MEGAWATT

It's Electrifying

SCIENCEWORKS

Contents

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Acknowledgments

The school-based activities included in this education kit were developed by a team of Education Officers at Scienceworks Museum (Museum Victoria) and other educators.

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Introduction

Megawatt is a multi-media exhibition that explores the role of electricity in everyday lives. It features interactive exhibits.

The purpose of the kit is to assist teachers to prepare for a visit to the ***Megawatt*** exhibition and to provide them with school-based activities to further explore the concepts introduced in the exhibition.

The ***Megawatt*** education kit has been written for teachers and students in Years 3-10 and Secondary Physics. It supports the ***Megawatt*** exhibition at Queensland Museum South Bank available for school bookings from 19 February 2011 to 5 February 2012.

The writers have assumed that primary students have no prior knowledge of electricity and secondary students have had some prior experience in the topic area.
Procedure, report and explanatory text types have been included to enable teachers to enhance the scientific literacy of students.

The science concepts explored in this education kit are static electricity, the construction of a cell, electrical safety, energy transformations, the function and use of electrical appliances, electromagnetism, electric circuits and alternating and direct current.

The kit contains:

- **school-based activities** divided into topic areas that can be completed before or after the visit. Selected activities are supported by student worksheets that are marked by the logo shown below

- **a word list for teachers** to assist with the understanding of concepts covered in the exhibition and the education kit
- **background information** sections of this kit contain additional information for teachers. The activities are directed to the teacher.

We encourage teachers to adapt these activities to meet the needs of their students.

Essential preparation

What to do before you visit Megawatt

Research has shown that setting objectives for a museum visit is extremely important for students. It makes the purpose of the visit clear to them and assists their ability to focus and cooperate during the visit.

Creating interest in the subject is vital to a successful and enjoyable visit to Scienceworks. This education kit contains suggestions for activities you may choose to do prior to your visit. See pages 11-44.

Read the **Medical condition caution** below and assess whether this may affect any of your students.

Medical condition caution

This exhibition contains many electrical and magnetic fields. Sudden loud noises also occur in this exhibition. Persons with any of the following may be at risk:

- **heart pacemakers**
- **heart conditions**
- **cochlear implants**
- **hearing aids**
- **other hearing problems**
- **prostheses (including internal metal wires and pins)**
- **and very young children.**

We strongly suggest that persons who may be affected do not attend the exhibition. If it is suspected that you or your students may be affected please seek medical advice before visiting Megawatt.

Megawatt exhibition information

The major communication objective of ***Megawatt*** is safety when dealing with electricity. The exhibition will be divided into seven colour coded modules. These are:

Module	Title	Colour code
Main module	Electricity is everywhere, in everything!	WHITE
Transport and Travel	Electricity takes us places!	GREEN
Entertainment	Electricity entertains us!	YELLOW
Household Uses	Electricity - safety at home!	PURPLE
Communication	Electricity for communication!	BLUE
Generation and Transmission	Electricity - a controlled energy supply!	RED
Renewable Energy	Electricity - sustainable energy!	ORANGE

Each module has:

- hands-on interactives to facilitate the learning of electricity concepts relevant to that module

Word list for teachers

alternating current

A flow of electric current in which the direction of movement periodically changes. The number of complete cycles in a second is called the frequency. In Australia, AC current has a frequency of 50 cycles per second or 50 Hertz.

ammeter

An instrument which measures electric current.

ampere

The unit of measurement for electric current. It corresponds to the flow of approximately 6 x 10^{18} electrons per second. Ampere is usually shortened to amps or A.

arc

A brief flash of light caused by an electric current moving through a gas between two points with a high voltage difference. An arc lasts much longer than a spark.

battery

A battery is a combination of cells connected together in series. Most car batteries are made up of six separate cells.

capacitor

A pair (or pairs) of conductors separated by insulators. A capacitor stores electric charge.

cell

A single device that changes chemical energy into electrical energy. It usually consists of two electrodes and a conducting liquid called an electrolyte. Many commonly used batteries (for example a D sized torch battery) more correctly should be called a cell.

charge

An excess of electrons results in an object having .a negative charge and a deficiency of electrons results in an object having a positive charge. The unit of measurement of charge is the coulomb (C). One coulomb is the amount of charge carried by approximately 6 x 10^{18} electrons.

conductor

An object or substance through which electricity can flow easily.

current

The rate of flow of electrons. The symbol for current is I. Current is measured in amperes (A).

direct current

A flow of electric current in one direction only. Batteries supply direct current (DC).

dry cell

A cell where the conducting liquid (electrolyte) is in the form of a paste or jelly so that it doesn't spill. The common torch battery is an example of a dry cell.

electricity

A general term for the phenomena associated with electrons at rest or in motion.

electrode

A conductor which allows electricity to flow in or out of a material or object. Electrodes are usually made from a metal or graphite.

electromagnet

A coil of wire which only becomes magnetic when electricity passes through it. The coil may be wound around a material such as iron to increase the magnetic effect.

electrolysis

A process where electricity is used to bring about a chemical change. For example, electrolysis of sea water can be used to produce chlorine.

electrolyte

A liquid that conducts electricity. The liquid may be in the form of a paste or gel.

electron

A sub-atomic particle found in every type of atom. Electrons have a negative charge and are found outside the nucleus of an atom.

galvanisation

An electrolytic process where iron objects are coated with a thin layer of zinc. This reduces the rate at which the iron rusts.

galvanometer

An instrument which can be converted for use as a voltmeter or an ammeter.

generator

A machine which converts one form of energy into another. An electricity generator converts kinetic energy into electrical energy.

insulator

An object or material that has a high resistance to the flow of electricity.

Leyden Jar

An old fashioned device for storing static electricity.

magnet

A piece of metal that exists naturally with a magnetic field surrounding it. This field exerts a force on other magnets and iron pieces.

motor

A machine which converts electrical energy into kinetic energy.

ohm

The unit of measurement of the resistance to the flow of electric current in a circuit. Ohms is often represented by the symbol 51.

parallel circuit.

A way of arranging wires and 'appliances' in a circuit The circuit is in parallel when the current flowing has more than one pathway to flow through.

resistance

The tendency for materials to resist the flow of electric current and convert electrical energy into heat. The unit of measurement for resistance is the ohm. The symbol for resistance is R.

series circuit

A way of arranging wires and 'appliances' in a circuit. A circuit is in series when all the parts are arranged end to end in a continuous path.

solar cell

A device for converting the Sun's energy into electrical energy. A solar panel is made up of many solar cells.

solenoid

A coil of wire which is usually wound around a tube. It is used to produce a magnetic field (see electromagnet).

spark

A brief flash of light caused by an electric current moving through a gas between two points with a high voltage difference. A spark lasts for a very short time.

static electricity

Electric charge acquired by an object as a result of being rubbed, being brought close to, or touching another charged object.

transformer

A device used to alter voltage or (alternating) current. They work without moving parts by the process of electromagnetic induction.

volt

A unit of measurement of voltage. Voltage is a measure of the amount of electrical energy available. The symbol for volt is V.

voltmeter

An instrument which measures voltage.

watt

The unit of measurement of power: In electrical systems it is the number of amps multiplied by the number of volts. The symbol for watt is W.

wet cell

A cell where the electrolyte is in the form of a liquid. This means that they must be kept upright to avoid spillage. Most car batteries are wet cells.

Static electricity

Background information

You may be familiar with getting zapped while getting out of a car, zapping yourself or someone else after walking on carpet. All these incidents involve static electricity. When you rub certain materials together, you can set up a charge. If the static electricity is strong enough, you can see and/or hear a spark moving from one object to another as it discharges. Discharging occurs when the charged object loses its electricity to another object on the Earth.

There are two types of charge, positive charge and negative charge.

- when two materials have the same charge (positive and positive or negative and negative), they repel each other
- when two objects have different charges (positive and negative and vice versa) they attract each other
- charged objects attract neutral objects (objects that have no charge).

If an object is charged, it will discharge by coming in contact with or close to the Earth either directly or indirectly. For example, a charged rod will discharge through the Earth via the human body when it comes in contact with a human finger. The charge is given a pathway to the Earth via the person's finger. A strong charge can jump to the Earth through the finger if it is close enough. The person may feel a little shock as the rod discharges.

Lightning is a discharge of static electricity on a much larger scale.
Buildings have lightning rods that reach high in the sky so that the charged clouds can discharge through them to the Earth. This protects buildings by providing a safe path for the electricity to pass through as it travels to the Earth.

Activities 1-4 relate to static electricity.

Activity 1: Static experiences

What to do

Students can list their daily encounters with static electricity. For example:

- pulling clothes out of the dryer
- touching door handles in a carpeted room
- getting out of the car
- taking off certain clothes
- emptying rice out of its plastic bag.

Students can compare their findings in small-group discussion or by making a list for class display.

Activity 2: Hundreds and thousands

What you need

- 'hundreds and thousands'
- shallow (I or 2 cm) container with a clear plastic lid (e.g. a small take away food container)
- woollen clothing or cloth.

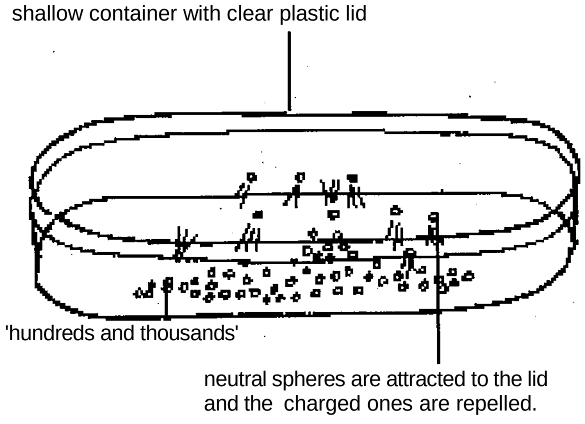
What to do

Ask your students to:

1. Put a small amount of 'hundreds and thousands' in the container.
2. Put the lid on the container and charge the lid by rubbing it with a woollen cloth. Observe what happens.
3. Gently move a finger over the top of the container and observe what happens.

Questions

1. Why do the 'hundreds and thousands' often jump back down?
2. What happens when you move your finger over the top of the container?



Activity 3: Boat races

What you need

- corks
- plastic pens
- woollen cloth or clothing
- large bowl of water.

What to do

Static electricity can be used to play a simple boat-race game.

1. Each player floats a cork `boat' in the large bowl of water.
2. The boats are pushed under water so they come up wet.
3. Each player then charges up a plastic pen by quickly rubbing it on the woollen cloth or clothing.
4. Players then use their pens to pull the boats from one side of the bowl to the other by placing the pen close to the wet cork (being careful not to touch the cork or the water). The first cork/boat to touch the other side of the bowl wins.

If the pen touches the wet boat or the surface of the water, the pen will discharge and the boat will stop. The students may need to charge their pens more than once during the race.

Activity 4: Shocking facts about lightning

What you need

A collection of reference books such as the Guiness Book of Records, Latest Great Moments in Science, encyclopedias or access to the Internet.

What to do

Ask the students to find out one or more amazing facts about lightning. For example:

- How long is a lightning bolt?
- Can lightning's energy be caught and stored?
- Big buildings get hit by lightning all the time, why don't they burn down?
- How many people are killed by lightning per year?
- What can you do to prevent yourself from being struck by lightning?
- Some people have been hit by lightning many times, why have they survived?
- How many bushfires are started by lightning strikes?
- `Lightning never strikes twice in the same place.' Is this a myth or a fact?

Students can:

- compare their findings in small-group discussion or make a list for class display
- write a fictional story using one or more of the amazing fact(s) found through the research
- write a creative poem using the information researched
- write a song that explains how getting struck by lightning can be prevented.

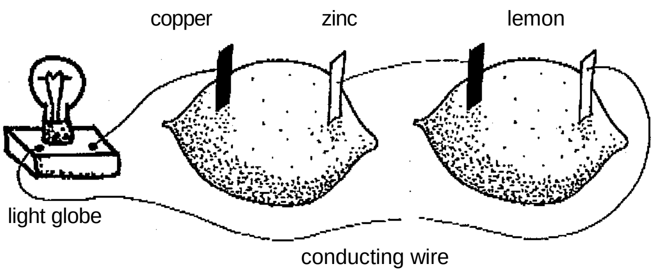
Cells and batteries

Background information
A cell is a single device that changes chemical energy into electrical energy. A torch battery is actually a cell (in scientific terms). A battery is a number of cells connected together in a particular way (in series). A car battery is made up of at least six cells. In 1800, Volta made the first battery using the principle that two different metals connected by certain liquids produce electricity. A simple low-powered cell can be made using a lemon and two different metals. If you wanted to make a 'battery' using lemons, one lemon would need to be connected to another lemon with wires connecting alternate metals.

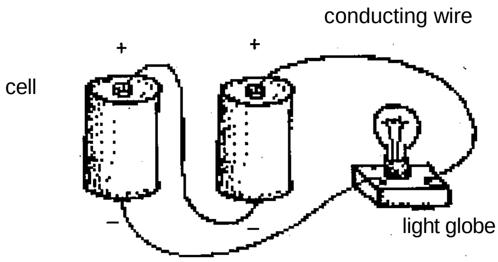
When a cell or battery is connected to a conductor, one end becomes the positive terminal and the other end becomes the negative terminal. To connect one cell in series with another cell, the positive terminal of one cell should be connected to the negative terminal of the next cell.

Activities 5-7 relate to cells and batteries.

lemon battery



battery



Activity 5: Lemon battery

What you need

- lemons
- small pieces of zinc
- small pieces of copper
- wires
- a voltmeter or multi-meter (switched to volt)
- small light globe.

What to do

Ask the students to:

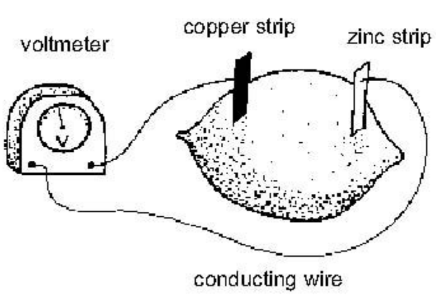
1. Give a lemon a good squeeze, but be careful not to split the skin.
2. Connect one wire to one piece of zinc and push the metal into the lemon.
3. Connect another wire to a piece of copper and push the metal into the lemon.
4. Connect the wires to the voltmeter (see diagram).
5. Record the voltage created by the lemon cell.
6. Connect a light globe into the circuit in place of the voltmeter and record what happens.
7. You may have found this current is too small to light a light globe. Connect a number of lemons together as shown in the diagram until the current is large enough to light the light globe. Record your results.

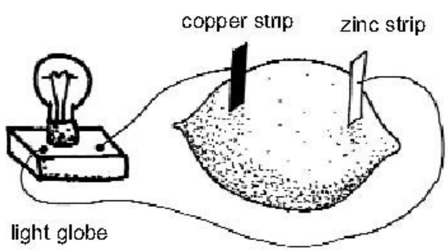
Questions

1. Is the voltage supplied by one lemon enough to light the light globe?
2. How many lemons did it take to light the light globe?
3. If you assume that each lemon supplies the same voltage, calculate the voltage supplied to the light globe to make it light up.
4. Describe the energy transformations taking place in this circuit.

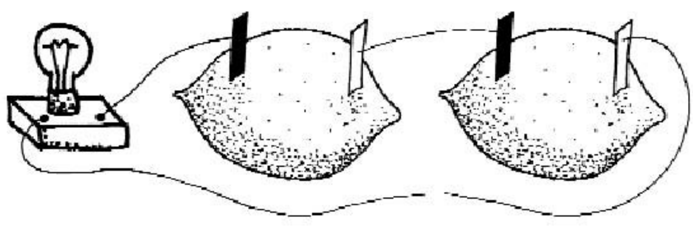
Optional

Students could also experiment with other substances in place of the lemons such as vinegar, potatoes, cola or a cactus.





cell



lemon battery

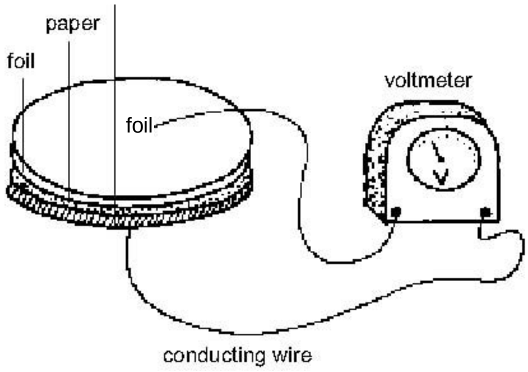
Activity 6: Voltaic piles

What you need

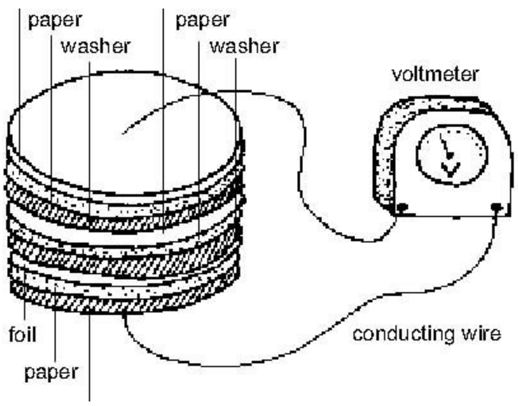
- aluminium foil
- metal washers
- paper
- salt water
- other materials such as copper, zinc
- 10 cent and 2 cent coins
- voltmeter
- wires.

What to do

1. Make a voltaic pile, (see diagram below) with paper dipped in salt water sandwiched between aluminium foil and a washer.
2. Measure the voltage between the two metals with a voltmeter and record this value.



3. Try multiple layers, (see diagram below) and record the voltage each time.
4. Try other combinations of metals, each time measuring and recording the voltage with the voltmeter.



Questions

1. State whether you constructed a single cell or a battery in each trial? Explain your answer.
2. Which combination gave the greatest voltage reading?
3. Describe the energy transformations taking place in this circuit.

Activity 7: Battery life

What you need

- voltmeter
- wires
- light globe
- clock/watch
- several types of cells (for example, cheap and expensive carbon cells, rechargeable Nicad cells, alkaline cells). They all need to be of the same size, for example, D cells. Note the purchase price of each.

What to do

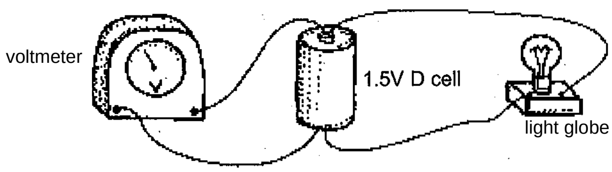
1. Set up the circuit shown in the diagram.
2. Take the voltage reading across the cell every two minutes and record the results in a table.
3. As the cell goes flat and the light grows dimmer, note the voltage at which you would consider the cell to be of little further use.
4. Mark this point on a voltage versus time graph for this cell.
5. Repeat for the other cells. If you wish for a shorter experiment, choose smaller cells such as AA.

Questions

1. Which cell lasted longest?
2. Which one(s) died with very little warning?
3. For each cell, work out:

$$\frac{\text{time lasted (minutes)}}{\text{cost (cents)}}$$

4. Which gave the best value for money?



Electric circuits

Background information

Moving charge is called current. Conductors are materials that allow current to flow easily through them. Metals for example are good conductors of electricity. Insulators are materials that don't allow current to flow through them easily. Examples of insulators are wood, glass and plastic.

When an ammeter (instrument that measures current) is connected in a circuit with a light globe and a good conductor, it will cause the light globe to light up and the ammeter needle to move. Poor conductors will allow electricity to pass through them and will make the ammeter needle move but will not light the light globe. Insulators will not allow electricity to pass through them so the light globe will not light up, nor will the ammeter needle move.

When a battery or cell is connected in a circuit, it produces a current that travels in one direction only. A current that flows in one direction only is called direct current or DC current. The current that comes to your home is called alternating current or AC current. This type of current is produced by generators. AC current changes direction many times in one second. The current that comes to your home alternates back and forth 50 times in one second (50Hz). Some appliances have special electronic devices in them to convert the AC current to DC current.

Electrical appliances convert electrical energy into other forms of energy such as movement (kinetic), sound, light, heat (thermal) and stored energy (potential energy). The energy in food and batteries is called chemical potential energy. There are other types of potential energy. The energy of compressed springs and drawn archery bows is mechanical potential energy. Examples of objects that have gained gravitational potential energy are lifts that are going up and boxes raised by forklift trucks.

Activities 8-17 relate to electric circuits.

Activity 8: Conductors and insulators

What you need

- ***Conductor worksheet*** (1 copy per group or individual, see page 19)
- 1.5 V battery
- small light globe
- four lengths of insulated wire
- a collection of objects such as a fork, copper wire, aluminium foil, plastic object, dish of water, dish of salty water, graphite pencil (with both ends sharpened), piece of wood, chalk, silver and gold rings and keys
- an ammeter (if available).

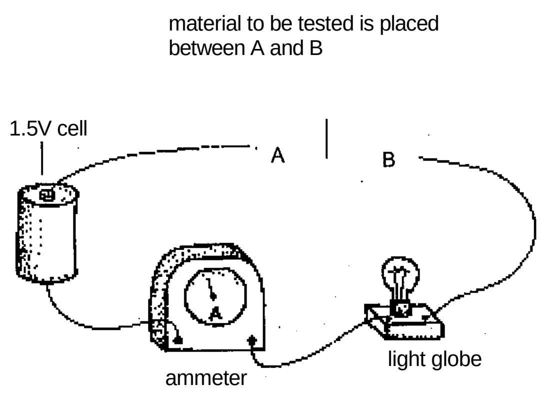
Primary teachers:
Many handy people may have a multi-meter which can act as an ammeter. Alternatively, your local secondary school is likely to have an ammeter that you can borrow.

What to do

1. Students construct an electrical circuit as shown in the diagram below.
2. Test the circuit by connecting a piece of wire between A and B. The light globe should light up. Supply the groups with the objects to be tested.
3. Allow the students to explore which objects act as good conductors and light the light globe.
4. Students can then complete the ***Conductor worksheet*** that can be found on the next page.

Questions

1. Which objects or substances caused the light globe to light up?
2. Are these materials good conductors or poor conductors?
3. Which objects or substances caused the needle on the ammeter to move but not the light globe to light up?
4. Are these materials good conductors or poor conductors?
5. Which objects or substances didn't affect the needle on the ammeter or light up the light globe?
6. What are these materials called?



Conductor worksheet

Object tested	Made of?	Ammeter reading (Amps)	Light globe not lit	Light globe dimly lit	Light globe brightly lit	Conclusion
Example:						
Conducting wire	copper	1.4			✓	conducting wire is a good conductor

Activity 9: Role-play a circuit

What you need

- a class of willing students
- a playground
- a bag of sweets.

What to do

This is a role-play activity which can be used to explain some of the potentially confusing concepts involved in understanding electricity. It is designed for students of all ages and the discussion can be extended or simplified to suit the understanding of the students.

It should be emphasised to the students that in order for electricity or current to flow, the circuit needs to have a continuous pathway (constructed with wires) for the current to travel from the cell, through a load (light globe or electrical appliance) and back into the cell.

This activity involves going outside and setting up a running track with several obstacles. The obstacles could include benches to jump over, tyres to run through or even playground bars to swing along. Explain the track to the students. Position the students, one behind the other at the starting point of the track. Emphasise that they are not to pass each other, and they must try to keep the line intact with no stragglers. Tell them that they will get a sweet each time they pass you as you stand on the track. Students must run around the track to obtain their sweet. Say go and let them run around the track several times.

Classroom discussion

Parallels between the running track and electricity flowing in a circuit:

- the track represents the electric circuit
- the teacher on the track was the battery or energy source giving each student new energy to run the circuit again
- the students are the charges running around the track
- the obstacles represent light globes or other appliances in a circuit
- the obstacles require a lot more energy to pass through or over than just running on the track. The energy passing through anything is the voltage. Light globes use a lot of voltage, wires require little voltage
- the sweets represent the current getting another boost of energy or voltage to send them around again.

track = circuit
teacher on the track = battery or energy source
students = charges
energy = voltage

Optional

- a student can sit on the sidelines and count the number of students who pass in a given time. The counting student represents the ammeter. The number of students passing in a given time represents the current
- add a short-circuit potential to your track by giving the students an option of missing one of the obstacles. Observe their choices and discuss what happens in a real circuit with most of the energy taking the easiest (least energy intensive) route, but with some still choosing to complete the obstacle course
- senior students could discuss its effectiveness as a model to describe electricity in a circuit. Some questions that could be included are listed below.

Questions

1. How close are the definitions provided by the model to the actual definitions of current, voltage and charge?
2. When a high resistance load is short-circuited, some charge still flows through the high resistance load. How effective is the model at explaining this?
3. Why does this model not satisfactorily explain how the voltage (energy source) is used by the current as it moves around the wires in the circuit?

Activity 10: Switches and circuits

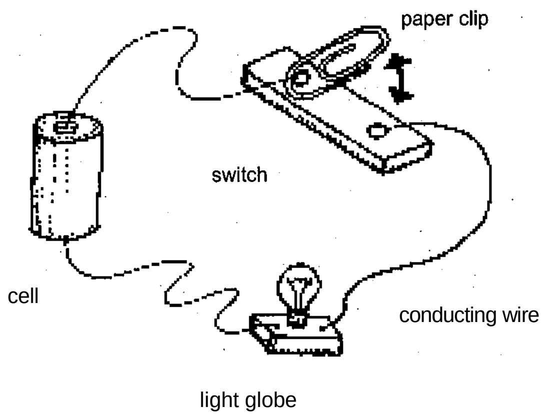
What you need

- cell (battery)
- tape
- three pieces of insulated wire
- light globe
- two drawing pins
- small piece of cork
- paper clip.

What to do

Ask the students to:

1. Try to use one cell and one wire to make the light globe light up. Is this possible?
2. Use one light globe, one cell and two wires and make the light globe light up.
3. Make a switch as seen in the diagram below. Tape one wire to the base of the cell and attach it to the light globe.
4. Fix the third wire to the top of the cell with tape, and to the light globe as well. By pressing the paper clip down, the circuit will be complete and the light globe will light up.



Questions

1. Were you able to light up the light globe using only one cell and one wire? Try to explain why.
2. Describe the energy transformations that took place in the circuit you constructed in part 2.
3. Why do you think switches are useful in electric circuits?

Activity 11: Appliance science

What you need

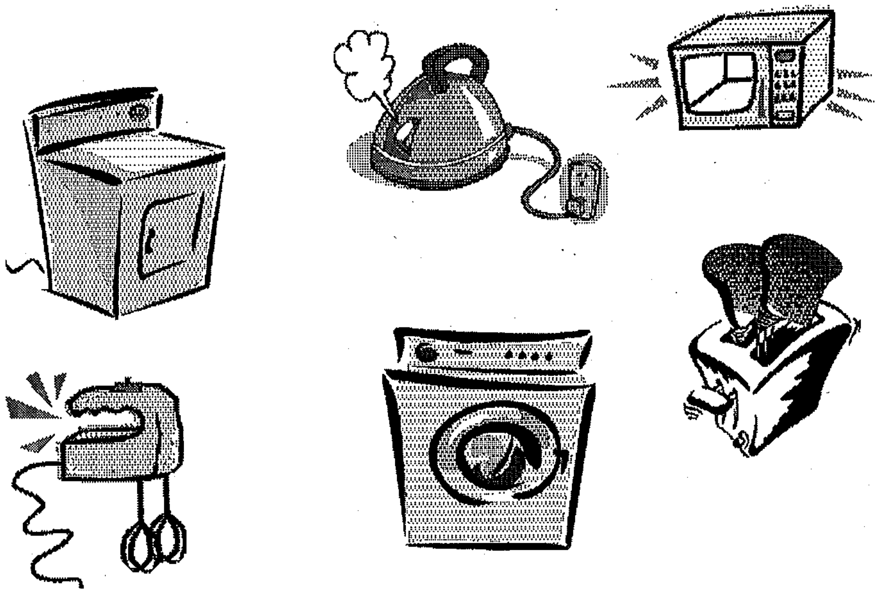
• a copy of the ***Appliance worksheet*** per student (page 24).

What to do

On the ***Appliance worksheet,*** students fill in the household electrical appliance name, its use and the forms of energy produced, as shown by the example.

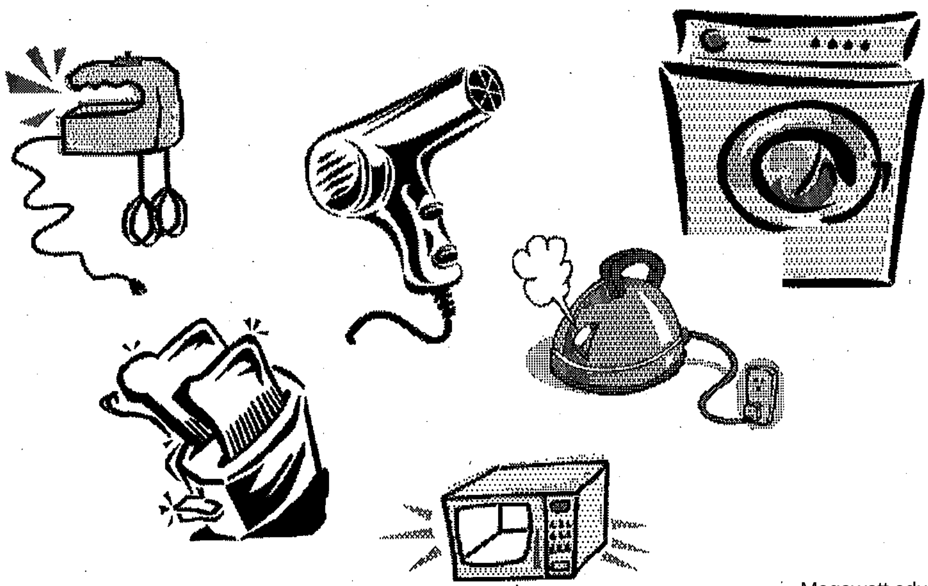
Questions

1. Which ones are the most efficient, and produce only the energy we want or need? Which information are you basing your answer on?
2. Which of these devices could you easily live without?
3. Were these devices available fifty years ago? If not, what was used as the alternative? For example you might consider a hand whisk instead of an electric beater.
4. Cut out pictures of appliances from various catalogues and glue them onto an A3 sheet and create a collage illustrating the appliances that produce particular types of energy.



Appliance worksheet

Name of appliance	Energy we want	Other forms of energy produced	Alternative (before electricity)
Example: light globe	light	heat, some sound	candle



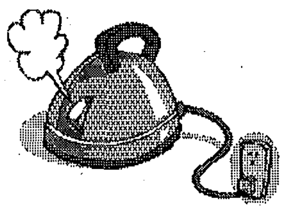
Activity 12: Electric Jug

What you need

- paper
- pencils
- electric jugs (old and new ones if possible).

What to do

1. Ask the students to imagine and then draw an electric jug.
2. Ask them to label its parts and to list the materials it is made from.
3. Display some electric jugs for them to compare to their drawing.
4. Discuss the various parts and materials used in each jug and how their construction relates to the age of the jug.
5. Examine an electric jug by pulling one apart.
6. Discuss the various parts and materials further.
7. What energy transformations are taking place in this appliance?



Activity 13: Invent an appliance

What you need

- advertising brochures containing pictures of electrical appliances.

What to do

1. Discuss with students the fact that there are new appliances coming onto the market all the time (especially at Christmas). Some of these may be considered to be less useful than others, (for example, an electric nose hair clipper).
2. Look in catalogues or science magazines to discover any appliances that may fall into this category.
3. Design an electrical appliance.
4. Consider what its power source is, how much it will cost and who it is designed for.

Activity 14: Electrical safety

What you need

- research facilities
- poster paper
- graph paper
- volunteers
- multiple copies of the ***Electrical safety worksheet.***

What to do

Ask the students to:

1. Answer the questions on the ***Electrical safety worksheet*** to find out how much they know about electrical safety.
2. Do some research on electrical safety and investigate common misconceptions about electrical safety.
3. Make a poster demonstrating the do's and don'ts when using electrical appliances.

Optional

Ask the students to:

1. Survey ten people they know using the ***Electrical safety worksheet*** and graph the findings.
2. Survey classmates or other year levels using the ***Electrical safety worksheet*** to compare different age groups.
3. Compare the results of boys against girls in a graph.

Answers to the quiz

1F	6T	11F
2T	7F	12T
3T	8T	13F
4T	9T	14T
5F	1OF	15F

Electrical safety worksheet

Are you switched onto electrical safety?

Read each statement carefully and decide if it is true or false.
Write T or F in the box.

1. ☐ Any tradesperson listed in the telephone book is qualified to do electrical work in your home.
2. ☐ If you are outside playing in a thunderstorm the best thing to do is to go indoors.
3. ☐ Using double adaptors increases the risk of overheating and fire.
4. ☐ You should not use the telephone during a thunderstorm.
5. ☐ All houses in Victoria have a safety switch in their switchboard.
6. ☐ You should always wear shoes when you use the washing machine.
7. ☐ It is safe to fly a kite near power lines.
8. ☐ The human body can conduct electricity.
9. ☐ If a power line is broken and has fallen down you should stay at least six metres away.
10. ☐ When working outside with electrical appliances you should wear thongs.
11. ☐ If an electric cord is frayed, the best thing to do is wrap electrical tape around it.
12. ☐ All electrical appliances should be switched off and unplugged when not in use.
13. ☐ If someone gets an electric shock you should move them to a safe position.
14. ☐ If an appliance is faulty you should have it fixed or destroy it.
15. ☐ Babies are too small to get hurt if they poke things into a power point.

Activity 15: Check your electricity use

What you need

- paid electricity bills.

What to do

Electricity bills are presented with bar graphs comparing our monthly consumption.

Ask the students:

1. To bring in a paid bill and in groups think of reasons why the electricity usage fluctuates.
2. Brainstorm ways to save on electricity bills.
3. Think about and record how they can put these suggestions into practice.
4. Find out whether the appliances at home have a star rating. Find out what the energy star rating represents.

Activity 16: Electrical safety at home

What you need

- research facilities.

What to do.

Ask your students to use the research facilities available to complete the following questions.

Questions

1. Draw circuit diagrams to help explain why and how metal appliances are earthed.
2. How do safety switches (earth leakage circuit breakers) work?
3. Why aren't normal fuses adequate?
4. How does a danger still exist even when safety switches are being used?
5. What is the International Colour Code for electrical wiring and why did Australia change over from the old code?
6. What is the lethal dosage of current for the human body?
7. How should you approach and treat anyone who suffers a large electric shock from
    a. a domestic 240V source and
    b. a high voltage source?

Activity 17: Life without electricity

What you need

- elderly relatives or friends or
- research facilities.

What to do

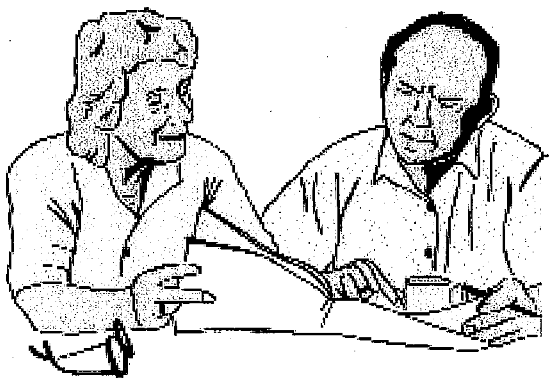
Ask the students to:

1. Predict the effect of the loss of electricity on their lives.
2. Discuss with an elderly adult what they used instead of selected electrical appliances (for example, a hand whisk instead of an electric beater, or a copper and a mangle instead of a washing machine).

The students can also research this using the library.

Results can be presented as:

- an oral presentation to the class
- inviting a grandparent to visit the school to discuss the questions the students may have
- a tape recording of an interview between the elderly person and the student
- a creative story describing the experiences of the elderly person
- a role-play demonstrating the hardships experienced when completing a task that is now made easier by an advanced electrical appliance.



Electromagnets and electric motors

Background information

Hans Christian Oersted discovered that electric currents produce magnetic fields. He noticed that a magnetic compass needle moved when it was placed near a wire carrying current. This suggested that current carrying wire had a magnetic field just like ordinary magnets. When the current is switched off, the wire stops being a magnet. Magnets that you are familiar with are generally magnetic all the time. By winding wire around particular metals and passing a current through the wire, we can make a stronger electromagnet. Big electromagnets are used to move scrap iron junk in car yards from one pile to another by switching the electromagnet on to pick up the metal scrap and off to drop it.

The power supply in Australia brings AC current to every household. The frequency of the household power supply in Australia is 50 Hertz. This means that the current goes forwards and backwards 50 times each second. If you brought a magnet close to a light globe which was switched on, the filament would vibrate. The filament vibrates because the magnetic field around the magnet and the magnetic field produced by the current carrying wire are interacting causing a force to be exerted on the filament. The direction of the force will depend on the direction of the current. Since the current is moving back and forth many times a second, the filament is seen to vibrate.

The discovery of electromagnetism led to the discovery of the principle behind the electric motor by Michael Faraday. Michael Faraday discovered that when a current carrying wire is placed between magnets, the wire experiences a force.

When a coil of current carrying wire is placed between magnets, the coil turns. This is the basis of a simple electric motor. The speed of the rotating motor can be increased by increasing the number of coils between the magnets, increasing the current in the wire or by using stronger magnets.

Activities 18-22 relate to electromagnets and electric motors.

Activity 18: A simple electromagnet

What you need

- ***Electromagnet worksheet*** (1 per student or group, see page 32)
- large nail or bolt
- long piece of insulated wire
- 1.5V cells (batteries)
- a packet of paper clips.

What to do

Ask the students to:

1. Strip the insulation from each end of the wire and twist the strands together.
2. Wind the wire around the nail about 15 times.
3. Connect the two ends of the wire to opposite ends of the cell.
4. Hold the nail close to a small pile of paper clips.
5. Count how many paper clips were picked up and record the number in the table on the Electromagnet worksheet.
6. Repeat steps 2-5 changing the number of coils of wire wrapped around the
7. nail, each time recording the number of paper clips picked up by the electromagnet.
8. Try connecting two cells in the circuit and repeat steps 2-6.

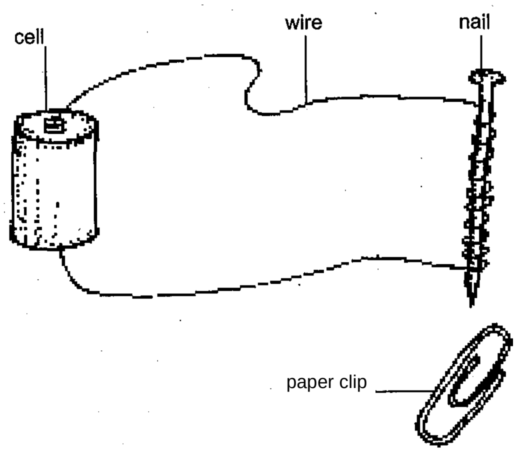
Questions

Refer to the findings on the ***Electromagnet worksheet.***

1. How many paper clips can be picked up using 15 coils and one cell?
2. How many paper clips were picked up using 25 coils and two cells?
3. Did connecting more cells in the circuit affect the number of paper clips picked up?
4. What affects the number of paper clips that can be picked up?

Optional

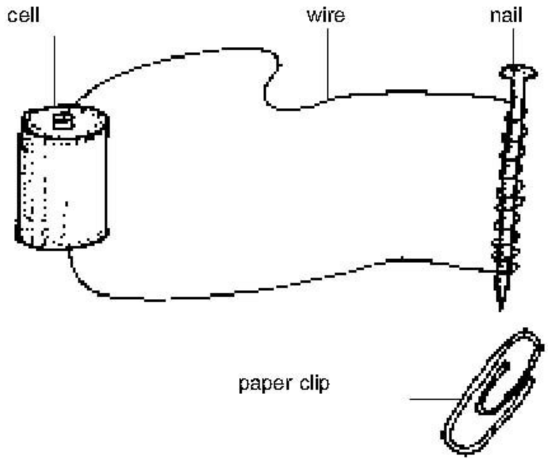
Encourage the students to experiment with various combinations of the number of cells and the number of coils.



Electromagnet worksheet

Fill in the number of paper clips lifted in each column.

		Number of winds of wire			
		15	20	25	30
Number of cells	**1**				
	2				



Use the results in the table above to answer the following questions.

Questions

1. How many paper clips can be picked up using 15 coils and one cell?
2. How many paper clips were picked up using 25 coils and two cells?
3. Did connecting more cells in the circuit affect the number of paper clips picked up?
4. What affects the number of paper clips that can be picked up?

Activity 19: An electromagnet with a switch

What you need

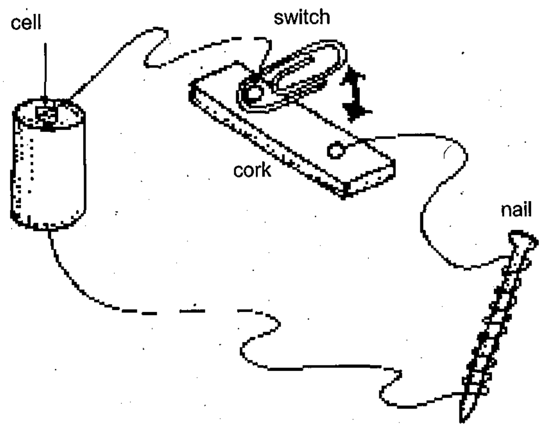
- large nail or bolt
- long piece of insulated wire
- smaller piece of wire
- 1.5V cell (battery)
- a packet of paper clips
- two drawing pins
- small cork.

What to do

Ask the students to:

1. Make a switch using the drawing pins, the cork and a paper clip.
2. Press one drawing pin into the side of the cork so that it anchors the single end of a paper clip.
3. Push the other drawing pin into the other end of the same side of the cork.
4. Swivel the paper clip so it is able to touch the other drawing pin. This closes the switch.
5. Wind the long piece of wire around the nail 15 times.
6. Connect one end of each wire to one end of the cell and the other end to one of the drawing pins.
7. Connect the second wire to the other end of the cell and the other drawing pin.

When the switch is closed (touching the drawing pin) the electromagnet should be able to pick up paper clips. When the switch is open it is no longer magnetic.



Activity 20: Dancing dolly

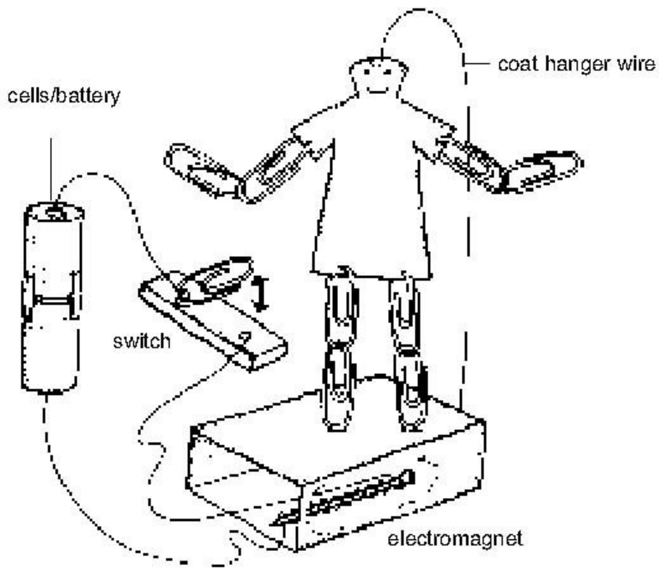
What you need

- thick steel bolt
- insulated wire
- stiff paper
- scissors
- pencils
- paper clips
- small cardboard box (about the size of an individual fruit drink box is suitable)
- two cells (batteries)
- tape
- switch from Activity 19
- rubber band
- wire coat hanger.

What to do

Ask your students to:

1. Wind the wire around the bolt about 100 times.
2. Connect to the switch and the cell as in the previous activity, but use two cells taped together. (See diagram below.)
3. Place the cardboard box over the electromagnet making sure the magnet is close to the top of the box.
4. Draw and cut out a doll body from stiff paper. Use two paper clips for each arm and each leg of the doll.
5. Connect wire from the coat hanger to the box with tape and twist the free end so that the doll can hang just above the box with the aid of a rubber band.
6. Press and release the paper clip switch and the doll will dance.



Activity 21: Vibrating light globes

What you need

- strong magnet
- clear 240V household light globe connected to the mains power supply (for example, a table lamp with the shade removed). Use a low wattage light globe to avoid eye damage.

What to do

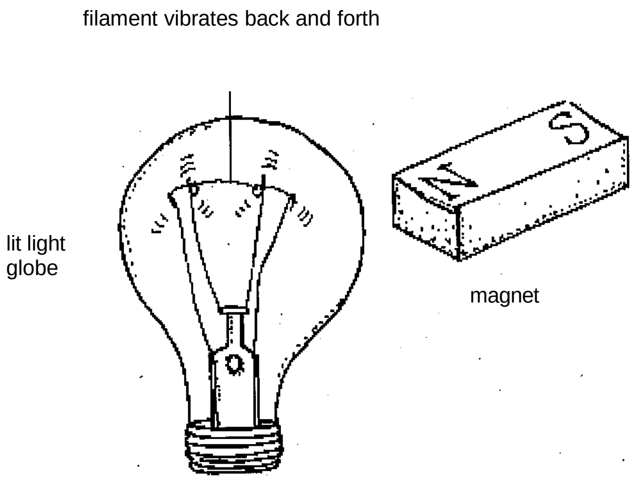
Ask students to:

1. Bring the magnet near a light globe that is not switched on and record observations.
2. Now bring the magnet near the light globe when it is switched on and record observations.

Questions

1. Is the filament a magnetic material? Explain.
2. Why do you think the filament vibrated?
3. Your observations are based on what happens when you put a magnet near a filament using AC current. What do you think the filament would do if the current through it only moved in one direction (using DC current)?

It is very important that magnets should not be brought close to computer screens or televisions as this can permanently affect the screen image.



Activity 22: Simple electric motors

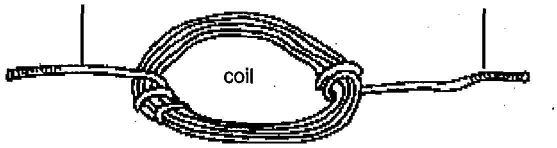
What you need

- lacquer-coated copper wire (about 80cm)
- large paper clips
- small box or cylinder
- rubber bands
- wire
- 6V DC power supply or a 6V battery
- strong bar magnet
- sharp knife or razor blade
- a plastic film canister.

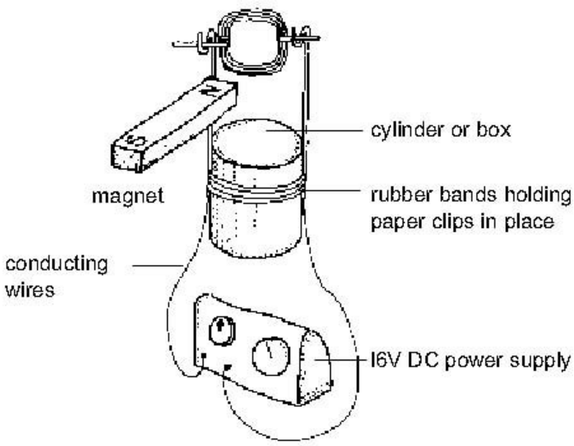
What to do

Ask students to:

1. Make a coil from copper wire by winding it around a suitable cylinder.



2. Set equipment up as in the diagram below, with the power supply set to 6V DC or using a 6V battery.



3. Spin the loop by hand. With the magnet in the right position (found by trial and error) the loop will continue to spin.

Questions

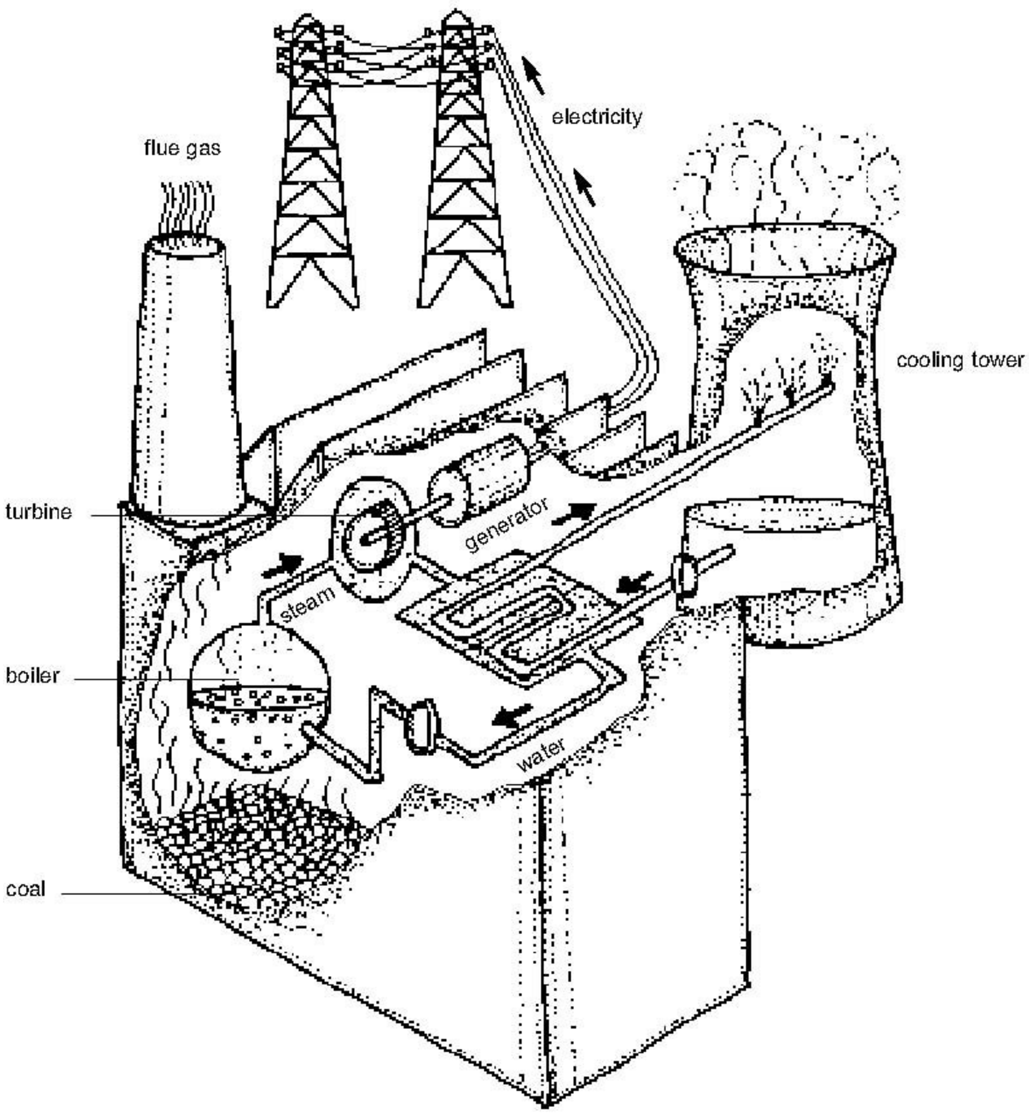
1. What is the basic principle behind the electric motor?
2. Who was the person credited with making the first electric motor?
3. Find out what changes you can make to your model to make the motor spin faster.

Generators

Background information
Michael Faraday was the first person to make an electric generator. He understood that many electrical effects are reversible. A simple electric generator is just a simple electric motor in reverse. Generators convert movement into electricity. A motor requires electricity to turn coils of wire between magnets and a generator produces electricity when coils of wire are turned between magnets.

Power stations have huge turbines that are used to turn a huge number of coils between magnets to produce electricity that eventually reaches your home. There are different types of power stations. There are those that turn turbines using steam from burning coal. Others use nuclear energy. Some are more environmentally friendly and use wind or water.

Activities 23-24 relate to generators.



Activity 23: Do-it-yourself generator

What you need

- solenoid (wire coil)
- iron bars to place in the solenoid (the uprights can be unscrewed from retort stands),
- bar magnets
- wires
- galvanometer.

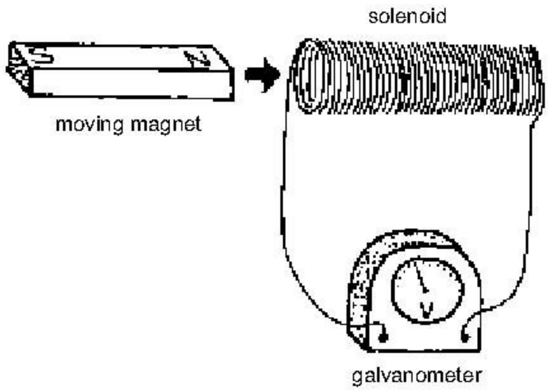
What to do

Ask students to:

1. Connect the solenoid to the galvanometer.
2. Move the north end of the magnet in and out of the solenoid (more than once) and record their observations.
3. Move the south end of the magnet in and out of the solenoid (more than once) and record their observations.
4. Move the magnet back and forth around the solenoid and record their observations.
5. Insert an iron bar inside the solenoid and see what effect this has on the current reading. Record their observations.
6. If you can alter the number of coils in the solenoid, increase the number of coils.
7. Repeat steps 1 - 5 and record the differences observed.

Questions

1. Was a current registered on the galvanometer when the magnet was not moving?
2. Did the direction or reading of the current change when the magnet was inserted and then removed? Explain.
3. Did the speed of the magnet's movement affect the current?
4. Was there a difference in the current reading or direction when the magnet was inserted the other way around (with the south end entering the solenoid first)?
5. Does placing an iron bar in the coil have any effect?
6. Does increasing the number of coils affect the direction of the current or the current reading on the galvanometer?



Activity 24: Power to the people

What you need

- recording materials.

What to do

Brainstorm with students where they think mains electricity comes from. This activity will allow you to assess their level of understanding.

Classroom discussion points

- in coal-powered power stations the generators convert the energy of brown coal into electrical energy
- it is easier to transport electricity rather than brown coal, thus the power station is close to the coal supply
- is electricity a clean source of power? Consider living next to the power station
- about half the energy from brown coal is lost as heat. One quarter is used to dry the brown coal itself. One quarter is turned into electrical energy
- the energy from brown coal is used to turn a generator. What other forms of energy can be used to turn a generator? Which alternative forms of electricity production do not use an electrical generator?

Sustainable energy

Background information

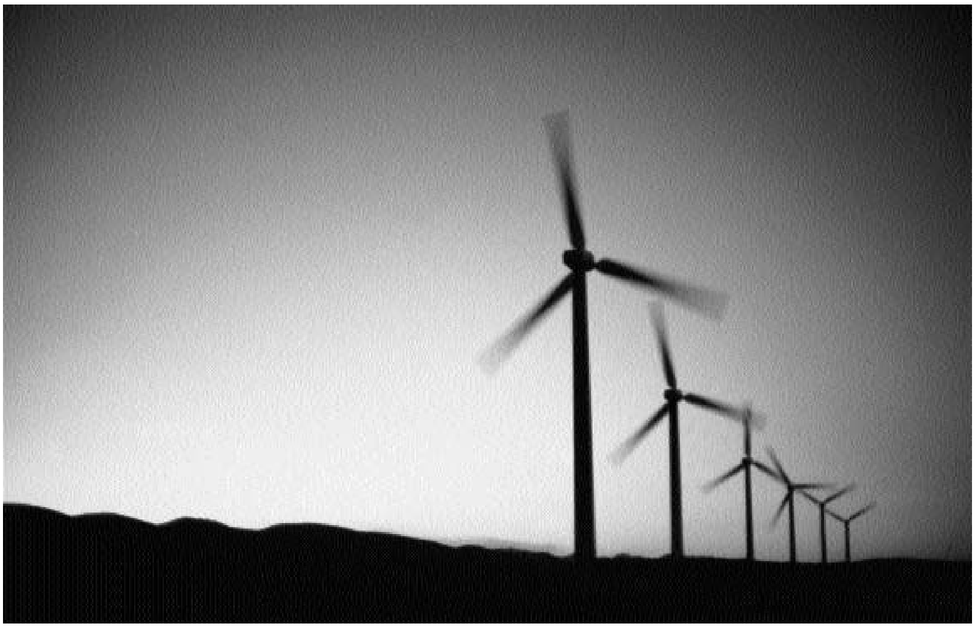
Energy is the ability of something to do work.
Energy cannot be created nor destroyed, but can be transformed from one form to another.
Kinetic energy is due to an object's movement (from the Greek word Kinema, from which we also get the word cinema).
Gravitational potential energy is due to the height of an object above some surface. Heat is due to the movement or vibration of particles (atoms or molecules). The higher the temperature of an object, the faster the particles move or vibrate.) Light is a form of radiant energy.
Electrical energy is due to the movement of electricity.
Chemical energy is due to the chemical reactions that can occur in the object. You contain chemical energy because of the food you ate, you can transform it to kinetic, potential, sound and heat when you walk up stairs. Batteries contain chemical energy and transform it to electrical energy

Work is done when energy is transformed from one form to another, or a force moves something through a distance.

Solar energy is light energy that comes from the Sun. It is usually transformed into heat. It can be transformed into electricity using photovoltaic (PV) cells. Photovoltaic cells are often called solar cells. Plants convert solar energy into stored chemical energy by the process of photosynthesis.

Wind energy is the energy of moving air, so it is an example of kinetic energy. It can be transformed into electrical energy using a turbine to drive a generator.

Water has kinetic energy when it is moving. It too can be transformed into electrical energy using a turbine to drive a generator.



Activity 25: Photovoltaic cell

What you need

- Solar (photovoltaic) cell
- Connecting wires and clips
- Small DC motor
- Fan

(The above can be purchased in the Solar Educational Kit (K1060) from Dick Smith for about $10. It comes with solar cell module, solar-powered motor, wires and plastic turntables.)

What to do

1. Connect the fan blades to the motor shaft.
2. Connect the motor to the solar cell module.
3. Place the solar cell module flat on the ground in direct sunlight.
4. Observe what happens when you alter the angle that the solar module makes with the sunlight.
5. Slowly slide a piece of thick card across the solar module to cover it. Observe the effects on the speed of the fan.

Questions

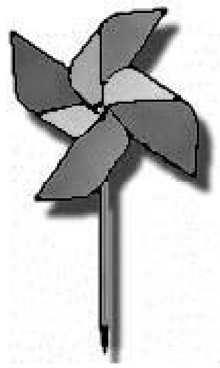
1. Describe what happens when the solar module is placed in direct sunlight.
2. Describe the effects of changing the angle of the solar module.
3. How much of the solar module was covered before the fan stopped rotating?

Wind or water turbines

A turbine is a prime mover that usually consists of a wheel with a number of curved vanes attached. Wind or water pushes the vanes and makes the wheel rotate. The turbine is connected to a generator to produce electricity. A pinwheel is an example of a turbine.

Activity 26: Make a pinwheel

What you need



- Thin cardboard (for example, manilla folder)
- Ruler
- Pencil
- Scissors
- Pin
- Eraser-tipped pencil
- Photocopy of the pinwheel template (see page 43)

What to do

1. Glue the template onto the cardboard and cut out.
2. Cut along the diagonal broken lines.
3. Make five small holes where indicated, then bend the cardboard to line up the holes.
4. Push the pin through the five holes, then push the sharp end into the eraser.
5. Hold the pinwheel near a fan. Change the speed of the fan and try to count the number of times the pinwheel spins around every 10 seconds, at different fan speeds.

Questions

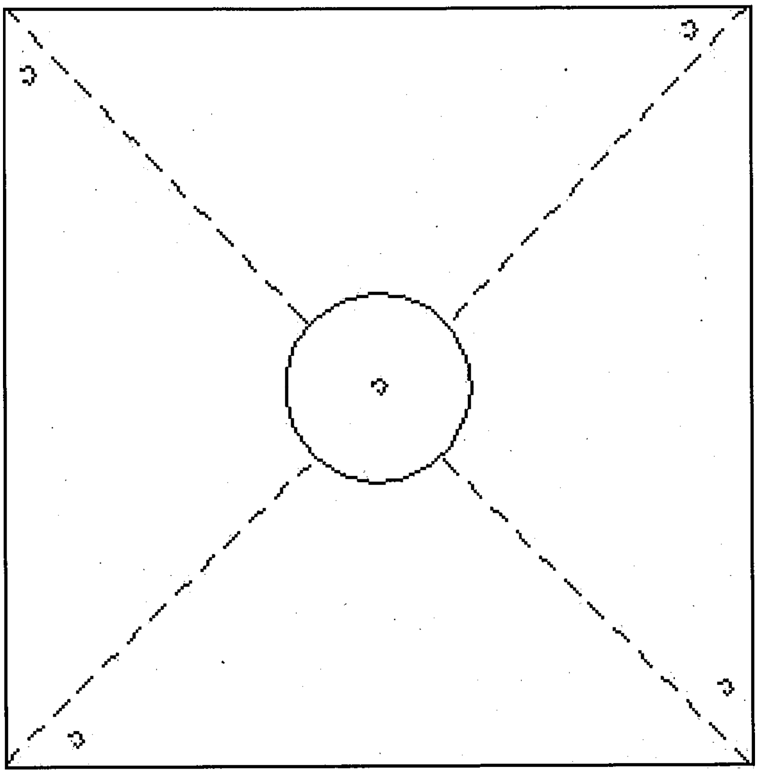
1. What energy transformations are happening?
2. How many times did the pin wheel spin when the fan was on the following settings?

Low ______________________________

Medium ______________________________

High ______________________________

3. How can water be used to turn the pinwheel?
4. Describe a way of using a pinwheel to make electricity.



Pinwheel template

Activity 27: Electricity time-line

What you need

- brief biographies of the famous people associated with electricity found on pages 45-47.
- research facilities and/or other resources.

What to do

Ask students to:

1. Construct a 'developments in electricity' time-line using the relevant information outlined on pages 45-47.
2. Choose one of the following people to research in more detail and write a report about them:

- Thomas Edison
- Nikola Tesla
- Alessandro Volta
- Michael Faraday
- Benjamin Franklin
- Hertha Ayrton.

Optional questions

1. When did they live?
2. What was/were their main contribution(s) to our knowledge of electricity?
3. Were any units named after them?
4. Describe what life was like in their day and the effect that their discovery had on people's day to day lives.

Present the report in poster form for display in the classroom.

Biographies

Namarrkon

The Aborigines of northern Australia have a number of stories that explain thunder, lightning and the wet-season clouds and rain. Namarrkon (spelling varies as the consonant sounds have no exact equivalent in English) is the Lightning Spirit of the Kunwinjku people of Western Arnhem Land in the Northern Territory. He/she has a circle of lightning leading from his/her head to the lower parts of his/her body representing flashing lightning. Namarrkon creates electrical storms and destroys trees by throwing the stone axes that protrude from his/her knees and elbows. It is widely believed that the marrkidjbu or 'clever men' have the power to call on Namarrkon to strike a particular person whom they wish to have killed.

Thor

Thor was the God of Thunder in Norse (Northern European) mythology. He had a magic hammer which he threw with the aid of iron gloves. It always returned to him. Lightning strikes occurred when his hammer hit something hard. Thunder was the sound of his rolling chariot. Thor was the eldest son of Odin, the ruler of all gods. Thursday is named after Thor.

Thales (about 580 B.C.)

Thales found that a piece of amber (fossilised plant sap), when rubbed with a cloth, attracted feathers and the dried pith of plants. Thales was born in Miletus in Asia Minor. He is considered to be the founder of Greek philosophy and was one of the so called Seven Sages (Wise Men) of Greece. He explained many natural phenomena. The Greek word for amber is elektron (hlektron).

William Gilbert (1544-1603)

William Gilbert determined that a compass needle points north because the Earth behaves as a giant magnet. In 1600 he published a book, De Magnete, which gave a full account of all his experiments on magnets and electrical attractions. His book was used as the 'bible' of electricity and magnetism for over 150 years. William Gilbert was an English physicist and physician who was educated at the University of Cambridge. He was appointed physician to Queen Elizabeth I.

Benjamin Franklin (1706-1790)

Benjamin Franklin performed his famous experiment with a kite in 1752. He flew a kite in a thunder storm. The kite was used to 'capture' lightning, using a special storage device called a Leyden Jar. The Jar was connected to the kite by a string. His experiments were the first to show that lightning is electricity. He was very lucky not to have been killed! Others have not been so fortunate. He also explained how objects became charged and discharged using his theory of 'positive' and 'negative' charge. Benjamin Franklin was an American printer, author, diplomat and philosopher as well as a scientist.

Petrus van Musschenbroek (1692-1761)

The Dutch physicist, van Musschenbroek is one of the two people credited with the invention of the Leyden Jar which was used to store static electricity. His Jar was a water-filled glass jar with an iron rod in it. The Leyden Jar was discovered in about 1745 by two scientists who were working independently. The other scientist was Ewald George von Kleist. The Leyden Jar was named in honour of the city of Leyden, where van Musschenbroek was born.

Ewald George von Kleist (1700-1748)

Ewald George von Kleist discovered the Leyden Jar independently of van Musschenbroek. His model used a chain in a glass jar, quite different to van Musschenbroek's, which used an iron rod. Ewald George von Kleist was the Dean of the Kamin Cathedral in Pomerania (now a part of Poland).

Otto von Guericke (1602-1686)

Otto von Guericke developed the first machine for producing an electrical charge. It consisted of a sulfur ball which could be spun on an axle. The turning ball would be brushed with a hand, a soft leather pad or a wool cloth. Its operation was accompanied by showers of sparks. Otto von Guericke was a German physicist who studied law and mathematics. He also did many experiments on air pressure, including the famous Magdeburg hemispheres demonstration, and invented the first air pump.

Luigi Galvani (1737-1798)

Luigi Galvani accidentally discovered that he could make a frog's leg twitch violently when it was touched in different places by iron and copper rods. He (wrongly) thought that the frogs leg contained 'animal electricity' that was released when it was touched by these metals. It was Volta who proved that the frog's leg and the two different metals were behaving like a battery. Luigi Galvani was an Italian professor of anatomy. The electrical terms, GALVANISM and GALVANISATION, were named in his honour.

Allesandro Volta (1745-1827)

Alessandro Volta developed the first battery, called a Voltaic Pile. It consisted of stacked copper and zinc plates, separated by paper or cloth that had been soaked in salt water. Voltaic piles were the first steady source of electric current. He was an Italian physicist who performed many experiments with electricity. In honour of his work, Napoleon made him a Count, and the electrical unit the VOLT was named after him.

Hans Christian Oersted (1777-1851)

In 1818, Hans Christian Oersted discovered that a magnetic compass needle will move when it is placed near a wire carrying a current. He also discovered the first electromagnet. This discovery began the study of electromagnetism, an important step in the path to the first electric motor. Hans Christian Oersted was a Danish physicist who was educated at the University of Copenhagen. He was the first person to extract the metal aluminium. The magnetic unit, the OERSTED, is named in his honour.

Andre Ampere (1775-1836)

Andre Ampere built the first meter for measuring electricity. He was the first person to work out the mathematical relationship between electricity and magnetism. He was a child prodigy who mastered every aspect of mathematics by the time he was twelve. He went on to become a professor of physics, chemistry and mathematics at different universities in France. The unit of measurement of electric current, the AMPERE, is named in his honour.

Michael Faraday (1791-1867)

In 1821, Michael Faraday discovered the principle of the electric motor. A motor converts electricity into movement. He understood that many electrical effects are reversible. For example, he was the first person to make an electrical generator, which converts movement into electricity. Michael Faraday was the son of an English blacksmith and he received little formal education. He became a physicist and chemist, best known for his discoveries of electromagnetic induction and electrolysis. The electrical unit, the FARAD, was named in his honour.

Thomas Edison (1847-1931)

Thomas Edison developed the electric light bulb, the electric generator, the phonograph and the motion picture. Altogether, Edison patented more than 1000 inventions. In 1882, he developed and installed the world's first large central electric power station in New York city. The generator supplied direct current. Later generators produced alternating current, as proposed by Nikola Tesla and George Westinghouse.

Nikola Tesla (1856-1943)

In 1888, Nikola Tesla developed the first system for generating alternating current. George Westinghouse installed this system in the Niagara Falls power station, which opened in 1895. In 1891, Tesla developed a high voltage transformer—the Tesla coil—which has important applications in the field of radio communications. He was an electrical engineer and inventor who was born in Smiljan (in the former Yugoslavia) and emigrated to the United States in 1884. He later became an American citizen. The magnetic unit, the TESLA, is named in his honour.

Hertha Ayrton (1854-1923)

Hertha Ayrton worked on the development of electric arc lamps. Her inventions were used as searchlights during World War I and in the cinema. Hertha Ayrton was born in England. She was trained as a mathematics teacher, but went on to become an electrical engineer. She published many papers on electric lighting. She was the first woman to become a full member of the Institution of Electrical Engineers. She was refused membership of the Royal Society on the grounds that she was a married woman.

Resources

Internet addresses

Power stations, generation and electricity

Queensland Government's Electricity in Queensland web site:
http://www.dme.qld.gov.au/Energy/electricity_in_queensland.cfm

Queensland's Energy Futures web site:
http://www.energyfutures.qld.gov.au/energy_in_queensland.cfm

Electricity distribution in Queensland
http://www.qca.org.au/electricity/

Renewable Energy from the Department of Climate Change and Energy Efficiency
http://www.climatechange.gov.au/what-you-need-to-know/renewable-energy.aspx

Queensland Government's Office of Clean Energy
http://www.cleanenergy.qld.gov.au/

Understanding electricity

More activities to do with electricity and sustainable energy resources suitable for Years 1-10:
http://www.originenergy.com.au/about/about_subnay.php?pageid=565#

ENERGEX Switched ON web site
http://www.energex.com.au/switched_on/index.asp

Energy Activities from Ergon Energy
http://www.ergon.com.au/ergonia

CS Energy Learning Centre
http://www.csenergy.com.au/content-(69)-learning-centre.htm

Power for a Sustainable Future

This highly recommended site contains fact sheets, student activities, teacher resources and a glossary http://www.sustainableenergy.eq.edu.au/html/what.html

Understanding static electricity

Detailed information about static electricity as well as some fun experiments to try.
http://www.sciencemadesimple.com/static.html

Lightning photography

http://www.photopixels.com/lightning/index.html

Dick Smith Electronics

Suppliers of science education materials
http://www.dse.com.au