Oxford EDUCACIÓN

GEN iOX

CORE

TECHNOLOGY

SECONDARY 3

ANDALUSIA

1 An electrical circuit

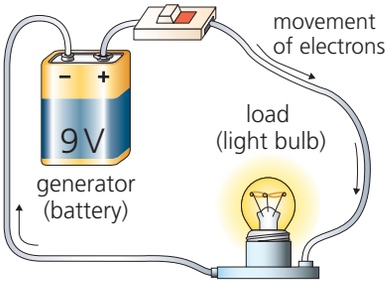
An electric circuit is a path for the flow of negatively-charged particles called **electrons**. These particles can flow as electric **current**[1].

Electric current is a continuous flow of electrons though a circuit.

[1]**current:** continuous, flowing movement.

[2]**device:** tool or machine that perform an action.

[3]**glance:** a quick look.



Parts of an electric circuit

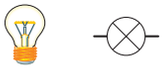
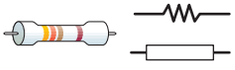
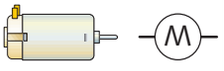
An electric circuit consists of various **components**: generators, conductors, switching devices and loads.

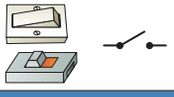
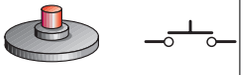
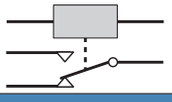
Generators provide electric current and **conductors** carry it through the circuit. **Switching devices**[2] control the flow of electricity, while **loads** transform it into other types of energy, such as light, heat or motion.

Circuit diagrams

We use standard symbols in diagrams of electrical and electronic circuits. This makes the diagrams easier to understand at a **glance**[3].

Generators	
Electrochemical cell	Battery
	

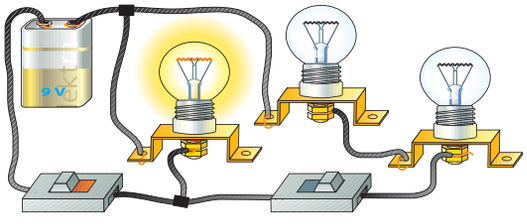
Loads			
Light bulb	Resistor	Motor	Bell
			

Switching devices			
Switch	Push button	Three-way switch	Relay
			

Safety elements
Fuse


CLIL activities

1 In your notebook, draw a diagram of the cirucit using standard symbols.



2 Listen to the four sentences. Write *true* or *false*. Correct the false sentences.

3 Work in pairs. Discuss the differences between the following components of a circuit.

a. a battery and a relay
b. a wire and a light bulb
c. a bell and a fuse

A ... can/uses/is for ... but/while/unlike a ... which can/uses/is for ...

4 List electrical devices in your home. Explain if they are easy and safe to use to a classmate.

A ... is/isn't very safe because ...

2 Electrical quantities

Voltage or potential difference

The amount of energy that a generator (a cell or battery) can transfer to the electrons in a circuit depends on its electrical tension or **voltage** (**V**).

A generator creates a potential difference (electromotive force) between two points in a circuit. This causes electrons to flow from one point to the other. The energy transferred to the electrons is measured in **volts**[1].

[1]**volt:** SI unit of electromotive force carrying 1 amp of current against 1 ohm of resistance.

[2]**coulomb:** SI that equals 6.25×10^{18} electrons.

[3]**cross-section:** surface shown when we cut through something.

Electric current

Electric current (*I*) is the charge or number of electrons that flow through a conductor in a second. It's measured in **amperes** or **amps** (**A**). One amp equals a flow of one **coulomb**[2] per second through the **cross-section**[3] of a conductor.

$$I = \frac{Q}{t}$$

$$1\text{A} = \frac{1\text{C}}{1\text{s}}$$

Electrical resistance

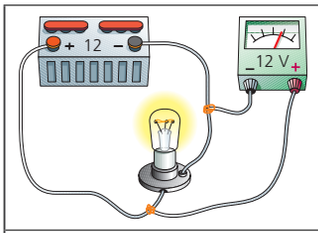
Electrical resistance (*R*) is a measure of how easily electrons flow through the components of a circuit. It is measured in SI units called **ohms** (**Ω**).

Electrical resistance depends on the length (*L*) and cross-sectional area (*A*) of a component. Longer components offer more resistance, while a larger cross-section gives electrons more room to flow. Electrical resistance also depends on the material used to make a component. Some materials offer more resistance than others.

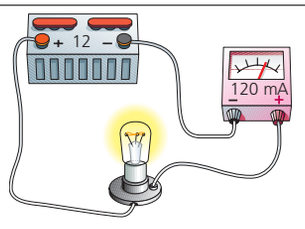
$$R = \rho \frac{L}{A}$$

Measuring electrical quantities

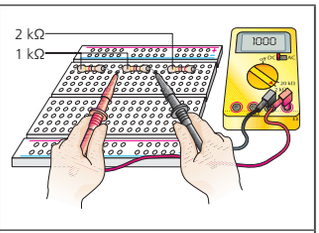
We can use a **multimeter** to measure voltage, electrical current and resistance.



A **voltmeter** measures voltage. We connect it **in parallel** to the component.



An **ammeter** measures electric current. We connect it **in series** so that all the current flows through it.



An **ohmmeter** measures electrical resistance. We connect it **to opposite ends** of the component.

Electrical resistance and Ohm's Law

The resistance (***R***) of a material is equal to the voltage (***V***) divided by the intensity of electric current (***I***) passing through it. This is Ohm's Law, which we can express in three ways:

$$V = R \cdot I \qquad I = \frac{V}{R} \qquad R = \frac{V}{I}$$

When there is more resistance, less current can flows. When there is less resistance, more current can flow.

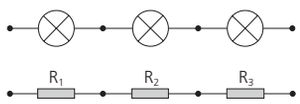
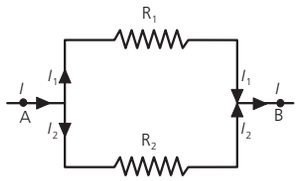
CLIL activities

5 Listen and copy four questions into your notebook. Then answer them.

6 How many electrons are there in 10 coulombs of charge? And in 100 coulombs?

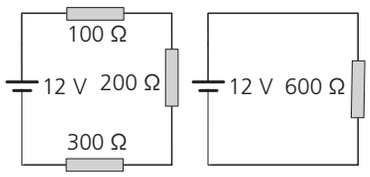
7 Decide with a classmate. How would an increase in resistance affect the voltage in a circuit? How would it affect the current?

3 Series and parallel circuits

	In a **series circuit**, the current flows along one path through all the components.		In a **parallel circuit**, the current flows along more than one path to each of the component.

Analysing series and parallel circuits

1 Series: Calculate the total resistance.



$R_T = R_1 + R_2 + R_3$

$R_T = 100\ \Omega + 200\ \Omega + 300\ \Omega = \mathbf{600\ \Omega}$

2 Use Ohm's Law to calculate the total current.

$I_T = \frac{V_T}{R_T} = \frac{12\ V}{600\ \Omega} = \mathbf{0.02\ A}$

3 Use Ohm's Law to calculate individual loads.

$V_1 = I_T \times R_1 = 0.02\ A \times 100\ \Omega = \mathbf{2\ V}$

$V_2 = I_T \times R_2 = 0.02\ A \times 200\ \Omega = \mathbf{4\ V}$

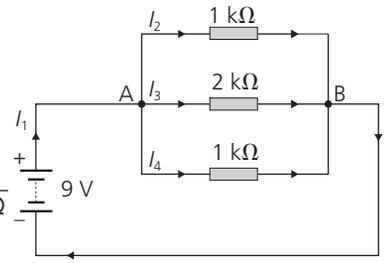
1 Parallel: Calculate the total resistance.

$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R_T} = \frac{1}{200\ \Omega} + \frac{1}{300\ \Omega} + \frac{1}{600\ \Omega}$

$\frac{1}{R_T} = \frac{3}{600\ \Omega} + \frac{2}{600\ \Omega} + \frac{1}{600\ \Omega} = \frac{6}{600\ \Omega}$

$R_T = \frac{600}{6} = \mathbf{100\ \Omega}$



2 Use Ohm's Law to calculate the total current.

$I_T = \frac{V_T}{R_T} = \frac{12\ V}{100\ \Omega} = \mathbf{0.12\ A}$

3 Use Ohm's Law to calculate individual currents.

$I_1 = \frac{V_T}{R_T} = \frac{12\ V}{200\Omega} = \mathbf{0.06\ A}$

$I_2 = \frac{V_T}{R_2} = \frac{12\ V}{300\Omega} = \mathbf{0.04\ A}$

CLIL activities

8 Work in pairs. Calculate V_3 for the series circuit in 3.1. Then calculate I_3 for the parallel circuit, in your notebook.

9 Listen and explain how you would find the missing values.

I would multiply / divide the ... by the ...

10 Look at the triangle. What does it represent? How can we use it?

Analysing combination circuits

A **combination circuit** has some components connected in series and others connected in parallel. We analyse them as follows:

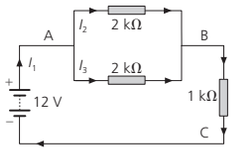
1 Calculate the total resistance of the components in parallel.

$\frac{1}{R_T} = \frac{1}{R_2} = \frac{1}{R_3} = \frac{1}{200\ \Omega} + \frac{1}{300\ \Omega} = \frac{3}{600\ \Omega} + \frac{2}{600\ \Omega} = \frac{5}{600\ \Omega}$

$R_{23} = \frac{600}{5} = \mathbf{120\ \Omega}$

And in series.

$R_T = R_1 + R_{23} = 80\ \Omega + 120\ \Omega = \mathbf{200\ \Omega}$



2 Use Ohm's Law to calculate the total current.

$I_T = \frac{V_T}{R_T} = \frac{12\ V}{200\ \Omega} = 0.06\ A$

3 Use Ohm's Law to calculate the individual loads.

$V_1 = I_T \times R_1 = 0.06\ A \times 80\ \Omega = 4.8\ V$ $\quad V_{23} = I_T \times R_{23} = 0.06\ A \times 120\ \Omega = 7.2\ V$

4 Use Ohm's Law to calculate the individual currents.

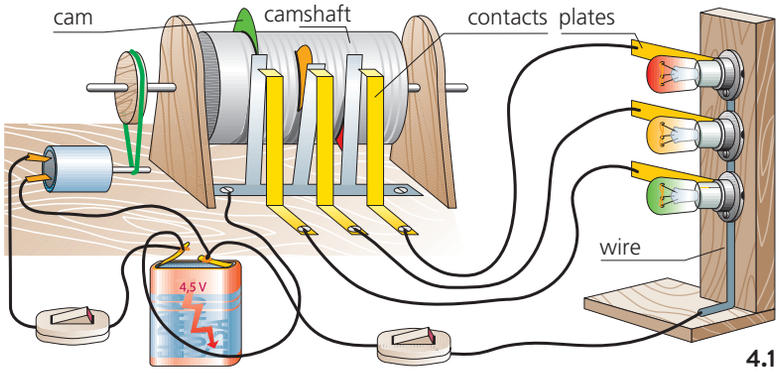
$I_2 = \frac{V_T}{R_T} = \frac{7.2\ V}{200\ \Omega} = \mathbf{0.036\ A}$

4 Electromagnetic control systems

An **electromagnetic control system** activates parts of a machine at the right moment for a certain amount of time. This allows the machine to function.

Cam switch controller

The device in the picture below uses a **cam** to control when and how long each light is turned on. The cams push the metal contacts together for a short period of time. This happens once every time the camshaft rotates.

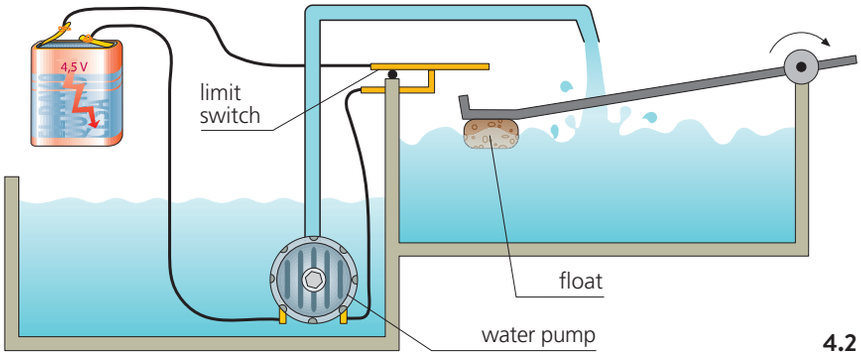


4.1

Limit switch

A **limit switch** has two possible positions: open and closed. Some limit switches are **normally closed** (N/C) and others are **normally open** (N/O). Limit switches change position when they are activated.

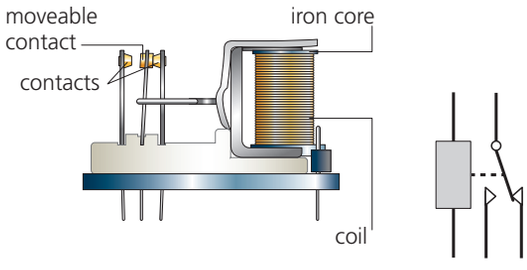
The water pump in the picture below has a limit switch. When the float rises, it activates the switch, opens the circuit and turns off the pump.



4.2

Relay

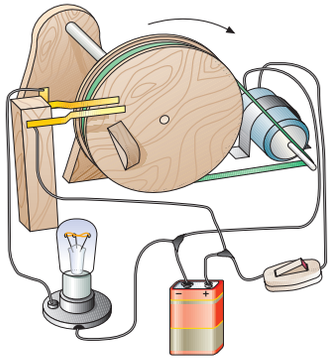
A **relay** has a coil that becomes magnetic when electricity passes through it. The coil attracts a moveable contact and closes the circuit. When the electricity stops flowing, the contact returns to its original position. Doorbells and buzzers often use relays.



CLIL activities

11 Why does the control system in 4.1 have three cams? Why are they in different positions?

12 Work in pairs. Describe the control system below. How does the cam control the light bulb? How could we use a similar system to produce an intermittent sound?



13 Look at the water pump diagram in 4.2. When will the water pump turn on again? Explain how this happens.

14 Listen and answer the questions about traffic lights.

a. When was the first electric traffic light used?

b. What type of control system do modern traffic lights use?

c. What sends signals to turn the lights on and off?

d. What happens when there isn't any electricity?

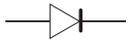
Now research and prepare a short presentation about another job that used to be done manually but was replaced by a control system.

5 Electronics

Electronic symbols

Resistor 

Capacitor 

Diode 

LED 

Electronics involves the study of circuits and components that modify the intensity, direction and properties of electric currents.

Electronic components

Fixed resistances or resistors

A fixed resistance (or **resistor**) opposes the flow of electric current. Its value in ohms (Ω) is shown by a code of coloured stripes. The first two stripes give us a two-digit number. The third stripe tells us how many zeroes to add. The fourth stripe gives the tolerance, which is the maximum deviation from the labelled value.

	gold	black	brown	red	orange	yellow	green	blue	purple	grey	white
number			1	2	3	4	5	6	7	8	9
multiplier	×0.1	×1	×10	$\times 10^2$	$\times 10^3$	$\times 10^4$	$\times 10^5$	$\times 10^6$	$\times 10^7$	$\times 10^8$	$\times 10^9$
tolerance	± 5%										

Variable resistances or potentiometers

The value of a variable resistance (or **potentiometer**) can be adjusted between zero and the maximum value specified by the manufacturer.

Resistances affected by physical factors

- **Thermistors** are affected by **temperature**. There are two types:
  - **PTC** (positive temperature coefficient): the higher the temperature, the more resistance the thermistor offers.
  - **NTC** (negative temperature coefficient): the higher the temperature, the less resistance the thermistor offers.
- **Light dependent resistors** (LDR) can be used as light sensors because they offer less resistance when there is more light.

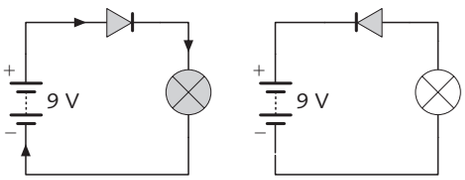
Capacitors	Diodes
	 
A capacitor can store electrical energy and use it to power a device, such as a light bulb. The charge that a capacitor can store is measured in **farads** (**F**).	A **diode** only allows current to flow in one direction. It has two electrodes: an **anode** (A) and a **cathode** (K). A light emitting diode (**LED**) produces light when current flows through it.

CLIL activities

15 Work in pairs. Use the colour code to find the value of the resistors below. Why do you think they are different sizes?

16 How are capacitors similar to batteries? What happens when a capacitor is depleted?

17 What do the diagrams below show? Which circuit is active?

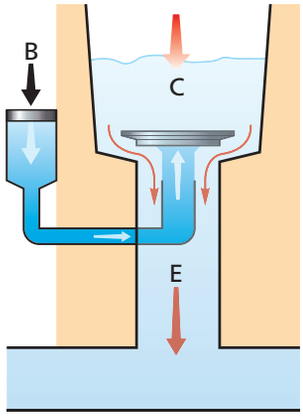


18 Listen to the four students. What mistakes do they make? Correct them in your notebook.

Transistors

A **transistor** is a switch that is activated by a small electric current. Transistors are made of semiconductor materials and have three electrodes: the base (B), the collector (C) and the emitter (E).

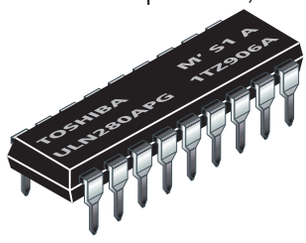
- When no electrons are flowing through the base, electrons cannot flow from C to E. The transistor is in the **cutoff region**.
- When a lot of electrons are flowing through the base, the route from C to E is totally open. The transitor is in the **saturation region**.
- When the flow of electrons through the base is between the cutoff and saturation regions, the transistor is in the **active region**. The flow of electrons from C to E is proportional to the flow of electrons through B.



Integrated circuits

Integrated circuits contain a variety of miniature electronic components, such as transistors, resistors and capacitors. For example, a UL-N2803A integrated circuit has eight pairs of Darlington transistors.

Integrated circuits can be **analogue** or **digital**. We can use them to make amplifiers, radio receivers, microprocessors and other devices.



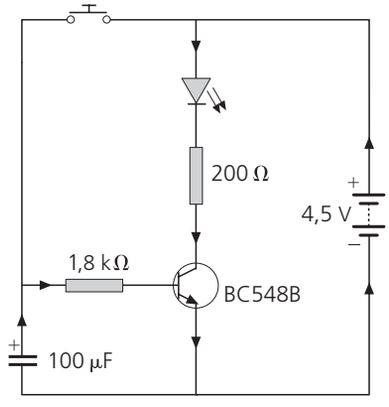
Basic devices with electronic components

We can build various devices with the electronic components discussed in the previous section. Here are two examples:

A timer

The first diagram on the right represents a timer that shuts off automatically.

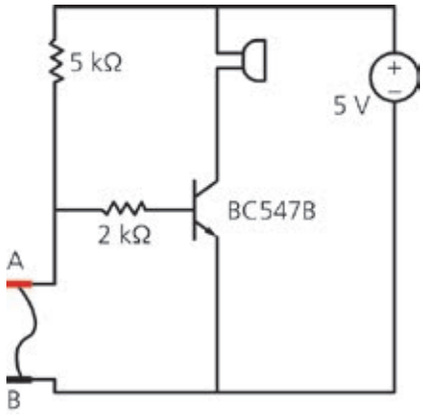
- At first, there is no current flowing through the base. The transistor is in the cutoff region. When we push the button, current flows through the base, the transistor is activated and the LED turns on. The capacitor also begins to charge.
- When we release the button, the LED stays on for some time, using current from the capacitor. When the capacitor runs out of energy, the transistor cuts off and the LED turns off.



A security alarm

The second diagram on the right represents an alarm that rings when a cable breaks.

- When the cable (AB) is connected, electrons don't flow through the base. The cable is an easier route for the electrons to follow.
- When the cable is broken, electrons flow through the base. When the base is saturated, current flows from the collector to the emitter. This activates the alarm bell.



CLIL activities

19 Listen to the four sentences. In your notebook, write what they describe.

20 What devices in your home have timers that shut off automatically? Why are they necessary?

The ... has a timer. It shuts off because ...

21 TASK STEAM Design a circuit for a light that turns on automatically when it gets dark. Use these components: a 4.5 V battery, a light dependent resistor (LDR), an LED and a 2N3055 transistor.