical energy, kinetic energy and potential energy.

Energy can be converted from one form to another, but it cannot be created or destroyed. This can also be stated as *energy input is equal to energy output*. This is a difficult idea for students who may hold a belief that energy is 'used up' during interactions — for example, the energy in fuel and batteries. They need to consider the range of energy conversions and the idea that, in all energy transformations, some energy is converted to heat. In many situations, the heat energy produced is not useful.

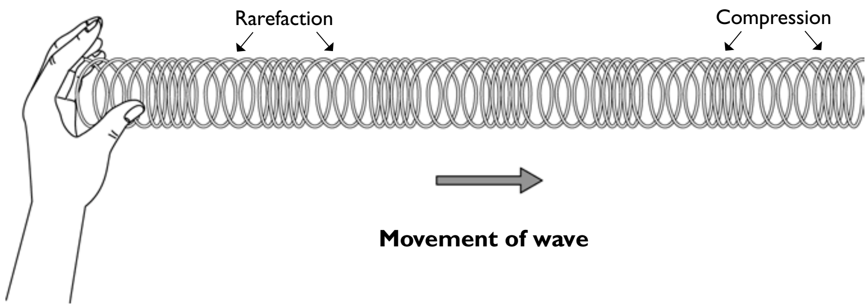
The efficiency of energy converters is determined by comparing the energy output (in a useful form) to the energy input and expressing this as a percentage:

$$\text{efficiency} = \frac{\text{useful energy output}}{\text{energy input}} \times 100\%$$

The efficiency of an energy converter is less than 100 per cent since some energy is always converted to heat in a form that is not useful.

Sound energy

Sound is a form of energy that travels in waves. Sound travels in longitudinal waves in which the particles of the medium through which the sound is travelling (for example, air or water) vibrate back and forth in the same direction as the direction of travel of the wave. Longitudinal waves can be demonstrated using a slinky spring. When the slinky spring is pushed quickly back and forth, some of the coils of the spring are close together (a region of compression) and others are spread apart (a region of rarefaction). All longitudinal waves have alternating regions of compression and rarefaction.



The wavelength of a wave is the distance between two corresponding points on consecutive waves. On a sound wave, this can be shown as the distance between two consecutive compressions. The frequency of a wave is the number of waves that pass a given point in a second. Frequency is measured in hertz (Hz); 1 Hz = 1 wave per second.

When a guitar string is plucked, it vibrates causing the air around it to vibrate. The vibrations in the air cause a person's eardrum to vibrate, which in turn causes vibrations within the inner ear. These vibrations stimulate nerve endings. The nerve impulse reaches the brain where it is recognised as sound.

The frequency of a sound wave is detected as 'pitch'. Low frequencies correspond to low pitches (deep sounds). High frequencies correspond to high pitches (high sounds).

The amplitude of a wave is the distance it moves from the rest position and depends on the energy of the wave. A wave with a large amount of energy will have large amplitude. The amount of energy carried by a sound wave is detected as 'loudness'.

Sound travels through a medium; it cannot travel in a vacuum. Sound travels at about 340 m/s in air; it travels faster in solids and liquids.

Rigid objects, such as walls or cliffs, reflect sound waves travelling in air. Echoes are caused by reflection of sound waves. Soft materials, such as carpets or curtains, absorb sound, thus reducing echoes. When sound energy is absorbed, it is converted into heat energy.

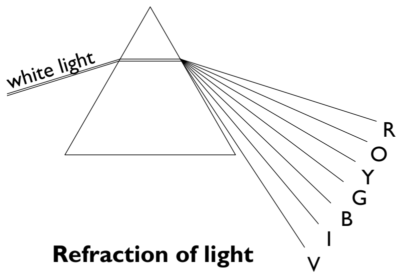
The Doppler effect is a phenomenon that is observed when a sound source, such as a train or car, moves towards and then past an observer. As the source approaches, the sound waves 'bunch up' and have a higher frequency and, therefore, a higher pitch. As the source moves away, the waves are more 'spread out' and have a lower frequency and, therefore, a lower pitch.

Light energy

Light is a form of energy emitted in the form of electromagnetic radiation. It does not require a medium for its transmission. It moves in a stream of photons that have properties similar to both particles and waves. Light travelling through a medium does not cause the particles of that medium to move. As light travels, there are wavelike changes in electrical and magnetic fields. Because of these changes, light can be described in terms of wavelength.

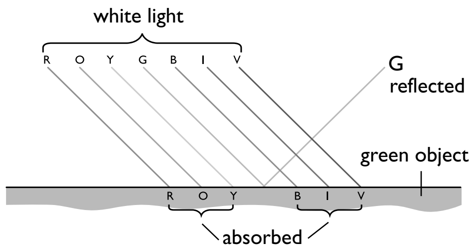
Visible light or white light consists of the seven colours of the visible spectrum — red, orange, yellow, green, blue, indigo and violet. The different colours have different wavelengths. Red has the longest wavelength, lowest frequency and lowest energy. Blue has the shortest wavelength, highest frequency and highest energy.

Refraction of light occurs when light is bent as it travels from one medium to another — for example, from air to water. The colours with shorter wavelengths (violet, blue) refract (bend) more than the colours with longer wavelengths (red, orange). Because of these different amounts of refraction, white light passing through a prism can be refracted into its constituent colours — the spectrum. Rainbows are formed when white light (usually from the sun) is refracted as it passes from air to water (in raindrops).



Refraction of light

Objects are seen by humans and some other animals as colours because of the way that visible light interacts with them. White objects reflect all the colours and hence are seen as white. Black objects absorb all the colours and are seen as black (the absence of colour). Coloured objects absorb some colours and reflect others. For example, a green object will absorb all colours except green, which it reflects.



Colours of objects

Electrical energy

Electrical energy is the energy associated with electric charges and their movement. Electricity is a flow of charge in an electric circuit. In a simple circuit, a battery or a cell provides electrons with electrical energy that is carried via conductors through the circuit and converted to some other form of energy — for example, to light energy in a light bulb. This flow of charge is an electric current. In a wire the current flows from a region of negative charge to a region of positive charge. Electric current (I) is measured as the number of charges that pass a given point per second. The unit of current is the ampere (A).

Voltage, measured in volts (V), is a measure of the energy supplied by a battery. Also called 'potential difference', voltage represents the work done (energy) per unit charge to move electrons around the circuit.

The resistance (R) of a material is the property of the material that helps resist the flow of electrons in it. Metals have low resistance and are good conductors. Wood has high resistance and is a poor conductor. Resistance is measured in ohms (Ω) and depends on the type of material and its cross-sectional area, length and temperature. Long wires have more resistance than short wires; thin wires have more resistance than thick wires. Resistance decreases at higher temperatures.

Ohm's law

Ohm's law describes the relation between V, I and R. In a given circuit with constant resistance, the current that flows is proportional to the applied voltage. When the voltage is doubled, the current also doubles. The ratio of V:I is a constant. This constant is the resistance of the circuit. This is expressed mathematically as:

$$V = IR \leftrightarrow R = V/I$$

Ohm's law is useful in calculations of voltage, current and resistance in simple circuits.

Calculating energy usage

Electrical energy supplied by mains electricity is the usual source of energy for most homes in industrialised societies.

Different appliances use electrical energy at different rates. For example, a clothes drier will use far more energy than a television when both are left on for the same amount of time. The rate at which devices convert electrical energy is their power rating. (Power ratings are shown on appliances.) Power is a measure of the rate of using energy. The unit of power is a watt (W).

Resource Sheet 5

The cost of electricity to consumers is based on consumption calculated in kilowatt hours (kWh). A kilowatt hour is the amount of energy used by a device with a power rating of 1 kilowatt when it is used for 1 hour. For example, a heater with a power rating of 1500 W (1.5 kW) would use 1.5 kWh every hour that it is turned on. The tariff applied to electricity depends on the use being made of it. Resource Sheet 5 lists some electricity tariffs. As this shows, Tariff 11 (Domestic Light and Power) is more expensive than Tariff 33 (Economy Plan) and Tariff 31 (Super Economy Plan).

Students' prior understandings

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

Energy

Some students may think that energy is a 'concrete' substance that can be used up, which differs from the scientific idea that energy is conserved. Teachers can help students develop their understandings by encouraging them to think carefully about all the energy conversions that occur in interactions, including conversions of energy to heat and sound.

Colour

Some students may have misconceptions about coloured objects reflecting their own colours and absorbing all others. They tend to suggest that the opposite occurs. Teachers can help students develop their understandings by encouraging them to focus on colour as something that people perceive rather than a property of a substance. They should ask themselves, 'What colour do I see the object as being?'.

Terminology

Terms associated with energy transfers and transformations and the consequences of energy use are essential to the activities in this module — for example:

amplitude	kinetic energy	rarefaction
battery	longitudinal waves	reflection
conductor	negative charge	refraction
current	Ohm's law	resistance
Doppler effect	pitch	sound energy
electric current	positive charge	spectrum
electron	potential energy	transverse waves
frequency	power	voltage
insulator	power rating	wavelength

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 using:

- mains electricity;
- a starting pistol.

Support materials and references

Davidson University, *Physics at Davidson*, 'Physlets'. Available URL: http://webphysics.davidson.edu/Applets/Applets.html (accessed September 2000).

Lahe, L. 1990, *An Autonomous Learners Guide — Future Studies*, Hawker Brownlow, Melbourne.

ACTIVITY

Batteries and bulbs

Introductory

Focus

This activity provides opportunities for students to clarify their ideas about the transfer of electrical energy in simple circuits.

Materials

For each group:

- battery
- two torch bulbs
- four connecting leads
- various conducting and insulating materials (e.g. wood, metal wire, paper, plastic, coins, Plasticine)
- overhead transparency and suitable pens

For each student:

- Resource Sheet 1, 'Circuit symbols'
- planning and reporting worksheets (sourcebook guidelines, appendix 3)

Teaching considerations

Resource Sheet 1

This activity provides an opportunity for students to explore ideas about electric circuits. Use questioning to encourage students to clarify their thinking about terms such as 'current', 'voltage', 'resistance' and 'circuits'. Some students will demonstrate that they have some experience in using circuit symbols and circuit diagrams. Use the sheet of circuit symbols (Resource Sheet 1) to discuss with students the advantages of using symbols and circuit diagrams.

Part 2 of the activity involves designing an investigation about conductors and insulators. Students could use the planning and reporting worksheets in appendix 3 of the sourcebook guidelines when structuring their investigations.

Students with vision impairment

Some students with vision impairment may need assistance for this activity. Seek advice from their support teacher.

Working scientifically

Time: 60 minutes

Designing and performing investigations
Handling materials
Drawing conclusions
Generalising
Creating diagrams
Using scientific report genres
Using scientific terminology

Part 1: Circuits

▶ In groups, students use a battery, a torch bulb and two connecting leads to find as many ways as possible of lighting the bulb. On an overhead transparency, each group creates diagrams of the arrangements that caused the bulb to light.

▶ Students use an additional bulb and two connecting leads to find as many ways as possible to get both bulbs to glow. Again they create diagrams on an overhead transparency. They record their observations, with possible explanations, on the diagrams.

▶ In groups, students present their findings to the class by displaying the overhead transparencies and explaining what happened. Students generalise about what is needed for an electric circuit (a power supply and a complete path of conducting material). Discussion questions could include:

- What is the source of energy for the circuit?
- What form (or forms) of energy is the light bulb emitting?
- How is the energy supplied by the battery transferred to the light bulb and then transformed into light energy?

Part 2: Conductors and insulators

▶ In small groups, students share their ideas about materials that conduct electricity (conductors) and those that do not (insulators). Each group designs an investigation to determine which of the common materials available are conductors and which are insulators. Students could use a scientific report genre or the planning and reporting worksheets in the sourcebook guidelines as a guide for designing their investigations.

▶ Students perform their investigation and record their results.

▶ Each group reports to the class. Students reflect on the results, referring to their ideas about the transfer of electrical energy. Discussion questions could include:

- What generalisations can you make about the materials that conduct electricity?
- What possible explanations are there for different materials behaving differently in terms of conducting electricity?

Gathering information about student learning

Sources of information could include:

- students' designs for investigations;
- students' explanations for the transfer of electricity;
- students' conclusions about conductors and insulators.

ACTIVITY

Pendulums and bouncing balls

Introductory

Focus

This activity provides opportunities for students to design and perform an investigation about energy transfer and transformation in a swinging pendulum or a bouncing ball.

Materials

For each group:

- balls (tennis balls work well)
- light string or fishing line to swing a pendulum
- small mass for the pendulum
- stopwatch
- metre ruler
- overhead transparencies (half of each OHT to have graph lines) and suitable pens

Teaching considerations

Falling objects and collisions with the ground are common phenomena that can be explained using ideas of energy transformations. In each, gravitational potential energy is converted to kinetic energy and back again. Ensure that students are aware of the different energy types and the idea of energy transformations.

Possible researchable questions could include:

- Does the height the ball is released from affect its bounce height?
- Does the temperature of the ball affect its bounce?
- Does the length of the pendulum affect its swing?
- Does the weight of the mass at the end of the pendulum affect its swing?
- Does the height from which the pendulum is released affect its swing?

Through careful questioning in a class discussion before the investigations, students should be able to suggest that both bouncing balls and pendulums involve energy transformations of gravitational potential energy and kinetic energy. They should also recognise that other energy forms such as heat and sound are produced in small amounts.

Students could use the planning and reporting worksheets in appendix 3 of the sourcebook guidelines when structuring their investigations.

Students with vision impairment
Some students with vision impairment may need assistance for this activity. Seek advice from their support teacher.

Working scientifically

Time: 60 minutes

Collecting information
Designing and performing investigations

▶ Students review their current understandings of energy transformations through a general discussion of common phenomena. The phenomena might include falling objects and simple collisions and should include a bouncing ball and a swinging pendulum.

Exploring phenomena
Formulating questions
Handling materials
Identifying and controlling variables
Measuring
Inferring from data
Summarising and reporting

Questions to guide discussion could include:

- Which forms of energy are involved?
- What energy changes occur?
- What are the factors or variables involved?

▶ In groups students use the materials provided to design and conduct an investigation that answers one of the above questions about a swinging pendulum or a bouncing ball.

▶ Groups report to the class, outlining what they did and what they found. Students graph the results of their investigations and display these on an overhead transparency and answer questions from the class. Possible questions include:

- Which variables were involved in your investigation?
- What did you do to control them?
- What conclusions did you draw?
- How confident are you that, if others did the same investigation, they would get similar results or draw similar conclusions? Why?

▶ Students work individually to summarise what they learned. Each student records the variables involved for each phenomenon and the energy transformations that occurred.

Gathering information about student learning

Sources of information could include:

- students' answers to questions about the energy transformations;
- students' reports;
- students' summaries including their discussion of energy transformations.

ACTIVITY

Energy in the home

Introductory

Focus

This activity provides opportunities for students to collect information about the ways that energy is used in the home.

Materials

- Resource Sheet 2, 'Reading an electricity meter'
- Resource Sheet 3, 'Energy audit'
- sample electricity bills (if available)

Teaching considerations

This activity involves students reading their home electricity meters over several days to monitor daily activities involving energy. Encourage students to reflect on their daily activities in relation to energy — for example, energy transformations and strategies to reduce the use of electricity.

Students whose primary source of electricity is a diesel generator, solar converter or wind generator may not be able to measure electricity in the way suggested in Resource Sheet 2. These students will also require some adaptation of the energy audit conducted in this activity.

Students with vision impairment
Some students with vision impairment may need assistance for this activity. Seek advice from their support teacher.

Working scientifically

Time: 30 minutes of class time plus time at home

Collecting information

Summarising and reporting

Resource Sheets 2, 3

▶ Students discuss ways in which energy is used in homes. They brainstorm the various ways they use energy and reflect on the sources of this energy.

▶ Students read Resource Sheet 2 for examples of how electrical energy is measured. They then use Resource Sheet 3 to measure electricity use in their homes by recording changes to the readings on the electricity meter.

▶ Students discuss the cost of electricity and how this is calculated. For simplicity they could consider a flat rate per kWh or examine an electricity bill to see how different tariffs are applied.

▶ Students use this information to conduct an energy audit for two days. They record the reading on the electricity meter at the same time each day, summarise this information and calculate the expected cost for those days. Students then present their summaries in groups. They discuss what they found, reflect on the types of activities that used the most energy and consider how to reduce the amount of energy used.

Gathering information about student learning

Sources of information could include:

- students' records of energy use at home (Resource Sheet 3);
- students' written summaries of the energy audits.

ACTIVITY

Electric circuit role-play

Developmental

Focus

This activity provides opportunities for students to formulate and elaborate their ideas about transfer of electrical energy.

Materials

- 2 tennis balls (or similar) for each student

Teaching considerations

Many students have heard and used the terms 'current', 'voltage' and 'resistance' in relation to electricity. In other activities in this module they are encouraged to use these terms when discussing their thinking. This activity utilises a simulation strategy to help students clarify the scientific ideas of electron flow. Encourage students to clarify their own ideas at the start of the activity so they are able to compare them to the scientific ideas to be discussed.

The simulation uses students and tennis balls to represent an electrical circuit. The focus is on what happens in the external circuit. Discussion of what happens in the energy source (power station, battery) would add a level of complexity that could lead to confusion.

Students sit in a circle. Each student has two tennis balls. The simulation is based on the following:

- The tennis balls are electrons.
- All but two of the students are atoms in the conductors of the circuit.
- The other two students represent the source of energy (battery) — one holds the electrons coming from the energy source, while the other holds the electrons returning to the energy source.
- Passing the tennis balls from one student to the next represents the current (flow of electrons) passing through a conductor.

The students representing the energy source can pass their electrons to each other when the circuit is complete. The circuit is started by the student representing the negative terminal of the battery passing two balls (electrons) to the student immediately to the left. The 'starter' student can then take two 'electrons' from the student on the right, and so on.

One way of representing a resistor in the circuit is to have students pass on only one electron at a time.

Discuss with students how models or simulations can be used to explain complex ideas. Also discuss the limitations of the particular simulation being used and the features that may not correspond to the real situation. It is important that strategies used to clarify one concept do not create misconceptions about others.

Working scientifically

Time: 30 minutes

Constructing meaning

Creating analogies

Using ideas, theories and principles

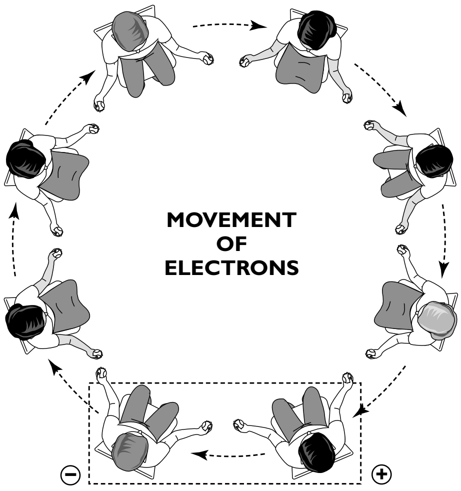
Clarifying ideas and concepts

▶ Students brainstorm and record scientific terminology used to describe electricity. They focus on terms the simulation is intended to clarify, particularly 'voltage', 'current' and 'resistance'. Students discuss their ideas and develop class definitions for the terms.

▶ Students discuss the simulation of an electric circuit, clarifying their roles and the role of the tennis balls. They then carry out the simulation.

Discussing thinking
Exploring and elaborating ideas
Using scientific terminology

Students representing an external circuit



These two students can 'open' and 'close' the circuit.

▶ Students discuss ways in which the simulation could be extended and enact each of their ideas in turn. For example, they could:

- give the role of 'ammeter' to one student who measures current by counting the number of electrons passing a given point in a set amount of time — for example, ten seconds;
- have one student in the 'circuit' play the role of a resistor, such as a light bulb or a speaker;
- represent a parallel circuit by having branches in the path.

▶ Students reflect on the effects on the current of any changes they have made to the circuit.

▶ At the end of the role-play, students prepare a summary of the activity, which includes a description of the concepts (scientific terminology should be used) and a discussion of the strengths and limitations of the simulation.

Additional learning

▶ Students use batteries, bulbs and connecting wires to set up a number of circuits, to provide a description of voltage, current and resistance in the circuit using ideas illustrated in the role-play.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' summaries of the ideas demonstrated in the role-play.

ACTIVITY

Ohm's law

Developmental

Focus

This activity provides opportunities for students to develop their understandings of how electrical energy is transferred in simple circuits.

Materials

For each group of students:

- Resource Sheet 4, 'Ohm's law investigation'
- materials listed on Resource Sheet 4

Teaching considerations

This activity builds on students' ideas of current, voltage and resistance. Ensure that these concepts are clarified with students before this activity.

Resource Sheet 4

Although this activity is presented as a closed, verification-style investigation, students can, through questioning and class discussion, have input into its design. Encourage students to think about appropriate experimental design by considering questions such as those listed in 'Working scientifically' below. Resource Sheet 4 can be used to guide the investigation.

Ensure that students are competent in connecting and using ammeters and voltmeters.

Safety

Inform students about safe practices for using electrical appliances. It is good practice for them to have the circuit checked by the teacher before switching it on.

Working scientifically

Handling materials
Identifying and controlling variables
Looking for patterns and meanings
Drawing conclusions
Creating tables and graphs
Discussing thinking

Time: 60 minutes

▶ Students review their understanding of the terms 'current' and 'voltage'. They discuss ways of investigating the relationship between these two variables to answer the following question: What happens to the current in a circuit when the voltage is changed?

▶ Through class discussion about the design of the investigation, students consider which variables are to be changed, which are to be measured, and which variables are to be kept the same. They discuss ways of recording and presenting their results using tables and graphs. Discussion questions include:

- Which variable will be changed? (independent variable)
- Which variable will be measured? (dependent variable)
- Which variables will be kept the same? (controlled)
- How should the results be recorded?
- Are the data continuous or discrete?
- What type of graph would be appropriate?

▶ In groups, students conduct the investigation and analyse their results by graphing the dependent and independent variables. As a class, they discuss the slope of the graph. Students prepare reports on their investigations.

▶ Students discuss whether they can generalise about the result (will this happen every time the experiment is done?) and are introduced to the formal definition of Ohm's law. They discuss the nature of a law in science and consider how this law can be applied.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' suggestions about the design of their investigations;
- students' reports on their investigations.

ACTIVITY

Electrical appliances

Developmental

Focus

This activity provides opportunities for students to collect information about energy use and to suggest alternative patterns of use of electrical energy in the home.

Materials

- Resource Sheet 5, 'Electricity tariffs'

Teaching considerations

The focus core learning outcome of this activity refers to the consequences of different ways of using energy. Guide students to use the information they have collected to consider such consequences. The suggestions given below for the investigation should be used as a guide only. Vary it appropriately to suit the experience and ability of students.

Working scientifically

Time: 60 minutes of class time plus time at home (e.g. over 1 week)

Collecting information

Designing and performing investigations

Looking for alternatives

Creating tables and graphs

Resource Sheet 5

▶ Students plan an investigation into the use of electrical appliances in the home to identify how electricity could be conserved at the local level. They decide the type of information to collect, and how to collect and record it. The following are suggestions for information to be investigated and reported:

- electrical appliances used in students' homes;
- the power rating of each appliance (on rating plates on the appliance or in the instruction booklet);
- a record of the time (in hours) each appliance is used each day;
- the energy used by each appliance over one week;
- the cost, based on current tariffs, of each appliance (see Resource Sheet 5);
- total energy and cost used by the household;
- a comparison of different appliances;
- carefully considered suggestions about how energy might be conserved, with a discussion of the consequences of each suggestion.

▶ Students collect information and present their findings. The emphasis should be on suggesting how energy consumption can be reduced. Students have the opportunity to challenge the feasibility of each other's suggestions. Presentations could be given in groups, with each group reporting the most feasible suggestions to the class.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' reports on the investigations;
- students' suggestions for alternatives and the associated consequences.

ACTIVITY

Exploring sound

Developmental

Focus

This activity provides opportunities for students to explore the phenomenon of transfer of sound energy.

Materials

- Resource Sheet 6, 'Sound explorations'
- materials listed on Resource Sheet 6 for each of the investigations

Teaching considerations

For the investigations in this activity consider using an approach in which students start in home groups, then break into expert groups so that each person from the home group is responsible for one investigation. The expert explains the investigation to the others, leads them through it, and reports to the class. This approach encourages student ownership of the investigations.

Encourage students to explain sound transfer in terms of particles vibrating. Some prior discussion of how sound is transferred will help students focus on this during the investigations.

The investigation of the speed of sound is best conducted as a class group in a large open area such as the school oval. Student 'experts' can still lead this, with each group discussing ideas afterwards. Two of each of the other investigations could be set up so that groups rotate through them.

Students with hearing impairment

Some students with hearing impairment may need assistance for this activity. Seek advice from their support teacher. An activity where sound is 'seen' through an oscilloscope could be added to Resource Sheet 6.

Safety

The teacher or another adult should operate the starting pistol for Investigation 4. Ear and eye protection should be worn.

Working scientifically

Exploring phenomena
Making and judging observations
Seeking reasons
Applying ideas and concepts
Discussing thinking

Resource Sheet 6

Time: 60 minutes

▶ In groups, students conduct a series of investigations into the way that sound energy is transferred. They complete each investigation on Resource Sheet 6 and record their observations. Students make inferences from their observations and use the idea of particles vibrating to provide explanations.

▶ Students create presentations to share their ideas about sound transfer with other class members. They discuss their ideas as a class, emphasising ways in which the relationship between vibrations and sound is applied. Sound in a vacuum could also be discussed.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' records of observations and inferences;
- students' presentations.

ACTIVITY

Soundproofing

Developmental

Focus

This activity provides opportunities for students to design and perform an investigation into the transfer of sound energy through various materials.

Materials

- sound source (e.g. ticking alarm clock, beeper)
- a small box or similar container to hold the sound source, with a small hole cut out of one side
- pieces of materials to be tested (cotton material, wool, carpet, foam)
- tape measure

Teaching considerations

Students have the opportunity in this activity to design their own investigation. Encourage them to consider alternative ways to investigate the problem. Also encourage them to consider how the investigation could be modified to be more quantitative.

The explanations that students provide should be in terms of the transfer of sound energy through different materials.

Students with hearing impairment
Some students with hearing impairment may need assistance for this activity. Seek advice from their support teacher.

Working scientifically

Collecting information
Designing and performing investigations
Identifying and controlling variables
Measuring
Making comparisons
Creating tables and graphs
Discussing thinking

Time: 45 minutes

▶ Students observe a demonstration in which a sound source is placed in a box with one small opening in one side. A student stands beside the box and then gradually moves away from it until the sound can no longer be heard. Students discuss the demonstration and list the variables involved.

▶ Students are shown pieces of materials that could be used for soundproofing. They suggest ways of investigating which of the materials makes the best soundproofing.

▶ In small groups, students design and conduct their investigations. Each group prepares and presents a report to the class, clearly explaining what was done and what was found. Data should be presented in an appropriate form — for example, as a bar graph.

▶ Students discuss the following questions:

- What did you measure to give an indication of how soundproof each material was?
- Which materials seem to soundproof better than others? Why do you think that is?
- If energy is not created or destroyed, what happened to the sound energy that could not be heard?

- How confident are you of the validity and reliability of your results?
- How could you improve your investigation?

Students' responses could be used as a basis for discussing the energy transfers that occurred during their investigations.

Gathering information about student learning

Sources of information could include:

- students' designs for investigations;
- students' reports;
- students' contributions to discussions.

ACTIVITY

Heat and fabrics

Developmental

Focus

This activity provides opportunities for students to design and perform experiments about the absorption of heat by different coloured fabrics and to apply their findings when considering why clothes of a particular colour are suited to particular climates.

Materials

- different coloured samples of a fabric
- other equipment, depending on investigations designed by students (e.g. thermometer, ray lamp, tape measure)

Teaching considerations

In this activity students design and conduct their own investigations. They could use the planning and reporting worksheets in appendix 3 of the sourcebook guidelines when structuring their investigations. Students may need assistance to consider all the variables and explain how the variables are being controlled.

Students are likely to suggest that darker fabrics will absorb heat more readily than lighter coloured ones. Encourage them to apply their knowledge of the colours of the spectrum and colour absorption to explain their suggestions.

Working scientifically

Time: 60 minutes

Designing and performing investigations
Formulating questions
Identifying and controlling variables
Predicting
Applying ideas and concepts
Interpreting data
Making comparisons
Creating tables and graphs
Explaining ideas and decisions
Using scientific report genres

▶ Students predict the heat absorption properties of different coloured fabrics. They place the coloured samples in order from most heat absorbent to least heat absorbent and explain their ordering.

▶ In groups, students formulate a research question about how the colour of a fabric affects its ability to absorb heat. They design an investigation based on this question. Groups share their designs with the class and offer each other comments and suggestions about how these might be refined.

▶ Students reconsider their designs on the basis of the advice received, conduct their investigations and present their results to the class. Each student prepares a report that includes predictions, describes the investigation and results, and compares what happened with what was predicted.

▶ Referring to the results of their investigations, students suggest which fabric colours are suitable for clothing designed for colder climates and which are more suitable for warmer climates. They provide reasons for suggestions.

Gathering information about student learning

Sources of information could include:

- students' contributions to discussions;
- students' reports.

ACTIVITY

Doppler effect

Developmental

Focus

This activity provides opportunities for students to collect information about the transfer of sound energy when the energy source and receiver are moving with respect to each other and to apply ideas and concepts about the wave motion of sound.

Materials

For the class:

- cassette recorder (for initial discussion; also for student use)
- audio recording of some sound demonstrating the Doppler effect (e.g. car driving past or aeroplane flying overhead)

Teaching considerations

The activity begins with an initial discussion of the Doppler effect — something most students will have experienced. Prepare for this by recording the sound of a vehicle approaching and receding to remind students what the Doppler effect sounds like.

The initial discussion of the Doppler effect requires that students be familiar with the terms 'pitch' and 'frequency' as they apply to sound. Be prepared to discuss the wave nature of sound.

Consider taking students to a place in the school grounds where they can hear vehicles driving past. This will allow them to listen to the different sounds as the vehicles approach and recede. Students are usually able to discriminate the sounds better when they do not look at the passing vehicles.

Students with hearing impairment

Some students with hearing impairment may need assistance for this activity. Seek advice from their support teacher.

Working scientifically

Time: 60 minutes

Collecting information

Applying ideas and concepts

Creating presentations

▶ Students listen to a recording of the Doppler effect of sound. They describe the pitch of the sound as it approaches and recedes. They also consider ideas such as 'frequency', 'wavelength' and 'speed of sound'.

▶ Individually, students make recordings of the Doppler effect of sound using an example of their own choice. (They could record a vehicle, as in the demonstration, or a whistle swinging round on a string, or a bull-roarer.)

▶ Students present their recordings, explaining what is happening to the sound wave as the source of the sound approaches and recedes. Their explanations could include annotated diagrams of the sound wave.

Gathering information about student learning

Sources of information could include:

- students' presentations and explanations of changes to the sound wave.

ACTIVITY

Efficient energy converters

Culminating

Focus

This activity provides opportunities for students to apply ideas of conservation of energy and efficiency to the common energy converters they use and to evaluate the immediate consequences of that energy use.

Materials

- print or electronic resources on energy converters

Teaching considerations

Energy converters include any electrical appliances found in the home. Before beginning this activity, students should understand the following:

- Energy is not created or destroyed;
- No energy converter can ever be 100 per cent efficient; some energy is always converted into forms that cannot be used. Some of the conversion is always to heat energy; some other forms of energy may also be produced.

Working scientifically

Time: 30 minutes class time, plus research time (some in class)

Collecting information
Applying ideas and concepts
Creating a presentation
Summarising and reporting

▶ Students research and analyse an energy converter they regularly use and prepare a presentation about it. Points to consider in the research include:

- use made of the energy converter;
- how the energy converter works;
- how the energy is supplied to run the energy converter;
- the energy transformations that occur;
- the desired energy transformations and the unnecessary energy transformations;
- the efficiency of the energy converter.

▶ Students select the format for presentation — for example, poster, model, oral presentation.

Gathering information about student learning

Sources of information could include:

- students' presentations;
- students' selection and synthesis of information.

ACTIVITY

Future consequences

Culminating

Focus

This activity provides opportunities for students to forecast consequences of current energy use and prepare scenarios related to future energy use.

Materials

- Resource Sheet 7, 'Sample futures wheel'
- butcher's paper or overhead transparencies and suitable pens
- print or electronic resources on commonly used methods of power generation and alternative methods

Teaching considerations

Futures wheel

Resource Sheet 7

In this activity, students develop a futures wheel. One of the purposes of futures wheels is to encourage students to reflect on the consequences of possible future events. It is suggested that students work in small groups to encourage sharing of ideas. Students who have little experience with this strategy will benefit from a demonstration. Resource Sheet 7 can be reproduced for this purpose.

Preparing scenarios

When students prepare scenarios, they can use a variety of presentations including an essay, a newspaper story, a letter to the editor or a group poster. Students use the opportunity to demonstrate their understanding of the issues involved in energy generation and of the scientific concepts involved.

Working scientifically

Forecasting and backcasting
Predicting
Preparing scenarios
Recognising and analysing options
Envisioning alternative futures

Time: 90 minutes

▶ Students find sources of information about methods of generating electricity including:

- typical methods used in Australia — for example, coal-fired generators, hydroelectric generators, diesel generators, solar converters;
- methods used in other countries but not in Australia — for example, nuclear power stations.

▶ Students gain an understanding of these methods by gathering and synthesising information about the following aspects of each method:

- advantages;
- disadvantages;
- energy transformations involved;
- energy efficiency;
- environmental issues, such as pollution and waste disposal;
- occupational hazards;
- cost issues.

▶ Using this information, students work in groups to create a futures wheel that forecasts consequences of possible future events. Groups might select or be assigned possible future events such as:

- a coal and oil crisis in 2010;
- massive population increases during the next 20 years;
- developing countries having access to first-world technology;
- cheaper solar converters;
- an increase in global pollution;
- control of nuclear fusion;
- sending nuclear waste into space.

Students present the futures wheel on butcher's paper or overhead transparencies to the class.

▶ Students prepare scenarios based on one or more of the consequences suggested in the futures wheels. The way that scenarios are presented can vary but could include:

- a day in the life of …;
- a discussion of major issues in the future;
- then and now comparisons.

Gathering information about student learning

Sources of information could include:

- students' location, selection and synthesis of information;
- students' futures wheels;
- students' scenarios.

ACTIVITY

Electrical safety

Culminating

Focus

This activity provides opportunities for students to collect information and create presentations on the safe use of electrical energy.

Materials

- materials for making posters
- information on safety devices

Teaching considerations

In this activity students prepare a poster or brochure to demonstrate their understanding of the ideas about electricity discussed in previous activities. The activity can be varied to be open or closed to suit the experience and abilities of students. Remind students that they should show what they know through their posters and brochures. They should, therefore, choose a topic that gives them the opportunity to do this and cover it in reasonable depth. They must refer to 'voltage', 'current', 'resistance' and 'electromagnetism'.

Discuss the posters and brochures with students to remind them of key points. Information should be clear and concise. If used, diagrams must be useful, not merely decorative.

Working scientifically

Time: 60 minutes

Accessing resources
Creating presentations
Illustrating

▶ Students choose a topic for a poster or brochure about some aspect of safety related to electricity. Possible topics could be suggested through class discussion — for example:

- safe practices with electricity in the home;
- reasons why electricity can be dangerous to humans;
- safety devices such as fuses and earth-leakage circuit-breakers.

▶ Individually or in groups, students research their topics. They report what they have found in a whole-class discussion, giving all class members opportunities to access the collected information.

▶ Students prepare posters or brochures that explain relevant concepts and demonstrate their understanding of ideas about electricity. For example, a student explaining how fuses work would discuss resistance in wires and melting points of various metals.

▶ Students share their posters or brochures with others (in the class group or in small groups).

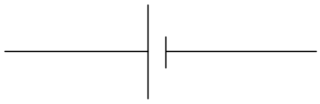
Gathering information about student learning

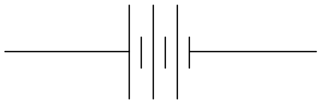
Sources of information could include:

- students' contributions to discussions;
- students' posters or brochures.

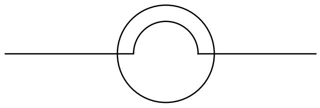
Circuit symbols

Resource Sheet 1

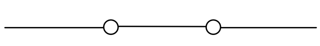
cell


battery


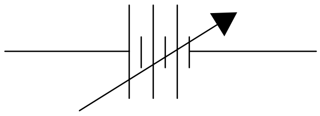
wire

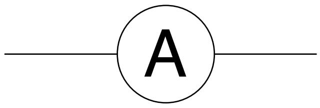
bulb


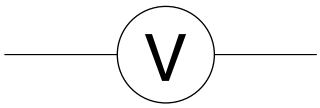
switch (open)


switch (closed)


resistor


variable power source


ammeter


voltmeter


Reading an electricity meter

A method of determining electrical energy usage is to record meter readings. Electrical meters measure electricity in kilowatt-hours (kWh). A kilowatt hour is the amount of electricity used by an appliance rated at 1 kilowatt (kW) when it is used for one hour. For example, a refrigerator rated at 700 kW uses 700 kWh in one hour. This is charged at a certain amount per kWh.

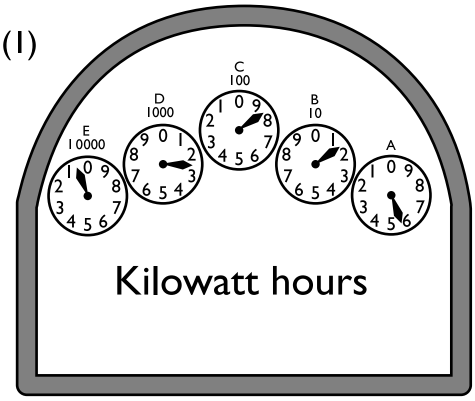
There are two types of meter — analog and digital.

Analog meter

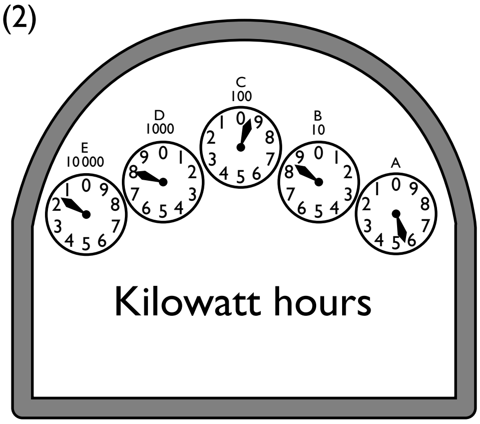
To read an analog electricity meter:

- Commence reading from the right-hand dial (A). Read each dial from right to left in sequence and write the numbers from right to left on your page.
- When a dial hand points between two numbers, write the lower of the two numbers. If it points between 0 and 1, write 0; if it points between 9 and 0, write 9. Remember that adjacent dial pointers rotate in opposite directions. For example, the reading in illustration 1 is 0 2 8 1 5 — 2815 kilowatt hours.
- When a dial hand appears to be exactly on a number as on dial D in illustration 2, look at the dial to the right. If the hand on dial C has not passed zero, the number (8) has not actually been reached on dial D, and the reading on that dial is the next lower number (7). The reading is 1 7 9 8 5 — 17 985 kilowatt hours.

(1)



(2)

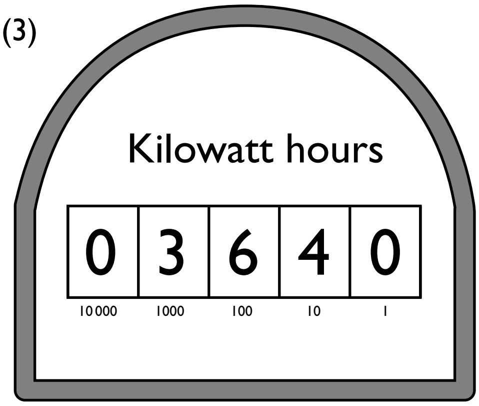


Digital meter

To read the digital electricity meter:

- Read the numbers from left to right; write them down from left to right on your page. For example, the reading in illustration 3 is 0 3 6 4 0 — 3640 kilowatt hours.

(3)



Energy audit

Use the blank dials below to take readings from your electricity meter. If your meter is different from the one shown, carefully copy the dials from your meter exactly as they appear and then draw each needle on the dial as it appears on your meter (do this on a separate piece of paper).

Try to read your meter at the same time each day. The first reading is the starting-point. The readings on the other two days enable you to calculate the amount of energy used in each 24-hour period.

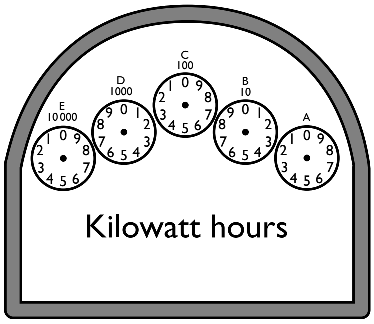
Daily usage of electricity over two days

Initial reading

Date: ________________________

Time: ________________________

Meter reading 1: _______________ kWh



Day 1

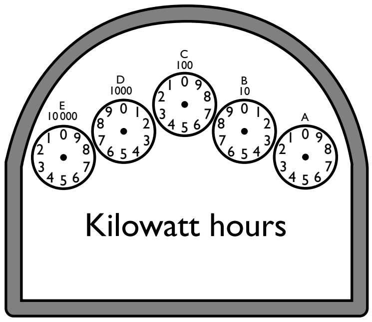
Date: ________________________

Time: ________________________

Meter reading 2: _______________ kWh

Electricity use for first 24 hours

(subtract reading 1 from reading 2) _______________



Day 2

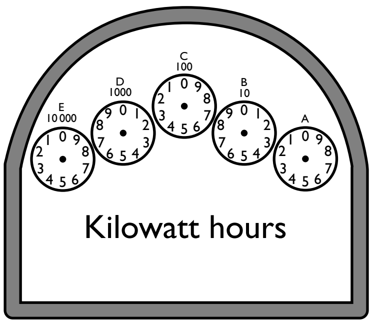
Date: ________________________

Time: ________________________

Meter reading 3: _______________ kWh

Electricity use for second 24 hours

(subtract reading 2 from reading 3) _______________



Comments/observations:

____

____

____

____

Ohm’s law investigation

R4 Resource Sheet 4

This investigation focuses on the relationship between current and voltage in a simple circuit. The question being answered is:

What happens to the current in a simple circuit when the voltage is increased?

You will need:

- power pack (0–12 volts)
- connecting leads
- fixed resistor/light bulb
- ammeter
- voltmeter
- graph paper

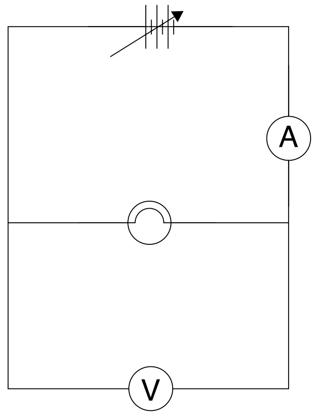
The independent variable is the **voltage** — as supplied by the power pack and measured by the voltmeter.

The dependent variable is the **current** — as measured by the ammeter.

All other components in the circuit and their arrangement are kept constant and are the **controlled variables**.

Setting up the equipment

- Connect the circuit as indicated in the diagram. This shows a variable power supply connected in series to an ammeter and fixed resistor (light bulb). A voltmeter is connected in parallel across the resistor.
- Vary voltage settings from 2 V to 10 V in increments of 2 V.



Recording and presenting results

- Record the voltage and current for each setting in a table like the following:

Voltage (V)	Current (I)	V/I

- Graph the results to clarify the relationship between V and I.

Electricity tariffs

R5 Resource Sheet 5

Tariff list

TARIFF	UNITS (kWh)	CENTS per kWh (GST inclusive)	MINIMUM PAYMENTS	REMARKS
Domestic Light and Power **Tariff 11**	First 100 per residence or flat per month Next 300 per residence or flat per month Remainder	17.116 11.627 10.373	Minimum payment per residence or flat per month: $7.68	This is your electricity tariff for general domestic usage. It is for all light and power used in domestic homes, flats and units. It may also apply to some caravan parks and serviced holiday flats. It may also be used for quick-recovery continuous-supply electric hot water systems. You may find that your consumption on this tariff is subject to seasonal variations with winter heating and summer airconditioning affecting the account of many customers.
Super Economy Plan **Tariff 31**	All consumption	4.796	Minimum monthly payment: $3.15	The Super Economy Plan is the cheapest tariff available for water heating. This is because the electricity can be used only at night when generators would otherwise be idle. Electricity supply is made available for eight hours per day usually between the hours of 10.00 p.m. and 7.00 a.m. This tariff is intended for electric storage water heaters. The hours of operation of this tariff are restricted. Some smaller heaters, e.g. less than 250 litres, may not meet your needs. This tariff is also available for a variety of other permanently connected loads including heatbanks. This tariff is also suitable for solar water heater boosters especially if fitted with a changeover switch. For further details on your specific application of the Super Economy Plan, please contact us.
Economy Plan **Tariff 33**	All consumption:	7.029	Minimum monthly payment: $3.15	The Economy Plan can be applied to most electric storage water heaters, solar-electric water heaters and heat pump water heaters. You can also use this tariff with other domestic loads such as swimming pool filters, clothes dryers and heatbanks, provided they are permanently connected. This tariff is about 30% cheaper than your normal domestic tariff. Electricity supply is available for at least 18 hours per day and is switched via load control equipment supplied and maintained by ENERGEX.

Source: Energex 2000, Residential tariff brochure.

Sound explorations

After completing each of the activities below, record your observations and draw inferences that explain what you observed. The explanations should be in terms of the vibrations that cause sound.

Investigation 1: Coathanger chimes

You will need:
- a wire coathanger
- a piece of cotton thread approximately 1 m long

1. Tie the middle of the piece of cotton thread to the hook of a wire coathanger.
2. Hold the coathanger chimes by the cotton thread so that you can place your hands on your ears and the coathanger can swing freely as shown in the diagram.
3. Let the coathanger strike something solid.

- What do you notice?

Investigation 2: String telephones

You will need:
- two empty tins with one end removed
- a piece of string approximately 8 m long

1. Make a small hole through the bottom of each tin. Thread the ends of the string through the holes and tie a knot so that the string is secured.
2. Hold one tin of the string telephone and have a partner hold the other. Stand apart so that the string is taut.
3. Speak into the tin and see whether your partner can hear you and send an audible reply.

- What do you notice about the string as you or your partner is speaking?
- What happens when the string is held loosely?

(continued)

Sound explorations *(continued)*

Investigation 3: Tuning forks

You will need:

- a tuning fork

1. Hold the tuning fork by the base and strike it firmly on a solid object.

2. Record what you could see happening.

- What do you hear? What do you see?
- Experiment by quickly placing the tuning fork on various objects, such as a desk or blackboard.
- What happens when you place the tuning fork against an inflated balloon?
- Observe what happens when you strike the tuning fork and place it so that one of the tines just touches the surface of some water?

Investigation 4: Speed of sound

You will need:

- a starter pistol
- 3 or 4 stopwatches

1. One person (probably the teacher) stands 100 m away (further if possible) in an open area such as an oval. This person fires the starter pistol.

2. Another person records the time between seeing the smoke and hearing the noise from the starter pistol.

3. Use several stopwatches and repeat the measurement several times so that an average can be calculated.

- Determine the speed of sound.
- Explain why the speed of sound can be measured this way.
- What is the speed of light?

(continued)

Sound explorations *(continued)*

Investigation 5: Slinky spring

You will need:

- a slinky spring

1. Two people hold the slinky spring stretched out along the ground.

2. One person acts as a 'fixed end' (keeping one end of the spring still).

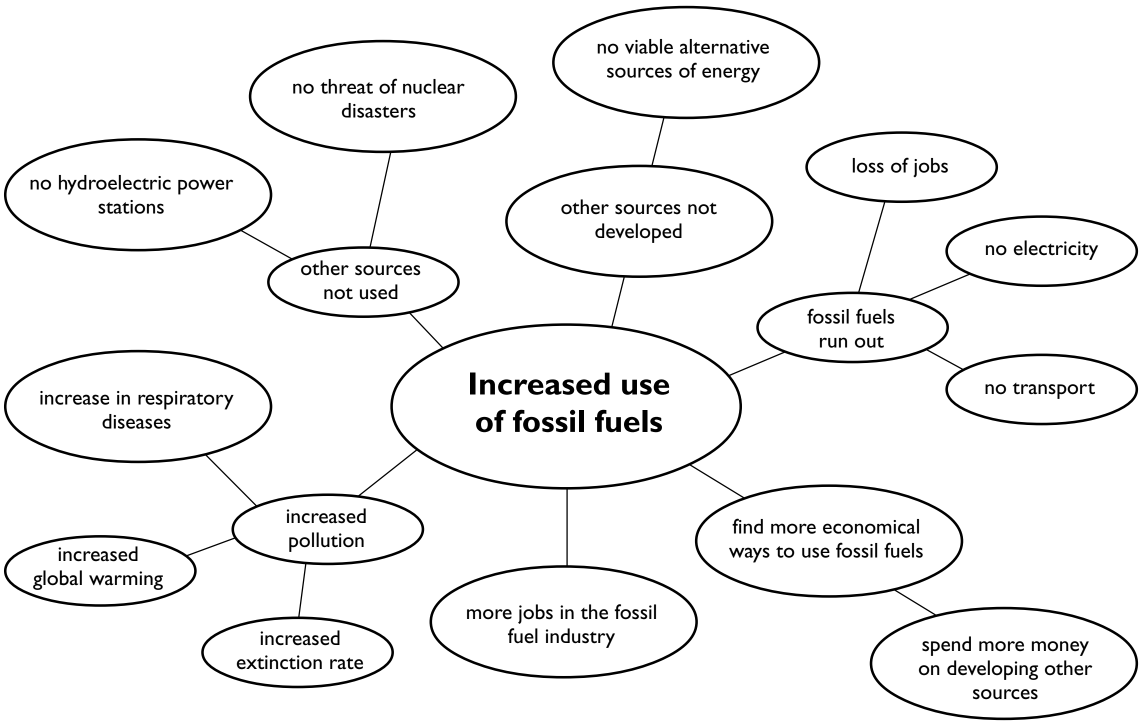
3. The other person sends down a *longitudinal wave* by quickly moving that end of the spring back and forth in the direction of the spring (moving the end sideways would create a *transverse wave*).

- What happens to the slinky spring?
- Can you see a pulse travelling down it?
- What happens to the pulse when it reaches the fixed end?
- Try changing the tautness of the slinky spring to see whether there is a difference.
- Record your observations and explain how the slinky spring can be used to model the transfer of sound.

Sample futures wheel

The futures wheel strategy encourages students to reflect on the consequences of possible futures. Students start with a possible future event that they have generated or have been assigned. They discuss the event and generate consequences. First-order consequences lead to second-order consequences and so on. The number of consequences and the number of levels used are flexible. Both positive and negative consequences are considered.

An example is shown below:



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Energex for material on residential tariffs

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

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