2.1 Static electricity

Lesson outcomes

At the end of this activity students will be able to:

- describe the difference between neutral and charged objects
- know that opposite charges attract
- describe the transfer of electrons.

What ideas might your students already have?

- Both positive and negative charges move.
- They may have a model of charged particles being like ball bearings.

Key vocabulary

Charge, electricity, electrons, grounding, negative, opposite, particles, positive, static.

Equipment list

Each GROUP will require:

- soft cloth
- two balloons
- short length of string.

Each STUDENT will require:

- ***Notebook***
- access to computer.

Teacher content information:

This activity is designed so students explore the idea of charging, before considering the idea of electrons as the charged particles that can move in conductors.

Your climate will affect the results, so try to avoid doing this activity on a wet/humid day.

Lesson plan

Step 1 Introduce the activity by asking a student with long, clean hair to stand before the class. Give the student a blown-up balloon and ask him/her to rub it against his/her hair and then hold the balloon just above their hair. Ask the students to explain what they see.

Step 2 Give each pair two balloons and a piece of string. Ask them to inflate and tie the balloons together. They hold the string in the middle and see what happens. Is it different when first one of the balloons is rubbed?

Step 3 Conclude with a class discussion of their findings. Note any misconceptions for future reference.

Step 4 Invite the students to check their understanding by exploring the *Science by Doing* **Student Digital** activity.

Suggested questions

1. Why do you sometimes hear crackling when removing your jumper?
2. Why do you sometimes get a shock from furniture?
3. Why do you think that …?
4. What prior knowledge are you applying here?
5. Why do two charged balloons stick together?

2.2 Charging objects

Lesson outcomes

At the end of this activity students will be able to:

- design a fair test involving static electricity
- describe the transfer of electrons.

What ideas might your students already have?

Both positive and negative charges move. They may have a model of charged particles being like ball bearings.

Key vocabulary

Charge, electricity, electrons, negative, opposite, particles, polythene, positive, static.

Equipment list

Each GROUP will require:

Soft cloth, fur, silk, ebonite rod, glass rod, polythene rod, metal rod (you may wish to be specific or have a range), small pieces of paper, plastic comb, access to running water, a balloon, polystyrene beads (or rice bubbles).

Each STUDENT will require:

- **Activity Sheet 2.2 Triboelectric series** (optional)
- *Notebook*

Things to consider

An appropriate risk assessment is needed if the Van de Graaff generator is to be used

The weather will affect results, so try to avoid doing this activity on a wet/humid day.

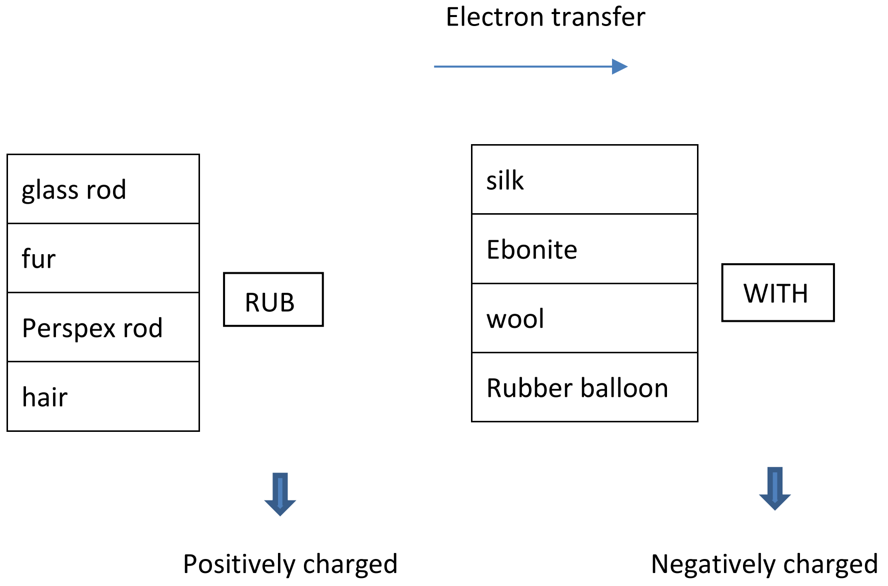
Teacher content information:

Ebonite® is the trade name for a very hard rubber developed by Charles Goodyear by treating natural rubber with sulphur (vulcanisation).

Perspex® is the trade name for polymethylmethacrylate (PMMA). It is also known as acrylic, Plexiglas®, Acrylite® and Lucite®.

There are many tribo-electric series that show the charging patterns of synthetic and natural polymers from most positively charged to most negatively charged. A comparison of these series will reveal some disagreement between the actual orders of charge (refer to http://www.sciencedirect.com/science/article/pii/S0304388604001287).

For most practical purposes:



You may use gold leaf electroscopes as well in this activity.

In the year 7 *Science by Doing* unit **Enough Water Fit For Drinking**, students explored the nature of water molecules, including polarity. The concept of polar molecules, having small oppositely charged ends, is useful when looking at static electricity.

In addition, a demonstration of the Van de Graaff generator, if the climate is favourable, will engage the students and allow a class discussion explaining what they saw. There is a video of this in the *Science by Doing* **Energy** unit

Lesson plan

Step 1: Introduce the activity by asking students to recall the previous activity and describe what happened with the balloons.

Step 2: Explain students will be designing a fair test to see if all objects charge in the same way and which charge the most. Remind them that water is a polar molecule, free to rotate, so direction moved does not indicate type of charge.

Step 3: Students design and share their ideas with you. Encourage them to test their ideas and collect data. Have a range of materials ready for the activity.

Step 4: During the activity, interact with students and pose questions about their methods to guide their thinking.

Step 5: Conclude with a class discussion on their findings. Note any misconceptions for future reference.

Suggested question/s:

- Why do you think that?
- What prior knowledge are you applying here?
- How will you measure …?
- Do all objects charge the same way?
- Did any object not become charged?

Follow up:

As a homework activity ask students to describe how different their journey to school would be if all materials were insulators.

2.3 Conductors and insulators

Lesson outcomes

At the end of this activity students will be able to:

- construct simple electric circuits
- identify conductors and insulators.

What ideas might your students already have?

That metals conduct heat, but wood and plastic do not.

Key vocabulary

Alligator clip, battery, cell, circuit, conductor, globe, insulator, leads, switch.

Equipment list

The CLASS will require:

A range of test materials including iron nail, square of fabric, glass rod, wooden ruler, balloon (not inflated), aluminium foil, graphite rod, copper wire, copper sulfate crystals, beaker of copper sulfate solution (graphite or iron/copper can be used as the electrodes, or have students dip the alligator clips in directly).

Each GROUP will require:

- battery
- leads
- alligator clips
- globe
- image showing the circuit.

Things to consider

You may wish students to use a power pack instead of a battery for this investigation. Or you may use commercial *Snap circuits*® if available.

Which common laboratory objects will students use in addition to those mentioned?

Do they need to share resources?

Do they need scaffolding to produce results in tabular form?

Teacher content information:

This activity allows students to explore conductors and insulators, as well as familiarise themselves with building circuits using the ***Predict-Observe-Explain*** methodology. You may also wish to introduce them to an ammeter in this activity and have them collect data on the current flowing as the test object is changed.

Dr Andrew Holmes and conductive plastics are mentioned in the *Student Guide*. He is president of the Australian Academy of Science (see http://www.bio21.unimelb.edu.au/news/prof-andrew-holmes-elected-next-president-of-the-australian-acad).

Lesson plan

Step 1: Introduce this section as: "We are going to make a light circuit and use it to test whether materials are conductors or insulators. What do you think a conductor is? An insulator?"

Step 2: Organise the students into working groups or pairs, depending on equipment availability and have them build the circuit and check whether the globe lights up when the alligator clips touch each other. If using an alternative to a globe (e.g. buzzer or electric motor) have them check these as well.

Step 3: This investigation uses the ***Predict-Observe-Explain*** strategy. Remind students to record their ideas in their ***Notebooks*** and encourage each member to make their own predictions and take turns at testing the objects.

Step 4: During the activity, interact with the groups and ask questions that will assist students' thinking. Conclude with a class sharing of results.

Suggested question/s:

- Does the globe always glow the same?
- Why did you think …?
- Do all objects let charges move through them?
- Were all materials conductors?
- What particles carry electrical charge?
- How do these particles move in a conductor?
- How do these particles move in an insulator?

2.4 Current

Lesson outcomes

At the end of this activity students will be able to:

- use an ammeter to measure current
- build series and parallel circuits.

What ideas might your students already have?

The year 8 *Science by Doing* **Energy** unit explored electrical energy and you may wish to recap that knowledge here.

Key vocabulary

Ammeter, circuit, current, electrons, energy, globe, parallel, series, potential difference.

Equipment list

The CLASS will require:

Each GROUP will require:

- ammeter
- power pack (6V DC)
- leads
- 3 6V globes.

Each STUDENT will require:

- *Student Digital*
- ***Notebook.***
- **Activity Sheet 2.4 Current** (optional digital activity that could be used to reinforce what is learnt in the laboratory activity)

Things to consider

You may wish to produce templates to cover multimeters allowing access to only the appropriate connections and setting the scale of the device. Alternatively you may have guidance sheets for your devices.

You may wish to substitute batteries or *Snap Circuits*® for the activity. Resistors and variable resistors can also be used if globes are limited.

You may want lab technicians on hand to help with broken globes, blown fuses in the meters etc.

This activity is followed with an exploration of how to change the brightness of a globe in **Activity 2.5 Bright lights**.

Teacher content information:

In a series circuit, the current is the same no matter where in the circuit it is measured.

In a parallel circuit, the current is different in each chain, but the total current remains the same.

The **Student Digital** interactive can be used in place of the classroom activity if time is short. It may also be a homework or revision activity.

Lesson plan

Step 1: Introduce the activity by drawing symbols on the board and asking students to describe their purpose or name them. Hand out **Activity Sheet 2.4 Current** and discuss the circuit symbols.

Step 2: Demonstrate how to operate ammeters – be they analogue with different scales, digital or multimeter.

Step 3: Invite the students to complete the first activity of measuring current.

Step 4: During the activity, circulate and ask students to explain their observations.

Step 5: At an appropriate time, bring the students back together to share their findings and explain the difference between series and parallel circuits.

Step 6: Conclude with a class discussion of the differences between the circuit types and encourage suggestions about any patterns in the findings.

Suggested question/s:

Is current the same in all parts of the circuit?

How do we measure current?

How did you …?

Are you sure you connected …?

How do you think the lighting in your house is connected?

Do more globes always mean dimmer lights?

Follow up:

Use the digital activity to revisit the ideas.

2.5 Bright lights

Lesson outcomes

At the end of this activity students will be able to:

- describe how loading a circuit can affect the efficiency of energy transfer.

What ideas might your students already have?

Students may have used dimmer switches at home or have observed a change in brightness in the earlier circuit activities.

Key vocabulary

Brightness, intensity, resistance, variable.

Equipment list

Each PAIR will require:

- three globes
- power pack (6V DC)
- leads
- voltmeter
- ammeter
- variable resistor.

Teacher content information:

This activity is designed to allow students to develop a richer understanding of loading a circuit.

Lesson plan

Step 1: Introduce the activity by having the students brainstorm how a dimmer switch works.

Step 2: Encourage students to read the guide and to follow the practical instructions.

Step 3: Encourage students to share their ideas from the practical, for example, did they manage to change the brightness of only two of the three globes? How did they achieve this?

Step 4: Conclude with a class discussion in preparation for **Activity 2.7**. You may wish to guide their thinking here.

Suggested question/s:

- How do we control the brightness of a globe?
- Why did you use …?
- Is that the only way?
- Would you use … regularly?

2.6 Voltage

Lesson outcomes

At the end of this activity students will be able to:

- use a voltmeter to measure voltage
- build series and parallel circuits.

Key vocabulary

Circuit, electrons, energy, globe, parallel, potential difference, series, voltage, voltmeter.

Equipment list

Each GROUP will require:

- power pack (6V DC)
- leads
- three 6V globes
- voltmeter.

Each STUDENT will require:

- ***Notebook***
- computer access.

Things to consider

You may wish to produce templates to cover multimeters, allowing access to only the appropriate connections and setting the scale of the device. Alternatively you may have guidance sheets for your devices.

You may wish to substitute batteries or *Snap Circuits*® for the activity. Resistors and variable resistors can also be used if globes are limited.

You may want lab technicians to help with broken globes, blown fuses in the meters etc.

Teacher content information:

The voltage across components in a series circuit will vary, depending on the component and its age, but the total voltage will always equal that of the battery.

In a parallel circuit, the voltage is the same across each component and the battery.

The concept of voltage or potential difference is explained using a comparison with food delivery. The trucks represent the electrons, the food is the energy, the house/restaurant/supermarket are the different devices, and the roads are the wires. You may wish to use other analogies to supplement this to convey the idea of energy difference.

The *Science by Doing* **Student Digital** activity allows students to explore the idea of voltage difference by considering possums on power lines.

Lesson plan

Step 1: Introduce the activity by drawing symbols on the board and asking students to describe their purpose or name them. You may wish to have a couple of students demonstrate building a circuit.

Step 2: Demonstrate how to operate your voltmeters – be they analogue with different scales, digital or multimeter.

Step 3: Invite the students to measure the voltage.

Step 4: During the activity, circulate and ask students to explain their observations.

Step 5: Invite students to interact with the **Student Digital** to consolidate their understanding of voltage.

Step 6: Conclude with a class discussion of the differences between the circuit types and encourage suggestions of patterns to the findings.

Step 7: Invite students to explore the **Student Digital** activity on possums and high-voltage wires.

Suggested question/s:

How do we measure voltage?

Is there a pattern?

How did you …?

Are you sure you connected …?

Is the voltage in all parts of the circuit the same?

How does this model help your understanding?

Why can birds or possums sit on uninsulated high-voltage power lines?

2.7 Ohm's Law

Lesson outcomes

At the end of this activity students will be able to:

- conduct a fair test
- state Ohm's law
- plot and interpret graphs.

What ideas might your students already have?

Students may know that voltage and current are directly proportional for a wire.

Key vocabulary

Current, diode, globe, ohm, proportional, resistance, temperature, wire.

Equipment list

Each GROUP will require:

- power supply (6v)
- leads
- 6V globe
- 1m nichrome wire
- 2 alligator clips
- ammeter
- voltmeter
- diode
- variable resistor.

Each STUDENT will require:

- ***Notebook***
- computer access.

Things to consider

If equipment is limited you may wish to form groups so students share the data collected, that is, each group collects data on one of the three devices (variable resistor, diode, 1m nichrome wire).

You may substitute resistors for the wire and use a multimeter as an ohmmeter to measure resistance of a device for comparison with the slope of a graph.

Do you wish students to hand plot graphs or use graphic calculators or Excel? In these cases, what support will they need in producing line of best fit?

Teacher content information:

Resistance of a conductor is defined as the ratio of the potential difference to current. This direct proportionality doesn't hold for conductors whose temperature changes – a globe is one good example.

Ohm's law states that the potential difference (voltage) across a device is directly proportional to the current through it *if the device is at a constant temperature*.

$$V = I R$$

Where V = potential difference (volts), I = Current (amps), R = resistance (ohms)

The distinction between Ohm's Law (as stated above) and the definition of Resistance according to the equation $R = \frac{V}{I}$ can be confusing. Whereas Ohm's Law rarely seems to apply to most devices and components used today, the same equation always applies as a definition of *resistance* regardless of whether Ohm's Law applies or not. This application of the equation is probably its most important one.

You may wish to extend the inquiry skills from this investigation and have students evaluate the method. E.g. not tested it three times, no control over temperature, only reliable if programming correct.

Suggest improvements – broader range of voltage/resistance/more accurate ammeter.

Lesson plan

Step 1: Introduce the investigation by asking students to explain what happens to the current in a resistor when the resistance increases? Review the ideas from **Activity 2.6 What is resistance?**

Step 2: Invite students to work in groups/pairs to design a fair test to solve the problem (i.e. whether Ohm's law always holds) through building a test circuit and collecting relevant data.

Step 3: During the activity interact with students, encouraging them to think about how they record the results and challenging them to justify their ideas.

Step 4: Allow students sufficient time to plot the three graphs (this could be done as homework and the discussion held next lesson) and to explore the **Student Digital** activity.

Step 5: Conclude with a class discussion of when Ohm's law is valid.

Suggested question/s:

- How does the current change if you alter the voltage across a fixed resistor?
- How was this a fair test?
- How does the current change if you alter the voltage?
- How could you improve this?

Why do you think …?

2.8 Test me

Lesson outcomes

At the end of this activity students will be able to:

- revise using a Concept Map
- identify any gaps in their understanding

Teacher content information:

The activity allows students to explore the use of the particle/wave models. Ideas they may suggest are:

	Particle	Wave
Rock concert:	People in the crowd move and jump around, colliding like particles.	The rock music is heard because it travels as a sound wave.
Striking a match:	Particles of phosphorus rub against the rough surface, this builds heat and the head of match ignites.	The lit match releases light and infra-red rays which travel as electromagnetic waves through space.
Water wave in tank:	Particles of water move up and down, they transfer energy through collisions.	Energy is transferred from A to B without the overall movement of the particles, therefore a wave is seen.
Electricity lines and pylons:	Electricity travels through the wires by the motion of small charged particles called electrons.	
Butterfly wings:		The surface of the wings reflect light of specific wavelengths and colour is observed.
Seismograph:		This instrument detects motion in the Earth and the pen vibrates across the paper, producing a wave-like signal (waves of energy travel through the Earth and are transmitted/reflected at boundaries to be detected at the device).
Laser reflecting off mirror:	Photons bounce off the mirror surface at the same angle they hit it.	The ray of light is reflected from the smooth shiny surface.

Equipment list

Each STUDENT will require:

- ***Notebook***
- computer access.

Lesson plan

Step 1: Introduce the activity as a revision and an opportunity for students to explore their understanding of electricity.

Step 2: Allow students time to explore the *Science by Doing* **Student Digital** revision, and the modelling imagery.

Step 3: Conduct a whole-class discussion of areas which need assistance and encourage students to engage in peer support.