

## ***D2 Describe technologies for transfer and control of electrical energy***

### ***D2.1 assess the potential danger of electrical devices, by referring to the voltage and current rating (amperage) of the devices; and distinguish between safe and unsafe activities***

# Electrical Safety

Electricity must be treated with respect at all times. Learn about the dangers of electricity and the safe practices when working with it.

Electric current is measured in amperage. Voltage is measured in volts. If either number is high, the electric current can be dangerous. Devices are required to have labels stating the necessary voltage and maximum amperage. For example, an electric mitre saw plugs into a 120V receptacle and is rated at 15A of current.

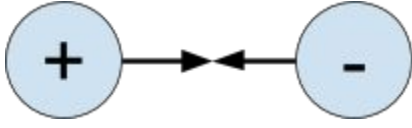
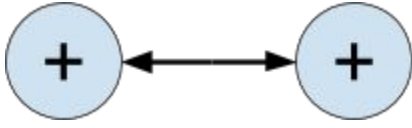
Become familiar with the following general rules for electrical safety:

- know the voltage and amperage of the electricity that you work with
- Respect high-voltage transmission lines. Transmission lines carry extremely high voltage current.
- Do not plug any electrical device into a wall outlet if the cords are damaged in any way, if the wire are exposed, or if the third prong (the ground) has been broken or removed from the plug.
- Avoid mixing water and electricity in all circumstances.
- If you are working with electricity coming from a wall outlet, be aware that this amount of electricity can cause serious bodily harm. Avoid standing in water or touching metal plumbing pipes, metal countertops, or any other conductors that could cause the electricity to pass through your body while working with electricity.

**D2.2 distinguish between static and current electricity, and identify example evidence of each**

# Electrical Current

Atoms build up a charge by losing or gaining electrons. An atom that loses electrons becomes positively charged. An atom that gains electrons becomes negatively charged. The behaviour of charged objects can be predicted according to the **law of electrical charge**. This behaviour is shown in the following chart:

Objects with opposite charges attract each other	
Objects with the same charges repel each other	

**Static electricity** occurs when two objects with opposite electrical charges come close enough to each other to allow electrons to move from the negatively charged object to the positively charged one. This electron movement is the cause of the shock a person felt or the zap heard or spark seen as the charged objects return to a neutral condition. A lightning flash is a very large discharge of static electricity.

Unlike static electricity, which occurs randomly, current electricity is predictable. **Current electricity** is the movement of electrons along a conducting path. For example, current electricity moves along copper wire.

**D2.3 identify electrical conductors and insulators, and compare the resistance of different materials to electric flow (e.g., compare the resistance of copper wire and nickel-chromium/Nichrome wire; investigate the conduction of electricity through different solutions; investigate applications of electrical resistance in polygraph or lie detector tests)**

# Conductors, Insulators, and Resistors

**Conductors** allow for the movement of electricity, whereas **insulators** oppose the movement. **Resistors** allow some, but not all, of the current to pass through. Current passing through a resistor can produce heat and light. Resistance is what makes a light bulb or a stove element work. Common examples of conductors, insulators, and resistors are listed as follows:

- Conductor - copper and aluminum
- Insulator - plastic and rubber
- Resistor - tungsten filament and heater element

***D2.4 use switches and resistors to control electrical flow, and predict the effects of these and other devices in given applications (e.g., investigate and describe the operation of a rheostat)***

## Controlling Electrical Flow

A switch can be used to control the flow of electricity through a circuit by turning it on or off. When the switch is open, the conducting points are not in contact with each other, and no current can flow through. When the switch is closed, however, the conducting points are connected, and current can flow through the system. That is why the light in a room will turn on when the light switch is set to “on.”

Resistance in an electric circuit is a measure of how easily the current flows. A resistor in a circuit is similar to a water pipe with a small diameter. Water flowing in a narrow pipe has more resistance than water flowing in a wide pipe. Because the resistor makes it more difficult for current to flow through, the voltage (or pressure) drops as it flows through the resistor. Components such as bulbs and motors act as resistors in a circuit.

***D2.5 describe, using models, the nature of electrical current; and explain the relationship among current, resistance and voltage (e.g., use a hydro-flow model to explain current, resistance and voltage)***

## Current, Resistance, and Voltage

Current, resistance, and voltage are related to each other. The voltage of a system depends directly upon the current and resistance in the circuit. Think of pouring some water from a bucket through a tube. If you pour water from a bucket 1m from the ground, it has less potential energy than if you pour water from the same bucket from a height of 10 m. The height of the bucket is like voltage. The amount of water flowing from the bucket is like current. A large amount of water poured out from a bucket demonstrates a large current. A small amount poured out demonstrates a small current. Resistance refers to how easily current can flow. If instead of a wide tubing, a piece of narrow tubing is used, the amount of water that can flow through the tubing is much less.

The narrower path creates more resistance. Because the resistance is high, not as much water (or current) can flow. Therefore, as resistance increases, current decreases.

**D2.6 measure voltages and amperages in circuits (e.g., determine the resistance in a circuit with a dry cell and miniature light; determine the resistances of copper, nickel-chromium/ Nichrome wire, pencil graphite and salt solution)**

- **apply Ohm's law to calculate resistance, voltage and current in simple circuits**

## Electrical Terms

The relationship between the current, voltage and resistance in a circuit is described by Ohm's Law using the terms listed in the table.

Electrical Term	Definition	Unit of Measurement	Symbol
Current	Rate of flow	Ampere (A)	I
Voltage	Force of flow	Volt (V)	V
Resistance	Obstacle of flow	Ohm ( $\Omega$ )	R

### Ohm's Law

Ohm's Law states that the voltage of a system is directly related to the current multiplied by the resistance:

$$V = IR$$

When one term changes, there must be a change in one or both of the others. The formula can be written to calculate voltage, resistance, or current.

$V = IR$	$V = \text{Voltage}$
$R = \frac{V}{I}$	$I = \text{Current}$
$I = \frac{V}{R}$	$R = \text{Resistance}$

### Example

An electric heater uses 12A of electricity when plugged into a 120V outlet. What is the resistance of the heater?

### Solution

$$\begin{aligned} R &= \frac{V}{I} \\ &= \frac{120V}{12A} \\ &= 10\Omega \end{aligned}$$

***D2.7 develop, test and troubleshoot circuit designs for a variety of specific purposes, based on low voltage circuits (e.g., develop and test a device that is activated by a photoelectric cell; develop a model hoist that will lift a load to a given level, then stop and release its load; test and evaluate the use of series and parallel circuits for wiring a set of lights)***

***D2.8 investigate toys, models and household appliances; and draw circuit diagrams to show the flow of electricity through them (e.g., safely dismantle discarded devices, such as heating devices or motorized toys, and draw diagrams to show the loads, conductors and switching mechanisms)***

# Circuits

An electrical circuit is a system made up of four subsystems.

Source: Cell or Battery

Conductor: Wire

Control: Switch

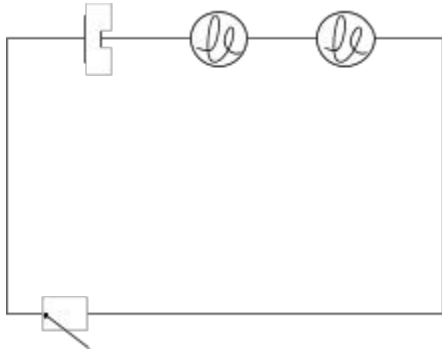
Load: Lamp or motor

When the switch is turned off and the current is interrupted, the circuit is said to be **open**. When the switch is on, allowing for the flow of current, the switch is **closed**.

If a simple circuit consisting of a cell connected to a switch and a light does not work, troubleshooting can possibly determine the cause. Troubleshooting involves checking to see if the cell is dead, the light is burnt out, or if the wires are improperly connected.

Electrical circuits can be set up as series circuits or parallel circuits.

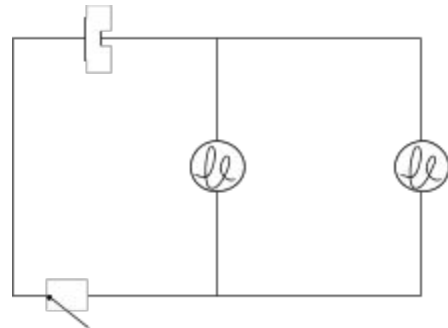
A series circuit is a circuit with one path of electron flow.



The voltage in this cell is shared by the two light bulbs, which causes the second bulb to be dimmer than the first.

If one bulb burns out, the other will not work.

A parallel circuit is a circuit with multiple paths of electron flow.



The voltage in this cell is shared equally by the two light bulbs. The bulbs will burn equally bright.

If one bulb burns out, the other will still work.

***D2.9 identify similarities and differences between microelectronic circuits and circuits in a house (e.g., compare switches in a house with transistors in a microcircuit)***

# Comparing Circuits with Microelectronic Circuits

Microcircuits, or integrated circuits are used in television and computers. These circuits differ in size from circuits that carry electricity throughout a house and use much less current and voltage. Microcircuits are extremely small and contain microscopic transistors and resistors. More than a million components can be placed on a chip that is no larger than one square centimetre. A transistor is often used instead of a switch in a microcircuit. Transistors have no moving parts and can be made much smaller than traditional switches used in homes.