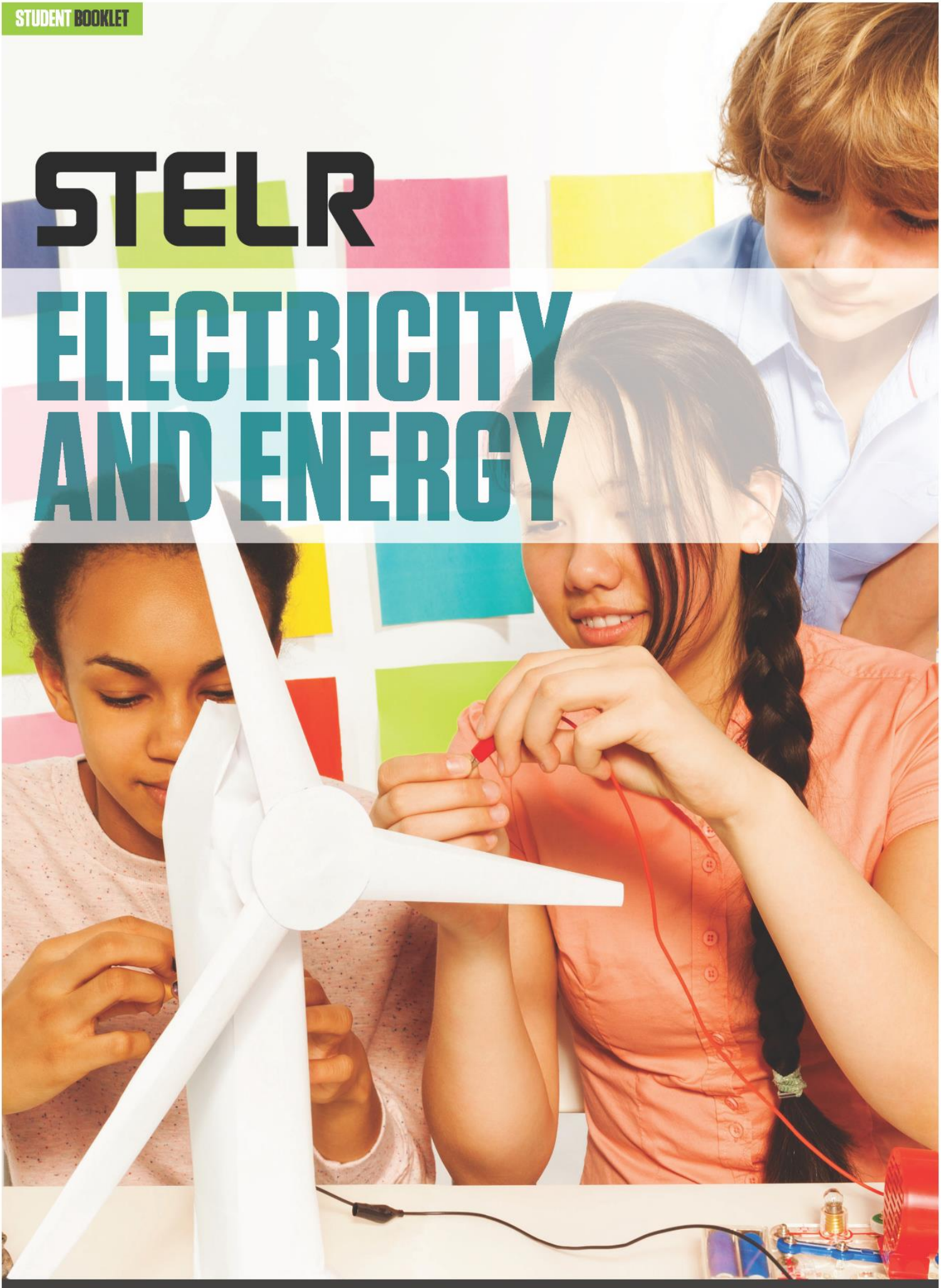
STUDENT BOOKLET

STELR

ELECTRICITY AND ENERGY



NAME

CLASS

STUDENT BOOKLET

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Electricity and Energy was written and produced by the STELR project team.

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SECTION ONE – ENERGY TRANSFERS AND TRANSFORMATIONS

Key Ideas:

Why do we need energy?

What types of energy are there?

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 1.1: 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 almost everything. You use many different types of energy in your daily life. Some different types of energy are heat, light, sound and movement.

There are also many different sources of energy. An energy source is where this energy comes from. Some sources generate more than one type of 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. One answer has been provided to help you get started.

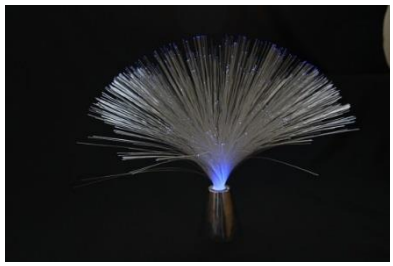
Energy type	Energy Source
Light	Sun, torch

WORK SHEET 1.2: ENERGY TRANSFER

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

Question 1

What sort of energy transfer is happening in these pictures?

	Type of energy being transferred
Cooking sausages 	
Fibre optic lamp 	
Power lines 	

Question 2

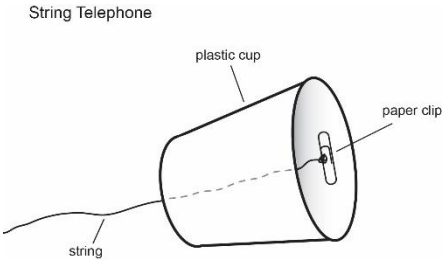
How is electrical energy transferred around your home?

QUICK ACTIVITY 1.1: STRING TELEPHONE

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?

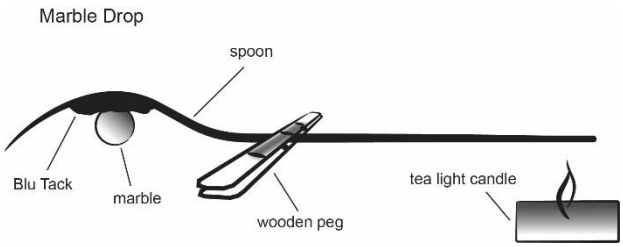
Question 4

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

QUICK ACTIVITY 1.2: MARBLE DROP

What you need:

- Metal dessert 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 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?

WORK SHEET 1.3: ENERGY TRANSFORMATION

Sometimes energy is changed from one type of energy to another. This is known as ***energy transformation.***

Question 1

What sort of energy transformation is happening in these pictures?

	Starting type of energy	**Final type of energy (there may be more than one type)**
Torch 		
Hair dryer 		
Wind turbine 		
Solar panels 		

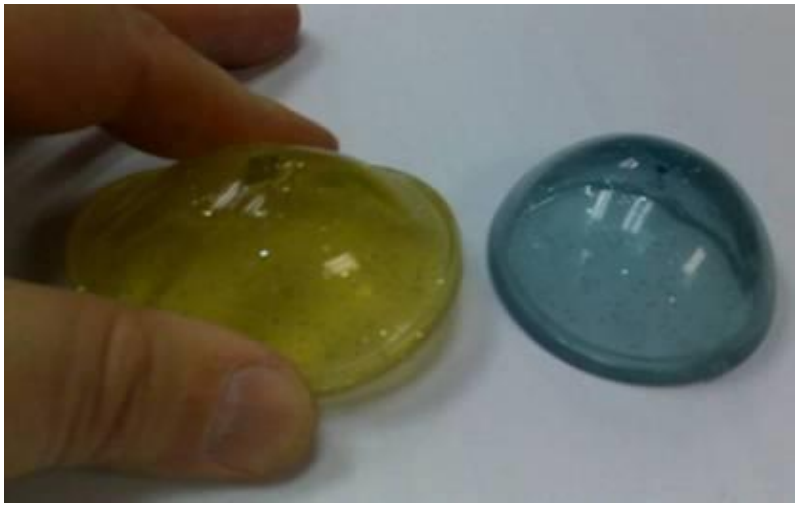
Question 2

What sort of energy is transformed into electrical energy in a battery that is used in a torch?

QUICK ACTIVITY 1.3: JUMPING CUPS

What you need:

- STELR jumping cup
- Different surfaces



What to do

1. Take the jumping cup by its edges, turn it inside out and carefully place it on a smooth surface.
2. Let it go.
3. Describe what happens?

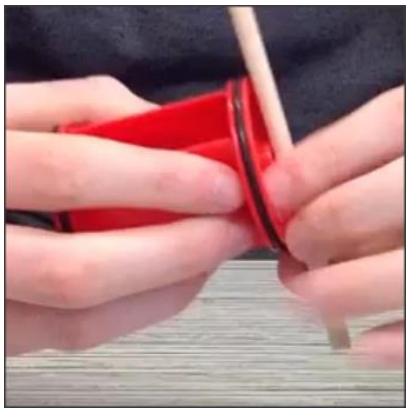
Question 1

What was the starting energy for the jumping cup.

Question 2

What energy transformations have you observed? Show your ideas in the space below.

QUICK ACTIVITY 1.4: COTTON REEL RACER



What you need:

- STELR cotton reel
- STELR dowel stick
- Rubber bands – different sizes

What to do

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

STELR Cotton Reel Racer

VIDEO https://www.youtube.com/watch?v=aJrVZ1Gtbsk&feature=youtu.be

Question 1

Describe how you think it works.

Question 2

What different energy types can you identify when you observe the cotton reel racer?

Question 3

What is the starting energy for the cotton reel racer.

Question 4

What is the finishing energy for the cotton reel racer.

Question 5

Represent the main energy transformation in the cotton reel racer with a flow chart.

Question 6

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

WORK SHEET 1.4: BRINGING IT ALL TOGETHER

Question 1

Use your own words to describe the difference between energy transfer and energy transformation.

Question 2

Use either the word **transfer** (transferred, transfers) or the word **transform** (transformed, transforms) to complete the following sentences:

When sausages are cooked on a fire, heat energy is _____ from the fire to the sausages.

A solar panel _____ solar energy into electrical energy.

When you ride a bicycle, the moving energy of your legs is _____ to the wheels of the bicycle to make them spin.

Your body _____ the chemical energy in your food into moving energy so that you can ride a bicycle.

A hairdryer _____electrical energy into moving energy, heat energy and sound energy.

The moving energy of the wind is _____ to a wind turbine to make it spin

A battery _____ chemical energy into electrical energy.

SECTION 2: ELECTRIC CIRCUITS

Key Ideas

What does a circuit need to allow electricity to flow?

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

What materials conduct electricity?

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

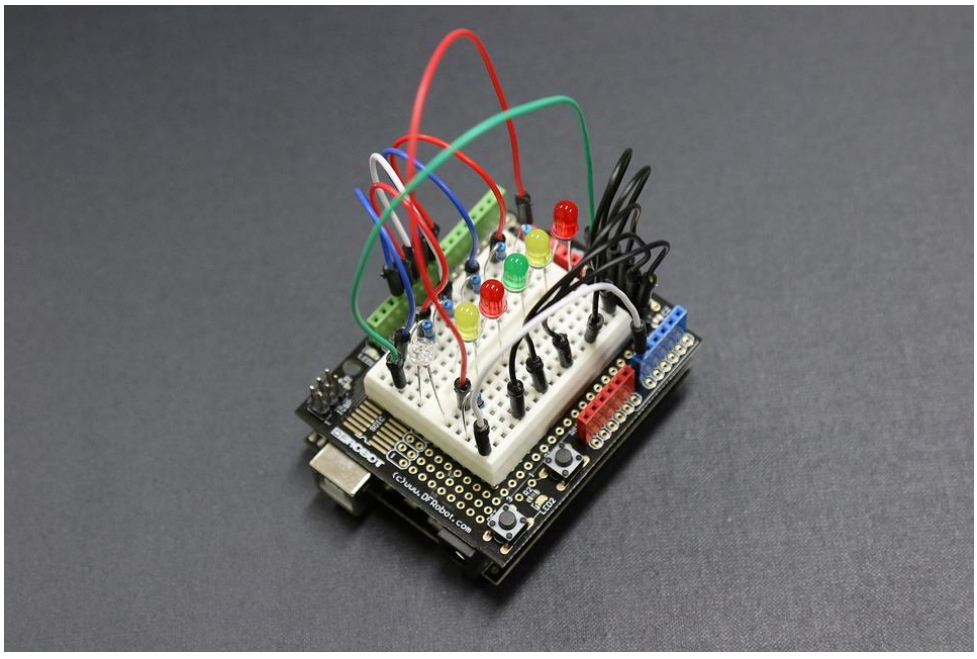
Electrical circuits

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.



ACTIVITY 2.1: SIMPLE ELECTRIC CIRCUITS

Inquiry question: Can you make a complete circuit?

What you need:

- STELR battery
- STELR lamp
- 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.

ACTIVITY 2.2: EXPLORING COMPONENTS – BATTERY PACK AND GLOBE

What you need

- STELR battery pack
- STELR lamp
- 1 x connecting lead
- Blu Tack or plasticine

The STELR battery pack has two 1.5 Volt batteries inside it. The pack holds the two batteries in place so that they can deliver 3Volts.

What to do

1. Take the back off the battery pack and look inside.

Question 1

Do you think that the two batteries are connected together? Explain why you think that.

2. Now take out the batteries and look at them closely. You will see that one end is positive, marked with a plus sign. The other end is negative, marked with a minus sign.
3. Stick the Blu Tack on the table so that the batteries and globe are connected. Use the wire to make the globe light up.

Question 2

Which ends of the battery have to be touching each other for the globe to light up?

Question 3

On this picture, show where the battery and wire must touch the globe for it to light up

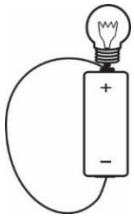
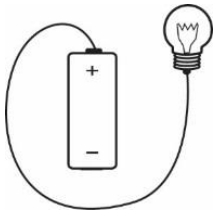
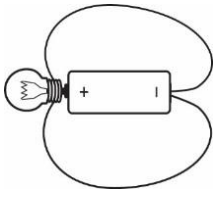
Trace the path the electricity takes though the globe.

Question 4

Below are four diagrams of circuits.

i. Predict which globes will light up and give a reason.

ii. Test to see if your prediction was correct.

	My prediction	What actually happened
		
		
		
		

Now look at the empty battery pack. Look at the wires inside.

Question 4

Use a coloured pen or pencil to trace the path the electricity takes though the battery pack (when the batteries are inside it).

Question 4

Explain why the batteries have to go in the opposite way up.

ACTIVITY 2.3: THE EFFECT OF A SWITCH

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

What you need

- STELR battery pack
- 1 STELR globe
- 3 x connecting leads
- 1 STELR 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.

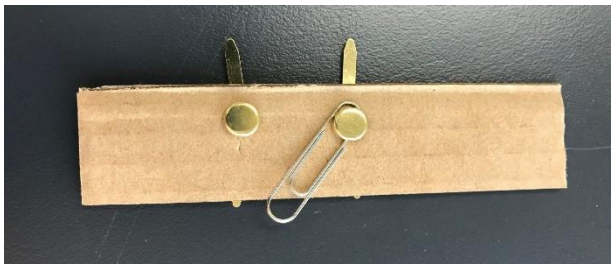
ACTIVITY 2.4: EXPLORING COMPONENTS – HOW A SWITCH WORKS

What you need

- STELR battery pack
- STELR lamp
- 3 x connecting leads
- 2 x alligator clip attachments
- small piece of cardboard
- a paper clip
- 2 x split (fold-back) pins

What to do

1. Make a switch by carefully pushing one of the split pins through the cardboard and fold back the two arms.
2. Take the second pin and thread the paper clip on and push it through the cardboard so that it looks like this. Make sure that the paperclip can touch the first pin when it is swivelled around.



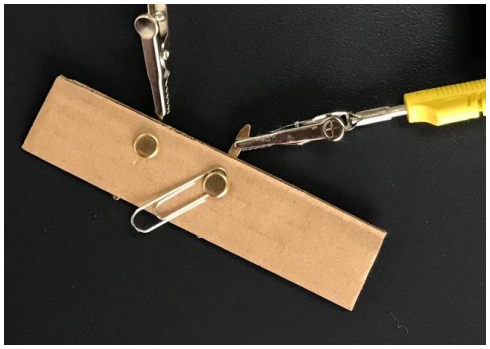
3. Connect up the switch to the battery pack and lamp

Question 1

What do you have to do to make the lamp light up?

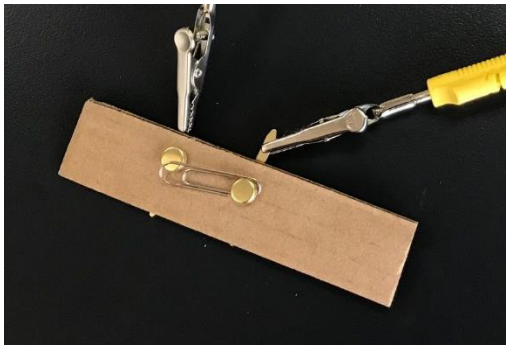
Question 2

Complete the following sentences by crossing out the wrong answer.



When the switch is OPEN the circuit is
INCOMPLETE COMPLETE

When the switch is OPEN the light is
OFF ON



When the switch is CLOSED the circuit is
INCOMPLETE COMPLETE

When the switch is CLOSED the light is
OFF ON

Question 3

What do you think would happen if you replaced the metal paper clip with a plastic paper clip? Explain your answer.

ACTIVITY 2.5: ENERGY TRANSFORMATIONS USING THE TESTING STATION

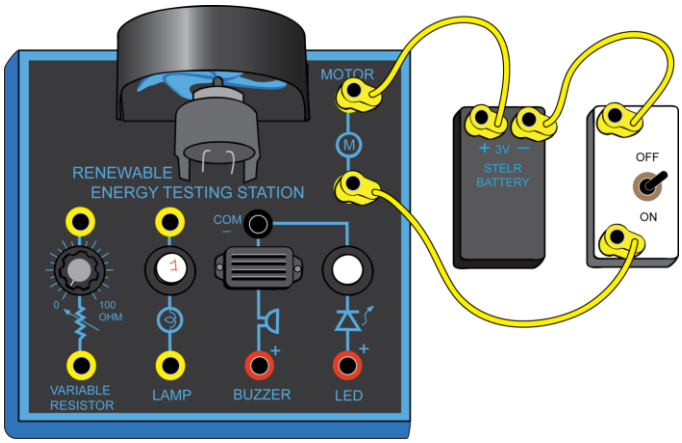
Inquiry question

What you need

- STELR battery
- STELR Testing Station
- STELR Switch
- 3 x connecting wires

What to do

1. Connect the circuit up to the motor on the STELR testing station like this.



Question 1

What happens when you turn on the switch?

Question 2

What happens to the fan if you swap the leads around?

2. Turn off the switch. Now move the two leads, plugging one into the black (COM) socket and one into the red buzzer socket. Turn on the switch.

Question 3

What happens? Reverse the two leads and now what happens?

Question 4

For the buzzer to work, the lead from the + terminal of the battery must be plugged into which terminal of the buzzer?

3. Once you have the buzzer working, turn off the switch. Now move the plug from the red terminal of the buzzer to the red terminal of the LED. Turn on the switch.

Question 5

What happens? Reverse the two leads and now what happens?

Question 6

Complete the following statements

A motor transforms electrical energy into _____ energy.

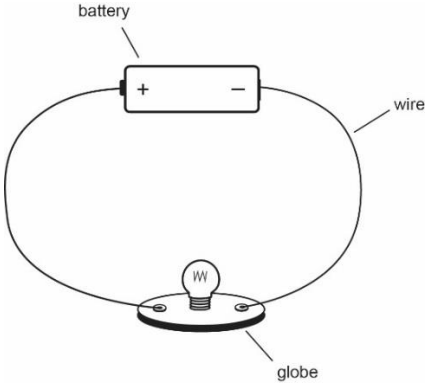
A buzzer transforms electrical energy into _____ energy.

A LED transforms electrical energy into _____ energy.

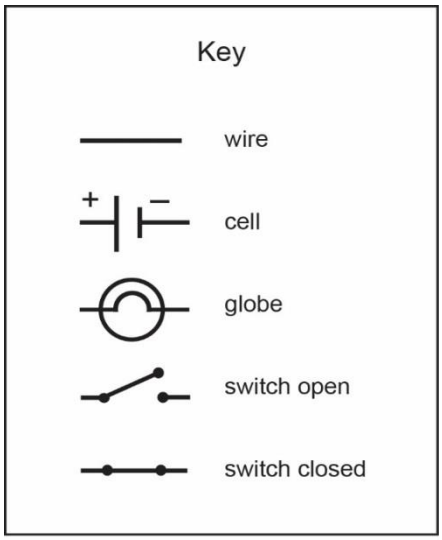
The buzzer and the LED only work if the positive (+) terminal of the battery is connected to the _____ terminal of the buzzer or the LED.

WORK SHEET 2.1: REPRESENTING ELECTRIC CIRCUITS

Electric circuits can be drawn 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 two wires, a battery and a globe. The diagram or picture from your simple circuit may look like this.



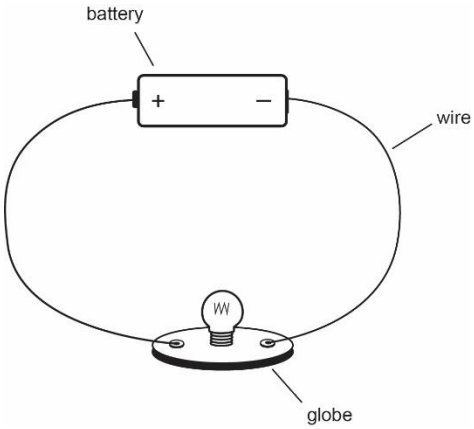
Circuit diagrams may also be drawn using symbols. Symbols are used because many electrical circuits are very complicated and drawing an accurate picture may be difficult.
All scientists and electricians around the world use the same symbols. Symbols for some of the components used in electric circuits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

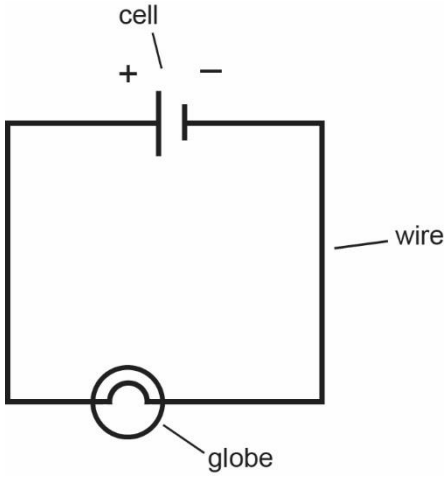


A **cell** is the scientific name for a single battery.

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

A **closed switch** is one that is switched **on**.
Electricity can flow through it.
To make circuit diagrams as clear as possible they are always drawn with connecting wires in a square or rectangle.

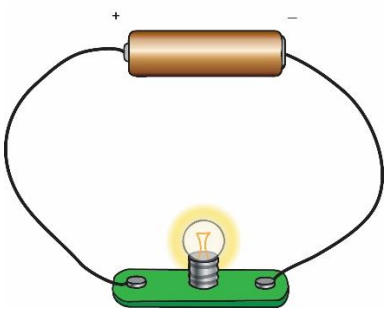




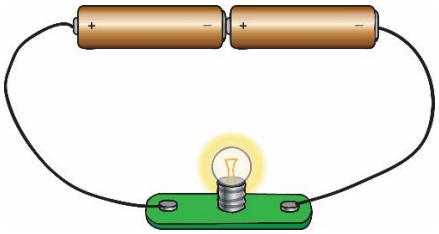
Question 1

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

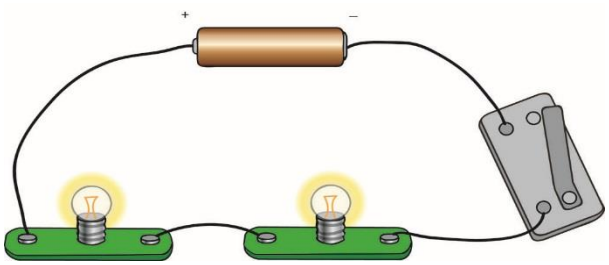
a.



b.



c.

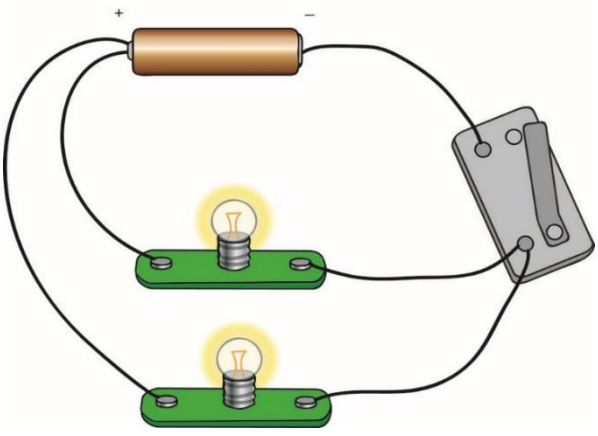


Question 2

Draw a circuit diagram using symbols of a circuit that contains a single cell connected to two light globes. Between the light globes is a switch which is on.

Question 3 Challenge

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



ACTIVITY 2.6: CONDUCTORS AND INSULATORS

Inquiry question 1: What types of materials conduct electricity?
Inquiry question 2: What types of materials are good electrical insulators?

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.

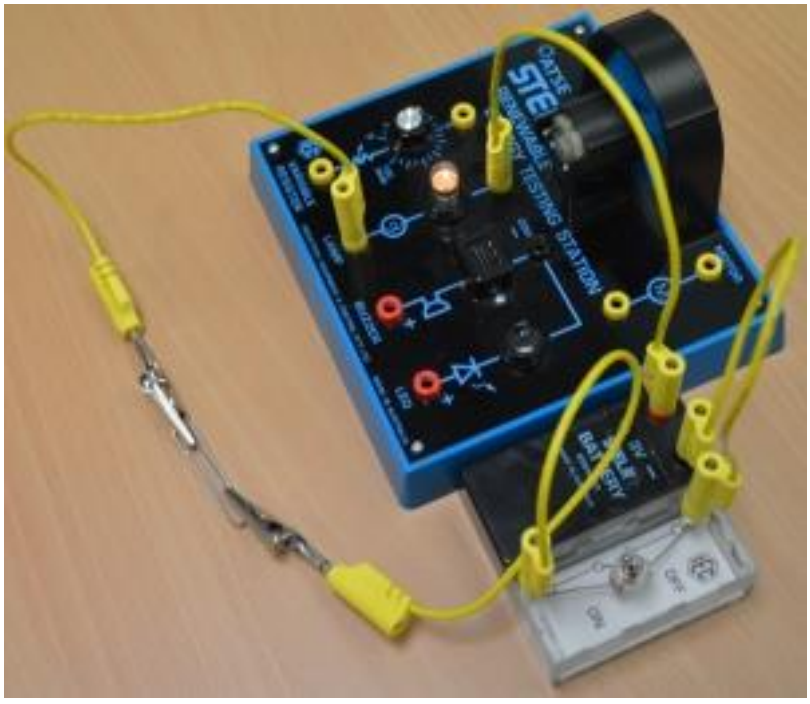
In this activity you will make a circuit to test if a material is a conductor or an insulator.

What you need

- STELR battery
- STELR globe (or testing station)
- 4 x Connecting leads - two with alligator clips on one end
- Switch
- Materials to test

What to do

1. Use the equipment to make a circuit to test materials to see if they are conductors or insulators.
2. Get your teacher to inspect your circuit before you start testing materials.



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	Results
eg. paper clip	*eg metal*	*eg conductor*	*eg conductor*

Question 4

What types of materials conduct electricity?

Question 5

What types of materials are good electrical insulators (do not conduct electricity)?

WORK SHEET 2.2: 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.

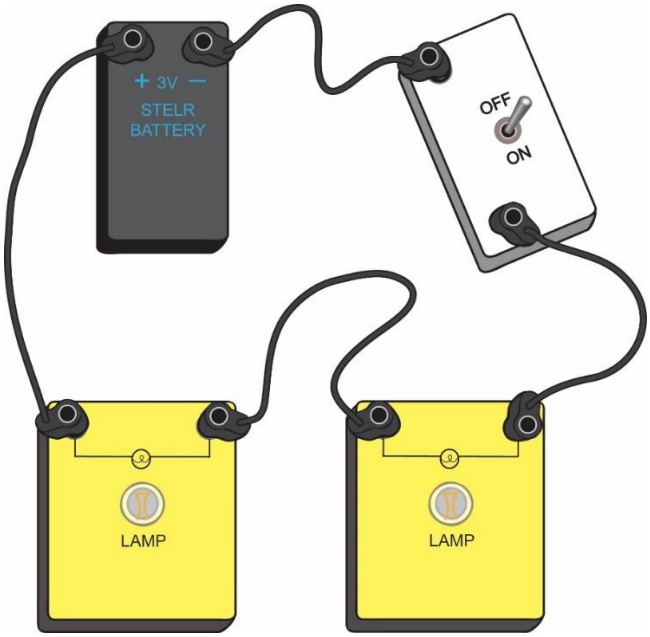


Figure 1: A basic series circuit

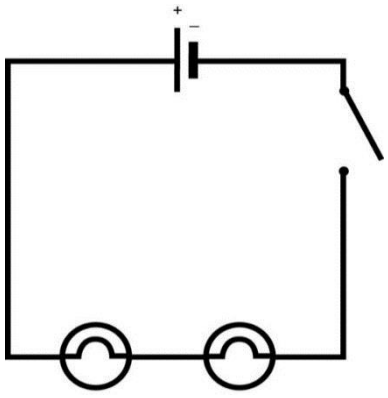


Figure 2: The circuit diagram of the series circuit

Predicting the outcomes of this experiment

You are going to make and test a series circuit like the one pictured on the previous page. 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 and the switch is closed?

b) Explain why you think this.

ACTIVITY 2.7: INVESTIGATING SERIES CIRCUITS

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?

What you need

- STELR battery
- 3 STELR globes
- Connecting leads
- Switch

Figure 1

What to do

Step 1

Set up the circuit shown in Figure 1. 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 on or off	Brightness of globe (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 ACITIVITY: 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
- 3 x STELR globes
- Connecting leads
- Switch

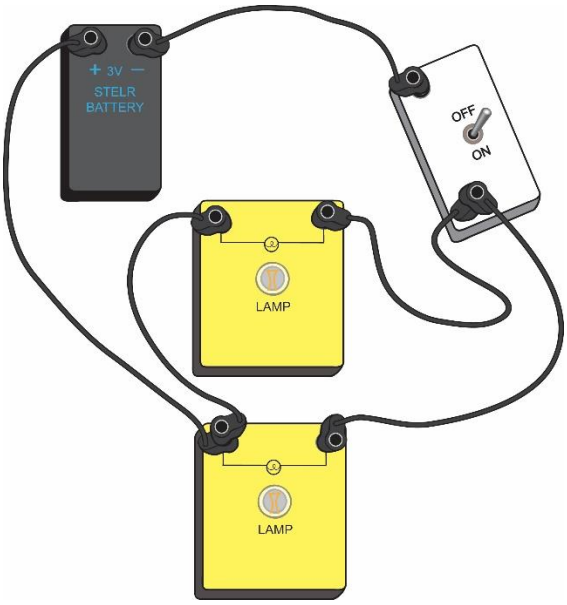


Figure 1

What to do

Step 1

Set up the circuit shown in Figure 1. 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 page 37, 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.

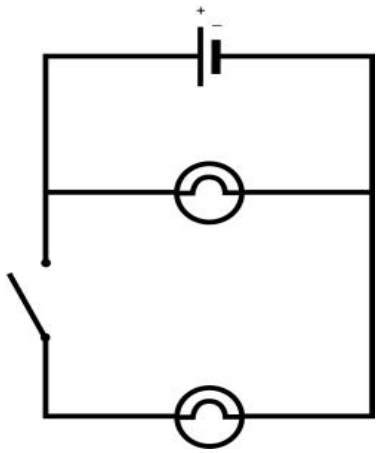


Figure 2

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.

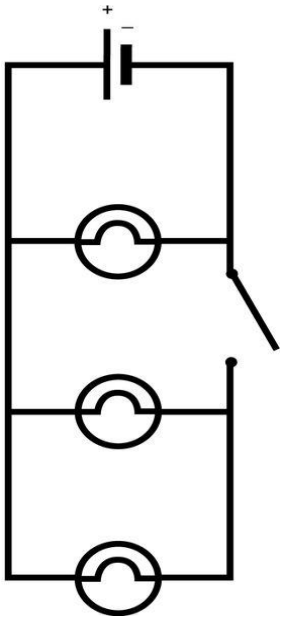


Figure 3

Observations

Write down your observations in this table.

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

Question 2

What is your answer to Inquiry Question 2: Does the position of the switch in the circuit affect which 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.

SECTION 3: GENERATING ELECTRICITY USING TURBINES

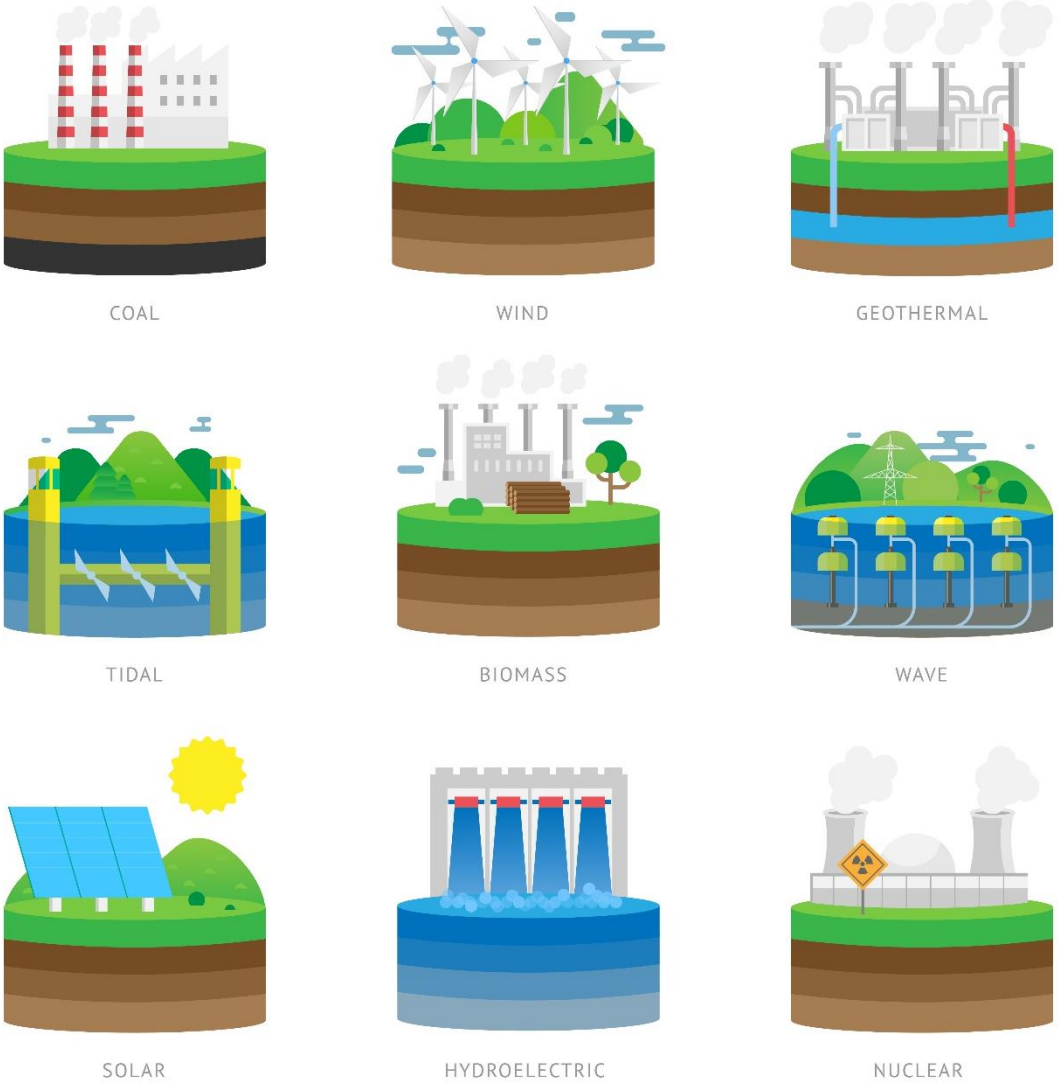
Key Ideas:

How can electricity be generated?

How does moving water generate electricity?

How do wind turbines deliver electrical energy?

Is there a best design for wind turbines?



WORK SHEET 3.1: GENERATING ELECTRICITY

Introduction

Electricity has become very important in our everyday life. It doesn't matter where we are – at home, at school, at the shopping centre we rely heavily of the use of electricity. We have become used to using devices including mobile phones, laptops, tablets and 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.

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

Energy sources for electricity

There are three main ways we can generate electricity:

Batteries

You have already been using batteries in these activities. By putting two different chemicals in a battery, these chemicals can be made to react together to produce electrical energy.

Generators

A generator is a machine that contains a coil of wire and a magnet. When it is rotated, the generator **transforms** moving energy into electrical energy.
There are different ways to make the generator move. You can use high powered steam from boiling water, falling water, wave and tide power or even your own energy.
In Australia, the majority of our power stations burn coal, oil or natural gas to heat up water to make the steam to drive the turbines.

Solar panels

These are made up of materials like silicon that transform light energy onto electrical energy.

Fossil fuels and electricity

In Australia, the majority of our power stations burn coal, oil or natural gas to heat up water to make the steam to drive the turbines. Coal, oil and natural gas are called fossil fuels because they formed over millions of years from the fossilised remains of plants or animals. There are two main problems with using fossil fuels to make electricity:

1. They will eventually run out and as they take millions of years to form, they are not a renewable source of energy.
2. When fossil fuels are burnt, they produce carbon dioxide gas which is relaeased into the atmosphere. Carbon dioxide is one of the gases that is causing our atmosphere to warm up, which leads to climate change.

The rest of this section looks at ways we can generate electricity without burning fossil fuels.

Question 1
The following table lists sources of different types of energy that can be used to produce electricity. For each source name the energy type which is provided by that source.

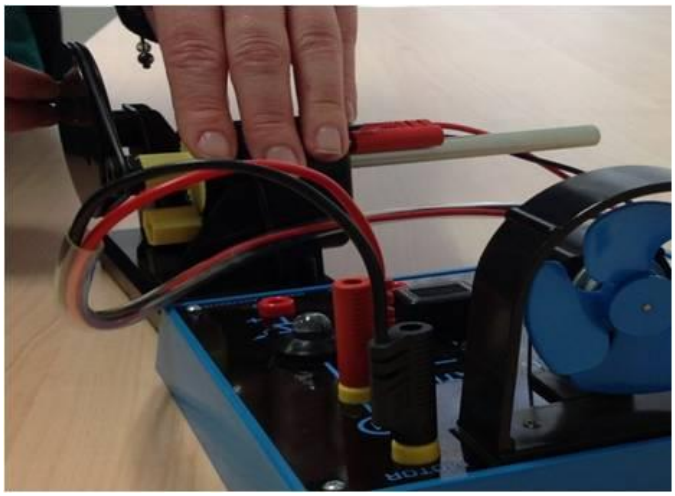
Energy Source	Energy Type
Wind	
Tidal flow	
Flowing water from dams	
Wave motion	
The Sun	
Oil	
Coal	
Natural gas	

ACTIVITY 3.1: HAND-CRANKED GENERATOR

(Teacher demonstration)

Inquiry question: How can humans generate electricity using muscle power?

Your teacher is going to show you how a generator works using their own muscle power!



What to do

1. Your teacher will set up the hand-cranked generator and connect it to the MOTOR sockets of the testing station.
2. Your teacher will wind the handle slowly and then faster.

Question 1

What happens if your teacher rotates handle in the opposite direction instead?

The generator will now be connected to the buzzer.

Question 2

What happens if your teacher rotates handle in the opposite direction instead?

Question 3

What happens to the sound of the buzzer as the handle is rotated faster and faster?

The lamp will now be connected to the buzzer.

Question 4

What happens if your teacher rotates handle in the opposite direction instead?

Question 5

What happens to the light as the handle is rotated faster and faster?

Question 6

What energy transformation(s) do you think happened?

What you observed	**Transformations happening**
Wheel turning and leads connected to motor and fan	
Wheel turning and leads connected to buzzer	
Wheel turning and leads connected to globe	

ACTIVITY 3.2: USING A WATER WHEEL TO GENERATE ELECTRICITY

(Teacher deomstration)

Inquiry question: How can water be used to generate electricity?

In this activity you will be using moving water to rotate the generator.

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**.

Water pushes a special water wheel called a **Pelton wheel**, which is attached to the generator to turn it. A Pelton wheel is a type of turbine. A **turbine** is a machine that can be pushed by air, water or steam to make a generator spin.

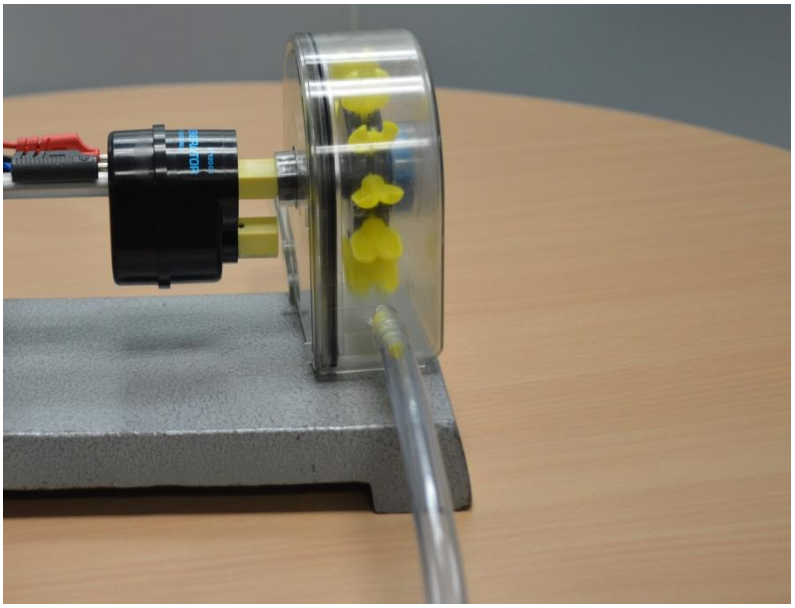


Figure 1. The STELR Pelton wheel that will be used in this activity

What you need

- STELR Pelton wheel
- Hose (supplied with Pelton wheel)
- Wind-turbine generator
- Retort stand
- Boss head
- Testing module or light globe
- Connecting cables

What to do

Your teacher will attach one end of the hose to the tap and the other end to the Pelton wheel.
The turbine will be connected to the lamp on the test panel using two cables. The generator will be fitted into the Pelton wheel and the tap turned on.
You can watch a video of how to set up the Pelton wheel at
https://www.youtube.com/watch?v=LADHkckpey0

Question 1

Take a photo or video or draw the Pelton wheel in action.

Question 2

Describe what happened when the tap was turned on.

Question 3

Where there any problems getting the Pelton wheel to generate electricity?

Question 4

What happenes if the tap was turned on more?

Question 5

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

WORK SHEET 3.2: WIND TURBINES

Wind has been used for a long time to grind grain and pump water. We now use wind to generate electricity.

This is a wind mill that uses wind energy to grind grain to make flour.

This is a wind pump. It uses wwnd energy to pump water into the tank next to it.

This is a wind farm. The wind energy is being used to generate electricity.

To generate electricity, wind pushes the blades of the wind turbine. The turbine is attached to a generator. In the next activities you are going to investigate how to get the most electricity from a wind turbine.

Question 1

Before you start, have a look at the pictures above and list some of the differences between the three different wind machines.

Question 2

Now look at the STELR wind blades and the STELR wind turbine hub. Think about how you could use these to design a wind turbine. Think about what factors might affect how much electrical energy you can produce. Discuss with your class and write down as many ideas as you can.

ACTIVITY 3.3: BLADE ANGLE AND ELECTRICITY GENERATION IN WIND TURBINES

inquiry question: What is the best angle for the blades on a wind turbine hub to produce the most electrical energy?

Introduction

In this activity 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.

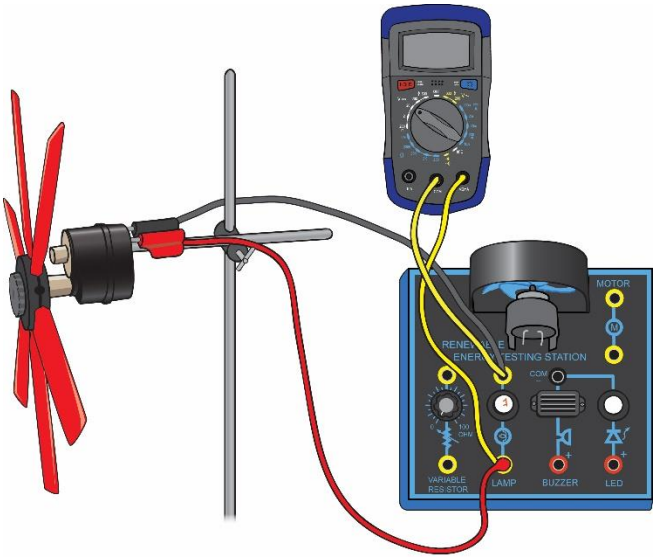


Figure 1: The set up

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 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.

Action	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°

1. 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.
2. Secure the model wind turbine to the retort stand, as shown in Figure 1.
3. 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)

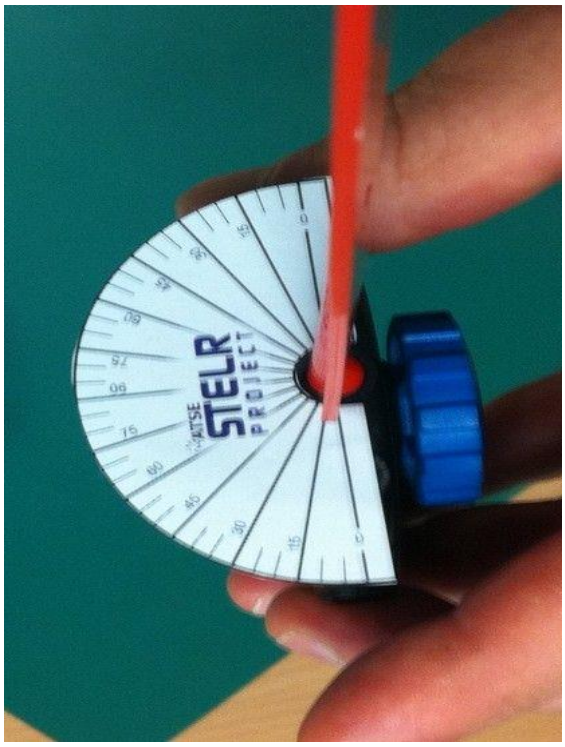
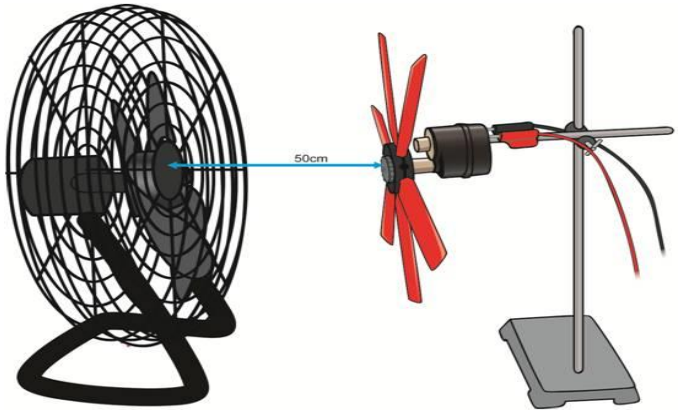


Figure 3: Using the STELR protractor to set the blade angle

4. Connect the circuit as shown in Figure 1, with the plugs inserted into the LAMP sockets of the STELR testing station.
5. 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

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

10. Turn off the fan and return the voltmeter to the OFF position.

Results

Results Table 1 – Testing the blades at 45 degrees

Voltage (V)	Brightness of the globe

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 Table 2 – 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 the blades	Voltage (V)	Brightness of the globe
45 degrees		
10 degrees		

Question 1

Did you have any practical difficulties in performing Part A (testing with the blades at 45°) 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 had 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

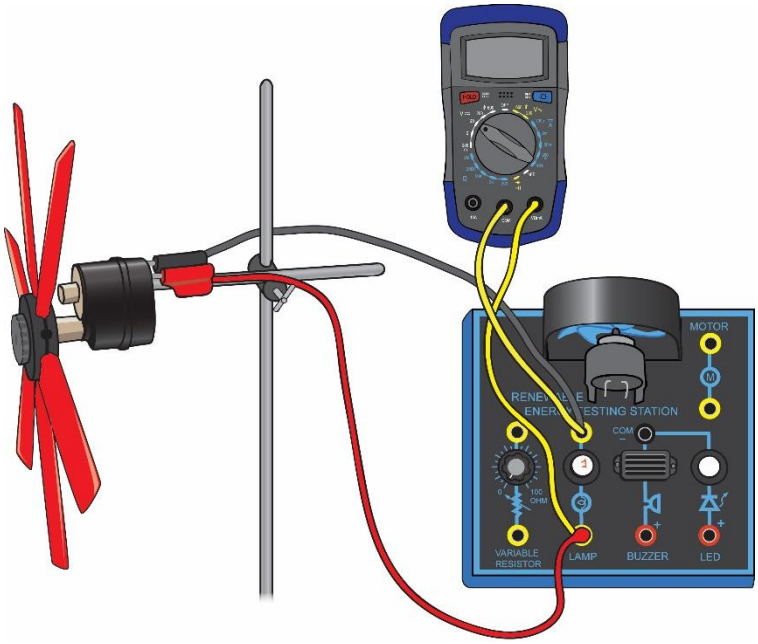
List the variables that were kept the same as you performed the experiment.

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?

EXTENSION ACTIVITY: BLADE NUMBER AND ELECTRICITY GENERATION IN WIND TURBINES

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 4. 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.

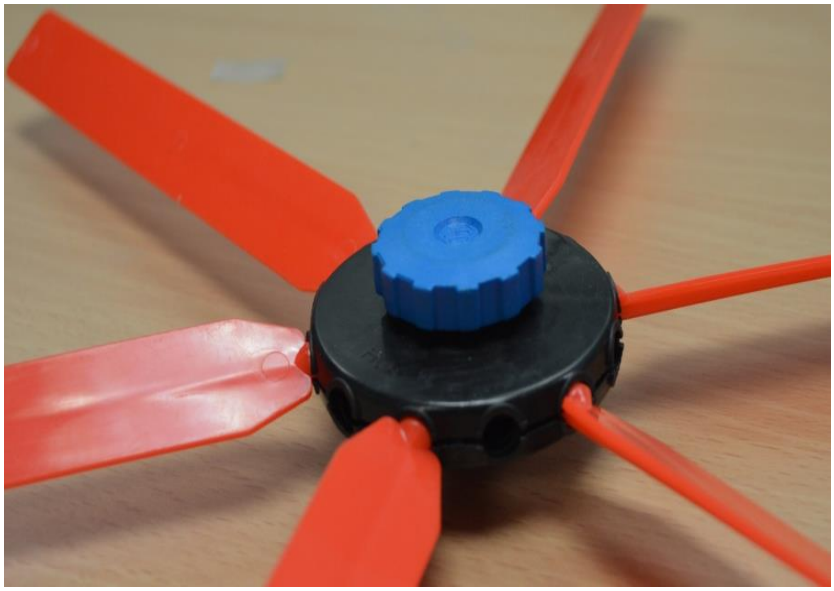


Figure 3: These blades have been set into the hub at the same angle (45^0)

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.

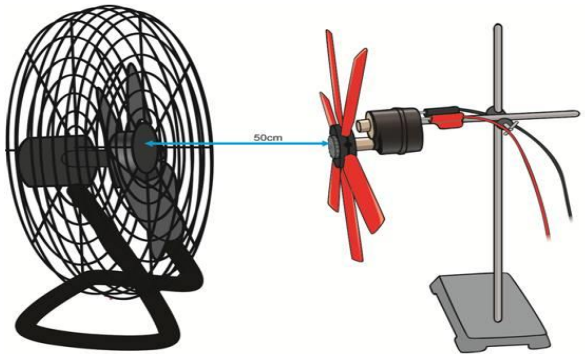


Figure 4: The correct relative positions of the fan and the turbine

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

Results

Results Table 1 – Testing with six blades

Voltage (V)	Brightness of the globe

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 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

Results Table 2 – Testing with other angles

Copy your results for 6 blades from Table 1. Enter your results for other numbers of blades.

Number of blades	Voltage (V)	Brightness of the globe
12		
6		
4		
3		
2		

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 you think 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?

ACTIVITY 3.4: THE BEST WIND TURBINE

In this investigation you will design, conduct and report on an experiment about 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 true?

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
- 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. Complete the following risk assessment for this practical investigation.

Action	What might be the risks?	What precautions will we take?

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?

Results

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

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?"

SECTION 4: SOLAR PANELS

Key idea

What affects the amount of electricity generated by solar cells?

Solar cells **transform** light from the sun into electrical energy
Solar cells are also called photovoltaic cells or PV cells. '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.

WORK SHEET 4.1: SOLAR PANELS

Question 1

Think about some of the advantages and disadvantages of using solar panels to generate electricity. List at least three of each:

Advantages	Disadvantages
.	

Discuss your answers with others in the class and add ideas to your list.

		Answers
	**Question 2** Do you think the angle or the way solar panels face is important?	
. 	**Question 3** Think of one advantage of having solar panels and sheep in the same field.	
	**Question 4** Do you think solar panels would work in the snow? Why?	

This solar cell is made from plastic. It is flexible, very light and partly transparent.

Question 5

Think of at least two uses for solar panels like this

This is one of the largest solar farms in Australia. The big green structures at the bottom right of the picture are giant rechargeable batteries.

Question 5

Why do you think that the giant batteries are next to the solar farm?

ACTIVITY 4.1: USING SOLAR CELLS TO GENERATE ELECTRICITY

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?

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.

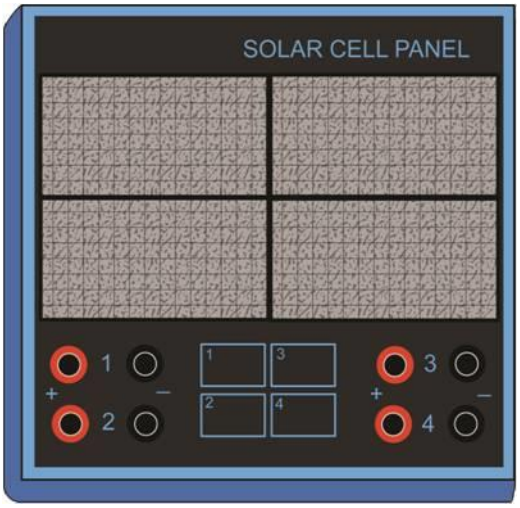


Figure 1:
The STELR solar panel

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

What you need

- STELR solar panel
- STELR testing station
- Connecting leads
- 1 x STELR multimeter
- Bright sunlight or a strong light

Risk Assessment

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

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.		

What to do

Part A – Using a single solar cell

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.

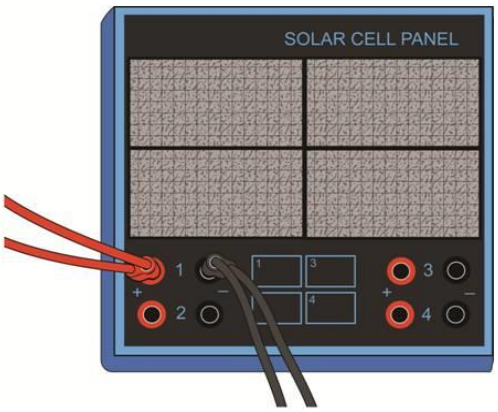


Figure 2: How to set up the wires for the single solar cell

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.
3. Why is it important not to move the lamps?
4. Trace the leads with your fingers to ensure that you have created two distinct pathways:
5. 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.
6. The other will be a small loop connecting the solar cell to the voltmeter.

Part B – Using four solar cells connected in series

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. 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 and connect the other end to the (+) terminal of Cell 3 and so on until all four cells are connected in series.

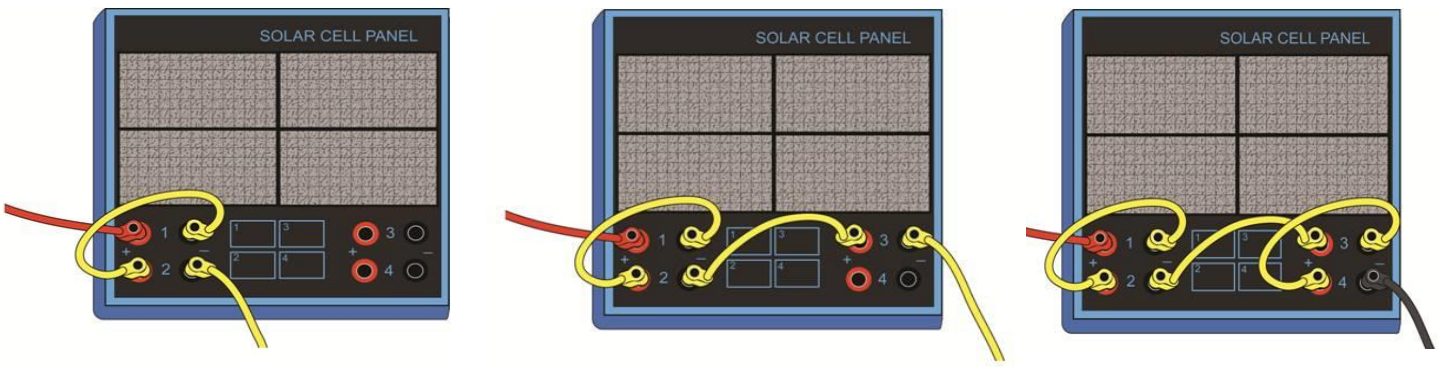


Figure 3: connecting the cells together

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

Figure 4:
The STELR testing station

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

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

5. 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)
Part A - Single solar cell					
Part B - 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.

SECTION 5: SUSTAINABLE ENERGY SOURCES

Key ideas

What are the advantages and disadvantages of the different ways of generating electricity?

Which energy sources are sustainable?

A **sustainable** energy source is one that will be available to meet the current and future energy needs and will not run out in the foreseeable future.

A **renewable** energy source is one that is produced by natural process and can be replaced or renewed easily.

An energy source like the Sun is **sustainable** because it will not run out in the foreseeable future. It is also renewable because it can be replaced or renewed easily.

Burning wood to heat your house is a **renewable** energy source, because you can grow more trees to replace the wood you burned. But is it sustainable? It depends on how much wood you need and whether the trees can grow quickly enough to provide enough wood for the foreseeable future.

WORK SHEET 5.1: SUSTAINABLE ELECTRICITY GENERATION

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 source sustainable?	Reason
Wind		
Tidal flow		
Flowing water from dams		
Wave motion		
The Sun		
Oil		
Coal		
Natural gas		

Question 2

Discuss your responses with other class member to see if they agree with your classification.
List down any types of energy source where members of your class have different ideas about whether they are sustainable or not.

Question 3

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

Wind as an energy source	Advantage or disadvantage	Reason
Wind is a renewable energy resource. It will never run out.		
Wind turbines do not produce greenhouse gases or other pollution when operating.		
Some people believe the sound they produce is annoying or even harmful.		
Wind energy is free.		
The electrical power delivered varies because wind speed and direction vary. Sometimes the wind speed is too low to even start rotation		
Very strong winds can damage turbines.	`	
Wind energy is available day and night.		
It can be costly to connect a wind farm to the electricity grid due to the distances involved.		
Wind turbines can be used in remote areas where there is no access to the electricity grid.		
Some people think they spoil the landscape.		
Wind turbines can be installed on land where cattle or sheep graze.		
Wind turbines need open spaces to work effectively.		

Question 4

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

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

WORK SHEET 5.2: WAYS TO REDUCE ELECTRICITY USE

One way to make an energy source more **sustainable** is to use it more carefully (not waste it) so it lasts longer. Another way is to design or invent something that is more energy efficient, so it needs less energy in the first place. LED light globes are and example of an efficient technology. They can use less than one fifth the amount of electricity as an old fashioned light globe but give out the same amount of light.

Question 1

Think about the following situations. Give at least one suggestion as to how you solve the situation by using less (or even no) electricity

Situation	Low energy solution
On a cold night you use your electric blanket	
On a cold day you leave the door open so that your dog can get in and out of the house.	
You leave your computer on all day in case you get an email.	
You catch the train one stop to go to school.	
You leave the light on in your bedroom even though you are not in there.	
You put the diswasher on when it is half-full.	

Question 2

Explain how the following actions could reduce electricity use at home or at school:

Action	How it reduces electricity use
Closing the windows, blinds and curtains on a very hot day.	
Having a sky light installed in a dark room	
Putting on a coat if you are cold.	
Having the whole family watch TV together.	
Only washing clothes on a sunny day so they can be put on the clothesline to dry	

GLOSSARY

Word	Meaning