ATSE

STELR PROJECT

Electricity and Energy

Student Book

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Section 1: Energy Transfers and Transformations

Big Ideas:

1. **Why do we need energy?**
2. **What types of energy are there?**
3. **What is the difference between energy transformation and energy transfer?**

A hydroelectric power station uses flowing water as the energy source to generate electricity.

Work Sheet 1: Types and sources of Energy

Question 1
Have a class brainstorm about energy: What does it do? What is it used for? Why is it important? Use the mind map below to connect all of your brainstormed thoughts about energy.

Energy

Question 2

Energy is all around you and even inside you. It is the driving force behind, well, pretty much everything. You use many different types of energy in your daily life. Some different types of energy you have already learnt about are heat, light, sound and movement. The scientific term for movement energy is kinetic energy.

There are also many different sources of energy. An energy source is where this energy comes from. Some sources generate more than one type energy. For example a desk lamp will produce light and heat energy.

Write down in the table below as many different types of energy as you can think of. Give an example of an energy source that produces this type of energy. (Use the images above for ideas). One answer has been provided to help you get started.

Table 1

Energy Type	Energy Source
Light	Sun, torch

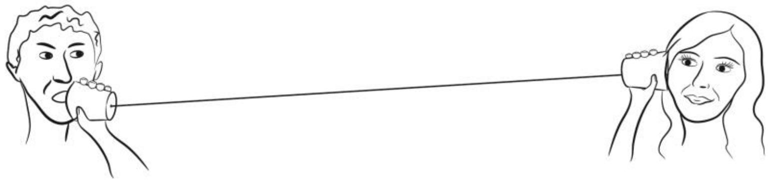
Work Sheet 2: Energy Transfer

Rather than staying in the same place, energy frequently moves from one place to another. This is known as *energy transfer.*

Imagine yourself at home, sitting down after a long day at school and switching the TV on to watch your favourite TV show. The TV lights up and the show theme song starts to play. How does the sound get from the TV to your ears?

The answer is that the TV's speakers produce the sound which is then *transferred* through the air all the way to your ears. In fact, if there weren't any air (for example if you were in outer space) you wouldn't hear anything at all! Sound is also transferred in solids and liquids. If fact sound often travels further and faster in this type of matter. A string telephone shows how well sound can be transferred in a solid.

String Telephone



You may well have also observed energy transfer occurring in your home kitchen. If you place a metal saucepan containing water on a hot stove, the water and saucepan lid soon become hot. This is because the heat energy of the flame or heating element is transferred from the base of the frypan and to the sausages.

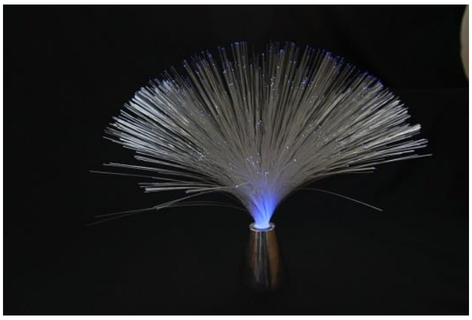
Question 1

Give an example which shows transfer of electrical energy.

Question 2

The picture on the right of a fibre optic lamp shows the transfer of which type of energy?

<add line for answer>



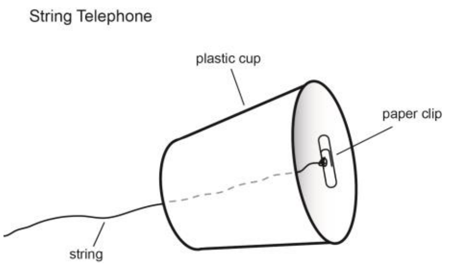
<image source: https://pixabay.com/en/light-glass-fiber-fiber-optic-lamp-1502758/>

Quick Activity 1 – String telephone

This activity is best conducted in an open space.

What you need

- Two plastic or paper cups with a small hole punched in the base
- 2 – 3 m piece of string
- 2 paper clips



What to do

1. Thread the string through the hole in the base of one cup and tie it to a paperclip. Make sure the paper clip is on the inside of the cup. Do the same with the other end of the string an the second cup
2. With different people each holding a separate cup move away from each other until the string is tight. (make sure the string isn't touching anything else)
3. One person whispers into their cup while the other person holds their cup to their ear and listens.

Question 1
What type of energy is being transferred?

Question 2
What is the source of this energy?

Question 3
What do you think would happen if the string was cut? Why would this happen?

Question 4
Challenge: How does the length of the string affect the transfer of sound? Why?

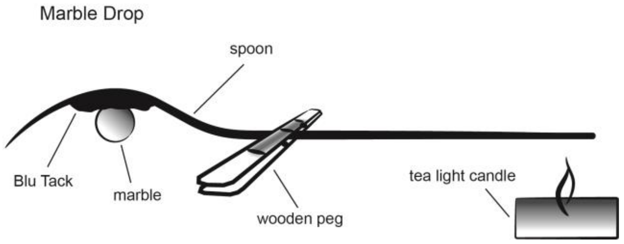
Quick Activity 2 – Marble drop

What you need:

- Metal desert spoon or knife
- Wooden peg
- Blu Tack
- Marble
- Tea light Candle
- Matches or lighter
- Timing device (clock or stop watch)

What to do

1. Place a piece of Blu Tack on the end of a spoon or knife away from the handle
2. Push the marble into the Blu Tack so it stays embedded when the spoon or knife is turned upside down
3. Attach the peg near the marble end of the spoon or knife
4. Hold the spoon or knife by the peg. Make sure the marble is facing down. Light the candle and hold the handle end of the spoon or knife over the candle high enough so that it is away from the flame but close enough to feel the heat. Note the time or start the timer.



Question 1
Describe what happens to the marble after the spoon or knife has been held over the heat of the flame. How long did this take to happen?

Question 2
Why do you think this happened?

Question 3
What different types of energy can be observed during this activity? What is the source of this energy?

Question 4
What kind of energy is being transferred from the candle flame along the spoon or knife?

Question 5
Challenge: Predict what would happen if a wooden knife or spoon was used instead? Why do you think this would happen?

Work Sheet 3: Energy Transformation

In worksheet 1 we looked at various different types of energy: light energy, electrical energy, sound energy, and so on. Sometimes energy is transformed from one type of energy to another. This is known as energy transformation and is shown in the following examples.

1. Energy transformations in a iPod
When you turn on an iPod that is plugged into a power point, electrical energy is transformed into sound energy. One simple way to represent the transformation of energy is with a flow chart such as the one shown below:

Electrical energy → Sound energy

If the iPod is powered by a battery, however, two energy transformations take place, one after the other. This is because the battery contains certain chemicals that react with one to produce electrical energy when the ipod is switched on. In this case, the series of energy transformations is:

Chemical energy → Electrical energy → Sound energy

2. Energy transformations in a light bulb
Using a torch involves energy transformations to generate light and also heat at the same time. When we switch on the light, electrical energy is transferred through wires to the light bulb where it is transformed into light energy and heat energy. We can represent this by the following flow chart:

Electrical energy → Light energy + Heat energy

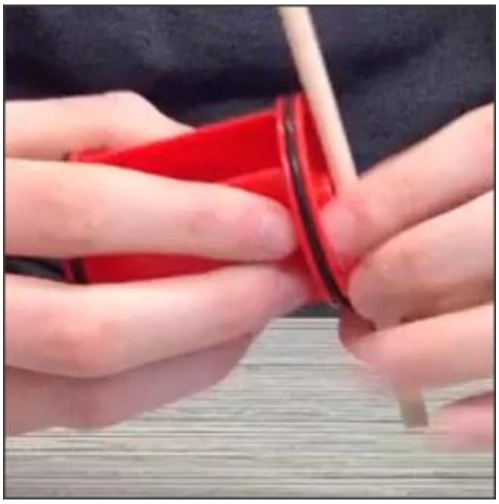
3. Energy transformations in a wind turbine
A wind turbine uses energy transfer and energy transformations to generate electricity. As the wind blows it's kinetic energy transfers to the blades of the turbine giving them kinetic energy. This turns a generator which transforms kinetic energy into electrical energy.

Kinetic energy (wind) → Kinetic energy (blades) → Electrical energy

Question 1
In your own words, describe the difference between energy *transformation* and energy *transfer*.

Quick Activity 3 - Cotton reel car

Watch the video below to learn how to make a cotton reel car! Once you have watched it, make your own and have a play.



https://www.youtube.com/watch?v=yzNwSYE03y0

Question 1
Describe how you think it works.

Question 2
What different energy types can you identify when you observe the cotton-reel car?

Question 3
Identify the starting energy for the cotton-reel car.

Question 4
Identify the finishing energy for the cotton-reel car.

Question 5
Represent the main energy transformation in the cotton-reel car with a flow chart.

Question 6

Challenge! Can you improve the design of the cotton reel car so it can go faster or further than anyone else's? What did you do to make it go faster or further?

Bringing It All Together

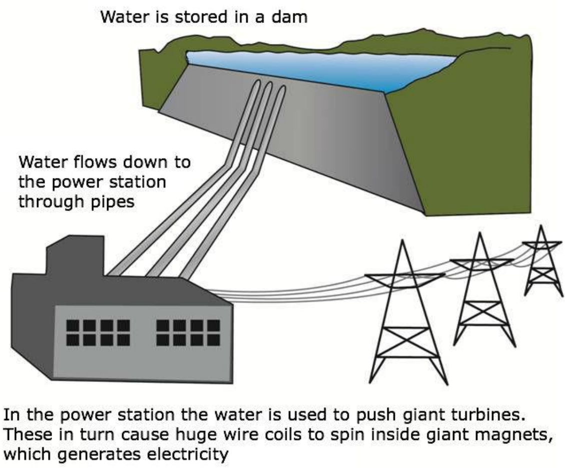
Question 1

Describe the difference between energy transfer and energy transformation.

Question 2

Name some common devices in which the following energy *transformations* take place:

	Energy Transformation	Example of device
1	Electrical energy to sound energy	
2	Electrical energy to light energy	
3	Electrical energy to both sound energy and light energy	
4	Electrical energy to heat energy	
5	Electrical energy to kinetic energy	
6	Elastic energy to kinetic energy	
7	Chemical energy to sound energy	



Question 3

Examine the above drawing of a hydroelectric power station and identify two energy *transfers* and two energy *transformations*. Use flow charts to represent them in the space below.

Section 2: Electric Circuits

Big Ideas

1. What does a circuit need to allow electricity to flow?

2. How does the position of the switch in the circuit affect which globes go on?

3. What materials conduct electricity?

4. What happens to the brightness of the globes when an extra globe is connected into a circuit?

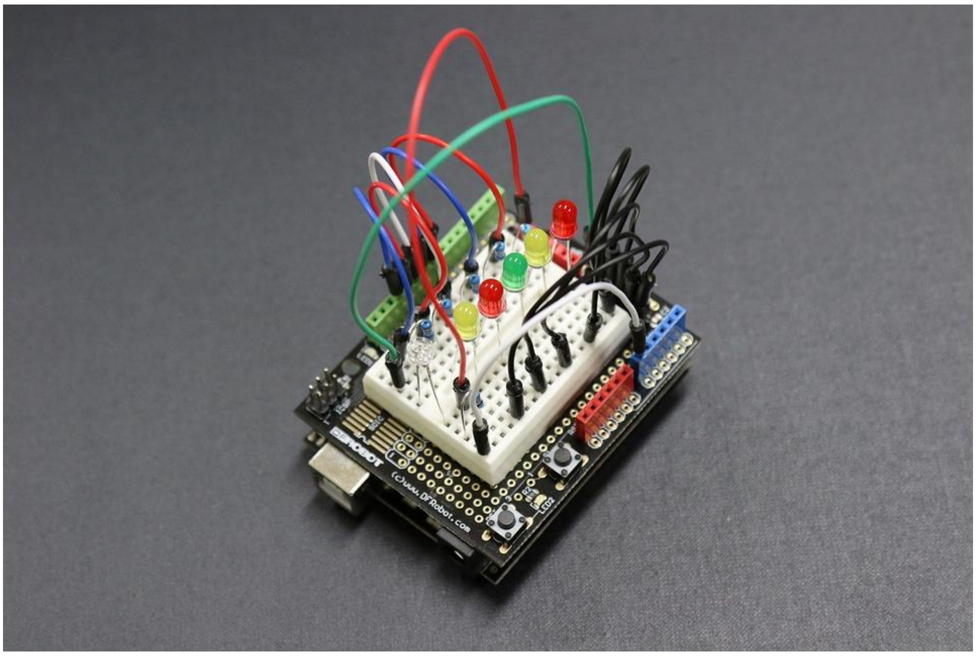
Electrical circuits

An **electrical circuit** is a pathway in which electricity flows from one terminal of a source of electrical energy, through wires and various other objects, and back to the other terminal.

For electricity to flow through the circuit there must be an unbroken path between one terminal of the source of electrical energy and the other. A circuit with an unbroken path is called a **complete** circuit. When the circuit is **incomplete** because there is a break in the path along which electricity flows the circuit will not function.

The objects which are part of the circuit are called the **components** of the circuit.

The picture below shows a complex circuit with many different components.



<Source: https://pixabay.com/en/arduino-circuit-electron-electric-1080213/>

Exploring Simple Electric Circuits

Inquiry question: Can you make a complete circuit?

What you need
• STELR battery (or two 1.5 V cells in a holder)
• 1.5 V globe
• 2 x connecting wires

What to do
Use the equipment you have been given to make a complete circuit.

Question 1
How did you know if the circuit is complete?

Question 2

Draw a picture or take a photograph of your complete circuit.

Challenge: Make a complete circuit using the battery, light globe and only one connecting wire

Question 3

Draw a picture or take a photograph of your complete circuit.

The Effect of a Switch

Inquiry question: Can you make a globe light up when a switch used in the circuit?

What you need
- STELR battery (or two 1.5 V cells in a holder)
- 1 x 1.5 V globe
- 3 x connecting leads
- Switch

What to do
Tinker with the equipment you have been given.

Question 1
Can you turn the light on and off using a switch?
When you are successful, draw a diagram or take a picture of your circuit.

Question 2
Explain how the switch changes the circuit allowing the light to be turned on and off.

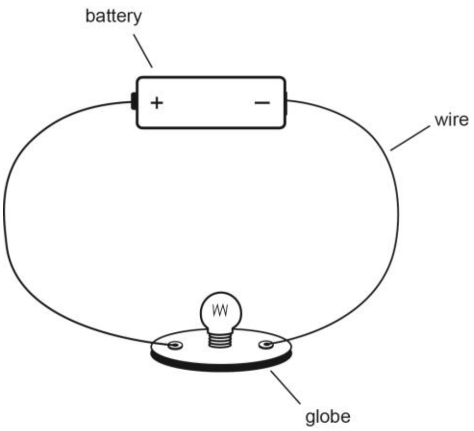
Question 3

Give two examples of where a switch is used.

<add 2 lines for answer>

Representing Electric Circuits

Electric circuits can be draw to show all the components in the circuit and the way they are connected. For example the diagram below shows a simple closed circuit constructed with 2 wires, a battery and a globe. The diagram or picture from your simple circuit may look like this.



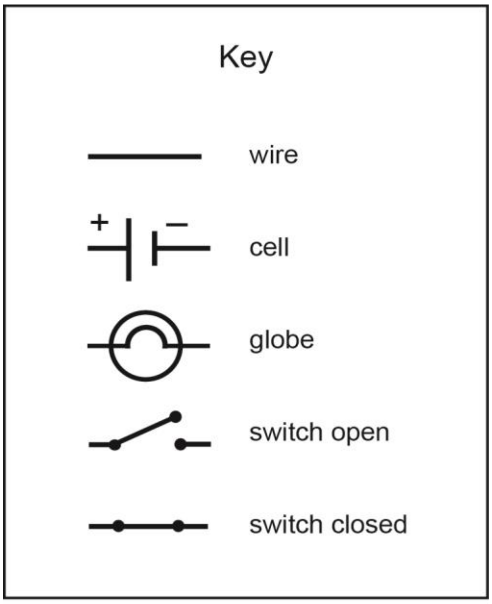
Circuit diagrams may also be drawn using symbols. Symbols are used because many electrical circuits are very complicated and drawing an accurate picture may be difficult. All scientists and electricians around the world use the same symbols.

Symbols for some of the components used in electric circuits are shown in the key below.

A **cell** is the scientific name for a single battery.

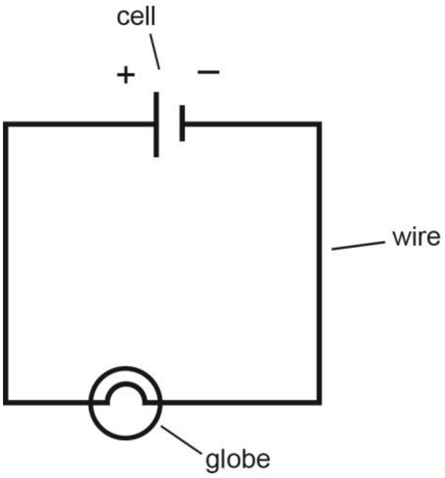
An **open switch** is one that is switched off. An electric current cannot flow through it.

A **closed switch** is one that is switched on. An electric current can flow through it.



To make circuit diagrams as clear as possible they are always drawn with connecting wires in a square or rectangle.

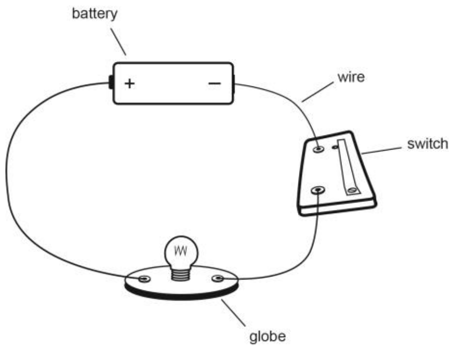
A circuit diagram of the simple circuit above drawn using symbols would look like the one below. Notice that the battery in the diagram is represented by a cell with positive and negative terminals clearly identified. If more than one battery is used then this is represented by the appropriate number of cells drawn side by side in the same positive/negative order.



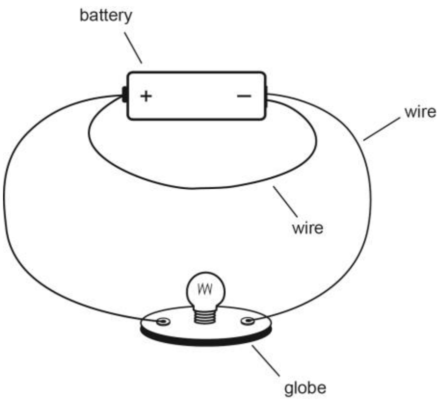
Question 1

Draw a circuit diagram using symbols next to each of the following circuits.

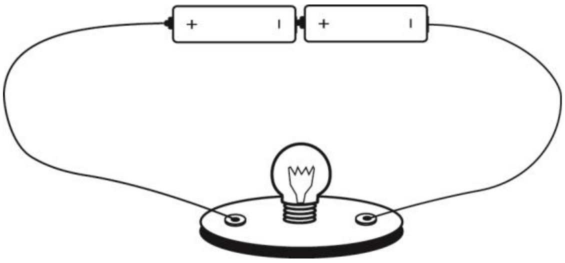
a.



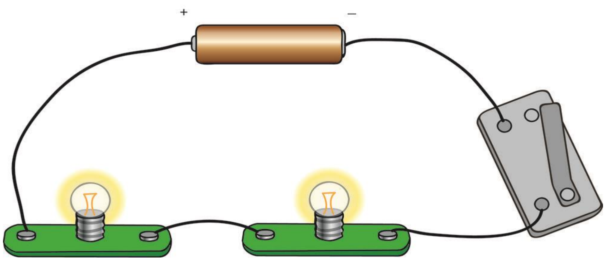
b.



c.



d.



Question 2.

Draw a circuit diagram using symbols to match each of the following descriptions:

a. Circuit A contains a single cell, connected to two light globes. Between the light globes is a switch which is on.

b. Circuit B contains two cells, two light globes and a switch which is off.

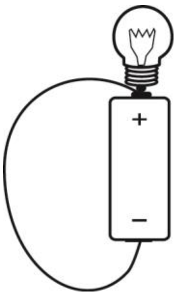
Question 3

Below are 4 diagrams of circuits.

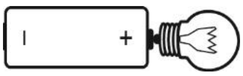
i. Predict which globes will light up.

ii. Give a reason why the globes in the other circuits will not light up.

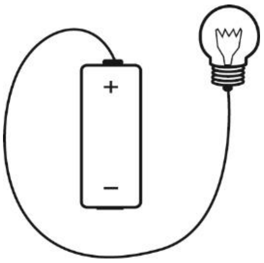
a.



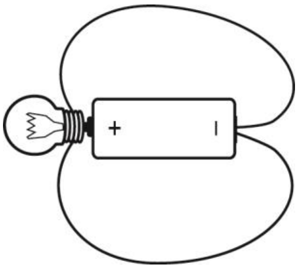
b.



c.

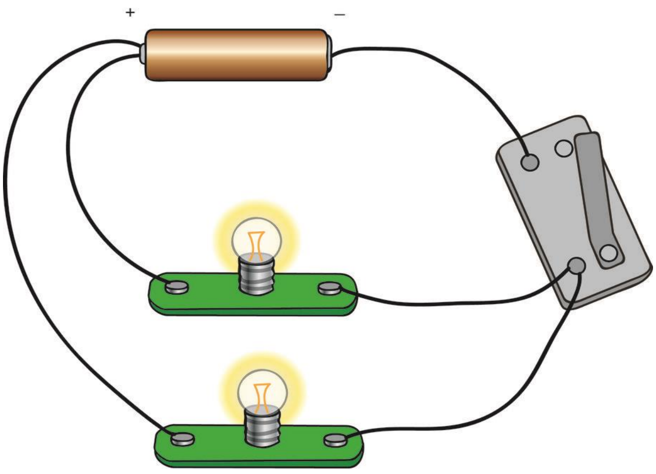


d.



Question 4 Challenge

Draw a circuit diagrams using symbols for the circuit shown below.



Conductors and Insulators

Inquiry question 1: What types of materials conduct electricity?

Inquiry question2: What types of materials are good electrical insulators?

Introduction

An **electric current** is usually the movement of negatively charged particles, called electrons, around an electric circuit.

A **conductor** is a material that electricity can travel through.

An **insulator** is a material that electricity cannot travel through.

An electric circuit is a complete pathway that electricity can travel around.

In this activity you will make a circuit to test if a material is a conductor or an insulator.

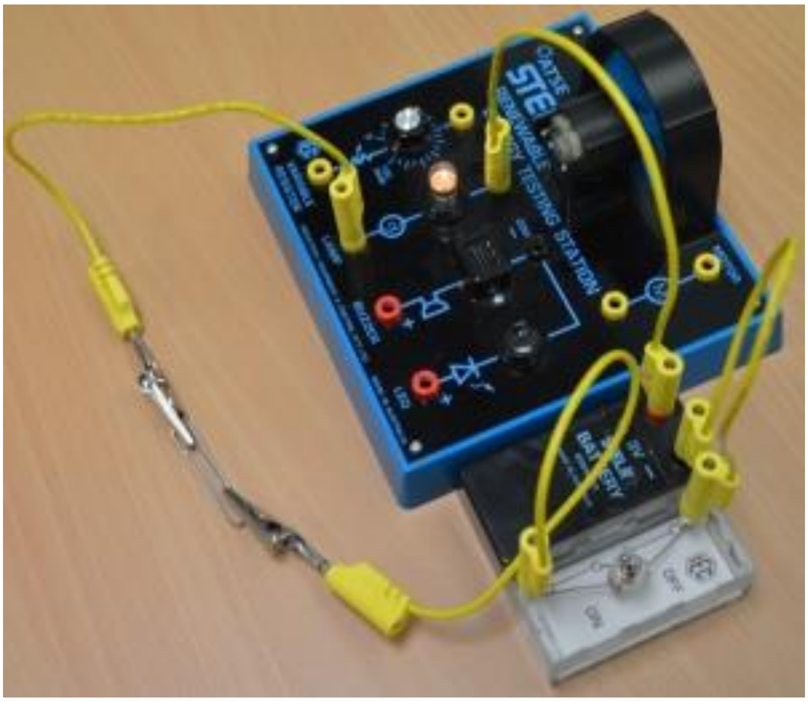
What you need

- STELR battery (or two 1.5 V cells in a holder)
- 1 x 1.5 V globe
- Connecting leads - two with alligator clips on one end
- Switch
- Materials to test

What to do

Use the equipment to make a circuit to test materials to see if they are conductors or insulators.

Get your teacher to inspect your circuit before you start testing materials.



One way to test if a material is a conductor or an insulator

Question 1
Take a photograph or draw your circuit.

Question 2
Explain how your circuit works.

Question 3
Test up to 10 different materials. Fill in the table to show your results.

Object	**Material**	**Prediction**	**Result**
eg. paper clip	*eg metal*	*eg conductor*	*eg conductor*

Discussion
Question 4
What types of materials conduct electricity?

Question 5
What types of materials are good electrical insulators?

Series Circuits

A **series circuit** is one in which the electric current can only travel along one continuous path.

An example of a series circuit and the matching conventional circuit diagram are shown in Figures 1 and 2.

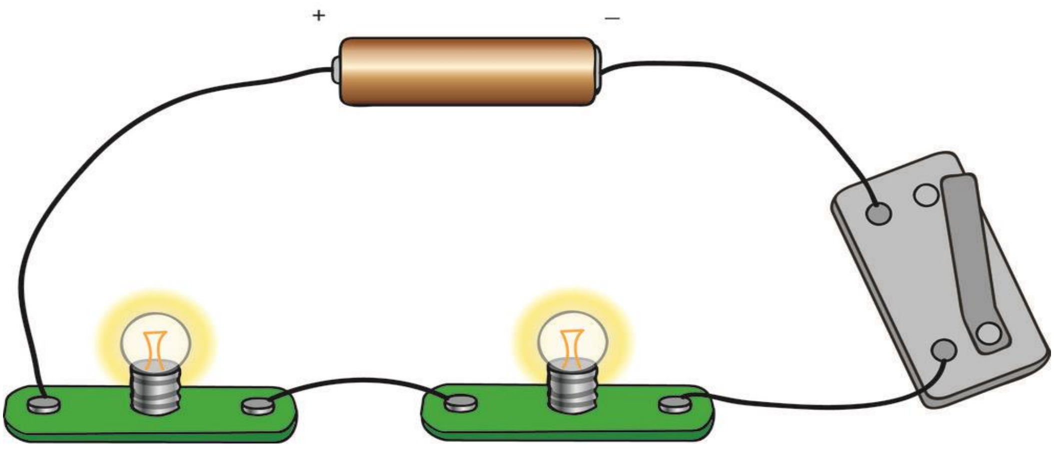


Figure 1: A basic series circuit

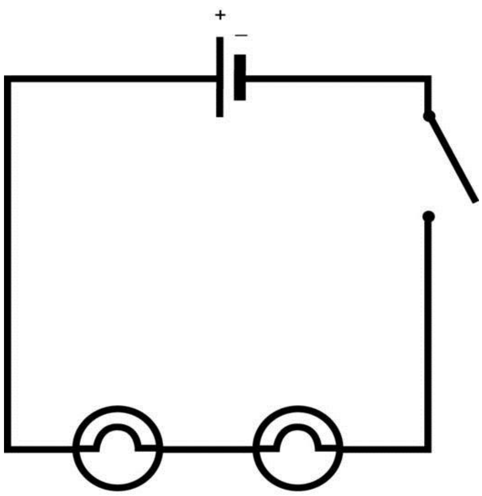


Figure 2: The circuit diagram of the series circuit

Predicting the outcomes of this experiment
You are going to make and test a series circuit but before you do that think about what you already know about circuits. Use your knowledge to predict what you think will happen in the questions below.

Suppose you set up the series circuit in Figure 1.

Question 1
a) Will either globe go on if the switch is moved from where it is now to between the two globes, then closed and opened?

b) Explain why you think this.

Question 2
a) What do you think will happen to the other globe if you move the switch back to where it was and then unscrew one of the globes from its holder? Will it go on when the switch is closed?

b) Explain why you think this.

Question 3
a) What do you think will happen to the brightness of the globes when you screw the second globe back into its holder then connect a third globe in series with the other two? Assume that the switch is closed.

b) Explain why you think this.

Investigating Series Circuits

What you need
- STELR battery (or two 1.5 V cells in a holder)
- 3 x 1.5 V globes
- Connecting leads
- Switch

Note: Make sure that you use identical globes.

Inquiry question 1: Can globes remain on if one globe is unscrewed from its holder when they are connected in series?

Inquiry question 2: Does the position of the switch in the circuit affect which globes go on?

Inquiry question 3: What happens to the brightness of the globes when an extra globe is connected into a series circuit?

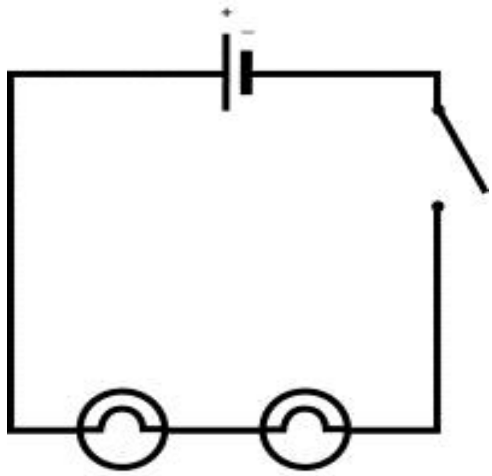


Figure 1

What to do
Step 1
Set up the circuit shown in Figure 1, except use the STELR battery in place of the single battery. Does either globe go on whilst the switch is open?

Now close the switch for just a few seconds.

Are the globes bright or dim? Is this what you predicted?

In the results table below, record your observations, then open the switch so that the battery does not go flat.

Step 2
Unscrew one of the globes from its holder.

What happens to the other globe when you close the switch for a few seconds?

Is it on or off? If it is on, is it brighter or dimmer than before? Is this what you predicted?

Record your observations. Screw the globe back into its holder and open the switch.
Step 3
Move the switch to between the two globes.

What happens to the globes when it is open then closed for a few seconds?

Are they on or off?

If they are on, are they bright or dim? Is this what you predicted?

Record your observations, then move the switch back to where it was and leave it open.

Step 4
Connect a third globe into the circuit, next to the other two. Then close the switch for a few seconds.

What happens to the brightness of the globes? Is this what you predicted?

Record your observations then open the switch.

Observations
Write down your observations in this table.

Step	**Switch open or closed?**	**Globe(s) on or off?**	**Globe(s) bright or dim (if on)?**	**Prediction correct?**
1: Switch & 2 globes	Open			
	Closed			
2: One globe unscrewed	Open			
	Closed			
3: Switch between globes	Open			
	Closed			
4: Add third globe	Open			
	Closed			

Conclusion

Question 1
What is your answer to Inquiry question 1: Can globes remain on if one globe is unscrewed from its holder when they are connected in series?

Question 2
What is your answer to Inquiry question 2: Does the position of the switch in the circuit affect what globes go on?

Question 3
What is your answer to Inquiry question 3: What happens to the brightness of the globes when an extra globe is connected into a series circuit?

Extension - Parallel Circuits

Introduction

A parallel circuit is one in which the electric current can travel along more than one continuous path. Each path must include the source of electrical energy.

An example of a parallel circuit and the matching conventional circuit diagram are shown in Figures 1 and 2.

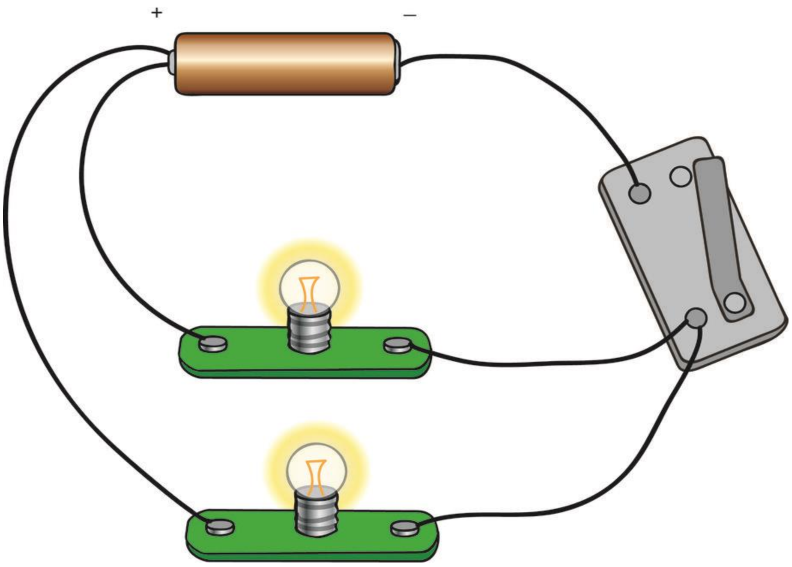


Figure 1: A circuit containing a single battery, a switch and two globes that are in parallel with one another.

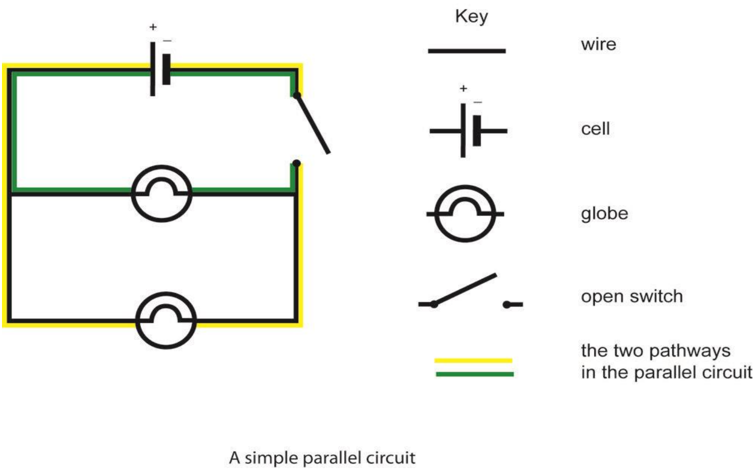


Figure 2: A circuit diagram for a parallel circuit

<Note to editor: In Figure 2 Delete all the key except for the two coloured lines and associated label>

Predicting the outcomes of this experiment

You are going to make and test a parallel circuit but before you do that think about what you already know about circuits. Use your knowledge to predict what you think will happen in the questions below.

Suppose you set up the parallel circuit in Figure 1.

Question 1
How bright do you **think** the globes will be in this case, compared with the globes if they were connected in series?

Explain why you think this.

Question 2
If the switch is placed along a different pathway like in Figure 3 below, what do you think will happen to the globes when the switch is closed?

Explain why you think this.

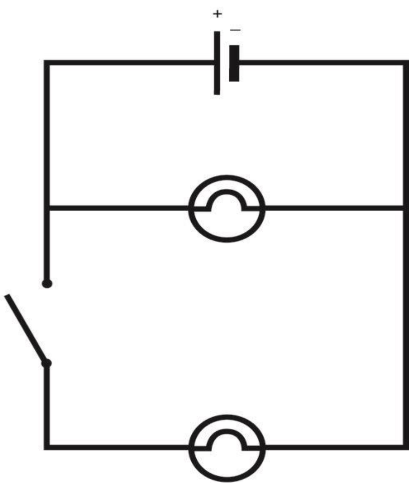


Figure 3

Question 3
What do you think will happen to the other globe if you put the switch back to where it was and then unscrew one of the globes from its holder? Will it go on when the switch is closed?

Explain why you think this.

Question 4
What do you think will happen to the brightness of the globes when you screw the second globe back into its holder then connect a third globe in parallel with the other two? Assume that the switch is closed.

Explain why you think this.

Investigating Parallel Circuits

Inquiry question 1: Can globes remain on if one globe is unscrewed from its holder when they are connected in parallel?

Inquiry question 2: Does the position of the switch in the circuit affect what globes go on?

Inquiry question 3: What happens to the brightness of the globes when an extra globe is connected in parallel with the other two?

What you need
- STELR battery (or two 1.5 V cells in a holder)
- 3 x 1.5 V globes
- Connecting leads
- Switch

Note: Make sure that you use identical globes.

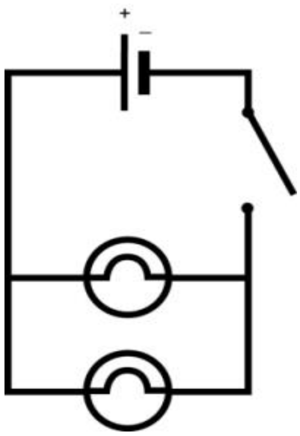


Figure 1

What to do
Step 1
Set up the circuit shown in Figure 1, except use the STELR battery in place of the single battery. Does either globe go on whilst the switch is open? Now close the switch for just a few seconds. Are the globes bright or dim? Is this what you predicted?

In the results table on the next page, record your observations. Open the switch so that the battery does not go flat.

Step 2
Unscrew one of the globes from its holder. What happens to the other globe when you close the switch for a few seconds? Is it on or off? If it is on, is it brighter or dimmer than before? Is this what you predicted?

Record your observations. Screw the globe back into its holder and open the switch.

Step 3
Move the switch so that the circuit is the same as shown in Figure 2. The switch is now on a separate path to the two globes. What happens to the globes when it is open then closed for a few seconds? Are they on or off? If they are on, are they bright or dim? Is this what you predicted?

Record your observations. Move the switch back to where it was and leave it open.

Step 4
Connect a third globe into the circuit, in parallel to the other two, as shown in Figure 3. Then close the switch for a few seconds. What happens to the brightness of the globes? Is this what you predicted?

Record your observations and open the switch.

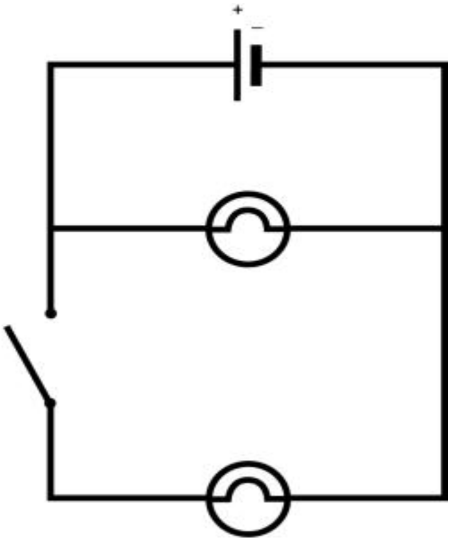


Figure 2

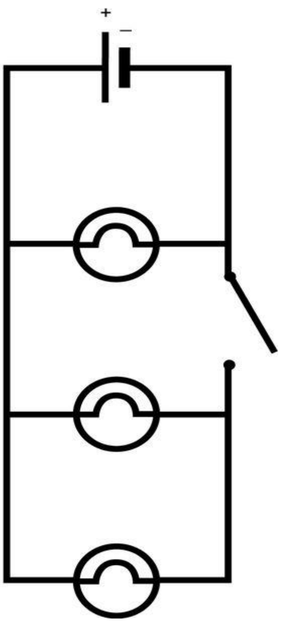


Figure 3

Observations

Write down your observations in this table.

Step	Switch open or closed?	Globe(s) on or off?	Globe(s) bright or dim (if on)?	Prediction correct?
1: 2 globes in parallel (fig 1)	Open			
	Closed			
2: One globe unscrewed (fig 1)	Open			
	Closed			
3: Switch on 3rd path (fig 2)	Open			
	Closed			
4: 3 globes in parallel (fig 3)	Closed			

Conclusion

Question 1

What is your answer to Inquiry question 1: Can globes remain on if one globe is unscrewed from its holder when they are connected in parallel?

Question 2

What is your answer to Inquiry question 2: Does the position of the switch in the circuit affect what globes go on?

Question 3

What is your answer to Inquiry question 3: What happens to the brightness of the globes when an extra globe is connected in parallel with the other two?

Fun Challenge

Can you set up circuits that contain one cell, three globes and one switch, which obey the following conditions?

1 When the switch is closed, one globe is brighter than the other two.

2 When the switch is closed, all three globes light up, but when it is open one globe remains on.

3 When the switch is closed, none of the globes are lit, but when it is open, they all light up.

In each case, when you have succeeded, you can either draw a circuit diagram of the circuit that worked or take a photo or video of the circuit

Explain why the circuits worked. You may label your circuit diagrams to show your explanation.

Discussion for Series and Parallel

Question 1
Compare your results with those obtained by the rest of the class. Did you all draw the same conclusions?

Question 2
Did any of the results surprise you? If so, which ones? Can you suggest an explanation?

Question 3
Would Christmas tree lights be in a parallel circuits or a series circuit? State your reasoning.

Question 4
How do the number and position of switches vary in a series circuit and parallel circuit?

Section 3: Generating Electricity

Big Ideas:

1. **How can electricity be generated?**
2. **How does moving water generate electricity?**
3. **What affects the amount of electricity generated by solar cells?**
4. **How do wind turbines deliver electrical energy?**
5. **Is there a best design for wind turbines?**
6. **What are the advantages and disadvantages of the different ways of generating electricity?**
7. **Which energy sources are sustainable?**

<Insert collage of pictures including wind turbine, hydroelectric, solar cell, water wheel>

Generating Electricity

Introduction

Electricity has become very important in our everyday life. It doesn't matter where we are – at home, at school of at the local shopping centre we rely heavily of the use of electricity. We have become used to using devices including mobile phones, laptops and tablets, fitness trackers which are powered by electricity. Can you imagine life without electricity?

Electricity is also very important for all the things that go on in the world around us. It powers factories, radio, television, navigation instruments and even some forms of transport such as electric trains, trams and buses.

Think about what life would be like without electricity. What would still work if we didn't have electricity?

Have a class brainstorm looking at what our life would be like without electricity.

Energy sources for generating electricity

In order to have electricity to use must be produced or generated. Unfortunately electricity cannot be stored as electricity – it has to be converted to another type of energy which can then be turned back into electrical energy when it is needed.

You are all familiar with batteries. These have chemical energy which is transformed into electrical energy when connected into a complete circuit. When the battery goes flat it has run out of useful electricity producing chemicals. A rechargeable battery works because when it plugged into electricity the chemicals in the flat battery are turned back into the ones needed to produce electricity again.

The source of energy for producing much of Australia's electricity is fossil fuel – coal, oil and natural gas. The chemical energy in the fuel is converted to heat energy, then to movement (kinetic energy) and finally electricity.

There are also other different ways of generating electrical energy which do not use fossil fuels:

- Hydroelectric
- Wind
- Solar
- Tidal flow
- Wave motion

Question 1

The following table lists sources of different types of energy for the use in producing electricity.

For each source name the energy type which is provided by that source.

Energy source	**Energy type**
Wind	
Tidal flow	
Flowing water from dams	
Wave motion	
The Sun	
The Sun	
Oil	
Coal	
Natural gas	

Hand-Cranked Generator (Teacher demonstration)

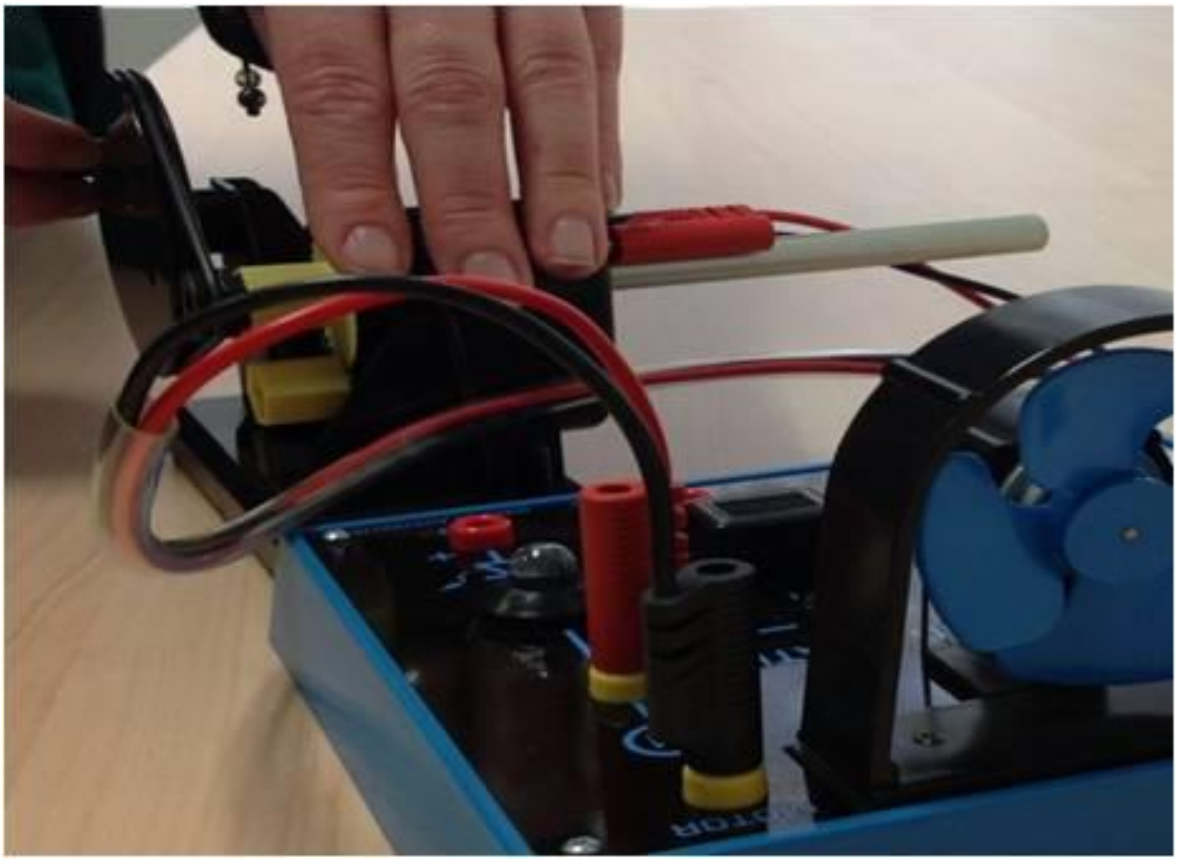
Most methods of generating electricity operate on the same principal of converting energy from the source (fuel, wind, moving water) into to the kinetic energy of a turbine which a generator converts into electrical energy.

In this device the kinetic energy from a moving arm rotates the generator which produces electricity.

What to do

- Attach the STELR Wind Generator to the STELR Hand Crank as shown. Make sure the ***knob*** is removed from the base of the Hand Crank and attached to the top of the Wind Generator for the ***winding band***.
- Connect two leads from the Wind Generator to the MOTOR sockets of the testing station.
- Use the handle to rotate the black wheel *clockwise*. Turn it faster and faster. What do you notice?
- What difference does it make if you rotate the black wheel in an *anticlockwise* direction instead?
- If there is time, try connecting the leads to the buzzer and the globe.
- Record your findings in the results table below.

The hand-cranked generator should be set up for you similar to the one in this image.



Question 1
Record your observations in the table below.

What did you observe?	What energy transformation(s) do you think happened? Represent them using flow charts.
Wheel turned clockwise; leads connected to fan	e.g. kinetic energy → electrical energy → kinetic energy
Wheel turned anticlockwise, leads connected to fan	
Wheel turned clockwise; leads connected to buzzer	
Wheel turned anticlockwise; leads connected to buzzer	
Wheels turned clockwise; leads connected to the globe	
Wheel turned anticlockwise; leads connected to the globe	

Question 2
Identify one example of an energy transfer that you observed with this equipment.

Question 3
Why do you think changing the direction in which you turned the handle had the effect you observed?

Investigating electricity generation using a Water Wheel

In this activity you will generate electricity using water.

Water has been used for a long time to generate electricity. Power stations that use moving water to generate electricity are called **hydroelectric power stations**.

A **turbine** looks like a giant fan. A turbine is a machine that consists of a set of blades, ‘scoops’ or rotors that spin very fast when pushed by fast moving air, water or steam.

In hydroelectric power stations, the turbine is pushed around by fast-moving water that has flowed down pipes from a dam. One kind of turbine that is used in these power stations is made up of ‘scoops’, which ‘catch’ the water. This is known as a **Pelton turbine**. The orange and yellow turbine in the foreground of Figure 1, below, is an example of a Pelton turbine. (Its outer casing has been removed to show its design.)

At a working power station, the mechanical energy of the spinning turbine is then transferred to a **generator** (via a shaft). In the generator, the mechanical energy is transformed into electrical energy. Inside one kind of generator, there is a copper coil placed between magnets. The spinning shaft makes the copper coil spin very fast inside the magnetic field. This causes an electrical current to flow inside the copper wires. This is the way the STELR generator works.

The Pelton turbine you will use in this experiment is shown in Figure 2. This simple working model also is known as a Pelton wheel.

The water runs into the turbine through the tube on the left, pushes on the ‘scoops’, which sets them spinning, and then leaves via the ‘spillway’ on the right.

More about the Pelton wheel

The Pelton wheel is among the most efficient types of water turbines. It was invented by Lester Pelton (1829–1908) in the 1870s.

Water turbines that existed before Pelton's design were very inefficient because the water leaving their wheels was still moving at high speed. This meant that only a small fraction of the water’s kinetic energy was transformed into mechanical energy. Pelton modified their designs with a new paddle shape which ensures that when the rim runs at half the speed of the water jet, the water leaves the wheel with very little speed. This means that most of the kinetic energy of the water is transformed into mechanical energy, making it a very energy-efficient turbine.

Figure 1. Turbines at the Waddamana Power Station in Tasmania. This power station is no longer in operation. It has been converted to a museum. Waddamana is a Tasmanian Aboriginal word meaning 'noisy water'.

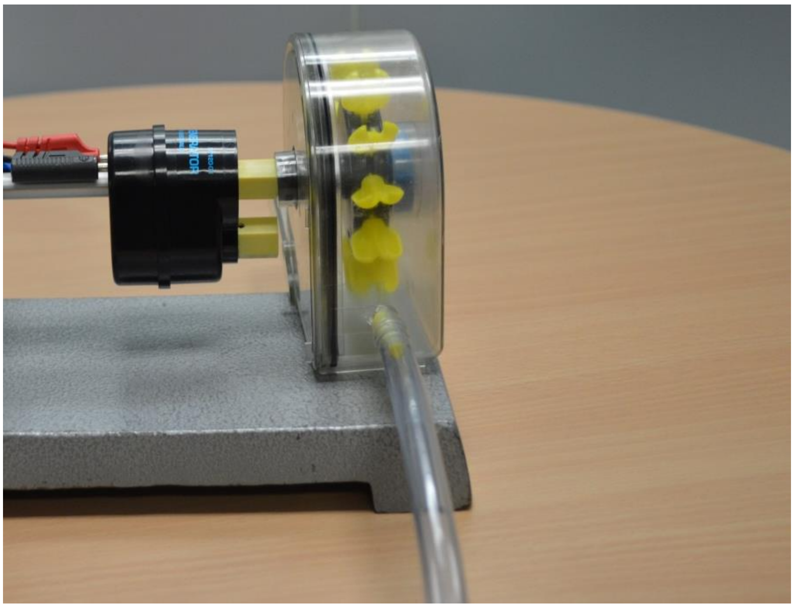


Figure 2. The STELR Pelton wheel that will be used in this activity

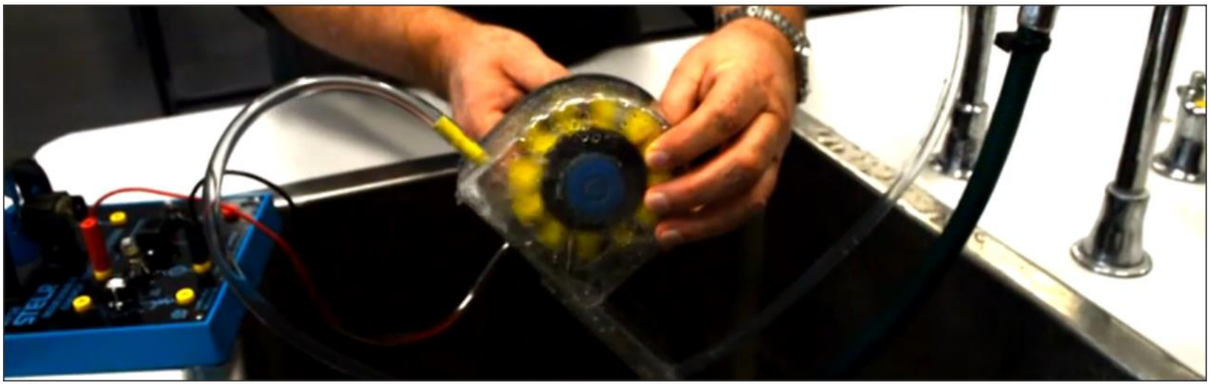
Investigating using a Pelton wheel to make electrical energy

What you need

- Pelton wheel
- Hose (supplied with Pelton wheel)
- Wind-turbine generator
- Retort stand
- Boss head
- Testing module or light globe
- Connecting cables
- Multimeter (optional) to measure voltage

What to do

1. Attach the wind-turbine generator to the retort stand
2. Place the retort stand into a sink
3. Connect the output of the generator to the globe using the cables
4. Connect the Pelton wheel to a tap nozzle using the hose
5. Hold the Pelton wheel so that the wheel fits to the geared attachment of the generator
6. Turn on the tap
7. Adjust the position of the Pelton wheel so the generator turns easily
8. (Optional) Measure the voltage across the globe as you change the force of the water
9. You can watch a video of how to set up the Pelton wheel at https://www.youtube.com/watch?v=LADHkckpey0



The Pelton wheel set-up – do this over a sink.

Discussion

Question 1
Take a photo or video of the Pelton wheel in action.

Question 2
Describe what happened when you turned on the tap.

Question 3
What problems did you have making the Pelton wheel work?

Question 4
How did you overcome any problems?

Question 5
Describe the energy transfers and transformations that occurred when you used the Pelton wheel to make and use electrical energy.

Solar Cells

Solar cells, or photovoltaic cells, are a renewable energy technology because they use the effectively limitless energy from the sun. This energy is used to make electrical energy that we can use in our everyday lives. ‘Photo’ means ‘light’ and ‘voltaic’ means ‘volts’.

A solar panel consists of many solar cells connected together. The greater the total area of solar cells, the greater the amount of electrical power they deliver.

Advantages of using solar panels include:

- Excess electrical energy can be sold back into the electricity grid.
- Solar panels have a life span of up to 50 years.
- Solar panels do not produce greenhouse gases when they are operating.

What conditions affect the amount of electrical energy produced?
Factors affecting the amount of electrical energy produced by solar panels include:

- The total area of the solar panel
- The intensity of light shining on the panel
- The type of solar cells being used
- How the solar cells are connected
- The angle of the panel to the direction of the light
- Clouds and shadows
- Dirt or other deposits
- The temperature of the panel

Investigating electricity generation using Solar Cells

In this activity you will investigate the solar panel and the STELR testing station to see which devices you can operate using the electricity produced by the solar panel.

Figure 1 below shows a STELR solar panel. You can see that it is made up of a grid of four solar cells.

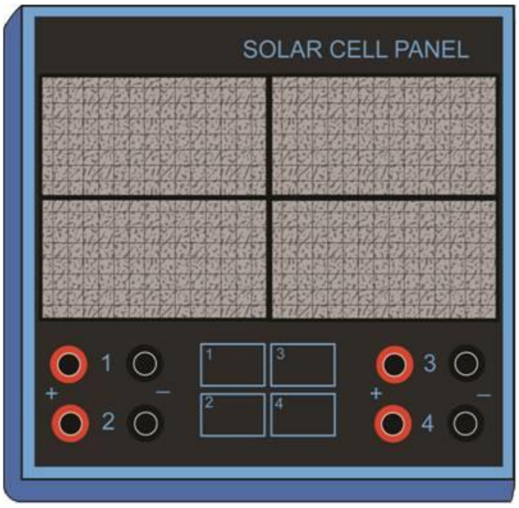


Figure 1: The STELR solar panel

The diagram in the centre at the bottom of the panel provides a numerical key to show how the cells are laid out. As indicated, the red sockets are the positive terminals and the black sockets are the negative terminals.

Inquiry Question 1 What can you power using a single STELR solar cell?
Inquiry Question 2: How can you connect solar cells together to get more devices to work?

What you need

- STELR solar panel
- STELR testing station
- Connecting leads
- 1 x STELR multimeter

If available:

- 2 x STELR lamps
- 6-volt power pack

If possible, do the investigations in direct sunlight.

Risk Assessment

Read the facts, imagine what could cause damage, and think of what you could do to prevent that problem. Hence complete the following table.

The facts	What might be the risks?	What precautions will we take?
1. Multimeters are very sensitive digital instruments.		
2. The solar panel could break if mishandled.		
3. The halogen lamps get very hot.		
4. The halogen lamps are connected to a power pack, connected to a mains electricity power point.		

What to do

Part 1 - Inquiry Question 1

1. Insert two red leads into the red socket for Cell 1, and two black leads into the black socket for Cell 1, as shown in Figure 2 below. The top two leads will be connected to the voltmeter. Set the voltmeter to the 20 V DC scale.
The bottom two leads will be connected to the testing station.

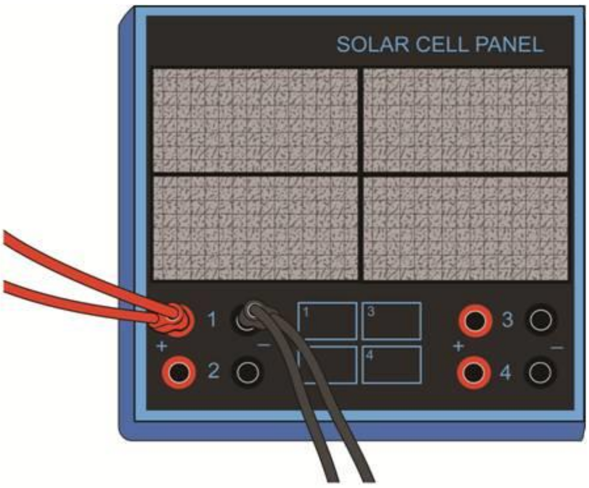


Figure 2: How to set up the wires for the single solar cell

2. Place the solar panel in direct sunlight. Wait until the voltmeter reading is steady, then record the voltage in Table 1 in the results section below.

OR

2. If you have halogen lamps, connect them to the power pack, and place them so they will shine evenly on all the cells of the solar panel.
DO NOT TURN THEM ON YET!
Be careful not to move the halogen lamps or the solar panel during this or the next part of the experiment.

Why is it important not to move the lamps?

3. Trace the leads with your fingers to ensure that you have created two distinct pathways:
   - One will go from the red terminal on the solar cell to the device on the testing station then to the black terminal on the solar cell.
   - The other will be a small loop connecting the solar cell to the voltmeter.

4. Turn on the halogen lamps. Wait until the voltmeter reading is steady, then record the voltage in Table 1 in the results section below.
If a device does not work, try switching the connecting cables around.

5. Turn off the lamps and the voltmeter. Do not change the circuit or move the solar panel or lamps. You will use them in the next part of the experiment.

Part 2 - Inquiry Question 2
1. Mark the position of the solar panel on the bench, then carefully remove it from the circuit so you can connect the solar panels together. But leave one of the red leads connected to the red socket in Cell 1.

2. As shown in Figure 3 below, connect the (-) terminal of Cell 1 to the (+) terminal of Cell 2. Then connect another lead to the (-) terminal of Cell 2, ready for the next connection.

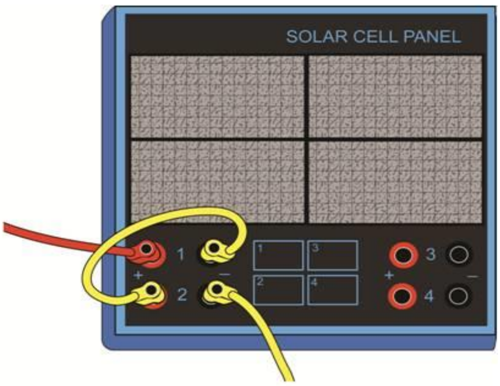


Figure 3: Connecting Cell 1 to Cell 2

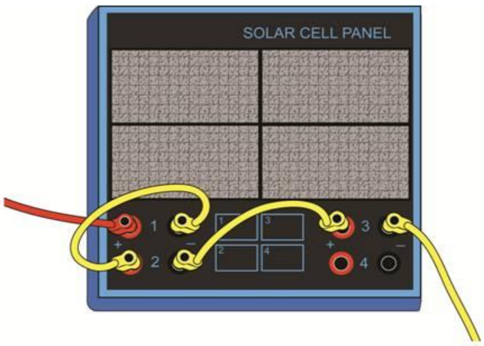


Figure 4: Connecting Cell 2 to Cell 3

3. As shown in Figure 4, connect the (-) terminal of Cell 2 to the (+) terminal of Cell 3. Then connect another lead to the (-) terminal of Cell 3, ready for the next connection.

4. As shown in Figure 5 below, connect the (-) terminal of Cell 3 to the (+) terminal of Cell 4. Then connect a black lead to the (-) terminal of Cell 4.

You have now connected your solar cells in series.

Notice that the terminals are connected (-) to (+) from one cell to the next.

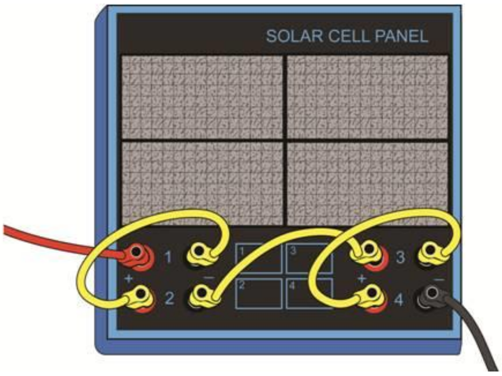


Figure 5: Connecting Cell 3 to Cell 4

Figure 6: The STELR testing station

5. Connect the solar panel into the devices in the testing station.

6. Connect the voltmeter across the devices as you test them.

Ensure that the solar panel and the lamps are in the same positions as before!

Results

Record your observations in Table 1 below:

Set up	**Globe**	**LED**	**MOTOR**	**Buzzer**	**Voltage V (V)**
Part 1 - A single solar cell					

Part 2 - Four solar cells in series					

Discussion

Question 1
Did it matter which way around you connected the solar panel to the devices? What did you notice?

Question 2
Were there any surprising results? What were they? Can you explain them?

Question 3
Did you have any practical difficulties in performing the experiment? If so, how did you resolve them?

Conclusion
Write a short sentence or two to summarise your results.

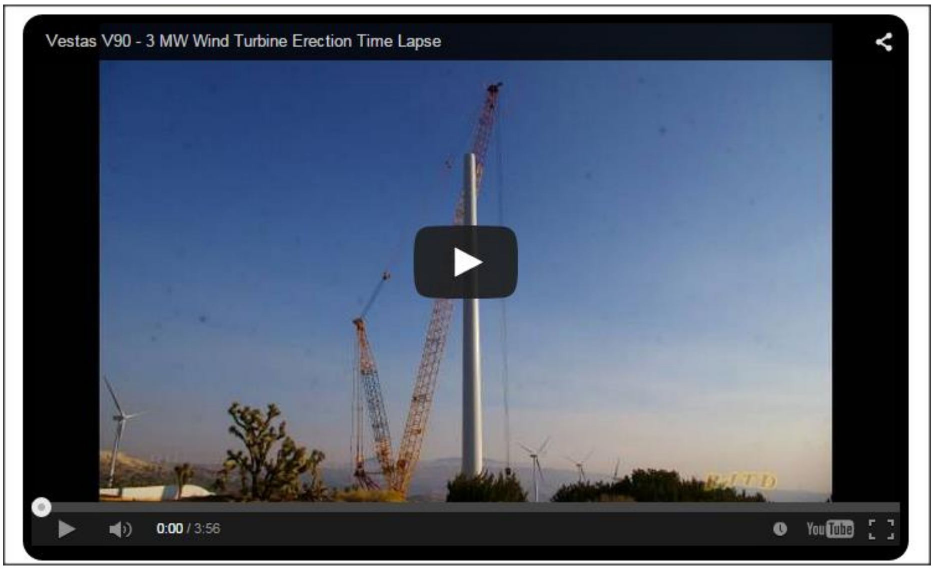
Wind Turbines

A wind turbine is a device that uses air movement (wind) to generate electricity. Wind turbines are a renewable energy technology because they use wind, which will never be used up, to turn turbines and electrical energy that we can use in our everyday lives.

Wind rushes across the blades of the wind turbine and pushes on them so that they start turning. The majority of the kinetic energy from the wind is converted into the kinetic energy of the turning blades. The turning blades produce a little heat due to friction as well as sound.energy, but most of the energy is transformed into electrical energy.

Watch the following video of the construction of a wind turbine.

https://www.youtube.com/watch?v=IZWREtoyY3s



Factors affecting the amount of electrical power produced by wind turbines include:

- The speed of the wind
- The number of blades
- The length of the blades
- The shape of the blades

- The pitch (angle) of the blades to the wind
- The use of gears
- The type of generator used

Investigating factors which affect electricity generation in wind turbines

Factor 1: Angle of Blades

Introduction
In this investigation you will be investigating the effect that the angle of the blades has on the power output of the STELR wind turbines. The set up for the circuit is shown in Figure 1.

TIP: the hub for the wind turbine can be loosened for easy attachment of the blades by turning the large blue screw.

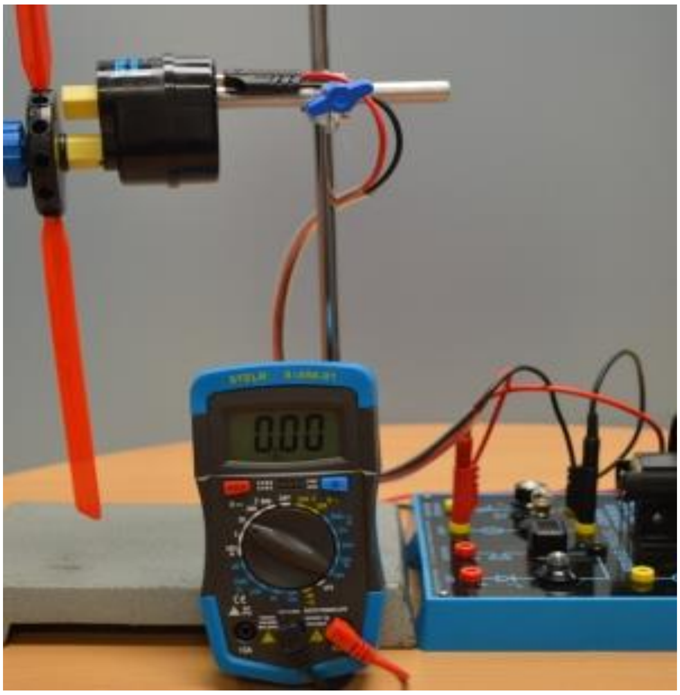


Figure 1: The set up

Inquiry Question: What is the best angle for the blades on a wind turbine hub to produce the most electrical power?

Before you start:
Predict what you think will happen to the power delivered by the model wind turbine as you change the angle of the blades.

Explain why you think this.

What you need

- STELR testing station
- 1 x STELR multimeter
- 2 x 150 mm (red) turbine blades set into a hub
- STELR model wind turbine
- Connecting leads
- Three-speed electric fan

- Tape measure or metre ruler
- STELR hub protractor
- Retort stand with clamp

Risk Assessment

Complete the following risk assessment for this practical investigation.

	What might be the risks?	**What precautions will we take?**
If the blades are not inserted firmly into the hubs, they may fly out at a high speed whilst the turbine is spinning.		
A fast-spinning electric fan will be used in this experiment.		

What to do

Part A – Testing with two blades at 45°.
Make sure the two blades are tight in the hub of the turbine and are both at 45^0 to the face of the hub, like those in Figure 2 below.

Secure the model wind turbine to the retort stand, as shown in Figure 1.

Make sure that the hub is tight on the motor drive shaft and that you are using the bottom socket, as shown in Figure 1.

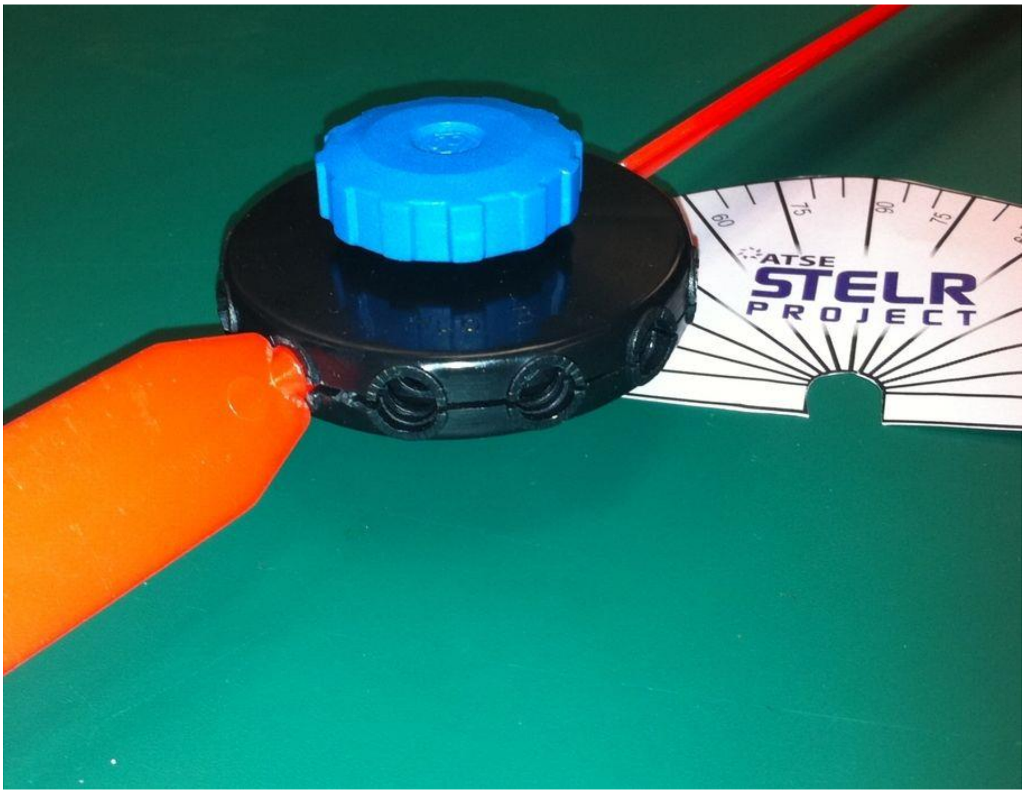


Figure 2: These blades have been set into the hub at the same angle (45^0)

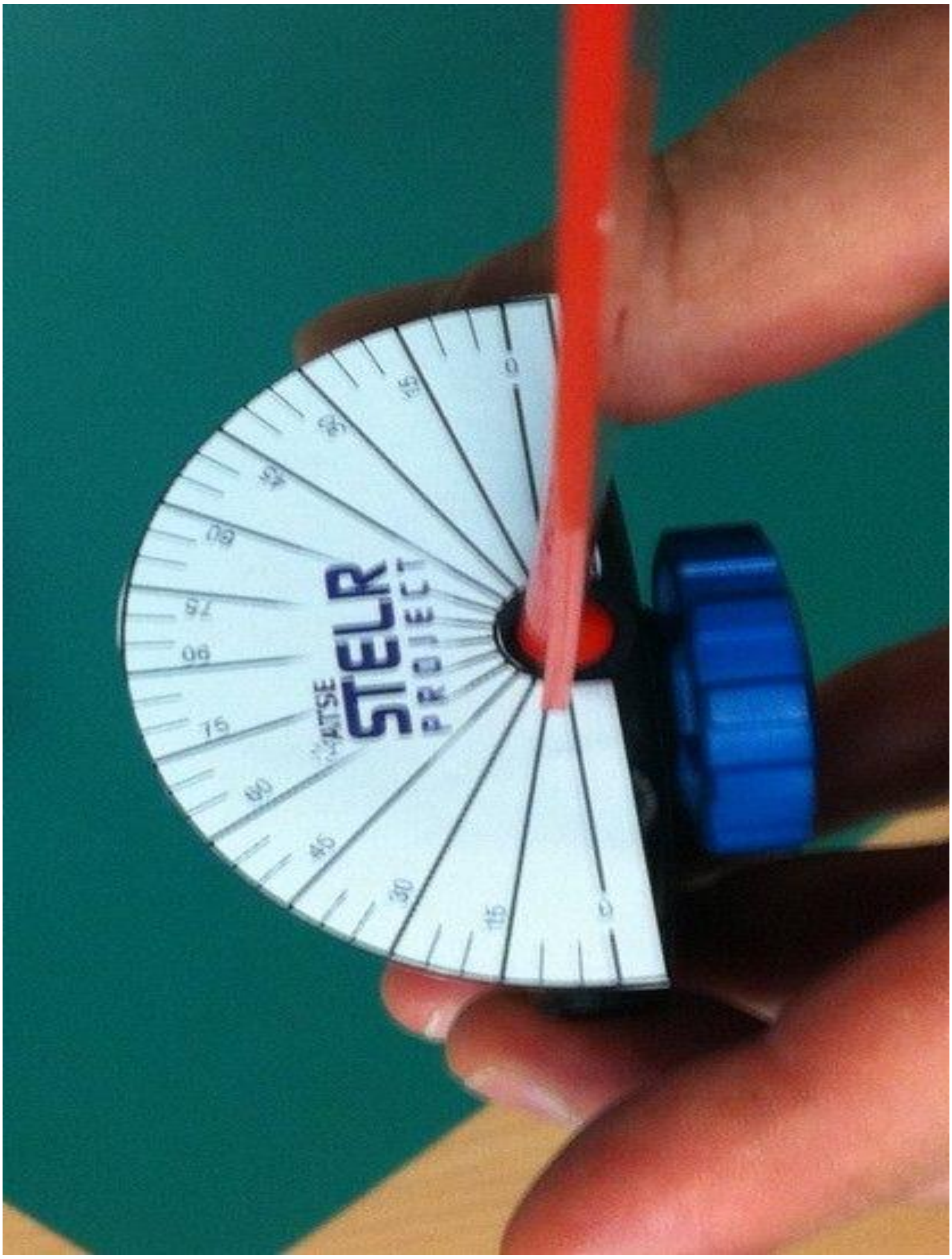


Figure 3: Using the STELR protractor to set the blade angle

2. Connect the circuit as shown in Figure 1, with the plugs inserted into the LAMP sockets of the STELR testing station.

3. Place the three-speed fan on the bench so that the front of the fan is 50 cm from the front of the hub on the wind turbine. Secure the wind turbine retort stand to the lab bench (with masking tape, for example). Do not turn on the fan yet!

Do not change the distance between the fan and the turbine over the course of the experiment!

4. Raise or lower the turbine on the retort stand so the centre of the wind turbine's hub is at the same height above the bench as the centre of the fan's hub.

5. Set the voltmeter to the 20 setting.
6. Have the teacher check your circuit. When your teacher has given permission, turn the fan on to the highest setting.
7. Once a steady reading is obtained, record the current and voltage in Results Table 1 below.
8. Turn off the fan and return the voltmeter to the OFF position.

Keep the set-up without altering it, ready for part B

Part B – Testing with other angles.
1. Carefully detach the hub from the turbine's motor drive shaft.
2. Use the protractor to set both blades at 10°. Tighten the screw if necessary so the blades are firmly held again. Insert the hub and blades back onto the bottom turbine shaft, as shown in Figure 1. Make sure that the hub is tight on the shaft.
3. Reset the voltmeter to the *20* setting.
4. Turn the fan onto the highest setting and once a steady reading is obtained, record the voltage in *Results Table 2*.
5. Repeat Steps 1 and 2 for the blades set at different angles. Record your results.
6. Pack up according to your teacher's directions.

Results
Results Table 1 – Part A – Testing the blades at 45o

Voltage *V* (V)	**Brightness of the globe**

Results Table 2 - Part B – Testing with other angles
Copy your results and record the voltage value for 45° from Table 1. For the other angles, enter your results.

Angle of turbine blades	Voltage V (V)	Brightness of the globe
45°		
10°		

Discussion Questions

Question 1
Did you have any practical difficulties in performing Part A (testing with the blades at 45^o) of the experiment? If so, how did you resolve them?

Question 2
In Part A, what do you think would have happened to the voltage and brightness of the globe if the fan has been set at the medium setting instead of on the highest setting? If you have time, test if your prediction is correct!

Question 3
a) Was the prediction you made at the start of this experiment correct?
b) Were you surprised with the results in Part B for this model turbine?
c) Suggest a reason why the prediction was or was not correct.

Question 4
a) Did all the groups in the class agree on the best angle for the blades?
b) If not, identify at least two sources of error for this experiment, which would help account for any differences in the results.

Question 5
List the variables that were kept the same as you performed the experiment.

Conclusion
State your answer to the inquiry question: what is the best angle for the blades on a wind turbine hub to produce the most electrical power?

Factor 2: Number of Blades

In this investigation you will be investigating the effect of different numbers of blades on the power output of the STELR wind turbines. The set up for this activity is shown in Figure 1.

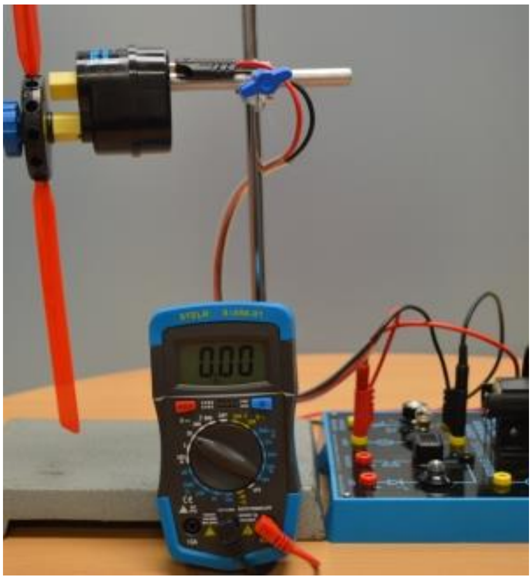


Figure 1: The basic set up

Inquiry Question 1: What voltage can be delivered by a STELR model wind turbine operating with 6 blades?

Inquiry Question 2: What is the relationship between the number of blades on the STELR model wind turbine and the voltage it delivers?

Inquiry Question 3: How many blades give the greatest voltage?

Before you start, predict what you think will happen to the power delivered by the model wind turbine as you reduce the number of blades. Explain why you think this.

What you need

- STELR testing station
- 1 x STELR multimeter
- 6 x 150 mm turbine blades set into a hub
- Extra 150 mm turbine blades
- STELR model wind turbine
- Connecting leads
- Three-speed electric fan
- Retort stand and clamp
- Tape measure or metre ruler

What to do

Part A – Testing with six blades:
1. Make sure the six blades are tight in the hub of the turbine and are all at 45^0 to the face of the hub, like those in Figure 3 below. Then set up the model wind turbine in the stand, as shown in Figure 1. Make sure that the hub is tight on the motor drive shaft and that you are using the bottom shaft, as shown in Figure 1, which means the model wind turbine will be ungeared.

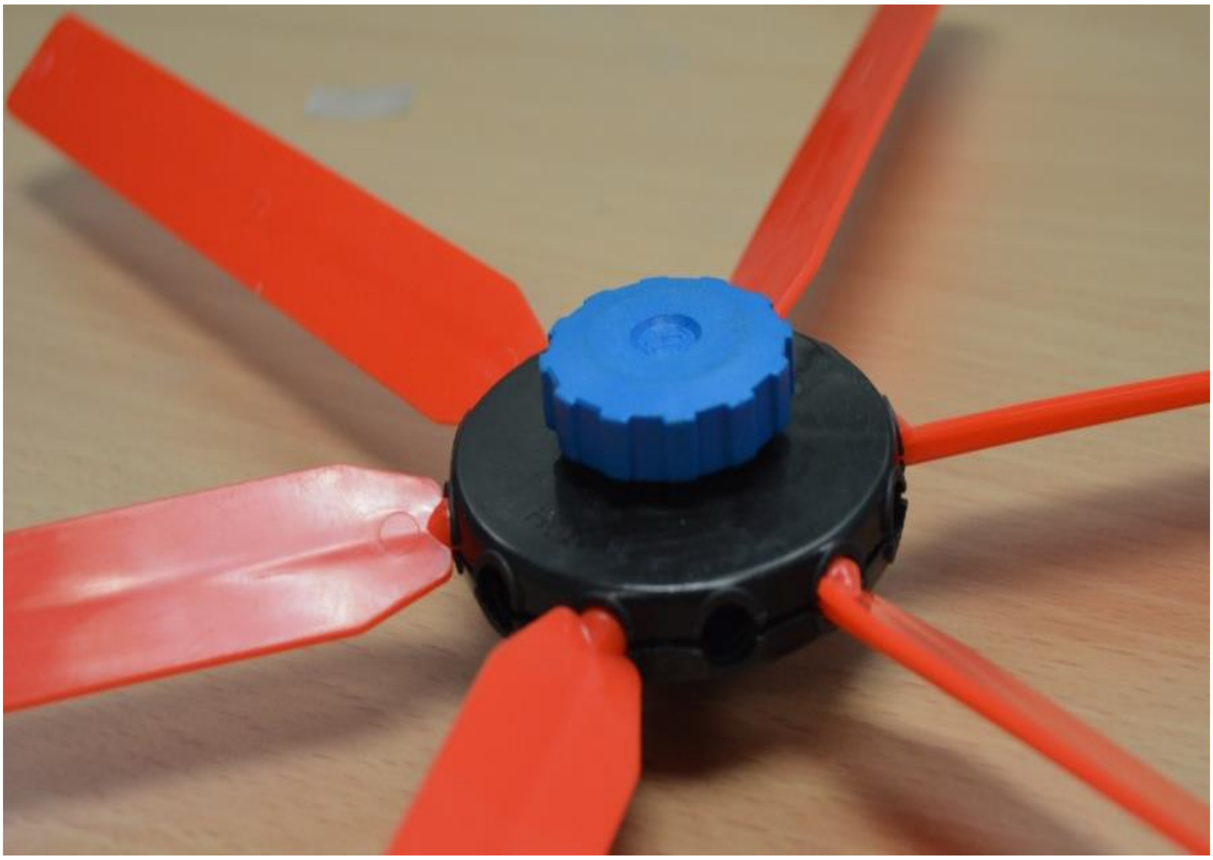


Figure 2: These blades have been set into the hub at the same angle (45^0)

2. Connect the circuit as shown in Figure 1, with the plugs inserted into the LAMP sockets of the STELR testing station.
3. Place the three-speed fan on the bench so that the front of the fan is 50 cm from the front of the hub on the wind turbine, as shown in Figure 3. **Do not turn on the fan, yet!**

Do not change the distance between the fan and the turbine over the course of the experiment!

4. Raise or lower the turbine on the retort stand so the centre of the wind turbine's hub is at the same height above the bench as the centre of the fan's hub. The two hubs should be in a direct line with each other, as in Figure 3.

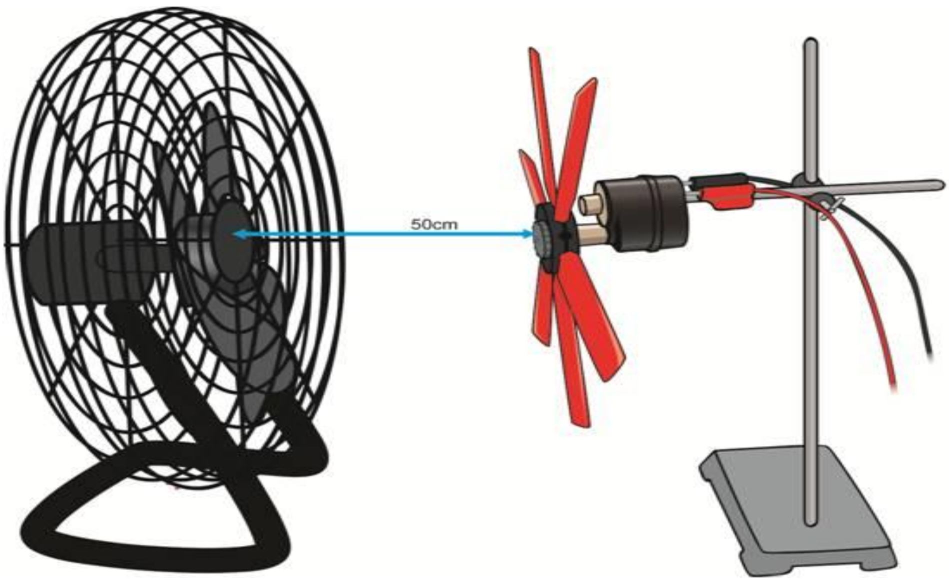


Figure 3: The correct relative positions of the fan and the turbine

5. Set the voltmeter to the 20 setting. (This allows a maximum reading of 20 V.)
6. Have the teacher check your circuit. When your teacher has given permission, turn the fan on to the highest setting.
7. Once a steady reading is obtained, record the voltage and brightness of the lamp in Table 1 below.
8. Turn off the fan and return the voltmeter to the OFF position.

Keep the set-up without altering it, ready for part b

Part B – Testing with other numbers of blades:
1. Carefully detach the hub from the turbine's motor drive shaft and loosen the blades a little by the turning the screw that holds them firmly in place.
2. Add six more blades to the hub so you now have 12 blades equally spaced, still set at 45°. Tighten the screw so the blades are firmly held again, and insert the hub and blades back onto the bottom turbine shaft, as shown in Figure 1. Make sure that the hub is tight on the shaft.
3. Reset the voltmeter to the **20** setting.
4. Turn the fan onto the highest setting and once a steady reading is obtained, record the voltage and brightness of the lamp in Table 2.
5. Repeat Steps 1 and 2, for four, then three, and then two evenly spaced blades in the hub, still all set at 45°. Record your results in Table 2.

Results

Table 1 – Part A: voltage and brightness with six blades.

Voltage V volts	Brightness of the lamp

Copy your results for six blades from Table 1. Then enter your results for 12, four, three and two blades.

Table 2 - Part B: voltage and brightness of the lamp for a wind turbine with different numbers of blades

Number of turbine blades	Voltage V volts	Brightness of the lamp
12		
6		
4		
3		
2		

Discussion Questions

Question 1

Did you have any practical difficulties in performing Part A of the experiment? If so, how did you resolve them?

Question 2

Was the prediction you made at the start of this experiment correct? Or were you surprised with the results in Part B for this model turbine? Suggest a reason why your prediction was or was not correct.

Question 3

a) Did all the groups in the class agree on the best number of blades?

b) If not, identify at least two sources of error for this experiment, which would help account for any differences in the results.

Question 4

List the variables that were kept the same as you performed the experiment.

Question 5
Were there any variables, other than those mentioned above, that were not controlled? If so, state what they were and describe what effect they could have had on the results.

Question 6
Do you think the results would have been the same if the set of blades had been shorter than the set you used in this experiment? Discuss.

Question 7
Do you think the results would have been the same if the blades had been set at a different angle than the angle used in this experiment? Discuss.

Question 8
Suggest why large wind turbines usually have three blades.

Conclusion
What are your answers to the three inquiry questions?
What voltage can be delivered by a STELR model wind turbine operating with six blades?
What is the relationship between the number of blades on the STELR model wind turbine and the voltage it delivers?
How many blades give the greatest voltage?

Challenge: The Best Wind Turbine

In this investigation you will design, conduct and report on an experiment into getting the most energy from a wind turbine . Who can get the lamp to shine most brightly? Who can generate the biggest voltage?

You can use the blades provided, or make your own shapes. How will you connect them to the turbine hub?

When you have completed the investigation you can communicate your findings by completing the report below.

Before you commence your investigation and start collecting data, make sure that your teacher has checked your materials, method, risk assessment, variables and draft data table.

Inquiry Question: What is the best set-up for getting the most energy using the STELR model wind turbine?

Identify the Variables

Question 1
What things can you change on the turbine that might change the output from the wind turbine?

Question 2
What will your dependent variable be, that is, the one you are going to measure during the experiment?

Question 3
Which variables will you have to keep constant in order for your investigation to be fair and valid?

What you need

Make a list of the materials you will need to carry out your investigation.

What to do

In numbered points, write a step by step procedure that can be followed in order to carry out this investigation. Include steps that show how to:

- set up the independent variable so that it can be varied
- measure the dependent variable
- control the variables other than blade length
- set up for reliability of data

Risk Assessment

Complete a risk assessment of your procedure by completing the following table. Number the risk factors and use new lines to keep the facts and their corresponding risks and precautions aligned.

The facts	What might be the risks?	What precautions will be taken?

Do your experiment

Keep a record of what you did and the results you gathered in this project space.
What did you change to get more voltage from your model wind turbine?

Discussion Questions

Question 1

How reliable do you think your results were? Discuss.

Question 2

Did your findings surprise you? Can you suggest an explanation for what you discovered?

Question 3

What are the implications of your findings for commercial wind turbines? Discuss.

Question 4

If you were given the opportunity, what further investigation would you carry out to build on what you learned from this investigation?

Conclusion

Summarise the conclusions drawn by the class overall, and hence answer the question: "What is the best set-up for getting the most energy using the STELR model wind turbine?"

Which energy sources are sustainable?

What is meant by sustainable and how is this different to renewable?

Although the terms renewable and sustainable are thought by many people to be the same thing this is not correct.

A renewable energy source is one that is produced by natural process and replaced at least as quickly as it is used. That means these energy sources won't run out in the foreseeable future. These sources have a low impact on the environment especially because they don't release additional greenhouse gases into the air. Examples of renewable energy sources are: wind, solar hydropower.

A sustainable energy source is one that will be available to meet the current and future energy needs.

While it is generally agreed that all renewable energy sources are also sustainable not all sustainable energy sources are renewable. Nuclear power is a good example of a sustainable energy source that is not renewable.

Think about the energy sources which are used for generating electricity in Australia. Do you know which are sustainable?

Question 1

The table below identifies energy source which are being used to generate electricity. Beside each energy source write yes if you think it is sustainable and no if you think it is not.

If you know about other sustainable energy sources add them to the bottom of the table.

Energy source	**Is this energy source sustainable? (Yes/No)**
Wind	
Tidal flow	
Flowing water from dams	
Wave motion	
The Sun	
The Sun	
Oil	
Coal	
Natural gas	

Question 2

Discuss your responses with other class member to see if they agree with your classification.

As the world's population increases so does the demand for electrical energy. In order to meet that demand sustainable energy sources will become increasingly important.

Question 3

Watch the video, Renewables round up which explains how many types of renewable resources.

https://www.youtube.com/embed/_JWxAAeQXe0

Question 4

Consider the features of wind turbines listed in the table below and state whether they are advantages or disadvantages, and why.

	Features	Advantage or disadvantage?	Reason for choice
1	Wind is a renewable energy resource. It will never run out.		
2	Wind turbines do not produce greenhouse gases or other pollution when operating.		
3	Some people believe the sound they produce is annoying or even harmful.		
4	Wind energy is free.		
5	The electrical power delivered varies because wind speed and direction vary. Sometimes the wind speed is too low to even start rotation.		
6	Very strong winds can damage turbines.		
7	Wind energy is available day and night.		
8	It can be costly to connect a wind farm to the electricity grid due to the distances involved.		
9	Wind turbines can be used in remote areas where there is no access to the electricity grid.		
10	Some people think they spoil the landscape.		
11	Wind turbines can be installed on land where cattle or sheep graze.		

Question 5

Consider the features of solar panels listed in the table below and state whether they are advantages or disadvantages, and why.

	Feature	Advantage or disadvantage?	Reason for choice
1	Solar cells convert solar energy directly into electrical energy		
2	They do not produce greenhouse gases or other pollution when operating		
3	There is often variable light intensity due to: day and night, clouds, shadows, changing angle of the incoming sunlight, dirt, pollution or other obstructions		
4	A large area of panels is required to produce enough electricity		
5	They provide electrical energy for over 50 years		
6	They can be used in remote areas		
7	It can be expensive to connect solar farms into a state-wide electricity grid, due to the distances involved		
8	Excess electrical energy can be stored in batteries for later use or fed back into the grid		
9	Many locations receive a lot of solar energy		

Teacher Resources: How to run *Electricity and Energy*

The STELR Electricity and Energy module has primarily been written for Year 6 students.

It is designed to meet many of the requirements of the Australian Curriculum: Science. The advantage of this scheme is that you can fulfil much of the Australian Curriculum: Science within a meaningful context. To cater for the wide range of schools implementing the program, a variety of activities have been provided.

We would expect that the STELR Electricity and Energy module will take approximately 20 lessons if all activities and investigations were done. However we do encourage you to select as much as you can from our 'smorgasbord', so that students are given a rich experience and can gain the most from the program.

We also strongly advise you to run the program within one term, and avoid splitting it across different terms, which breaks the continuity of the program and reduces impact.

The key ideas in the STELR Electricity and Energy module

The STELR Electricity and energy module focuses on the following key ideas:

- Electric circuits: basic, series and parallel
- Types and sources of energy
- Energy transformations and energy transfers
- Different ways for generating electrical energy
- How scientists work – designing experiments
- Recoding and analysing data and drawing conclusions

The practical activities

Overview

To a large extent the inquiry-based learning approach consists of first-hand practical investigations of a range of inquiry questions. These are in the form of directed investigations and guided student-designed investigations. Most are small group investigations; some are class experiments.

Safety!
Student practical investigations in this module have been designed in such a way that they pose little or virtually no risk.

The directed practical activities

Purpose

Overall, the set of directed practical investigations has been designed to:

- Model the way scientists work by providing experience in conducting hands-on investigations that are designed to explore one or more inquiry questions. This includes risk management, prediction and analysis of results, recording and displaying results effectively, identifying sources of error and evaluating their investigation.
- Reflect the principles of inquiry-based learning, by providing first-hand experiences through which new concepts are introduced and a greater depth of understanding of important concepts can be developed.
- Introduce or reinforce practical laboratory skills, including the use of the STELR equipment, so students can develop competence and confidence.
- Develop good time-management, organisational and communication skills.
- Provide a strong background to enable students to design and perform their own relevant investigations.
- Foster the ability to work in collaboration and co-operation with others, by working in small groups and with the whole class.
- Foster important values, including open-mindedness and ethical practice.

Advice on running the directed practical activities

Teachers are advised to:

1. Vary the way in which the students record and process their experimental data. Teachers are encouraged to give students the opportunity to use spreadsheets and graphing software for at least one of the investigations.
2. Trial each investigation before class, so that they know exactly what to expect and can predict problems that might arise in class. This will help streamline the process, reduce risk and avoid embarrassment.
3. Always ensure that the students are clear about what to do and how to set up and use the equipment risk and that they perform the risk assessment first. Then monitor what they do throughout the investigation very closely to ensure they comply with all expectations.
4. Always ensure enough time is left at the end of each investigation (approximately 15 minutes) for a productive class discussion, in which student findings are compared, analyse, and evaluated and explanations are proposed, and further inquiry questions or improvements to the experimental design are suggested.

The student-designed practical activities

Purpose

Overall, the set of student-designed practical investigations has been designed to:

- Model the way scientists work by providing experience in designing and conducting hands-on investigations to explore the answer to one or more inquiry questions. This includes developing a hypothesis, identifying variables, designing fair tests, taking accurate measurements, identifying and managing risks, predicting and analysing results, recording and displaying results effectively, identifying sources of error and evaluating their investigation.
- Reflect the principles of inquiry-based learning, by providing first-hand experiences through which new concepts are introduced and a greater depth of understanding of important concepts is developed.
- Further train students in practical laboratory skills so they can develop greater competence and confidence.
- Develop good time-management, organisational and communication skills.
- Foster the ability to work in collaboration and co-operation with others, through working in small groups and with the whole class.
- Foster important values, including open-mindedness and ethical practice.

Advice on running the student-designed practical activities

Teachers are advised to:

1. Encourage the students to make full use of appropriate ICT to record and process their experimental data. This includes the use of spreadsheets and graphing software.
2. Avoid advising the student on how to design and perform their own investigations, as they need to be given the freedom to be inventive and to use their own creativity and initiative, and to make their own mistakes. They will learn from their mistakes as well as from their successes. The chemicals they will use pose virtually no risk.

Introducing a new key topic

Overview

For each new topic, a selection of some of the big ideas behind the topic is provided in the form of questions at the beginning of the topic. These are intended to stimulate discussion and to encourage students to pose some of their own big questions.

Many of these activities are based on the teaching strategy **'Interview about instances'**. In this technique, some stimulus material, in such forms as a series of images, a video or demonstrations, is presented to the students and questions about the stimulus material are posed.

Purpose

The introductory activities are designed to:

• Introduce each new area of the curriculum in a way that will involve all students and stimulate their interest.

• Enable the teacher to gauge what the students already know and understand of the concepts involved and any alternative conceptions they have, to assist in the planning of future lessons.

• Clarify or reinforce concepts or to understand new concepts.

• Promote effective communication and student confidence.

The student activity sheets

Overview

The student activity sheets offer students a range of information, experiences and tasks to enable them to develop key science understandings and thinking skills and to give them opportunities to explore issues that are relevant and meaningful to them, and possible future careers.

NB The teacher will be expected to support the activity sheets with further material, including web links and some of the optional introductory activities.

Purpose

Overall, the set of student activity sheets is designed to:

- Enable the students to build up or extend and then apply their science skills, knowledge and understanding.
- Prepare students for a particular practical investigation, including essential background information and sample calculations.
- Enable the students to develop insights into science as a human endeavour, and to challenge their thinking about important contemporary issues and future pathways and careers.
- Encourage students to undertake further research into a fascinating aspect of a topic.
- Link students to other resources.

Advice on using the student activity sheets

Teachers are advised to:

Ensure that the activity sheets are woven around the practical investigations, so that students are well prepared for the investigations and can then apply what they have discovered through their investigations.

Give students the opportunity to discuss and compare their responses to any set questions in small groups or as a class. This will help build up their communication skills and help clarify concepts. It also will provide the teacher with an insight into the student's understandings and any alternative conceptions they may hold. This will also be a chance to encourage the students to raise their own questions.

The use of ICT in STELR modules

Overview

Students should have the opportunity to use a range of technology, to conduct web research, to record process experimental results using spreadsheets and graphing programs and other technology such as video recorders and digital cameras, and to present their findings using a range of technologies.

Advice

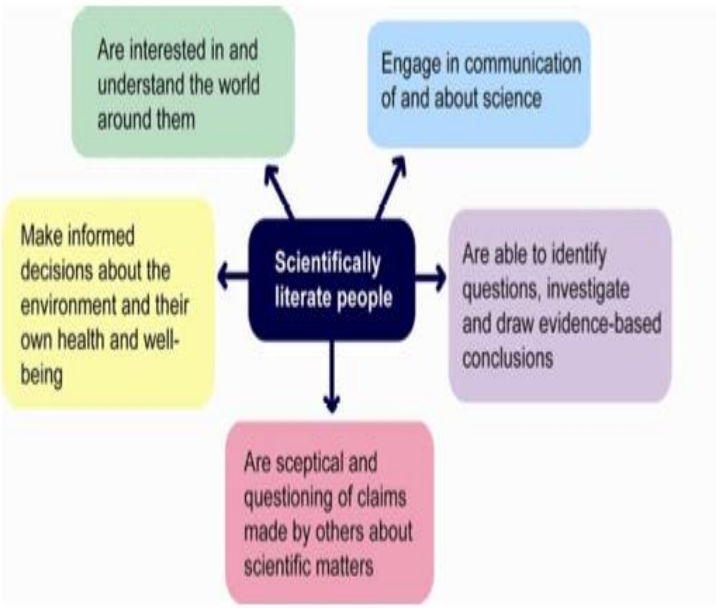
Teachers are advised to provide as many opportunities as possible for students to use the range of ICT available within the school.

This should include extensive use of the STELR website.

Teaching scientific literacy

Overview

The STELR Project prepares students to engage with science ideas in their work and their lives generally, as citizens. Leonie Rennie (2006) described scientifically literate citizens to have the following attributes:



The scientific literacy focus is strongly represented the in the STELR Curriculum as follows:

• Thinking and working scientifically are major aspects, with a particular emphasis
on evidence-based thinking.
• Engaging with the science-technology-society interface is emphasised.
• Social, ethical and economic issues are incorporated into the learning.
• The nature of science and its contemporary setting is strongly represented.
• Students are supported to develop a critical, objective, committed stance.

Advice

Teachers are strongly advised to use every opportunity within the program to:
1 Foster the students' ability to think and work scientifically, through class discussions, activities and practical investigations.
2 Encourage evidence-based critical thinking about the issues of global warming and climate change and society's and their own use of energy resources, including an examination of statements and information disseminated in the public arena.
3 Foster an appreciation of the way science and technology can be used to identify and address global issues.

Assessment

Overview

It is expected that teachers will choose modes of internal assessment that suit the school and their students. Assessment advice and an assessment rubric pro forma for assessment of science inquiry skills are included in this resource should teachers wish to use these for their assessment of students. (These are also provided in Word format so teachers can adapt them to their needs.)

The STELR Approach to Teaching and Learning

The philosophy behind the STELR approach

A recent and much quoted review of Australian Science education (Goodrum, Hacking & Rennie, 2001) listed, as their first theme for an ideal science curriculum, that : ‘The science curriculum is **relevant to the needs**, concerns and personal experiences of students.’ They have argued more recently (Goodrum & Rennie, 2006) that: ‘Many students find the school science curriculum on offer to be **unimportant, disengaging, and irrelevant** to their life interests and priorities.’

Glen Aikenhead (2004) has argued that: ‘A recurring evidence-based criticism of traditional school science has been its **lack of relevance** for the everyday world’, and that we need to emphasise humanistic aspects of science in our curriculum and teaching.

For this reason, the main theme of the STELR program is the highly relevant context of **global warming and renewable energy**.
STELR has adopted a number of principles designed to engage students through evidence-based teaching approaches and strategies. These include:
• Scientific literacy;
• Inquiry-based learning;
• A socio-scientific focus;
• The representation of science as a human endeavour; and • Embedded assessment.

Inquiry-based learning

Inquiry-based learning helps students actively pursue and use science knowledge rather than experience it as pre-packaged and complete – to be accepted and practised. Thus, in the STELR program there are many points at which students raise questions and explore ideas.

In the introductory activities the principle used is ‘guided inquiry’, but students are later encouraged to shape their own inquiry around questions that interest them. This involves being able to design investigative approaches. These include experimental as well as web-based research approaches.

A core principle that has been used to describe inquiry is ‘explore before explain’, meaning that students are introduced to science ideas only after they have explored phenomena and raised questions implying a need for these.

Inquiry-based pedagogies:

- Involve students in initial exploration before ideas are introduced and explanations developed;
- Incorporate and value students' own questions;
- Involve open-ended investigation as part of the teaching sequence;
- Use activities to explore and develop ideas rather than simply demonstrate previously presented ideas; and • Support students to create new knowledge.

The jigsaw approach

An integral part of the STELR program is the **jigsaw approach** to learning in which each student group or student pair becomes the class experts in particular aspects of renewable energy through practical and web-based investigations and various challenges, which they then communicate to the other members of their class. These activities involve students taking responsibility for the direction of their inquiry.

The 'interview about instances' teaching strategy

Many of the activities through which key concepts are introduced are based on the teaching strategy **interview about instances**. In this approach, some stimulus material, in such forms as a series of images, a DVD or demonstrations, is presented to the students and questions about the stimulus material are posed.

The role of the teacher is one of the questionner rather than the transmitter of answers. The teacher may find there is considerable variation in student thinking about the issues or concepts presented, or that alternative conceptions are presented.

Principles of inquiry-based learning

Engagement of Students

An inquiry based approach starts with engagement of the students prior to explaining. This serves several purposes:
• It provides a conflict between prior learning and the new more scientific understanding - such conflict will lead students to ask questions
• It gets students' attention and focus
• It elicits and assesses prior knowledge [students may have constructed alternative conceptions]
During this stage, students:
• ask questions • show curiosity • show interest
During this stage, teachers:
• create interest
• generate curiosity • raise questions
• elicit responses

Exploration without teacher explanation

During this stage, students:
• ask questions
• hypothesise
• work without direct teacher input [but are guided] • gather evidence
• record and organise information
• share observations
• make evidence-based claims
• draw conclusions
• work cooperatively and / or collaboratively

During this stage, teachers:
• encourage students to work cooperatively and / or collaboratively • observe and listen as students interact
• ask thought-provoking questions
• allow students time to puzzle through and to explore
• act as a facilitator and / or a consultant
• create a climate where students "want to know" and "want to learn"

Explanation

During this stage, students:
• draw on experiences to offer ideas and explanations in his / her own words • uses evidence to support ideas
• critically appraise explanations
• listen critically and respectfully to others
• reflect on and assess their own understanding
• produce multiple representations of concepts to improve understanding.

During this stage, teachers:

• elicit the students' explanations of concepts, definitions of words • ask for evidence and clarification
• formally provide definitions, explanations and new labels
• use students' experiences to build new concepts
• assess students' developing understanding of concepts
• provide opportunities for students or represent their ideas in a variety of formats.

Elaboration

During this stage, students:
• apply scientific terms, definitions
• apply understandings to new contexts
• use previous information to ask questions, propose solutions, to make decisions and design investigations • draw reasoned conclusions from the evidence
• check for understanding with their peers.

During this stage, teachers:
• expect students to use appropriate scientific terms, labels and definitions • expect students to use their understandings from explanations
• remind students of alternatives
• ask questions such as "What do you think?" and "Why do you think that?"

Assessment

During this stage, students:
• demonstrate their understanding of the ideas and concepts • answer open-ended questions
• evaluate his / her own progress
• ask questions
• participate in peer assessment.

During this stage, teachers:
• elicit or diagnostically assess students' prior knowledge and understanding
• explicitly develop the language of science and mediate where students have conflict in their understanding
• use formative assessment or assessment of learning throughout a unit of work to evaluate student understanding, to provide feedback to students and to direct the learning program
• use summative assessment to identify the students' congruence with the new understandings. • use conceptual mediation to overcome and reconcile alternative conceptions
• use a variety of assessment strategies.