TECHNOLOGY

Grade 9

Book 2

CAPS

Learner Book

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Chapter 1

Component symbols and simple circuits

In this chapter, you will revise the work you did on electrical systems and control in Grade 8. You will also revise simple circuits, circuit diagrams and connecting cells, and lamps and switches in series and parallel. You will then do action research on the effects of changing the voltage in a circuit.

Figure 1: A torch

1.1 Revision 1: Component symbols

"Components" are the parts that we connect in an electric circuit.

Do you remember the symbols for cells, lamps and switches?

Do you remember the difference between joining components in series and in parallel? Let's see what you can remember.

You have already learnt that an electric circuit is a closed path in which a current flows.

The simplest circuit has:

- a power source such as a cell,
- a conductor, and
- a load that provides resistance, such as a lamp.

Cells in series

In series means the cells are connected end-to-end, and the current flows through each cell in turn.

Two or more cells can be connected **in series** to increase the voltage in the circuit. Figure 2 below shows two cells connected in series in a circuit. The positive terminal of cell A is connected to the lamp. The negative terminal of cell A is connected to the positive terminal of cell B, and the negative terminal of cell B is connected to the other terminal of the lamp.

1. Draw a circuit diagram of the circuit in Figure 3 in the space to the right of it.

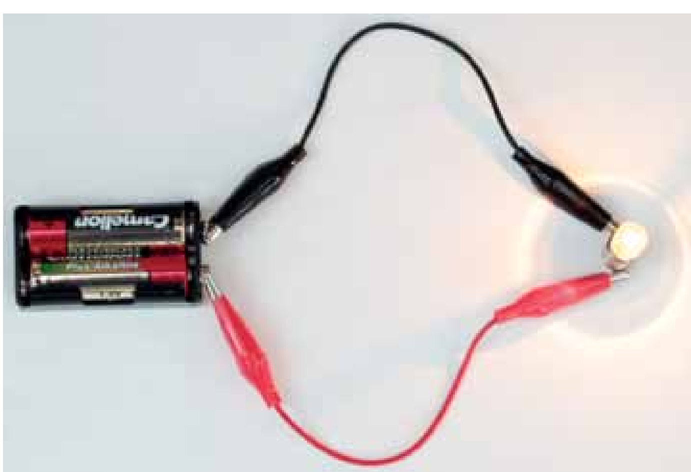

Figure 2: Two cells in series connected to a lamp

2. Figure 3 below shows three cells connected in series in a circuit. Draw a circuit diagram of the circuit in the space to the right of Figure 3.

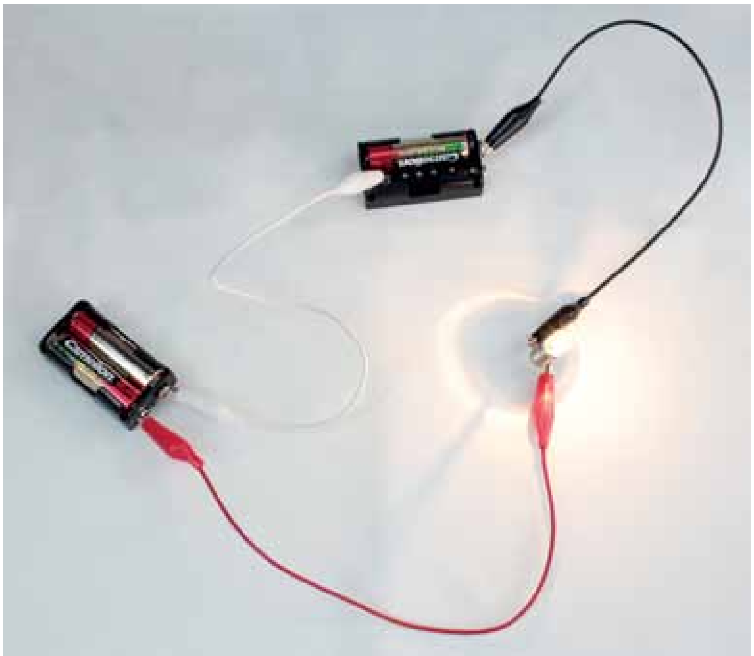

Figure 3: Three cells in series connected to a lamp

When cells are connected in series, their total voltage is the sum of the voltages of the three cells:
1,5 V + 1,5 V + 1 ,5 V = 4,5 V

Cells in parallel

Two or more cells can also be connected "in parallel". A parallel circuit has two or more different paths for the current to travel along.

Figure 4 below shows two cells connected in parallel in a circuit. The positive terminals of both cells are connected to each other and to the lamp. The negative terminals of both cells are connected to each other and to the other terminal of the lamp.

3. Draw a circuit diagram of the circuit in Figure 4 in the space to the right of it.

Figure 4: Three cells in parallel connected to a lamp

> When cells are connected in parallel, the total voltage of the cells is the same as that of a single cell (1,5 volts).

Lamps in series

Two or more lamps can also be connected in series.

The pictures below show circuit diagrams of two and three lamps connected in series with the battery. The positive terminal of the battery (+B) is connected to lamp 1, the other side of lamp 1 is connected to lamp 2, the other side of lamp 2 is connected to the negative terminal (B–) of the battery, and so forth.

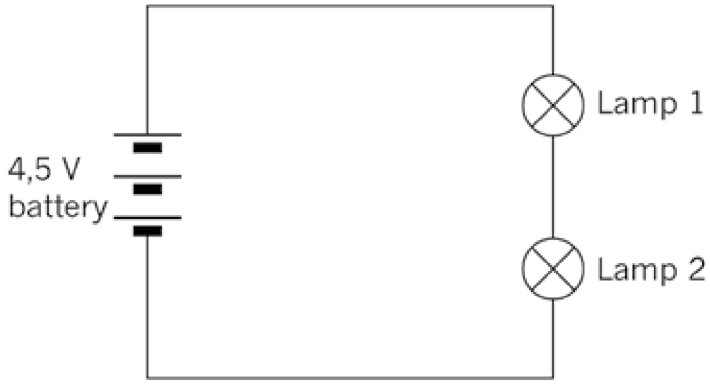

Figure 5: Two lamps in series

Figure 6: Three lamps in series

4. How does increasing the number of lamps in series change the current and voltage in the circuit?

....

....

If all the lamps have the same resistance, the voltage drop across each lamp will be equal to 1,5 V.
When the voltage drops of all the lamps are added, the total battery voltage of 4,5 V is obtained.
The current is the same through each lamp.

Lamps in parallel

Two or more lamps can also be connected to the battery in parallel, as shown in the pictures below. The positive terminal of the battery is directly connected to one side of each lamp and the negative terminal to the other side of each lamp.

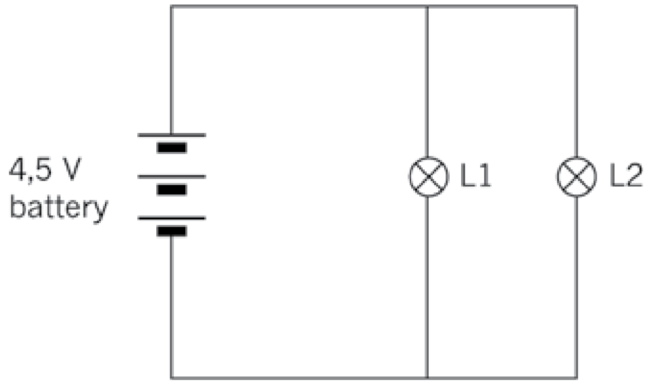

Figure 7: Circuit diagram of two lamps in parallel

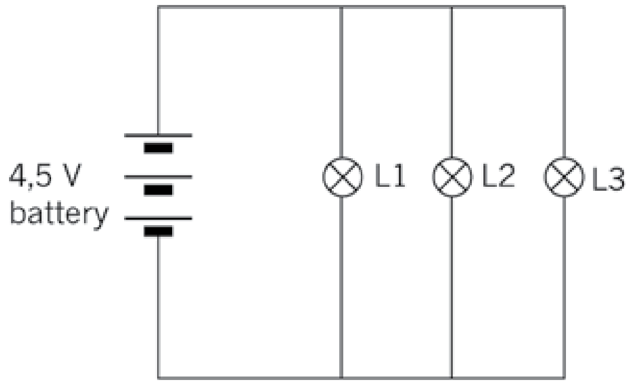

Figure 8: Circuit diagram of three lamps in parallel

The applied voltage is the same across each lamp.

The current is divided across each lamp, and the total current is the sum of the current through each lamp:

$I_t = I_1 + I_2 + I_3$

5. Look at the circuit diagram below and answer the following questions:

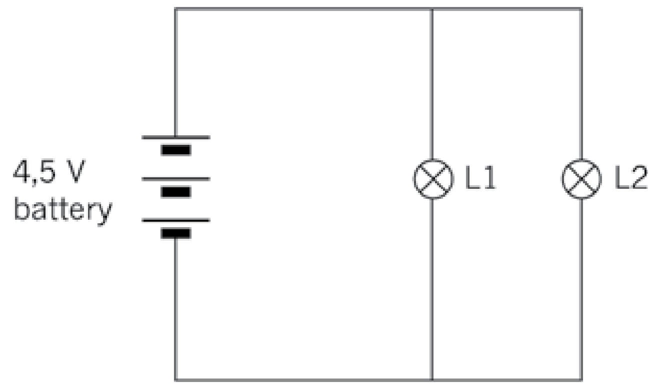

Figure 9

(a) What is the voltage drop across lamps 1 and 2?

....

....

(b) The total current in the circuit is 10 A. If lamp 1 has a current of 4 A flowing through it, what will the current be through lamp 2?

....

Switches in series and parallel

In a circuit with one switch, the switch controls whether the current flows through the circuit or not. If the switch is open, no current flows, as the circuit is not completed. The closed switch allows the current to flow.

Figure 10: Symbols for an open switch and a closed switch

We can use two or more switches to control components in a circuit in more complex ways.

> In a logic circuit, an open switch is regarded as having a value of 0, and a closed switch as having a value of 1.
>
> The switches are the inputs that control the final state of the circuit.
>
> If the circuit is not completed, the output is in the OFF state and has a value of 0.
>
> If the circuit is completed, the output is in the ON state and has a value of 1.

Switches in series

In the circuit below, there are two switches in series. This gives us four different switch combinations. They are:

- Switch A and B both open,
- Switch A open and B closed,
- Switch A closed and B open, and
- both switches closed.

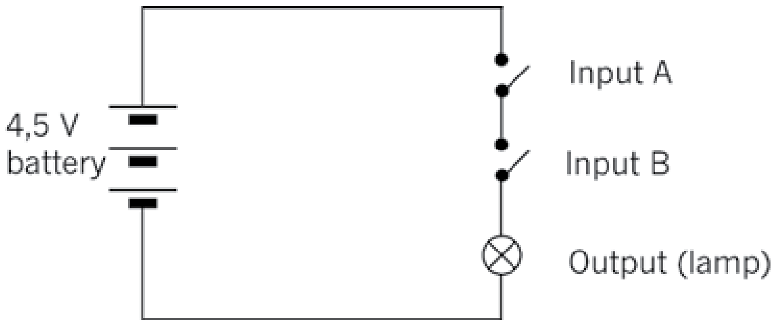

Figure 11: Circuit with two switches in series

Do you see that the current cannot flow through the circuit if either switch A or switch B is open? Both of them must be closed for the lamp to glow.

6. In the table below, "0" means off or open, and "1" means on or closed. Complete the table to show all the different combinations possible in the circuit in Figure 11. To help you, the first two rows of the table have already been completed. Make sure you understand those two rows before you complete the rest of the table

Input A	Input B	Output
0	0	0
0	1	0
1	0	
1	1	

The table showing these combinations is called a **truth table**.

Both switch A *and* switch B must be closed for the circuit to be completed (an output of 1).
So we can see that switches connected in series give us an **AND** function.

Switches in parallel

In the circuit below, there are two switches in parallel. This also gives us four different switch combinations.

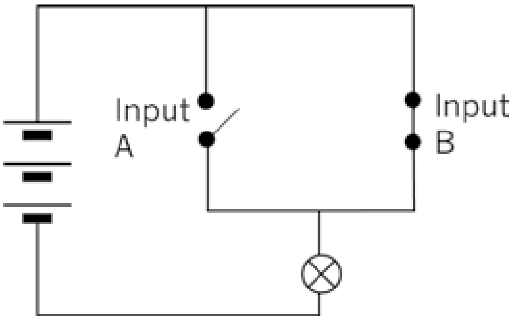

Figure 12: Circuit with two switches in parallel

Do you see that the current can go through the closed switch, even if the other switch is open?

7. Complete the truth table below for the circuit in Figure 12.

Input A	Input B	Output

The truth table shows that when switch A or switch B is closed, the output will be 1 (the lamp will be on).
We call switches in parallel an **OR** function.

Questions for homework

1. Would the lamp light up in each of these circuits? Explain your answer.
   (a)

   ....
   ....
   ....
   ....
   ....

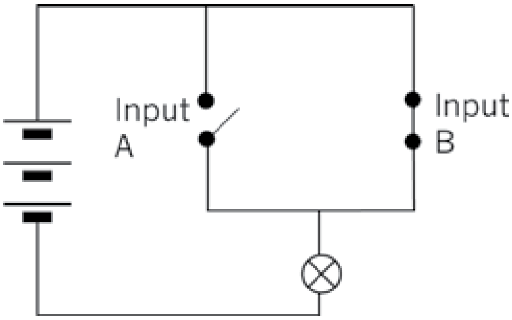

Figure 13

(b)

....

....

....

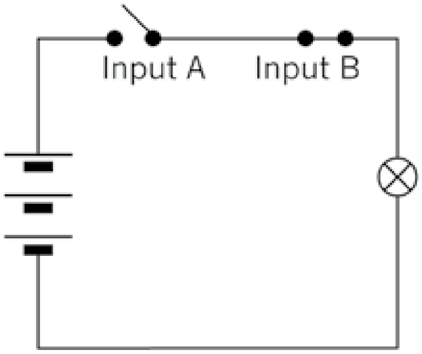

Figure 14

(c)

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....

....

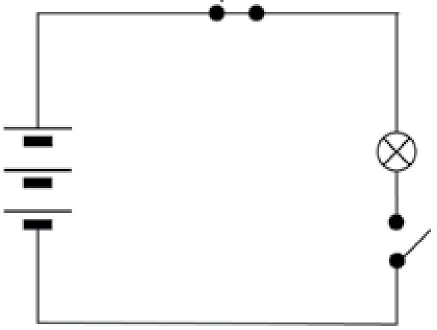

Figure 15

2. A kettle must be switched on at the wall plug first and then at the kettle itself.
   (a) Fill in the truth table to show all the possible combinations.

Wall plug switch	**Kettle switch**	**Output**

   (b) Is this an AND function or an OR function? Explain your answer.

....

....

1.2 Revision 2: Simple circuits

In this lesson, you will set up simple circuits, revising what you learnt about setting up circuits in Grade 8.

You will need the following for this activity:

- two AA cells in cell holders,
- connecting wires,
- a switch, and
- two lamps.

Note that you can use a homemade switch and a cell holder made of insulation tape for this activity.

1. Look at the circuit below.

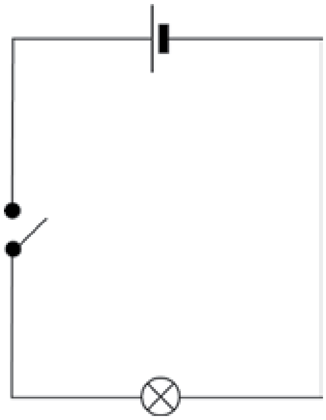

Figure 16

Set up this circuit and check that it works by closing the switch.

(a) Does the lamp light up?

....

When you have the circuit working correctly, move on to question 2. If you need to, you can troubleshoot your circuit by looking at the following:

- If the lamp doesn't light up, but the wires get hot, you may have a short circuit. This means that the lamp is not connected correctly in the circuit, or that it is faulty. Check that the lamp is connected correctly in the circuit.
- If the lamp still doesn't light up, check each component and connecting wire by replacing them, one by one. You can identify which one is faulty this way.

2. Add another lamp to the circuit in series with the first one.
   (a) Draw a circuit diagram for this circuit.

   ....

   ....

   ....

   ....

   ....

   (b) What do you notice about the brightness of the lamps?

   ....

3. Set up the same circuit, but add another bulb in series with the first bulb.
   (a) Draw a circuit diagram for this new circuit.

   (b) Write what you notice about the lamps in this circuit.

   ....

4. Write down your conclusions about changing the number of cells and the number of lamps in the circuit.

   ....

   ....

1.3 Testing voltage and current in circuits

In this lesson, you will investigate the relationship between the value of the voltage and the current in a circuit. You will need to use a multi-meter that can be set to measure the voltage, resistance or the current in a circuit.

V: volts (potential)
A: amps (current)
Ω: ohms (resistance)

Begin by reading the text below on how to use a multi-meter correctly.

Measuring resistance

Identify the section labelled "Ω" on the multi-meter in the picture below.

- Connect the red test lead to the "V ΩmA" terminal, and the black test lead to the "COM" terminal.
- Adjust the function selector switch to "Ω".
- Connect the ends of the test leads across the unknown resistor as shown. Ensure that the resistor is isolated from any other component or power supply.
- Read the value of the resistor from the display, and if necessary adjust the dial to ohm, Ω, to obtain a good reading. Do this in whole numbers rather than in decimals.

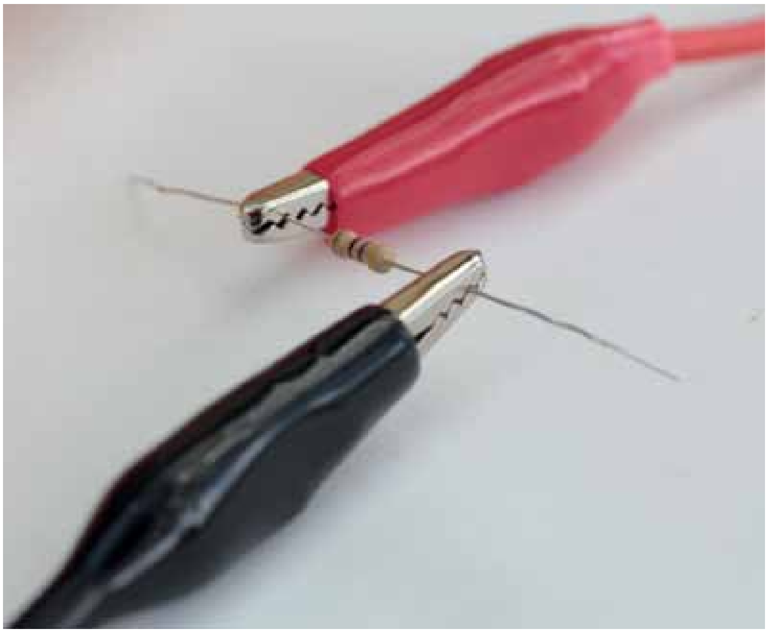

Figure 17: Multi-meter set and connected to measure resistance

Measuring voltage

Identify the section labelled "DCV" on the multi-meter in the picture below.

- Connect the red test lead to the "VΩ mA" terminal, and the black test lead to the "COM" terminal.
- Adjust the range selector to the "DCV".
- Set the meter on the highest range.
- Connect the other ends of the test leads parallel across the part of the circuit where the voltage is to be measured: red test lead to positive (+), and black test lead to negative (–).
- Read the voltage from the display. You may need to adjust the voltage selector until a good reading is displayed. Do this in whole numbers rather than in decimals.

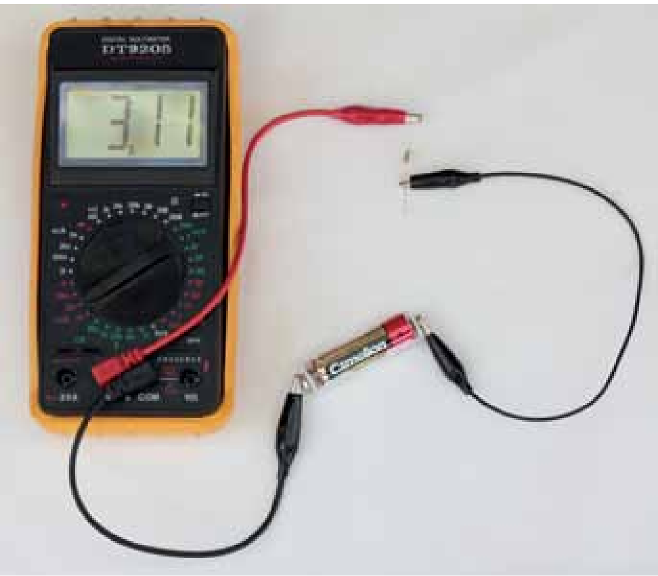

Figure 18: Multi-meter set and connected to measure current

Measuring current

Identify the section, labelled "DCA" on the multi-meter in Figure 18.

- Connect the red test lead to the "V mA" terminal and the black test lead to the "COM" terminal. If the current to be measured is between 200 mA and 10 A, connect the red test lead to the "10 A" terminal.
- Adjust the range selector to the "A" (ampere) region. If you are measuring an unknown current, start from the highest range, then adjust to a proper lower range for the best accuracy.
- Connect the other ends of the test leads in series with the part of the circuit where the current is to be measured. (Disconnect the circuit and place the meter in series.)
- Read the current value from the display.

Action research

You will need the following for this activity:

- three penlight cells (AA) in holders,
- a 500 ohm resistor, with the colour bands exactly as in Figure 19, and
- two multi-meters, or an **ammeter** and a **voltmeter**.

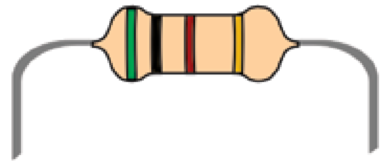

Figure 19: A 500 ohm resistor

In the next chapter, you will learn how the colour bands on a resistor tell you the resistance (ohms).

Set up the circuit as shown in Figure 20 below, using a cell, resistor and ammeter. If you use a multi-meter instead of an ammeter, set it on the amps scale.

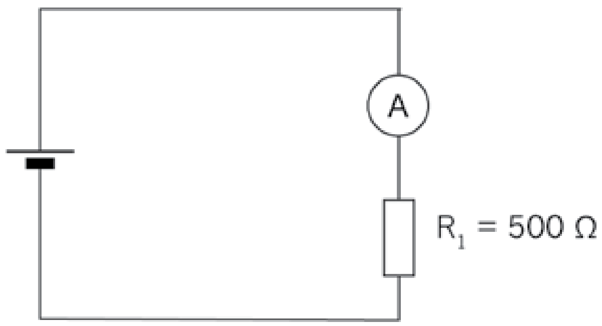

Figure 20: Circuit with one cell, resistor and ammeter

An **ammeter** is always connected in series with the part of the circuit for which you measure the current, so that it measures the full current through that part of the circuit. It has a very small resistance so that it does not change the current in the circuit.

Now connect a voltmeter across the resistor, as shown in Figure 21. If you use a multi-meter instead of a voltmeter, set it on the volts scale.

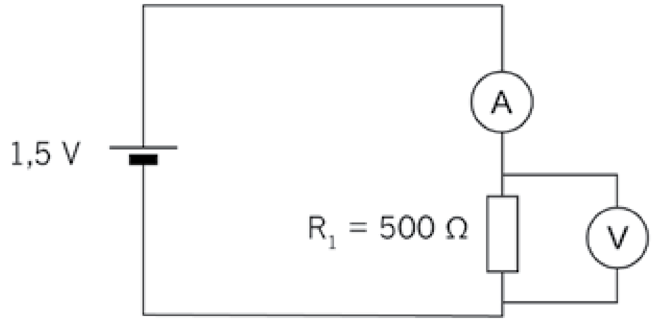

Figure 21: Circuit with one cell, resistor, ammeter and voltmeter across resistor

A **voltmeter** is always connected in parallel with the part of the circuit for which it measures the potential difference between two points. Very little current flows through a voltmeter since it has a very high resistance.

1. Record the reading:

   ....

   ....

Now connect a second cell in series as shown in the circuit diagram below:

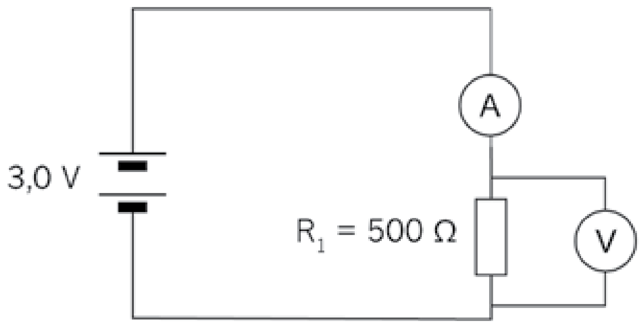

Figure 22: Circuit with two cells in series, resistor, ammeter and voltmeter across resistor

2. Record the reading:

....

....

Now connect a third cell in series as shown in Figure 23.

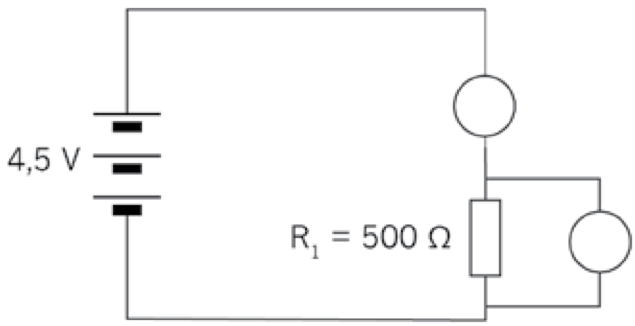

Figure 23

3. Record the reading:

....

....

4. Fill in your readings on the table below:

	With one cell	**With two cells**	**With three cells**
Voltage			
Current			

5. Plot the readings on the graph paper below.

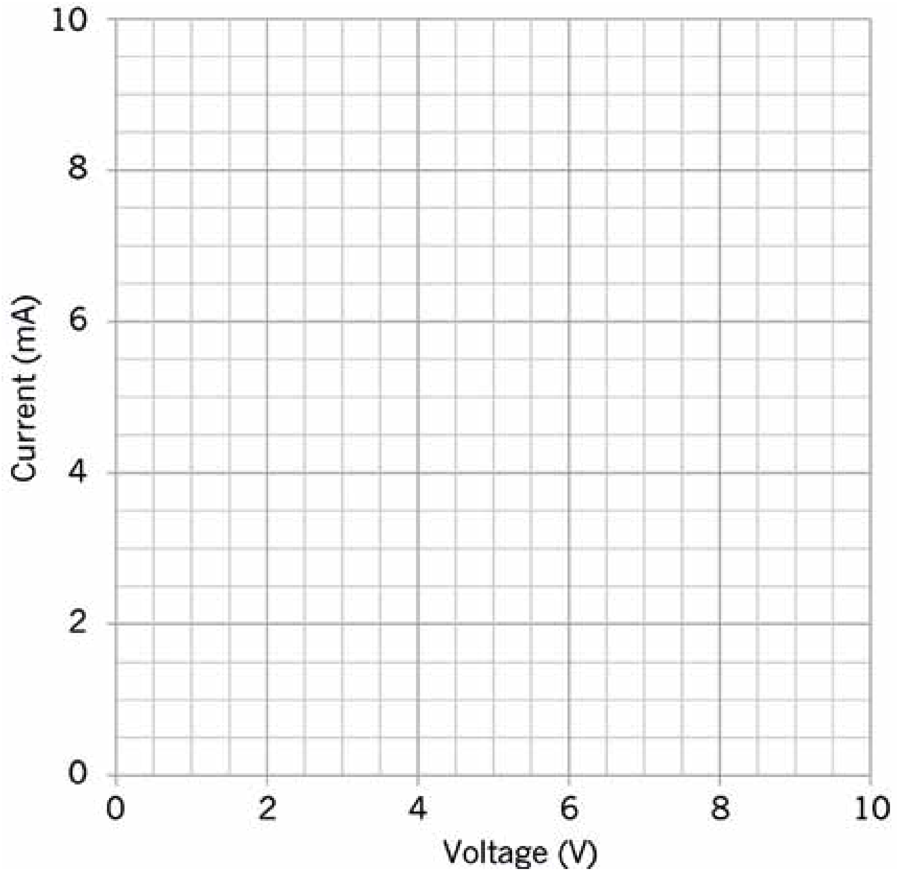

Figure 24: Graph of the relationship between potential difference and current

6. Describe the relationship between voltage and current for a 500 W resistor.

....

- Did you notice that as the voltage is increased the current increases?
- Is your graph in a straight line?

There is a **directly proportional relationship** between voltage and current. As the voltage is doubled, the current will double; and as the voltage is tripled the current will triple.

Next week

Next week, you will look at different kinds of resistors used in circuits. You will also practise doing calculations using the formulas in Ohm's Law.

Chapter 2
Resistors and Ohm's Law

In this chapter, you will learn how to use resistors in electric circuits to control a current. You will discover that there are different kinds of resistors for different purposes, and you will learn how to read the amount of resistance on a resistor. You will also learn about Ohm's Law, which relates the quantities of voltage, current and resistance, and you will use formulae to do calculations to find the values of voltage, current and resistance.

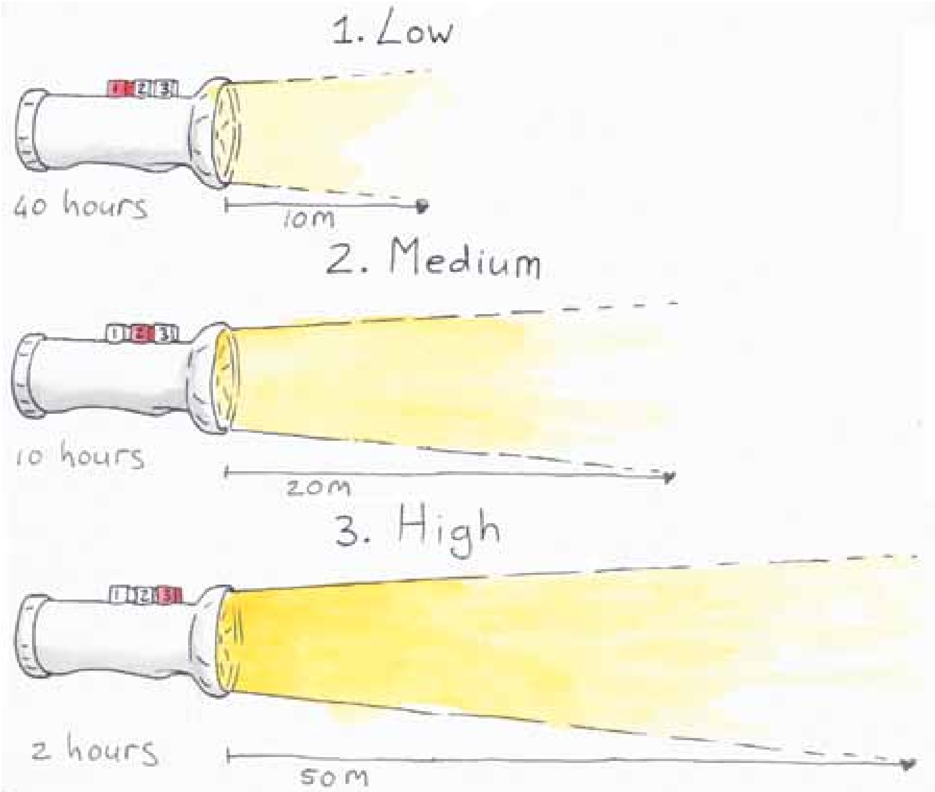

Figure 1: You can change the brightness of the light on some torches. The brighter the light you choose, the faster the battery will run out.

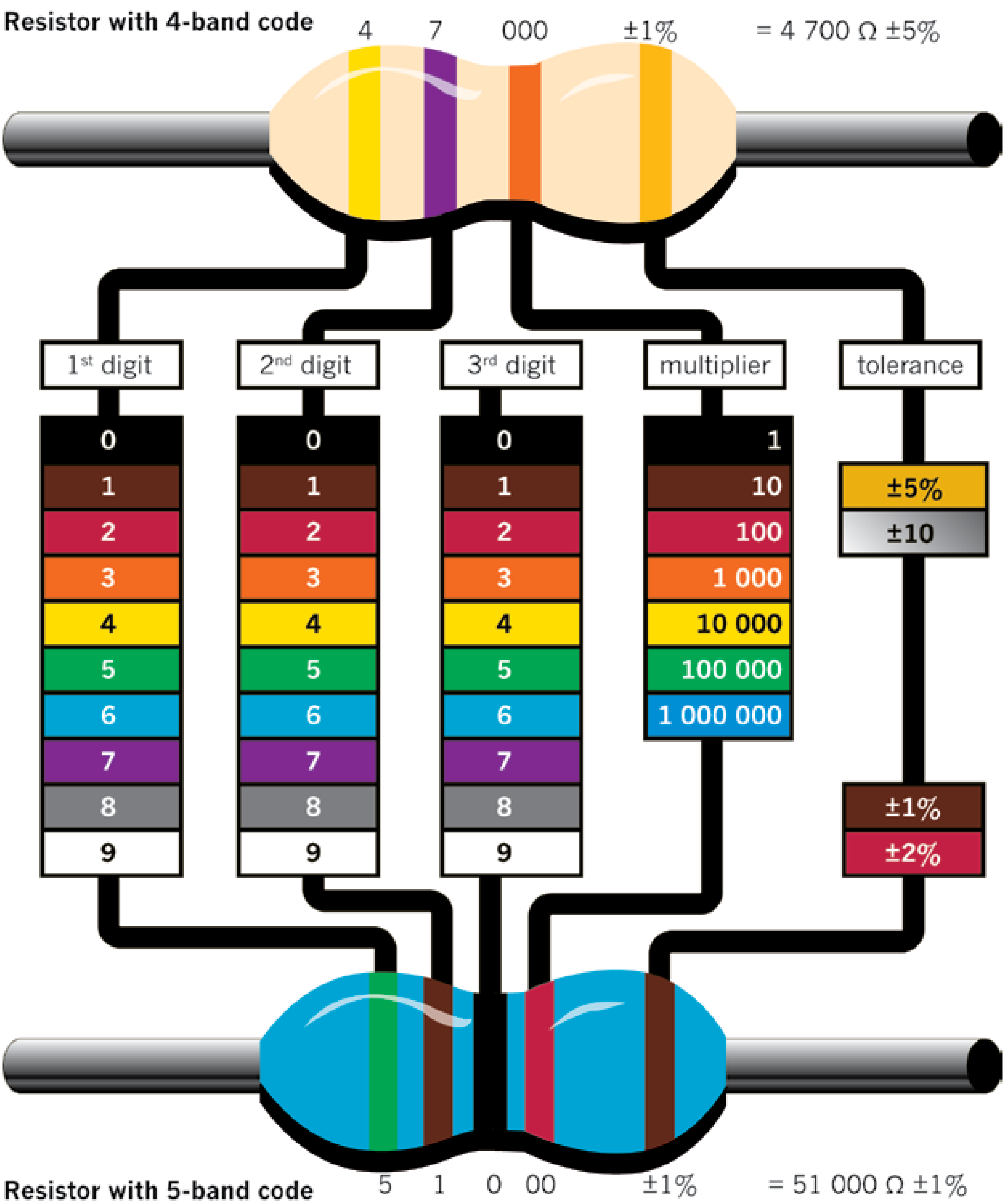

Figure 2: How to read the colour bands on a resistor to find out what its resistance is. (You will only work with resistors with four-colour bands, such as the one at the top.)

2.1 Resistors and their identification codes

What is resistance?

Electricity flows far more easily through copper wire than through plastic wire, string or grass. Copper wire has a low resistance to electricity flow, whereas plastic wire has a high **resistance**. Because electricity flows easily through copper wire, copper is a good **conductor** of electricity.

To **resist** something means to try to prevent it. If you sit in a tree and the wind blows hard, you can resist falling down by clinging to the branches.

To **conduct** means to allow something to pass through.

The resistance that an object, for example a piece of wire, offers to the flow of electricity can be measured.

> Resistance is measured in ohms. We use the symbol Ω.

When electricity flows through a conductor, heat is generated. Some metals, such as nickel and chrome, resist the flow of electricity quite strongly, and heat up when electricity is forced to flow through it. The heating elements of stoves and kettles are normally made of a mixture of nickel and chrome. When some metals get extremely hot, they **emit** light.

When something **emits** light, it is a source of light. A light bulb is a source of light, but a mirror is not a source of light as it only reflects light.

If the resistance in a circuit is very low, for example when the terminals of a cell are connected with a piece of thick copper wire, the current will flow very strongly. This is called a “short circuit”. It can result in so much heat being generated that damage is caused to the cell and other parts of the circuit, the conducting wires can melt and a fire can start.

By adding more resistance to a circuit, you can control how great the current is that flows through the circuit. In this way, you can protect the components in a circuit from too much current flowing through them. Increasing the resistance also means the cell or battery powering the circuit will last longer. You can add precise amounts of resistance by using resistors with the required resistance value.

What is a resistor?

A resistor is a specially designed component that is normally used in a circuit to limit the current. Resistors are made of materials with a high resistance to electricity flow, and come in the form of thin wires or films. Resistors also have precise resistance values that don't change much in different environmental conditions.

The most commonly used resistors look like tubes, with two wires to connect it to the circuit. The symbol to show a resistor in a circuit diagram is an open rectangle or a zigzag line.

Figure 3: A typical resistor

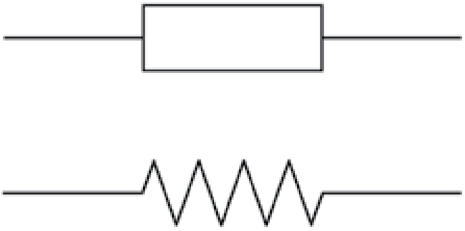

Figure 4: Circuit symbols for resistors

Low-value resistors often have their resistance value printed on them in numbers, while high-value resistors are coded, using coloured bands. The first three bands give the value of the resistor in ohms. The colour-code chart on the second page of this chapter will help you to work out the resistance value in ohms.

Resistors are the most commonly used components in electronics, as they are useful to control current. You will see how they are used in the following weeks.

Units of measurement: ohms, kilo-ohms and mega-ohms

- 1 kΩ = 1 000 Ω = 10^3 Ω
- 1 MΩ = 1 000 kΩ = 1 000 000 Ω = 10^6 Ω

The fourth band on a resistor shows the accuracy rating as a percentage. This is also called the "tolerance". The band is gold or silver, depending on the tolerance. For the circuits you will be building, this is not important.

Kilo means multiply by a thousand, for example 1 km = 1 000 × 1 m.

Mega means multiply by a million.

1. Work out and write down the resistance of each of these resistors:

(a)

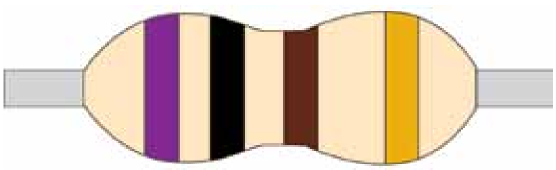

Figure 5

(b)

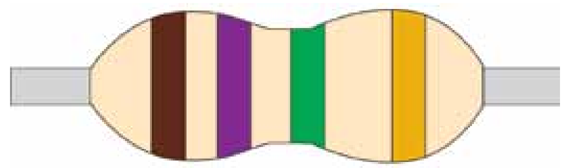

Figure 6

....

(c)

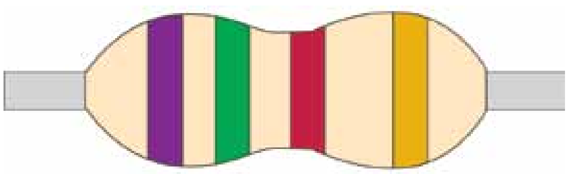

Figure 7

(d)

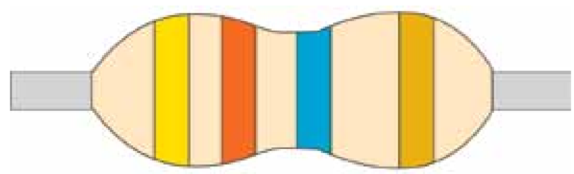

Figure 8

....

2. Fill in the colour codes on these blank resistors to show the given resistance, or write the colour of each band above it if you don't have coloured pencils or pens.

(a) 200 kΩ

(b) 300 Ω

....

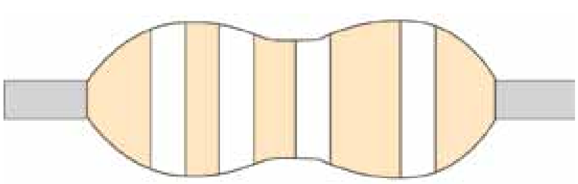

Figure 9

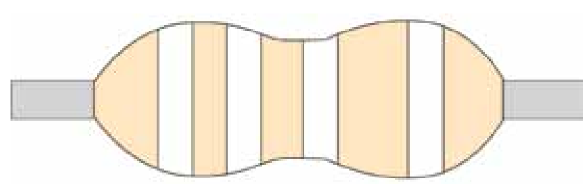

Figure 10

3. Describe the function of a resistor as a component in an electrical circuit.

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2.2 Ohm's Law

There is a special relationship between the voltage, current, and resistance in any circuit. You can control any one of these three **variables** by changing the other two variables.

Ohm's Law states that as voltage increases, the current increases if the resistance is **constant**.

A **variable** is a quantity that can have different values, for example the amount of water in a tank. A **constant** is a quantity that always has the same value, for example gravitational acceleration. Sometimes we call a quantity a constant because we decide to keep it constant.

In the formula for Ohm's Law:

- V is the **potential** or **voltage difference** measured in volts,
- **I** is **current** measured in amps, and
- **R** is **resistance** measured in ohms.

Figure 11 shows this relationship in a formula triangle.

When the voltage and current are known, the resistance can be calculated with:

$R = \frac{V}{I}$.

When the resistance and current are known, the voltage can be calculated with:

$V = I \times R$.

When the resistance and voltage are known, the current can be calculated with:

$I = \frac{V}{R}$.

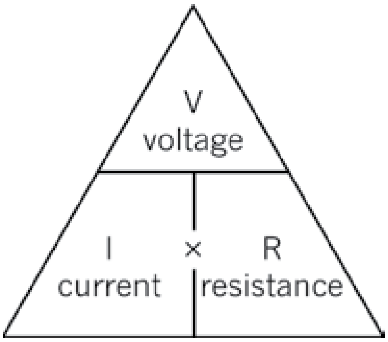

Figure 11

Questions

Consider the following circuit:

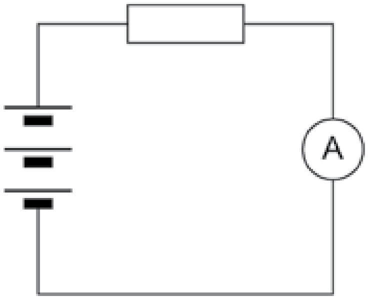

Figure 12

1. What does Ohm's Law say will change in a circuit when the resistance is kept constant but the number of cells in series is increased?

....

2. How will the current change if the voltage supplied by the battery of cells is kept constant but the resistor is replaced by another resistor with a lower resistance?

....

3. How would you describe the relationship between the current and the voltage in a circuit?

....

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4. How would you describe the relationship between the current and the resistance in a circuit?

....

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5. Which of these changes will cause the current through an electrical circuit to decrease? Write down all the letters of the statements that are correct.
   (a) a decrease in the voltage
   (b) a decrease in the resistance
   (c) an increase in the voltage
   (d) an increase in the resistance

....

6. An electrical circuit has three 1,5 V cells in series that is connected to a lamp and a resistor in series. Which of the following things would cause the lamp to shine less brightly? Write down all the letters of the statements that are correct.
   (a) an increase in the voltage of the battery (add another cell)
   (b) a decrease in the voltage of the battery (remove a cell)
   (c) a decrease in the resistance of the resistor
   (d) an increase in the resistance of the resistor

....

2.3 Calculations using Ohm's Law

Last week, you learnt how Ohm's Law can be used to predict what will happen when you change one or two of the following variables: current, voltage or resistance. You will now use the formulas of Ohm's Law to make predictions. Remember to use the correct units in the formula!

Example 1

Calculate the value of the resistance in the diagram below if the voltage across the resistor is 12 V and the current through the resistor is 2 A.

$$R = \frac{V}{I} = \frac{12\ V}{2\ A} = 6\ \Omega$$

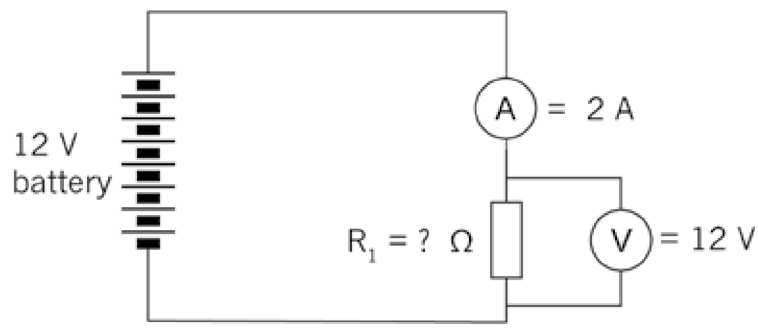

Figure 13

Example 2

Calculate the value of the voltage supply in the circuit below if the resistor has a value of 4 Ω and the current through the resistor is 2,5 A.

$$V = I \times R = 2{,}5\ A \times 4\ \Omega = 10\ V$$

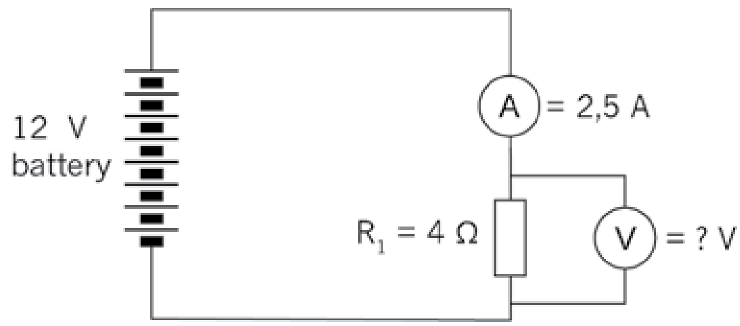

Figure 14

Example 3

Calculate the value of the current in the circuit below if the resistor has a value of 3 Ω and the voltage across the resistor is 12 V.

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

$$= \frac{12\ V}{3\ \Omega}$$

$$= 4\ A$$

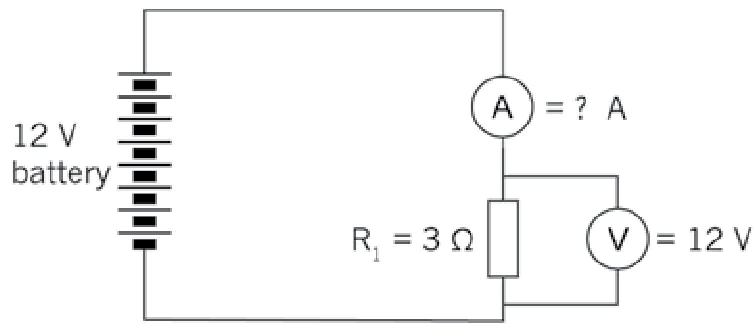

Figure 15

Questions

1. What will the potential difference be if the current in a circuit is 10 A and the total resistance is 1 000 Ω?

....

2. Given V = 10 V and R = 1 kΩ, what will the value of the current be in a circuit?

....

3. Given V = 20 V and R = 5 kΩ, solve for the current.

....

4. A tumble dryer in a laundry service uses a 220 V power source. The coils of the heater provide an average resistance of 12 Ω. What is the current flowing through the heating coils?

....

5. A 9 V battery maintains a current of 3 A through a radio. What is the resistance in the circuit?

....

6. If the voltage across a circuit is increased four times, what would you expect to happen to the current through the circuit?

....

7. (a) In the circuit below, calculate the value of the resistor.

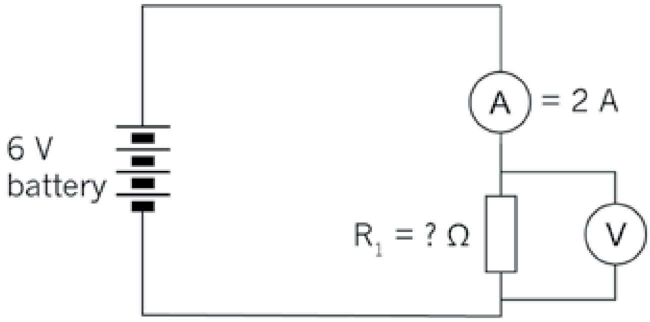

Figure 16

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(b) If two more cells are added to the circuit, will the current increase or decrease? Check your prediction using the formula.

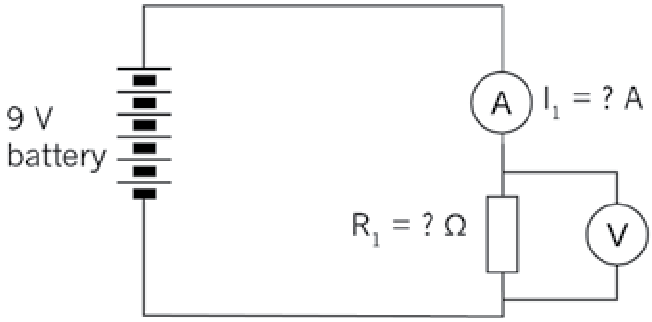

Figure 17

....

8. Calculate the battery voltage for the circuit below:

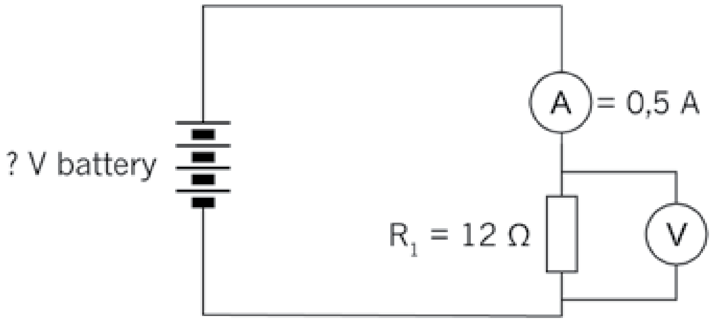

Figure 18

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9. Look at the circuit below:

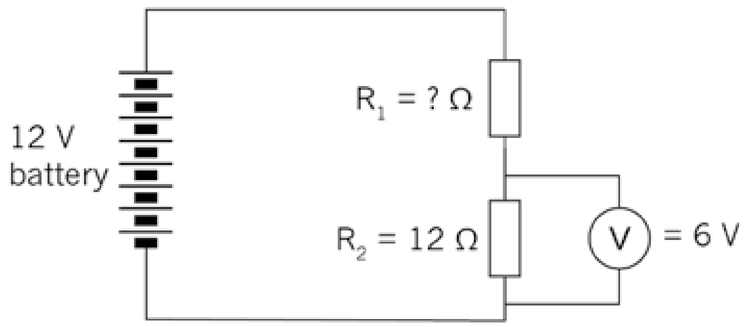

Figure 19

(a) Calculate the current through R_2.

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(b) What will the current be through R_1?

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(c) What will the voltage across R_1 be?

....

(d) What will the resistance value of R_1 be?

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Next week

In the next chapter, you will learn about components commonly used in electronic systems and their special functions.

Chapter 3
Electronic components 1

In this chapter, you will learn about electronic systems and about components in electronic circuits. You will also learn about the following control devices: switches, diodes and transistors. Finally, you will make a simple transistor circuit. An electric circuit consists of an energy source and conductors. Conductors connect components such as input, output and process devices to create a path for the electrons to flow to and from the source of energy. Insulators are used to keep the components from short-circuiting.

Figure 1: A few examples of electronic components that we will deal with in this chapter

3.1 Switches

A switch controls the electric current by closing or opening the circuit. There are various types of switches that control the circuit in different ways. In this lesson, you will learn about manual switches that a user can turn on or off.

1. Think about different switches that you use daily and list them here:

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Push button switch

Push button switches are often used for doorbell circuits, as in Figure 2. This simple doorbell circuit consists of cells in series, a push button and a buzzer, all connected by conducting wire. A person visiting the house presses the button for a short time and then releases it.

Figure 2: A simple doorbell circuit

2. Draw the circuit diagram of the doorbell circuit in the photograph. Use the correct circuit diagram symbols. Note that the cells are in series.

3. Explain in your own words how this circuit works.

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Single-pole, single-throw switch (SPST)

Switches are named using the words "pole" and "throw". Pole refers to the number of circuits the switch controls, and throw refers to how many contacts the switch can make.

Single-pole, single-throw switches (SPST) control one input circuit and make one contact with the output circuit.

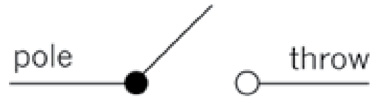

Figure 3: The symbol for an SPST switch

An example of an SPST is a light switch. Below is a typical lighting circuit.

When the switch is closed, the current will flow from the positive terminal (+) of the battery through the switch, through the lamp and back to the negative (–) terminal of the battery.

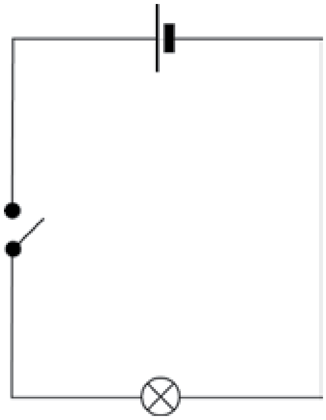

Figure 4: A typical light circuit with an energy source, switch and lamp

Single-pole, double-throw switches (SPDT)

Single-pole, double-throw switches control one circuit, but they make two contacts so that they can control two devices. They turn on device 1 in one position and device 2 in the other position. There is no "off" position for this switch.

An example of an SPDT is a switch that turns on a red lamp in one position and a green lamp in the other position.

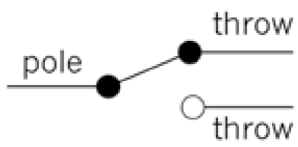

Figure 5: The symbol for an SPDT switch

The circuit diagram below shows a two-way lighting circuit.

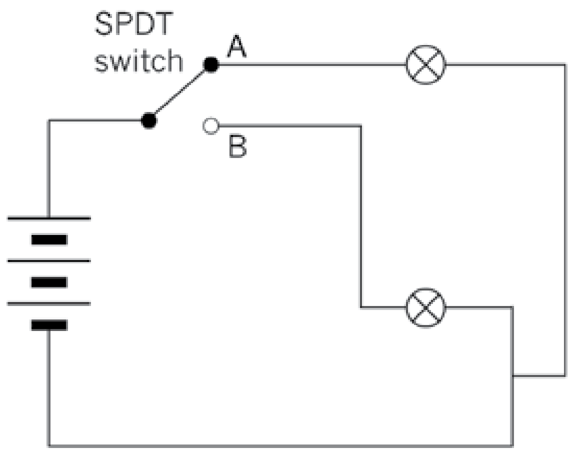

Figure 6: A circuit with a battery, two lamps and an SPDT switch controlling two outputs

4. Explain in your own words how this circuit works.

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5. Think about how you can use an SPDT switch. You can make up an example, as long as it makes sense.

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6. Look at Figure 6 again. An SPDT switch controls two possible outputs. They cannot both be ON, nor can they both be OFF. Is this an example of OR logic or AND logic? Explain your answer.

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7. Look at the circuit diagram below. It shows how one light can be controlled by two different switches.

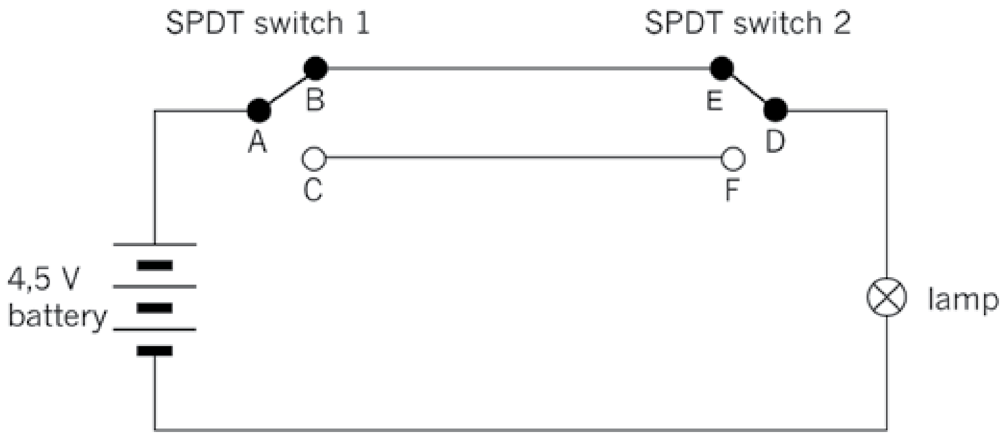

Figure 7: A circuit with two SPDT switches is often used to control a lamp with one switch at each end of a long passage. It is also used to control a lamp with one switch at the bottom of a staircase, and the other switch at the top of the staircase.

(a) Will the lamp turn on if A connects to C and D connects to F? ....

(b) Will the lamp turn on if A connects to C and D connects to E? ....

(c) Will the lamp turn on if AB and ED are closed? ....

(d) Will the lamp turn on if DF and AB are closed? ....

(e) Explain why the type of circuit in Figure 7 is useful for controlling the lamp in a long passage.

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Double-pole, double-throw switches (DPDT)

A double-pole, double-throw switch (DPDT) is like two SPDT switches with their switch levers attached to each other. There are two input circuits, and for each input circuit, there are two possible output circuits.

In the symbol below, the dotted line shows that the switches operate together.

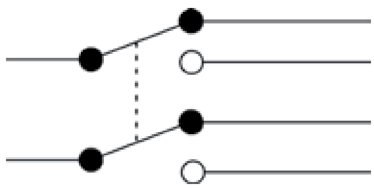

Figure 8

Consider an automatic car gate powered by an electric motor. To open the gate, the motor should turn in one direction. To close the gate, the motor should turn in the *opposite* direction. How can the direction in which the motor turns be changed? The way to do this is to change the direction of the current through the electric motor. Double-pole, double-throw switches can be used to reverse the direction of current through a circuit, so they are useful in applications such as automatic car gates. The circuit diagram below shows how a DPDT switch can change the direction of current through an electric motor.

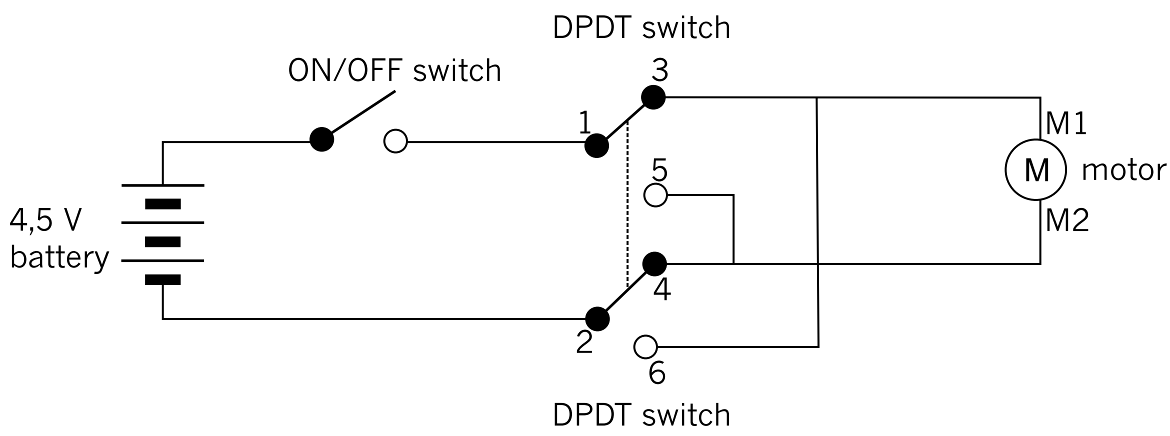

Figure 9: A circuit where a DPDT switch controls the direction in which an electric motor turns

The motor shaft will rotate in one direction when the current passes through it from terminal M1 to M2, but the motor shaft will rotate in the *opposite* direction when the current passes through it from terminal M2 to M1.

When the ON/OFF switch is switched ON, with the DPDT switch in the position indicated in the diagram above, the current will flow from the positive of the battery, through the ON/OFF switch to 1, to 3, through the motor from M1, to M2, to 4, to 2 and back to the negative of the battery.

When the DPDT switch is moved to the other position than in Figure 9, the current will flow through the circuit in the following order:

- from the positive terminal of the battery,
- through the ON/OFF switch to 1,
- through the top part of the DPDT switch from 1 to 5,
- through the motor from M2 to M1,
- to 6,
- through the bottom part of the DPDT switch from 6 to 2, and
- to the negative terminal of the battery.

8. Explain in your own words how this circuit works.

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9. Explain the difference between an SPDT and a DPDT switch.

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3.2 Diodes

A diode is a component with two terminals that can be connected in a circuit. The function of a diode in a circuit is to allow an electric current to flow in the forward direction and to block current in the opposite direction.

If the anode is connected to a higher voltage than the cathode, the current will flow from the anode to the cathode. This is called "forward bias".

If the diode is put in the circuit back to front, so that the voltage at the cathode is higher than the voltage at the anode, the diode will not conduct electricity. This is called "reverse bias".

Diodes are normally used to prevent damage to other components in circuits. For example, some components have positive and negative terminals and will be damaged if a current goes through them in the wrong direction. A diode can protect against a current flowing the wrong way if a battery was put in incorrectly to power the components. If you put batteries into a radio incorrectly, a diode will prevent damage to the radio.

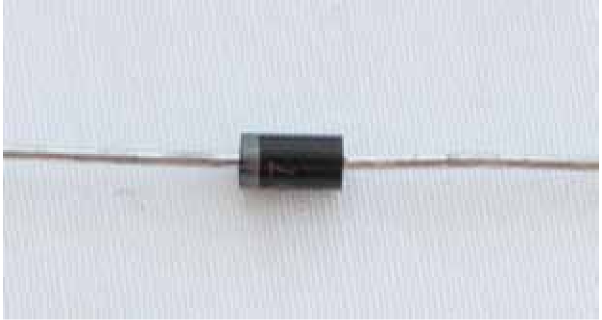

Figure 10: A diode

Diodes vary considerably in size, current-carrying capacity, and reverse blocking voltage. They range from small diodes that can only handle 20 mA with a reverse blockage of 30 V, to large industrial diodes that can carry hundreds of amps and block up to thousands of volts. You can use a multimeter or a simple tester (battery, resistor and LED) to check in which direction a diode conducts.

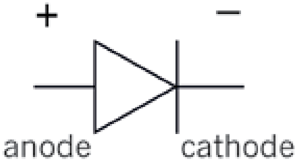

Figure 11: Circuit symbol of a diode. The current flow in a diode is in the direction of the arrow head.

Light-emitting diodes (LED)

A light-emitting diode (LED) is a special kind of diode that glows when electricity passes through it. LEDs produce light of specific colours, based on the materials they are made from. For example, they can produce red, amber, yellow, green, blue, violet and white. The most common colour is red.

LEDs are often used to show if a circuit is working. Think about the small red light glowing on the front of a TV set that can sometimes change from red to amber.

LEDs are used as indicators in many devices, including calculator screens and digital clocks.

The LED will only allow current to pass in one direction. The cathode is normally indicated by a flat side on the casing and the anode is normally indicated by a slightly longer leg. The current required to power an LED is usually around 20 mA.

The arrow symbol for an LED tells you in which direction the current flows.

Nowadays, LEDs are used in many cases where normal light bulbs were used. For example, household lighting is being replaced by LEDs. They are replacing light bulbs because they are more efficient and use much less electric energy. They also last for a long time.

To protect an LED from too much current, a resistor has to be added to the circuit, as in the diagram below.

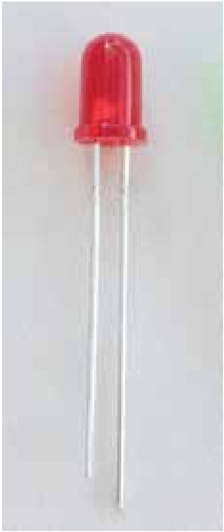

Figure 12: An LED. The longer of the two wires coming out of the LED should be connected to the positive terminal, and the shorter wire to the negative terminal.

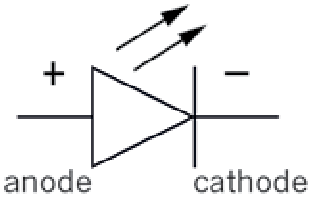

Figure 13: The circuit symbol for an LED.

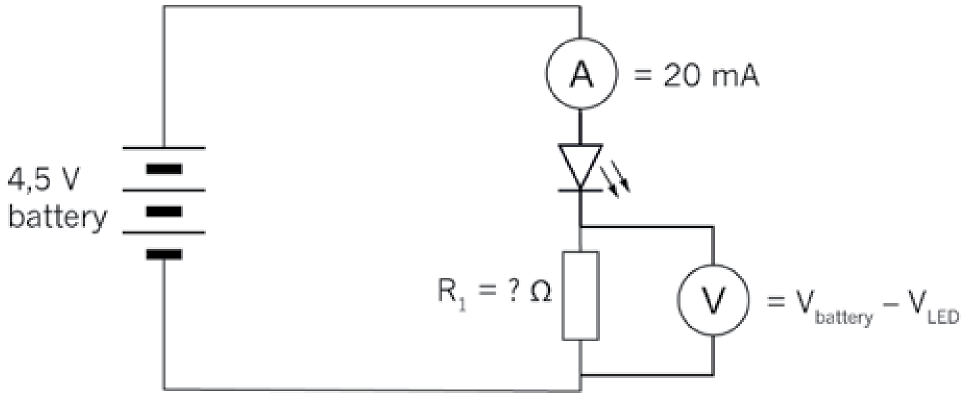

Figure 14: LED circuit with a current-limiting resistor.

Questions

1. Describe the function of a diode in your own words.

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2. List at least four places where LEDs are used. Don't use the examples already given.

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3. How can you make sure that a diode is put in a circuit in the right direction?

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4. Draw the circuit symbols for a diode and for an LED here:

3.3 Transistors

Transistors are very important building blocks of modern electronic devices. They enable us to design smaller and cheaper electronic devices.

A transistor is a semiconductor device that consists of three layers. Each layer has its own connection point with a specific name: **collector**, **base** and **emitter**.

Figure 15: One type of transistor

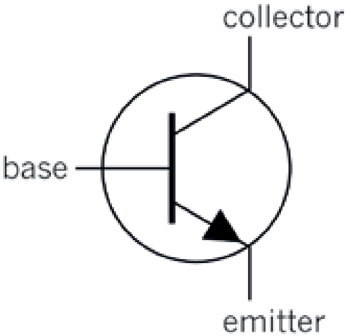

Figure 16: The circuit symbol for an npn transistor

A transistor works as a type of switch to turn current on and off. It can also amplify a current.

An **npn** transistor acts as if there is a switch between the collector and the emitter. With a positive potential on the base of the transistor, the switch is closed. So it is an electrically controlled switch.

Transistor is short for "trans-resistor" and this explains how it works. With a relatively small base current, the resistance between the collector and the emitter is changed. As the base current increases, the collector emitter resistance decreases.

In Chapter 5, you will learn about the applications of transistors.

There are other types of transistors, for example pnp transistors that work a bit differently from npn transistors. But you will only work with npn transistors in this term.

A transistor circuit

Suppose you want to make a switch that is ON or closed when you touch its two terminals with your finger, and OFF or open when you don't touch it. Look at the circuit diagram in Figure 17 for a touch-switch such as the one described. The purpose of this circuit is to light up the LED when you touch the touch-switch with your finger.

Unfortunately, this circuit won't work well, since your finger is a very weak conductor. In other words it has a very high resistance. So the current will be very small when you touch the switch. Therefore the LED will only emit a dim light.

By using a transistor, you can build a circuit that uses the very small current from your finger to switch on a larger current that passes through the LED, which will then emit a bright light.

Figure 18 shows a circuit that uses a transistor for this purpose. In this circuit, the touch switch is an "input device," the *npn* transistor is a "control device," and the LED is the "output device".

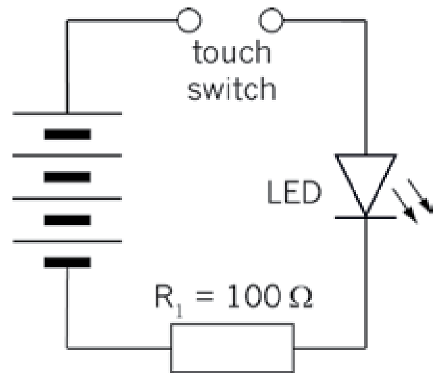

Figure 17: A simple touch-switch circuit that will not work well

A transistor uses a small current circuit to switch on a larger current circuit. This is why transistors are also used in music equipment to "amplify" the sound.

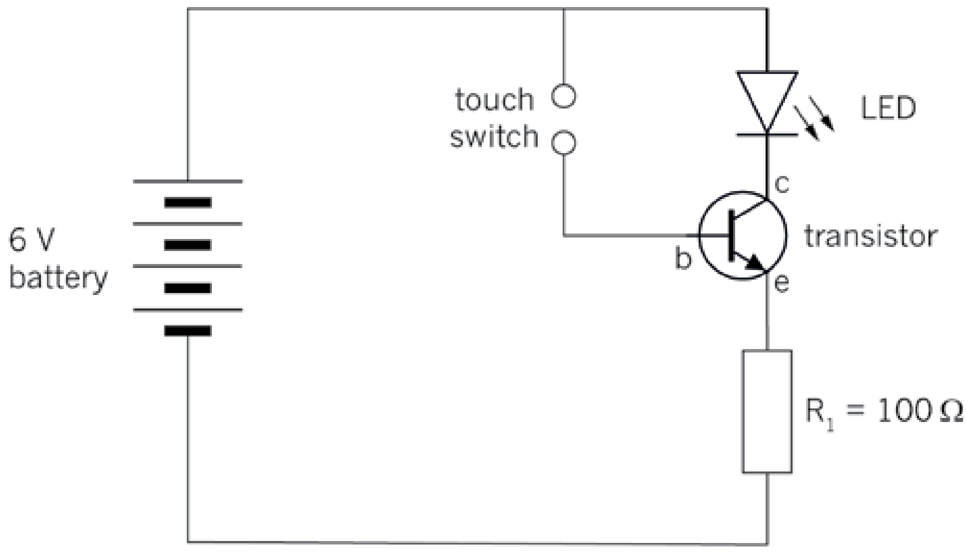

Figure 18: Circuit using a transistor as an electronic switch

1. The photograph below shows a circuit built according to the circuit diagram in Figure 18. Look at the photograph and identify each component in the circuit. Write labels for the different components and draw arrows pointing from the labels to the components.

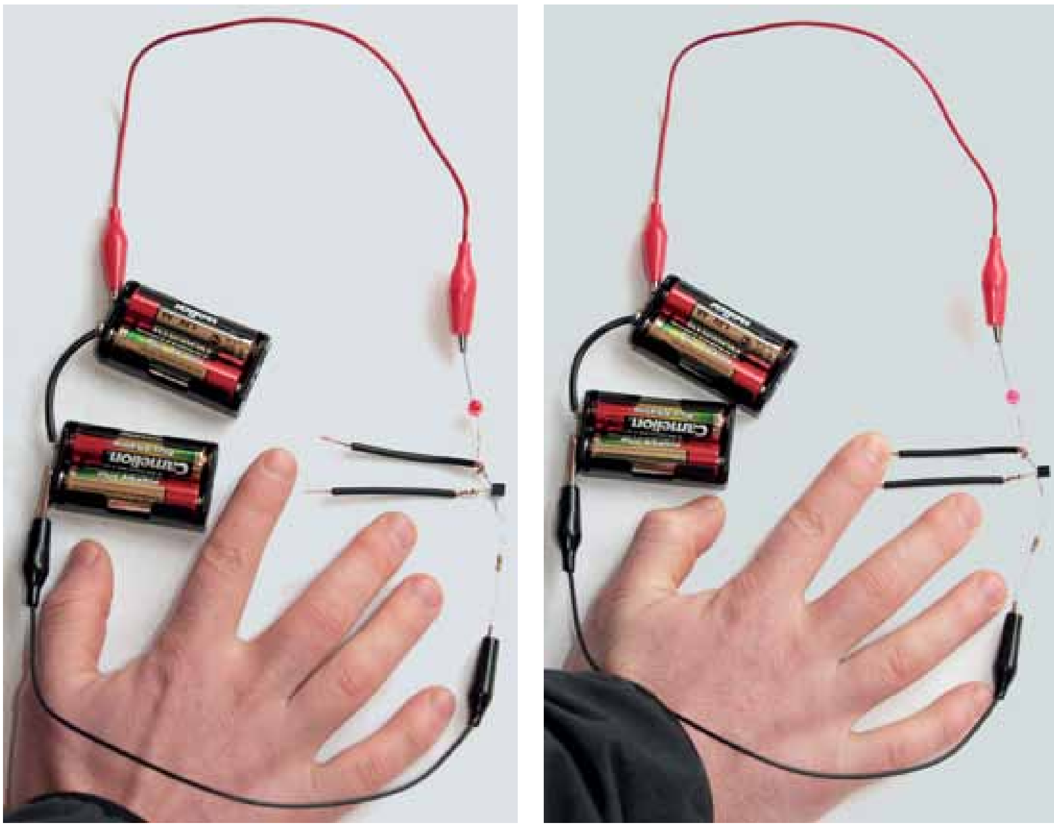

Figure 19: The construction of a touch-switch circuit with a transistor and an LED.

2. Explain how the different parts of the transistor are connected in this circuit.

3. Explain what you expect to see when the touch switch is activated.

4. Touch the two terminals of the touch switch with one finger. Describe what happens.

Next week

Next week, you will learn more about electronic systems and components in electronic circuits. You will also learn about various kinds of input devices: sensors and capacitors.

Chapter 4
Electronic components 2

In this chapter, you will learn more about electronic systems and components in electronic circuits. You will also learn about various kinds of input devices: sensors and capacitors. A touch switch is a sensor that works with the moisture on your skin. This is a very sensitive device that produces a small current. A transistor is required to make the current big enough to have an effect. This week, you will learn about other kinds of sensors and how they are used in devices.

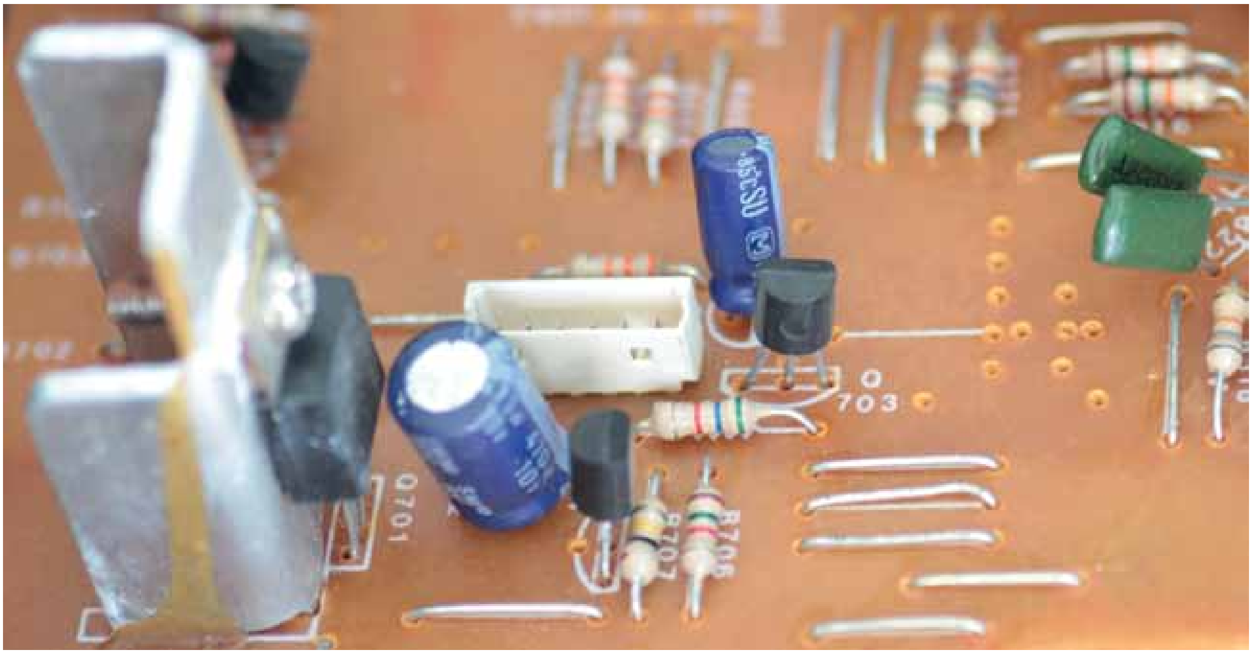

Figure 1: Components connected on a printed circuit board

Figure 2: Measuring the resistance of a thermistor at room temperature.

Figure 3: Measuring the resistance of a thermistor while heating it with a hot object. You can heat a metal thumb tack by pressing it into an eraser, and then rubbing it hard against a piece of wood or plastic for one minute.

Safety warning: *The thumb tack can get very hot and burn your skin, which can cause a wound.*

4.1 Light-dependent resistors (LDR)

A light-dependent resistor, also called an **LDR**, is a resistor of which the resistance *decreases* when it is exposed to light of a higher intensity. It can therefore be used to detect light and trigger warning devices in cases where light may cause problems.

- When an LDR is in the dark, its resistance value will be very high, around 1 MΩ.
- When an LDR is exposed to a light of high intensity, the resistance value will decrease. It could drop from 1 MΩ to 2 kΩ.

An LDR has two terminals that can be connected to a circuit in either direction.

Figure 4: A light-dependent resistor

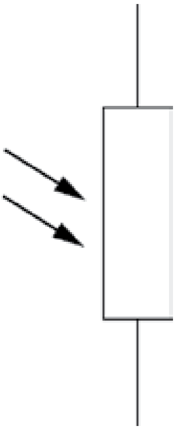

Figure 5: The circuit symbol for a light-dependent resistor

Circuit of a day/night switch

Day/night switches are often used to turn on street and outside lights once it gets dark. It has an advantage above time switches, since the time settings can go wrong, and the amount of daylight does not remain constant during different weather conditions.

In this example, a light-dependent resistor (LDR) is the input device, an *npn* transistor is the control device, and an LED is the output device.

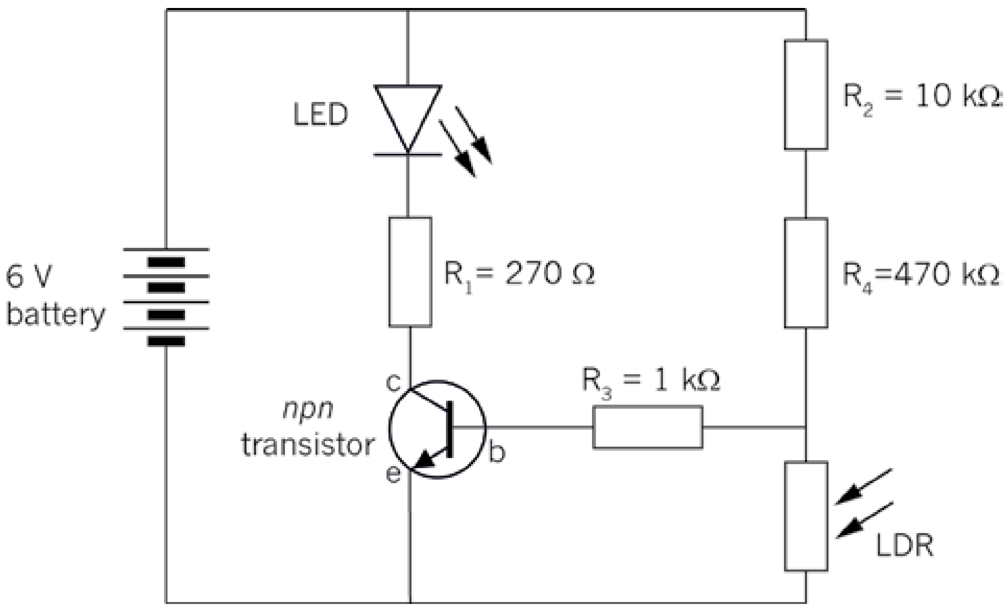

Figure 6: Circuit diagram of a day/night switch

1. Write four examples of when it would be useful to have a device that detects the amount of light, and does something in response to it.

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2. What is the role of the LDR in the circuit?

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3. Describe how the transistor is connected to the circuit.

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....

4. What is the role of the transistor in this circuit?

....

4.2 Thermistors (temperature-sensitive resistors)

The resistance value of this resistor depends on the temperature it is exposed to. There are two types of thermistors:

- A "negative-temperature coefficient" type thermistor, where the resistance value decreases with an increase in temperature.
  This is also called an "NTC" or "–T" thermistor.
- A "positive-temperature coefficient" type thermistor, where the resistance value increases with an increase in temperature.
  This is also called a "PTC" or "+T" thermistor.

Figure 7: A thermistor

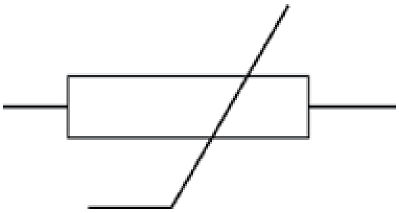


Figure 8: The circuit symbol for a thermistor

1. Write four examples of situations in which electronic devices that use a thermistor of either type would be useful.

   ....

   ....

   ....

   ....

   ....

   ....

   ....

Measuring the resistance of a thermistor

The photographs on the second page of this chapter show the resistance of a thermistor measured at room temperature, and when heated by placing it on a hot object. At room temperature, the resistance is 1 413 Ω. When the thermistor is heated with a hot object, the resistance decreases to 888 Ω.

2. Was the thermistor a PTC or an NTC?

   ....

3. Give reasons for your answer.

   ....

   ....

Heat-activated switch

A thermistor can be used in a heat-controlled switch for a fire alarm. When the thermistor is heated up, its resistance is decreased and the transistor starts conducting a current, switching on the LED.

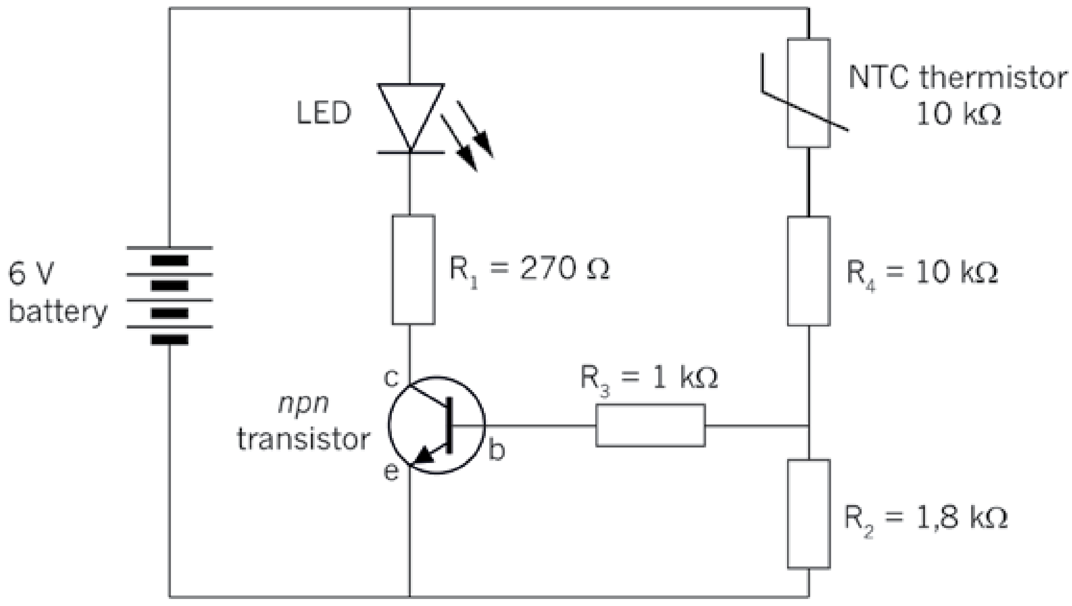


Figure 9: Diagram of a simple fire alarm with an NTC thermistor

4. What is the role of the thermistor in the circuit?

....

....

5. Describe how the transistor is connected to the circuit to amplify the current.

....

....

....

....

6. Draw a simplified circuit diagram for an indicator light to show when a heater has dropped below a certain temperature and starts heating up again.

4.3 Capacitors

The main function of a capacitor is to store electric charge. A capacitor consists of two metal plates separated by an insulator called a dielectric. The ability of a capacitor to store electric charge is called its capacitance.

Capacitance is measured in farad. The symbol "C" is used for capacitance. Because the farad is such a large unit, practical values usually have the prefixes m (milli-), μ (micro-), n (nano-) or p (pico-).

Figure 10: Different types of capacitors

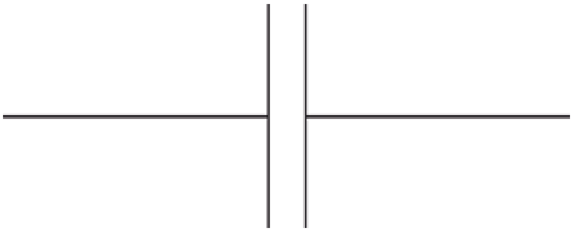


Figure 11: The circuit symbol for a capacitor

When capacitors are connected in parallel, the total area of the metal plates on each side is increased, so the total capacitance is increased.

When capacitors are connected in series, the distance between the opposite plates is increased. And because capacitance is inversely proportional to the distance between the plates, the total capacitance is reduced to less than that of the smallest capacitor.

Charge and discharge of a capacitor

The charging and discharging of a capacitor can be observed by building the circuit in the diagram below. When the switch is switched to position A, the current will flow from the + of the battery, through LED_1, through the switch to one plate of the capacitor. The negative of the battery is connected to the other plate of the capacitor through the resistor R_1. While the capacitor is charging, LED_1 will be ON.

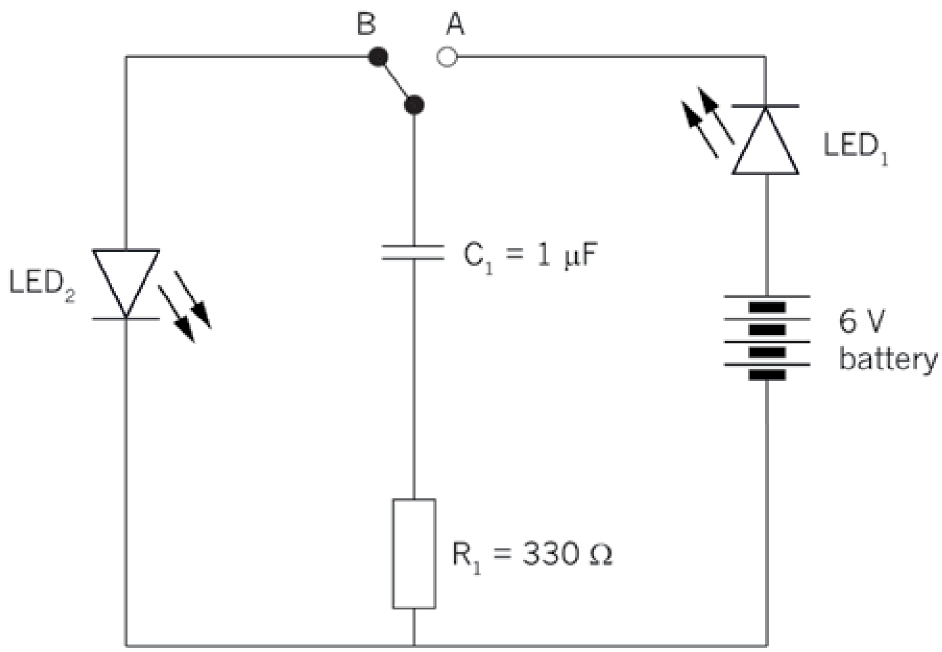


Figure 12: Capacitor charging and discharging circuit

After the capacitor has been charged and the switch is switched to position B, a current will now flow from the + plate of the capacitor through LED_2, and will discharge through the resistor R_1. While the capacitor is discharging, LED_2 will be ON.

Capacitors are often used in electronic devices that need a carefully controlled time delay, such as timers and traffic lights. The exact kind of capacitor can be chosen to get the exact time delay that is needed. Increasing the value of the capacitor increases the length of the time delay.

Questions

1. Name the component in the picture and draw the correct circuit symbol next to the component. Write a brief description of the main uses of the component.

Name of component	Picture	Symbol	Use
			
			
			
			

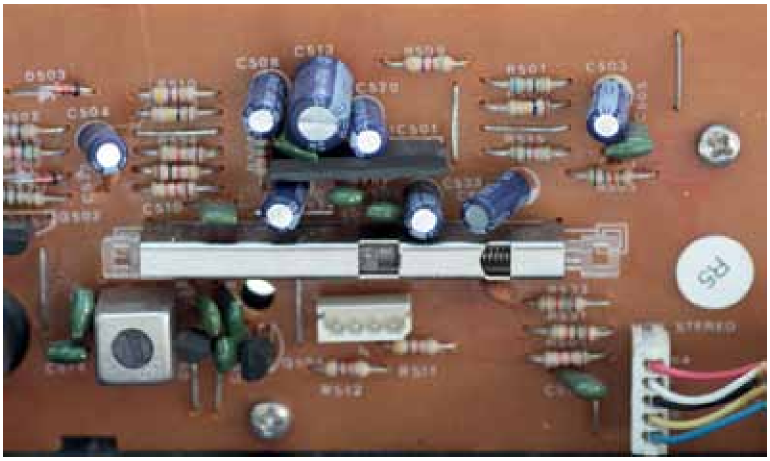
Name of component	Picture	Symbol	Use
			
			

Next week

Next week, you will draw circuit diagrams and build simple circuits.

CHAPTER 5
Build and draw electronic circuits

In this chapter, you will draw circuit diagrams and assemble four electronic circuits, using the components you have learnt about in Chapters 3 and 4.



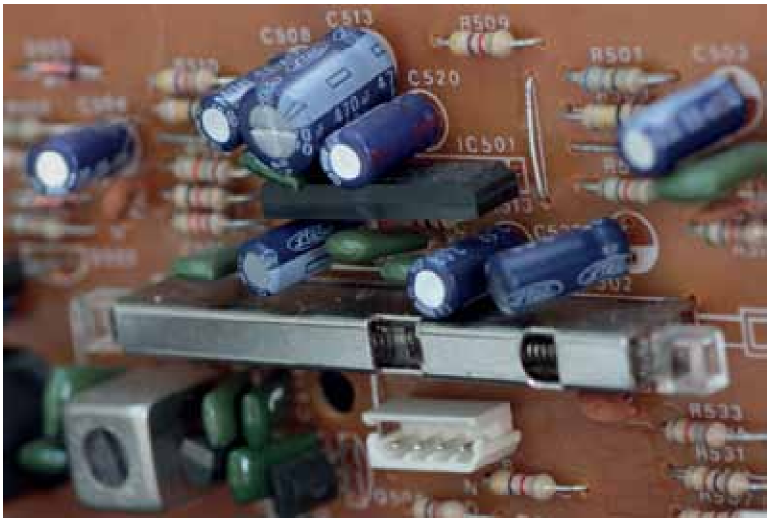


Figure 1: A part of the circuit for a radio

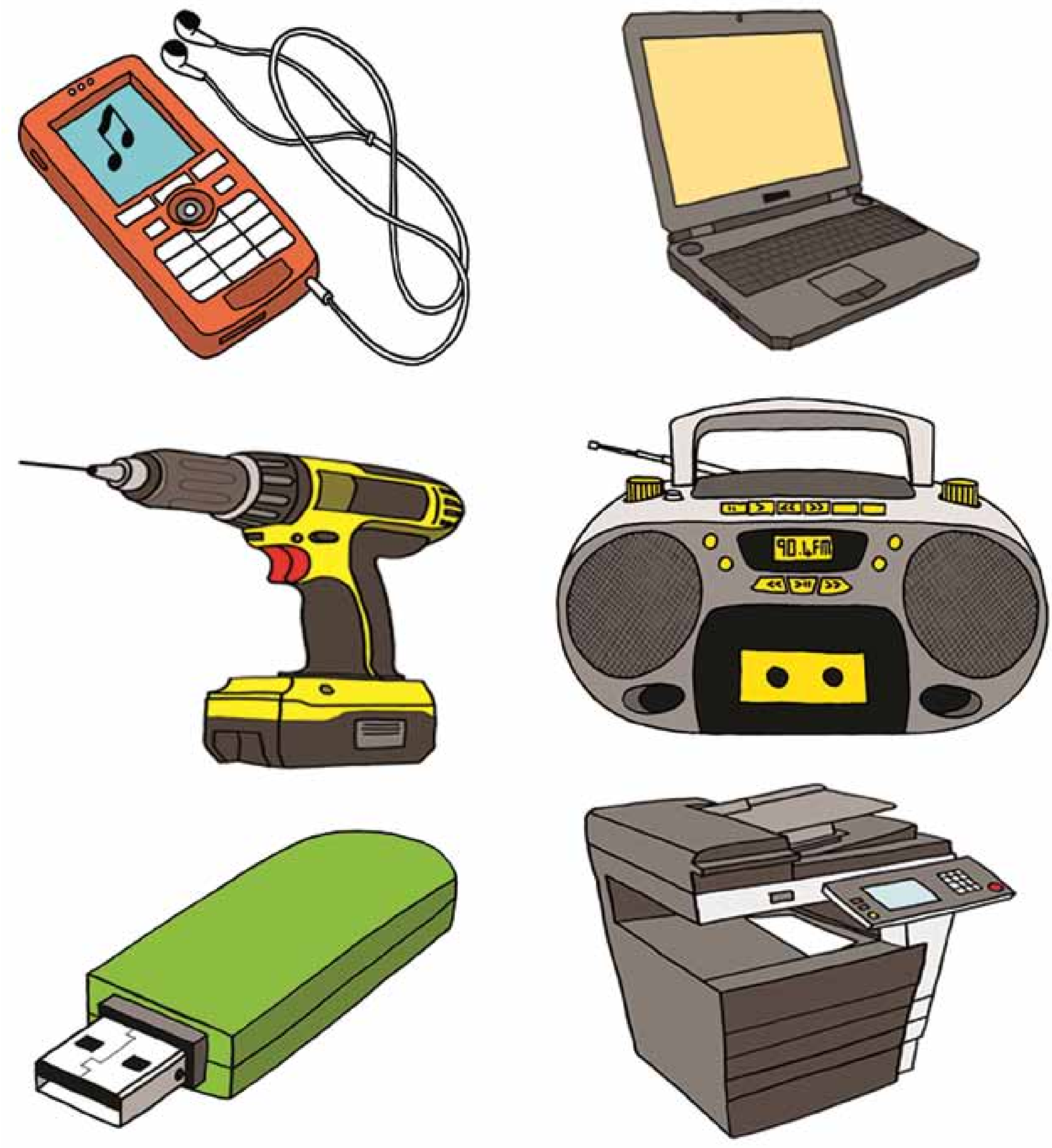


Figure 2: All of these appliances contain electric circuits.

5.1 Simple electronic circuits

A circuit with an LED

In this lesson, you need to assemble a simple LED circuit. You will draw the circuit diagram on your own and then work in pairs to assemble it.

You will need:

- an LED,
- a 470 Ω resistor,
- a switch,
- four 1,5 V cells in series, or a 9 V battery, and
- electric conducting wire with crocodile clips for connections.

The photograph below shows the circuit you need to build.

1. Draw a circuit diagram for Figure 3 in the space on the right.

Figure 3: A circuit with an LED, a battery, a switch and a resistor

A circuit with an LDR

Now you will build a circuit where an LDR regulates the current.

You will need:

- an LDR,
- four 1,5 V cells in a cell holder, and
- a buzzer.

Figure 4: A circuit where the current is regulated by a light-dependent resistor

The photograph on the right shows a circuit where an LDR regulates the current through the circuit.

1. Work individually to draw a circuit diagram of Figure 4 in the space below it.
2. Work in pairs to build the circuit.
3. Predict what will happen when:
   (a) The LDR is covered.

   ....

   ....

   (b) The LDR is in bright sunlight.

   ....

4. Is the buzzer affected by different sources of light, such as light from an electric lamp, light from a cell phone screen or light from a torch? Do a practical investigation and write down your findings:

   ....

5.2 A control circuit and a time-delay circuit

A fire alarm: A circuit with a sensor and a transistor

In the next lesson, you will build the electronic circuit for a fire alarm. In the next chapter, you will use the same circuit but for a different purpose, as part of an automatic kettle switch. It is very important that you complete the circuit and that it works, as you will use it in the Mini-PAT in the weeks that follow.

The type of circuit you will build is used very often to switch an *output device* on and off without using a switch. Instead of a switch controlled by hand, this type of circuit uses an *input sensor* in combination with a transistor to switch the output device on or off *automatically*, depending on the measurement of something by the input sensor.

This type of circuit is called a *control circuit* since one circuit controls another circuit. In the case where a transistor is used with a sensor such as an LDR, the base-emitter current controls the larger collector-emitter current.

Note that resistor 2 and the input sensor may have to change places depending on what relationship between the resistance of the input sensor and the output device you want.

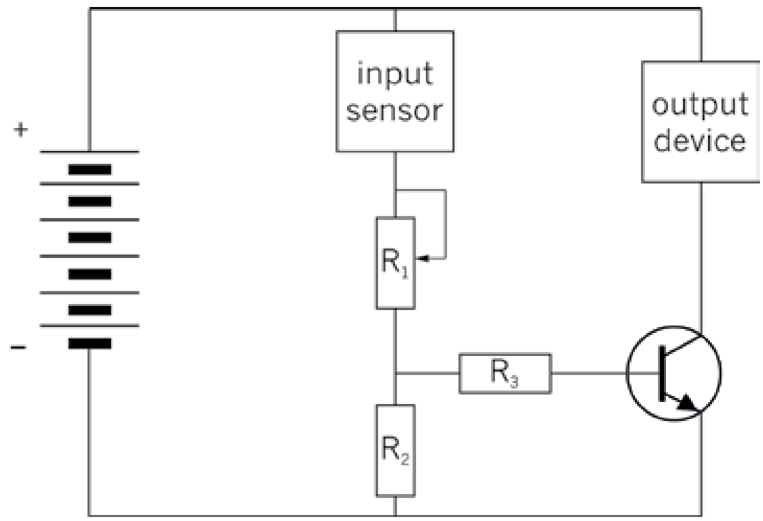


Figure 5: The circuit diagram for the control circuit

- If a *decrease* in resistance of the input sensor should switch on the output device, then resistor 2 and the input sensor should be arranged as in Figure 5. Look back at the circuit for a day/night switch using a light-dependent resistor (LDR) on page 48.
- If an increase in resistance of the input sensor should switch on the output device, then resistor 2 and the input sensor should be arranged in the opposite way of Figure 5. Look back at the circuit for a heat-activated switch using a negative-temperature coefficient (NTC) thermistor on page 51.

It is easier to understand the circuit if you think about a systems diagram. Look at Figure 6. The yellow part is the output side of the diagram.

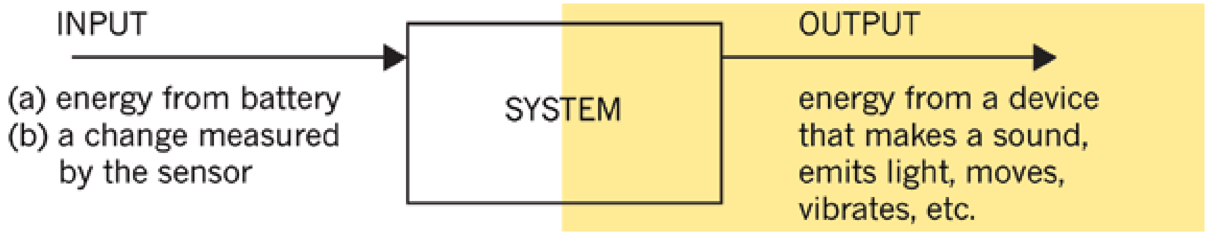


Figure 6: A systems diagram of a control circuit

Figure 7 shows how the circuit in Figure 5 is the same as the systems diagram.

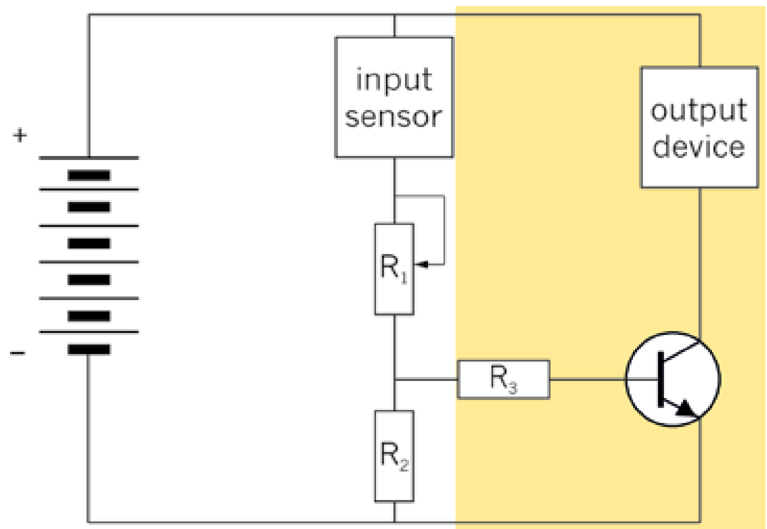


Figure 7

Identify the different components and draw the circuit

The circuit for the fire alarm contains the following components:

- a battery consisting of 6 cells in series,
- an input sensor to measure the temperature,
- a variable resistor to set the temperature at which the alarm should go off,
- an output device to make noise when it gets too hot, and
- a transistor to switch the output device on when it gets too hot.

1. What type of electronic component will you use as the input sensor?

   ....

2. What type of device will you use as the output device?

   ....

3. What voltage does the battery supply to the circuit?

   ....

4. Draw a circuit diagram for a fire alarm:
   (a) Show the correct symbols for the components you will use as the input and the output sensors.
   (b) Show the voltage of the battery.
   (c) Show the emitter ("e"), base ("b") and collector ("c") of the transistor. Look back on what you learnt about transistors in Chapter 3.

Figure 8: A circuit diagram showing the different components in a fire alarm

The purpose of the variable resistor R_1 has already been explained. The purpose of the other two resistors is difficult to explain. It has to do with the minimum current to the base of the transistor that is needed to allow current through from the emitter to the collector of the transistor. If you choose to study more electronics in FET or at university, you will learn about the purpose of these resistors, and how to calculate their resistances.

Someone has already done the calculations of the resistances of different components that should be used for the fire alarm to work. These are called the *specifications* for the resistances of components.

- R1 = 700 to 1400 kΩ (variable resistor)
- R2 = 820 Ω
- R3 = 1 kΩ
- input sensor: 10 kΩ

5. Show the specified resistances of the components on your circuit diagram.

5.3 Build a fire-alarm circuit

Work in pairs to build the circuit.

You need the following materials to build the circuit:

- a 9 V battery and a connection clip with red (+) and black (–) wires,
- conduction wires with crocodile clips,
- a 10 kΩ NTC thermistor,
- a 700 to 1 400 kΩ variable resistor;
- a 820 Ω and a 1 kΩ resistor,
- an *npn* transistor, and
- a buzzer.

1. Now build the circuit. Set the variable resistor to its lowest resistance.
2. Once your circuit is complete, check that all your connections are good.
3. Then connect the battery to the circuit.
4. To test the fire alarm, warm up a thumb tack by pressing it into an eraser, and rubbing it hard against a piece of wood or plastic for a minute. Then press it against the thermistor.

Troubleshooting

If the fire alarm does not work, then:

- test whether the battery is flat or not,
- test all your connections again,
- follow the flow of the current on your board with your finger, to check whether you connected the components the right way, and
- check that you connected the transistor the right way round.

If you have time: Build a time-delay circuit

Capacitors are often used in time-delay circuits.

You will need:

- four 1,5 V cells in series, or a 9 V battery,
- two LEDs,
- a 470 Ω resistor,
- a 1 000 μF capacitor, and
- an SPDT switch.

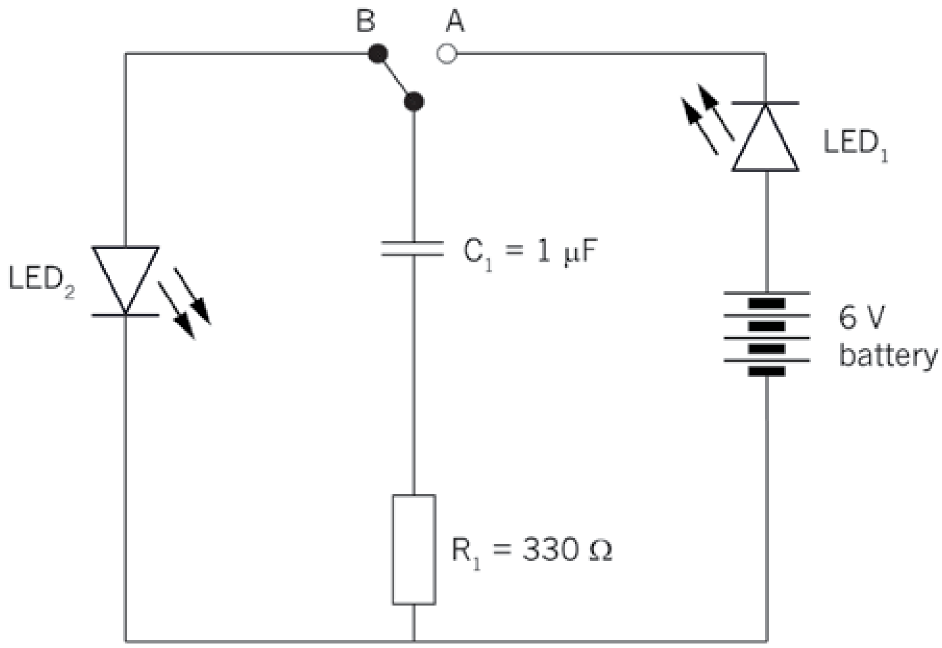


Figure 9: A time-delay circuit

1. Build the circuit. Put the switch to A and observe the LEDs. Describe what happens and explain it in detail.

....

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Further reading: Boards on which more complicated circuits are built

If you try to build a more complicated circuit by connecting components using conducting wire and crocodile clips, many wires will cross one another and the circuit will be messy, looking like a tangled bunch of ropes.

To make a complicated circuit in a neater and smaller way, most circuits are built on boards such as "bread boards", "strip boards", or "printed circuit boards" (PCBs).

Figure 10 below shows a simple LED circuit, such as the one you built in section 5.1, but here it is built on a strip board. Notice that there are no connecting wires used to build this circuit! This is because at the bottom of the strip board there are parallel copper strips connecting the holes in each column. This makes it possible to construct a circuit without using wire.

Figure 10: A simple LED circuit built on a strip board

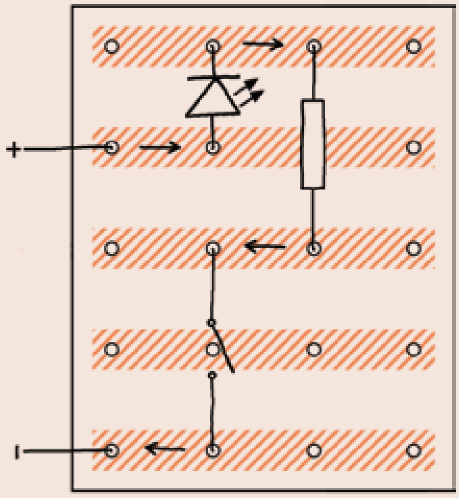


Figure 11: One possible layout of the simple LED circuit on a strip board

Figure 11 shows one possible plan of how to arrange the simple LED circuit on a strip board. The copper strips are at the bottom of a strip board, and not visible from the top. Therefore the copper strips on the drawing of the layout were drawn with hatching, to show that you cannot really see them from the top.

The arrows on Figure 11 are drawn to help you understand how current flows through the copper strips at the back of the strip board. The current flows in the direction of the arrows.

The connectors of the components are soldered to the copper strips at the bottom of the strip board. This is to ensure that they make proper electrical contact with the copper strips.

Soldering is done with lead, because lead is a good electrical conductor and has a low melting point, so it is easy and quick to melt it with a soldering iron.

Bread boards and printed circuit boards are other types of boards used to build complicated circuits. They also have copper connections at the back, but these connections are arranged in a different way than on a strip board.

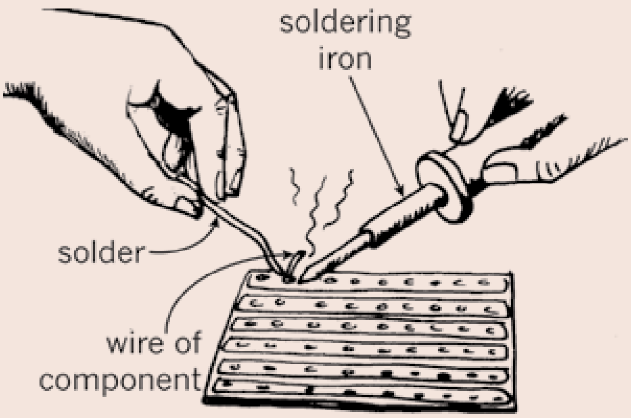


Figure 12: Soldering components onto the back of a strip board

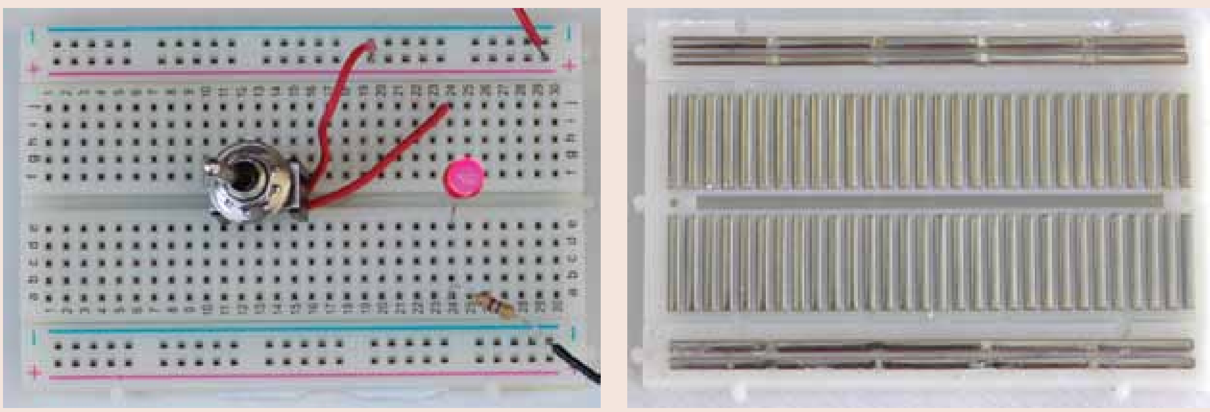


Figure 13: The front and back of a bread board

With a breadboard it is not necessary to solder connections, since each hole in the breadboard has a spring that grips the wire tightly to make proper electrical contact.

Almost all manufactured electronic devices use printed circuit boards, where the copper connections at the back can be made in any pattern. This makes it possible to make complicated circuits that are very small.

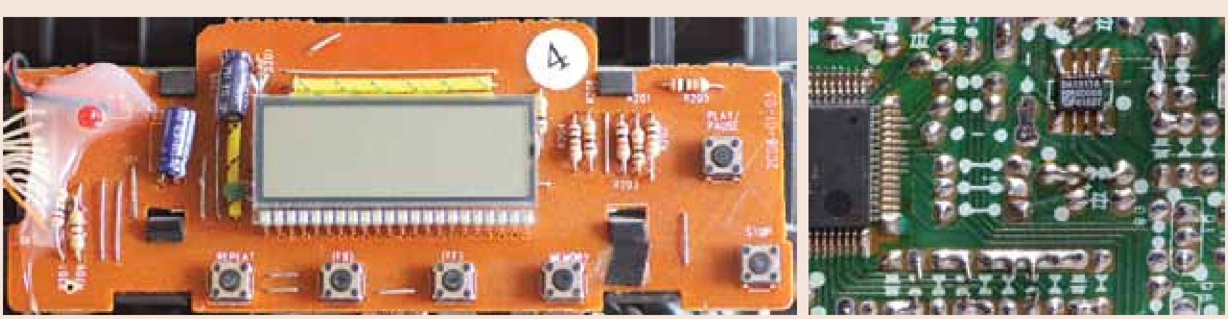


Figure 14: The front and back of a printed circuit board

Next week

The next chapter is your Mini-Pat for this term. You will learn how an electronic circuit can be used to control another circuit with a much bigger current. You will build a device using both circuits and then test it.

Chapter 6: Mini-PAT
Electronic systems and control

In this Mini-PAT you will first study where electronic circuits, using very small currents, are used to control electric circuits with much bigger currents. You will then design and build your own electric circuit that will be controlled by an electronic circuit.

Assessment

Situations where electronic systems control electric circuits (individual work)	[5]
Design brief and sketches (individual work)	[12]
Evaluate and improve the design (team work)	[8]
Final drawings of the design (individual work)	[15]
Make the switch (individual work)	[25]
Presentation (team work)	[5]
	[Total marks: 70]

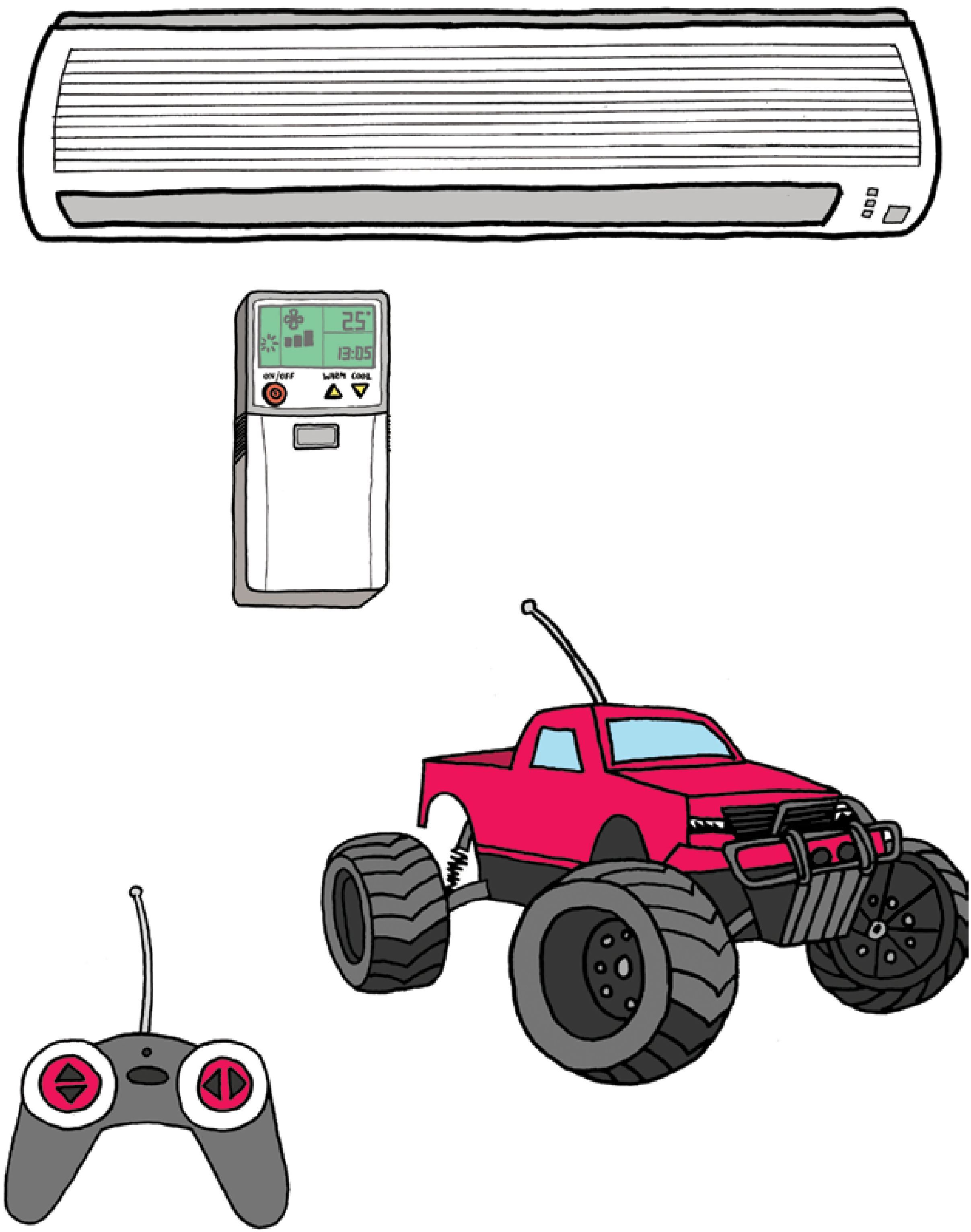
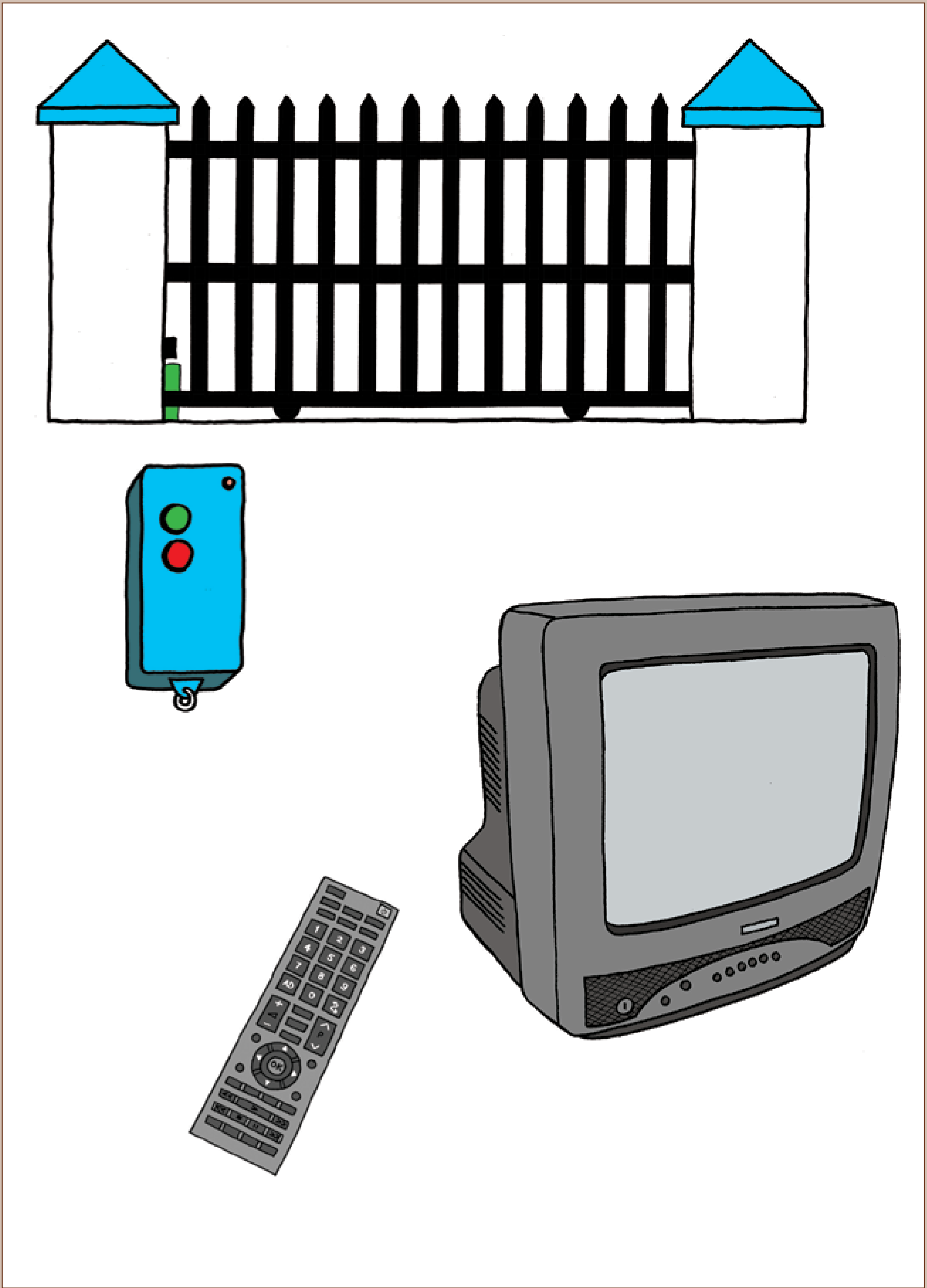


Figure 1: Many everyday devices use electronic control circuits.



Week 1

Situations where electronic circuits control electric circuits (30 minutes)

There are many household appliances that use **electronic circuits** to control electric circuits with bigger currents.

The following two devices are used inside the electric switchboard (or distribution board) of every building that is connected with electricity in a safe way.

An **electronic circuit** is different from an electric circuit because it only uses a very small current, and because it uses electronic control devices such as thermistors, LDRs, diodes and transistors.

- **Ordinary circuit breakers:**
  Shuts off a circuit (for example the circuit supplying all the lights in a house) when the current becomes too big (if the current is too big for the thickness of wire used, the wire will overheat).

- **Residual-current circuit breakers:**
  Switches off the main power supply if it detects a leakage of power, such as when a person accidentally touches a "live" electrical wire or contact and the electricity is then conducted through his or her body. This device has to cut the current very quickly; otherwise the person can die due to electric shock. Therefore it switches off the power even when it detects only a small amount of leakage of electrical current.

Figure 2: An electrical distribution board with circuit breakers

The following household appliances use electronic circuits to control them:

- **ovens:** to control the temperature,
- **radios and other music appliances:** to control the volume of the speakers,
- **some energy-saving lights:** to switch off automatically when there is enough natural light, and
- **kettles:** to switch off when the water boils.

1. Give two examples of situations or applications where electrical circuits are used. (1)

   ....

   ....

   ....

   ....

2. Give two examples of situations or applications where electronic circuits are used. (1)

   ....

   ....

3. Give three examples of situations or applications where electronic circuits and electric circuits are used together. (3)

   ....

   ....

Total [5]

Investigate: A circuit with an input sensor, control knob, transistor and output device (15 minutes)

A *sensor* is a control device that can have a *variable effect*. A switch can only be open (infinitely large resistance) or closed (zero resistance), so a switch is not a sensor. Devices such as thermistors and LDRs can have different resistances, depending on the temperature or amount of light. They can therefore be used as sensors. A device that can generate a voltage, such as a photovoltaic cell, can also be used as a sensor. A sensor "senses" something such as temperature, or light, just as your body's senses do. A variable resistor is also a control device, but it is not a sensor, because it is a device for which the user can *set* the resistance.

The circuit for the fire alarm that you built in Chapter 5 can be used for different applications where a small input current from an input sensor has to switch on a circuit with a larger current for an output device. There is also a variable resistor so that the user can determine at what level of light or temperature (for example) the output device should be switched on or off.

Figure 3: The control knob of a stove plate is connected to a variable resistor. This controls the current through the heating element. The bigger the current, the hotter the plate will be.

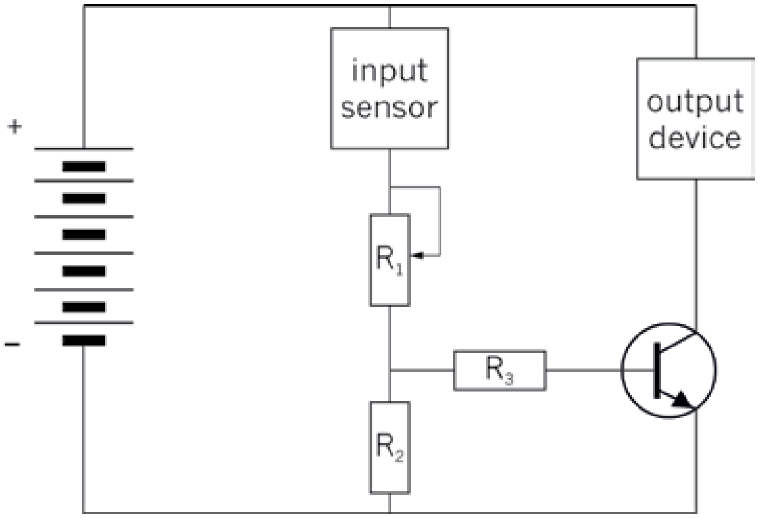


Figure 4: The control circuit that you built in Chapter 5 for a fire alarm

1. Name three input components that you know of.

   ....

2. Name three output devices that you know of.

   ....

3. Name a device that uses a control knob to set the level of something.

   ....

Design brief and initial sketches (75 minutes)

The scenario for the Mini-PAT

A kettle uses electricity at a rate 30 times higher than a normal light bulb. A lot of electricity can be saved if a kettle is used more effectively.

If a kettle keeps boiling without being switched off, it uses electricity unnecessarily. This leads to a waste of electricity.

If you drink your tea or coffee without cold milk, you do not want boiling hot water (100 °C), since it will burn you. So it is a waste of electricity and time to bring the water to boiling point (100 °C). Most of the time, a kettle only needs to heat water to a temperature of about 75 °C. If the kettle keeps heating the water to a temperature of 100 °C, it is a waste of electricity.

You will design and make an "energy-saving switch" for a kettle. The switch will be controlled by an electronic circuit so that the kettle will automatically switch off when the water reaches the required temperature. The electronic circuit will have a variable resistor so that the temperature at which the kettle will automatically switch off can be set by the user.

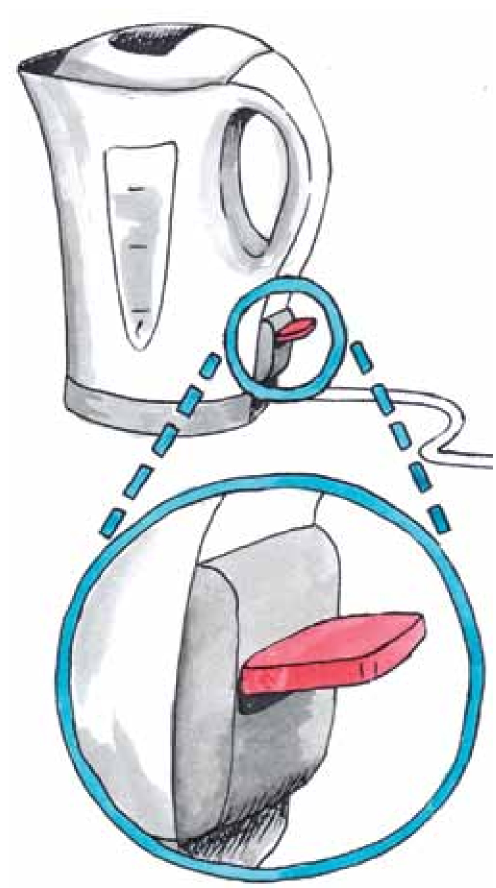


Figure 5

The drawings below show how an electric door lock works. This may give you useful ideas for your design of an energy-saving kettle switch.

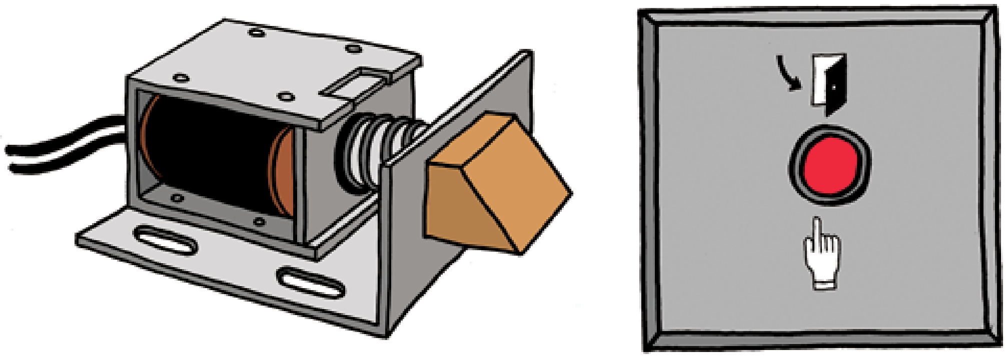


Figure 6: An electric door lock

Look at the brown part on the right-hand side of the lock mechanism above. This is the part that moves in or out to open or lock the door. This part is called a "latch".

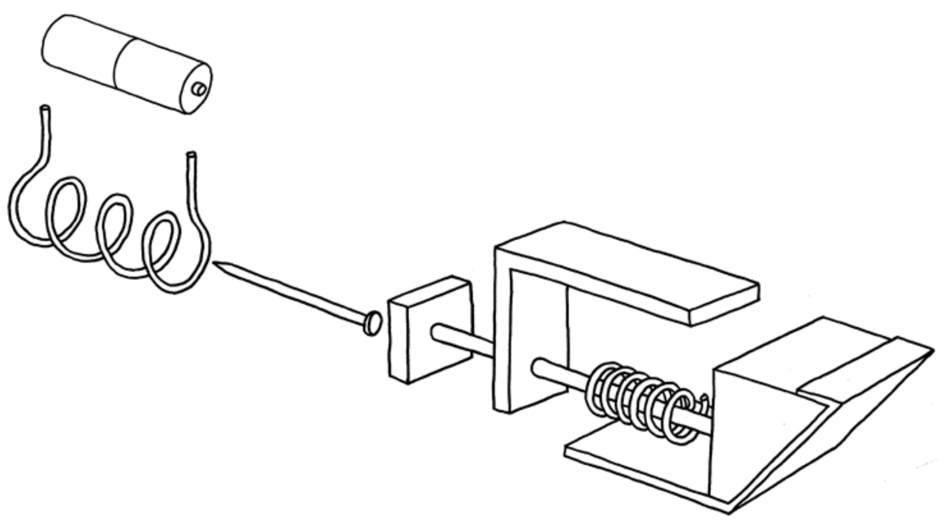


Figure 7: A 3D assembly drawing of the parts inside an electric door lock

Design brief

1. What is the purpose of the switch you will be designing?
   Hint: Think about how easy it is for people to do things, the impact on the environment, and costs involved. (½)

Specifications

2. What parts should the device have where the user must press or turn something by hand? (½)

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....

....

3. Are there part(s) of the device that would sometimes be moved by the user, and other times be moved automatically? (1)

....

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....

4. How should the moving parts of your switch work? For example, what should cause it to move one way, and what should cause it to move the other way? Use names for the different moving parts, as well as for the other parts that will make the moving parts move or stop them from moving. (2)

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5. What type of electrical component can generate the automatic movement that your device has to perform? This component will be the output device in the control circuit on page 74. (½)

....

6. Does your device need a container or supporting structure to keep all the parts together? What type of container or structure do you think will work well? (½)

....

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Constraints

7. Make a list of all the materials you will need. (1)

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8. Make a list of all the tools you will need. (½)

....

....

....

9. Make a time schedule showing how much time you have to design and make the product. (½)

....

....

Design sketches

10. Make at least two rough sketches of your design. Use labels and notes to explain your design. If your second sketch is an improvement on your first sketch, keep the first sketch, but simply label the second sketch as “improved design”. (5)

Total [12]

Week 2

Evaluate as a team: Learn from one another's designs to make a better design together (60 minutes)

1. Each team member should explain his or her design to the rest of the team, and the others should ask questions if they don't understand something.
2. After everyone has explained their designs, you should make a list of the advantages and disadvantages of all the designs.

....

....

....

There is no such thing as a perfect design! For example, you can make a complicated design that will work very well, but that will be expensive and difficult to build. Or you can make a simple and cheap design that works, but is not strong enough.

Learn from the different designs that different people made

Don't throw an idea away too quickly even if there is a problem with it. First sketch and explain it to the others. This idea can lead to another better idea. If everyone throws their ideas away too quickly, there will be no ideas on the table to work with. Design teams work well when they separate the work into two stages:

- First generate ideas, sketch and explain them, without anyone saying anything negative about the ideas.
- Once you have several ideas on the table, start thinking about how and whether the different ideas will work or not. Don't talk about "Mary's design" or "Sipho's design". Rather talk about "Design C" or "Design B". Once someone has put a design on the table, you talk about the design. You do not talk about the person. You evaluate the designs. You do not evaluate yourself or someone else.

If someone makes a negative remark at this stage, you should say *"Red flag! No negative remarks at this stage."*

Saying "Mary's made a bad design" or "Sipho's is much better", for example, will hurt someone's feelings or make others feel proud or arrogant. If someone says "Mary's design ...", you should say *"Red flag! We call that Design C."*

3. Now combine different ideas from different designs into one better design. Your team will only succeed at this if you talk and sketch together "creatively". Being creative means "playing with ideas".

   To communicate well and to be creative, you have to make many rough sketches. Do that in the space provided below. Include labels and notes to help explain the sketches. (4)

4. Now each person should make their own sketches of the improved design that the team made together. Once again, show labels and notes to explain the sketches.

   Make at least two sketches, so that both the whole design and hidden detail can be seen. You might want to draw the design from different view points, or draw a few parts on their own. (4)

Total [8]

Make individually: 2D Working drawing and 3D drawings of your design (60 minutes)

1. Make a 2D working drawing of your design in first angle orthographic projection. It should be drawn to scale and show as much detail as possible. Show dimensions and the scale. Show all hidden details. (8)

2. Make an isometric drawing of your design to scale. Do not show the container or structural support for the inner parts of your design. Only show the inner parts. Do not show any hidden details, but choose your view point so that as much detail as possible is shown. Show the scale, but do not show the dimensions. (7)

Total [15]

Homework: Planning to make and gathering materials

Make lists of the materials and tools you will need to build a model of your automatic kettle switch next week. You need to include the materials you will need to build the output device for the control circuit that you will later connect to your model of the switch. (Look back at your answer to question 5 on page 78.)

If there are any materials on your list that are not available at school, gather waste materials that you can use instead and bring it to school next week. *If you do not do this, you won't be able to build a model of your design.*

Week 3

Make and test your prototype of the switch (120 minutes)

1. Work alone to build a model of your design for the switch. A model of a new design is called a **prototype**.
2. Work alone to build the output device for the control circuit that you will later connect to your switch.
3. Test your model with a simple circuit consisting of a battery and the electric output device that you made.

Designers and engineers usually make many **prototypes** before the design is good enough to start manufacturing and selling it. Each prototype is an attempt to improve on the previous one.

4. Test your model by connecting it to the control circuit that you made in Chapter 5.
   (a) Before you connect the control circuit to any model, your team should test the control circuit as you did before, see page 64, because some of the connections may have come loose.
   (b) To test your automatic kettle switch, you can use a thumb tack pressed into an eraser that you heat by rubbing it on a piece of wood or plastic for a minute.
   (c) If you were not able to build a control circuit successfully in Chapter 5, you can use the simple circuit discussed in question 3 above to test your model of the switch.

5. You will probably find that your model does not work the first time you test it. This is normal! Most new things that people design don't work the first time they test it. Try to find out what's wrong, and then go back and fix it before you test it again.

Your teacher will give you marks for the following:

- You brought all the materials needed to make a model of your design. (2)
- You accurately made the model according to your design drawings. (8)
- You successfully built the electric output device. (2)
- You connected your model to the simple circuit with the output device, and used a good method to test it. (1)
- After you tested your model for the first time, you made a list of all the possible reasons that your model is not working or why it is not working well. (2)
- You used the list to fix or improve your model. (2)
- You tested your model again, writing down the problems, and going back and fixing or improving your model until it worked, at least one more time. (4)
- Your model worked, or you wrote a good explanation and made sketches of what you still need to change on your model to make it work. (4)

Total [25]

You need to keep a record of all your testing and improvements on your model, otherwise you will not get marks for that work. Use the next two pages to keep that record, and show your sketches where necessary.

Record-keeping of your testing of and improvements to your prototype

Week 4

Present your design process and final prototypes

Your team will give a presentation of your project later this week. The presentation should be between three and five minutes long. Each member of your team should do a part of the presentation. The other learners in the class may ask you questions after your presentation.

Your presentation should be mostly about the design process that you followed to design, make and improve your prototypes.

Team meeting: Prepare your presentations (30 minutes)

1. Decide which part of the presentation each of you will do. Write it down below. (1)

   ....

   ....

   ....

   ....

   ....

2. Decide in what order you will give the different parts of the presentation. Who will talk first, and who will talk next?

   Write the parts of the presentation in the order that you will do them below, and write who will do which part. (1)

   ....

   ....

   ....

   ....

   ....

   ....

3. For homework, you should practise your part of the presentation.

Total [2]

Giving the presentations (90 minutes)

Your teacher will look at the following to give you marks for your part of your team's presentation:

- You were well prepared for your presentation. (2)
- You explained how you made progress during the design process. (2)
- You looked at your audience and spoke clearly. (1)

Total [5]

An alternative to the kettle swicth project: Designing and building a circuit continuity tester

Your teacher may decide to let you do the following project instead of designing and building an automatic kettle switch.

Often when people have to connect wires in electric circuits, there are so many wires that it is difficult to know which two wire ends are of the same wire.

It would help to have a device that shows whether two wire ends are connected or not. This is what a "circuit continuity tester" does.

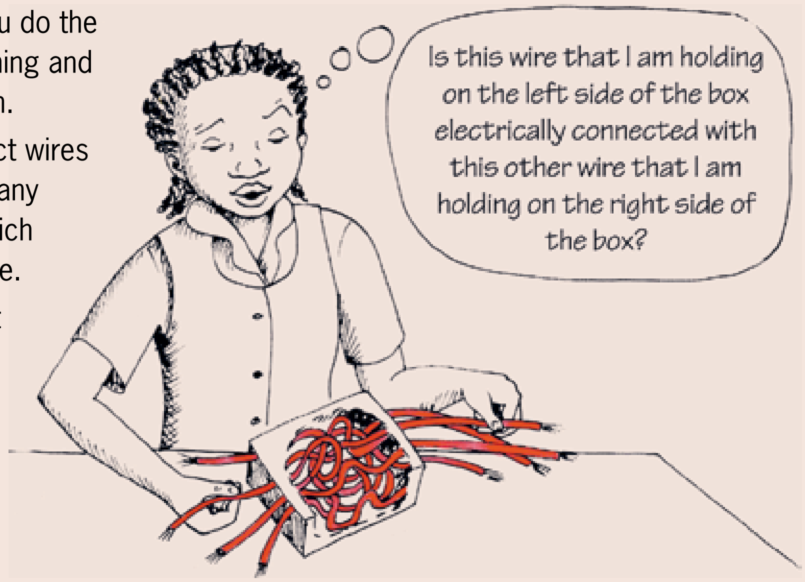


Figure 8

A circuit continuity tester is actually an open circuit. The circuit can only be closed by the two wire ends that you are testing. Use the two test leads of the circuit continuity tester to touch the two wire ends that you want to test. If there is a path for current to be conducted between the two wire ends, this will complete the circuit and a light or a buzzer on the circuit continuity tester will be activated.

Safety warning:
First switch off the power supply before you do a test such as this one.

Note that a circuit continuity tester cannot tell you whether the two wire ends are of the same wire. It can only tell you whether there is a path for current to be conducted between the two wire ends, in other words whether the two wire ends are electrically connected. But if you know that there are no splitting or joining of wires in between the two wire ends, then the wire ends can only be electrically connected if they are of the same wire.

If you design and build a circuit continuity tester as your project, think about the following:

- It should be easy to let the test leads of the circuit continuity tester make proper electrical contact with the wire ends.
- The tester should be small.
- The tester should be protected from shocks, for example if it gets dropped.
- The tester should be protected from water, since water can cause a short circuit.

A few ideas for building a circuit continuity tester are shown in the photos below.

Figure 9

Figure 10

TERM 4

Chapter 7

Preserving metals

In Grades 7 and 8, you learnt how to classify metals into **ferrous** and **non-ferrous** metals. In this chapter, you will revise this skill of classifying metals.

You will learn how to preserve metals by painting, galvanising and electroplating. If we recycle materials and equipment, it will help to reduce the need for mining, which has a negative impact on the environment. You will also learn how to electroplate an object.

Ferrous refers to the presence of the element iron in a metal such as steel. This generally makes the metal more prone to react with oxygen (oxidisation).

Non-ferrous metals don't contain iron molecules, such as aluminium, copper, zinc and gold. They are generally more expensive than ferrous metals.

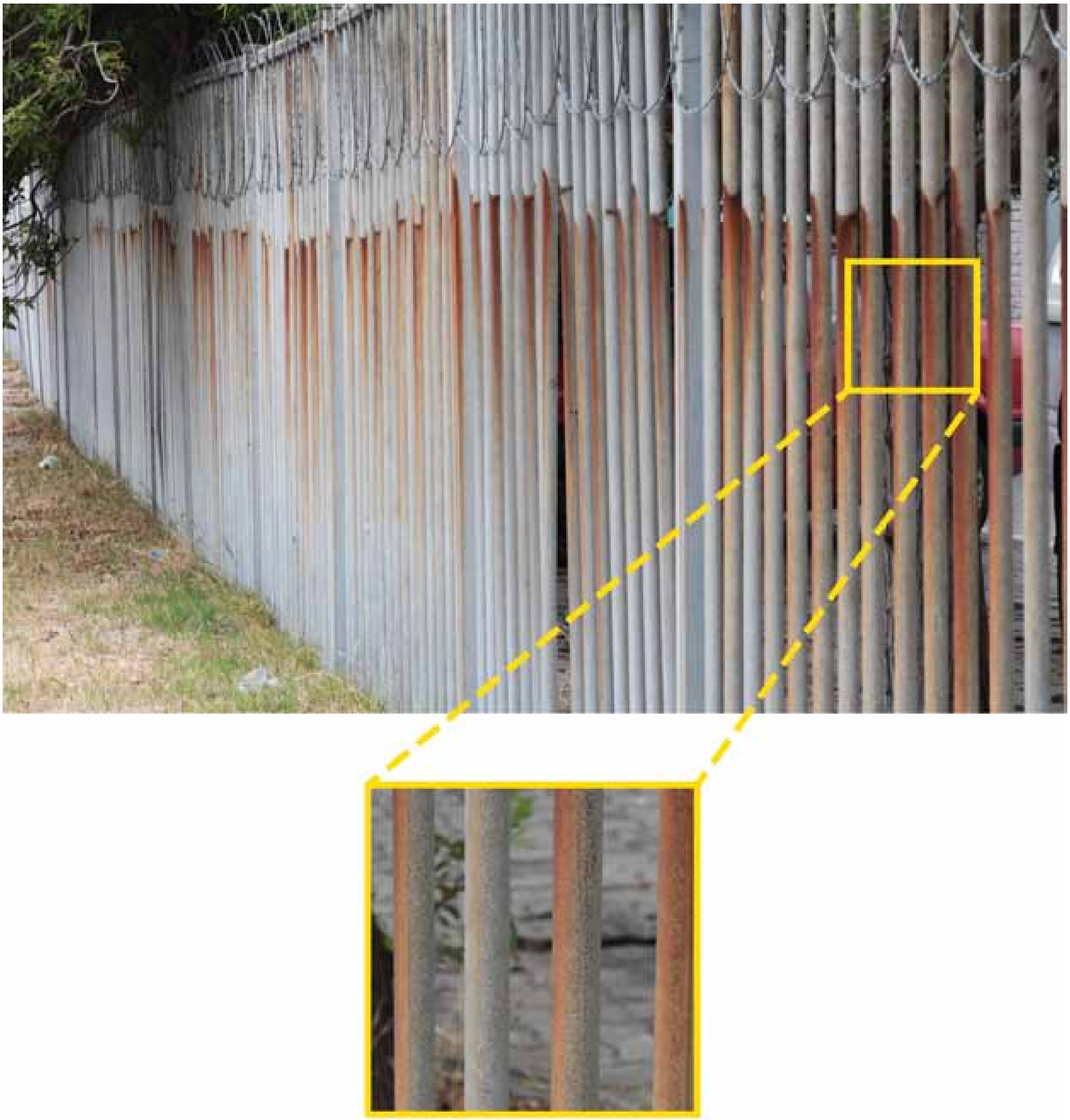
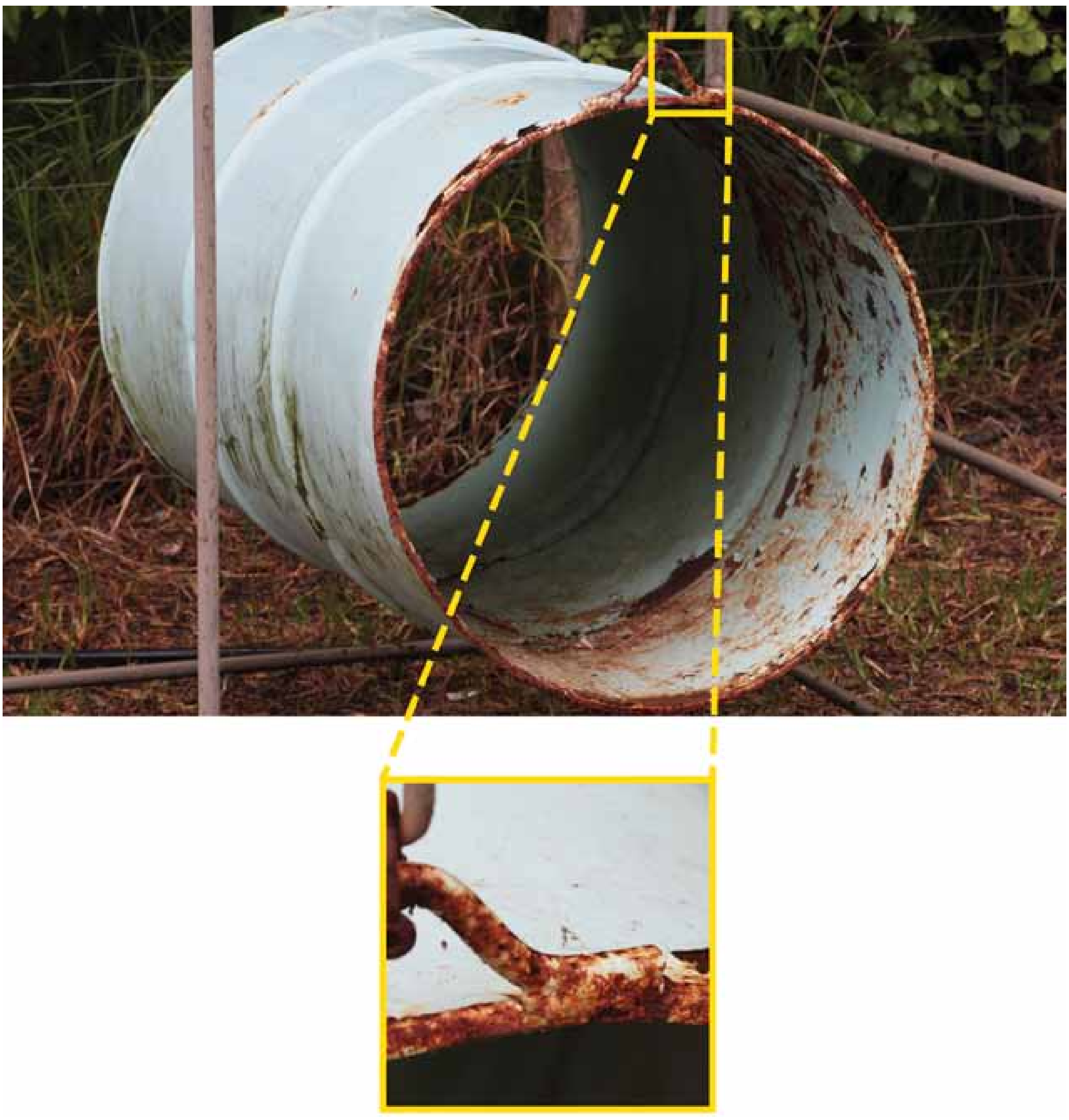


Figure 1: Examples of metal corrosion or rust



7.1 Painting metals

Figure 2: A lady painting a door frame

Although metals, as we usually perceive them, are generally very tough, they do break down over time. Rust is one of the most common ways that metals can deteriorate. Plants and animals die, become compost and return to the earth. When metals rust, they break down into smaller particles and also return to the earth. As you know by now, metals come from the earth originally and humans extract metals by mining.

But what causes metals to rust? Sometimes a chemical reaction occurs between a metal and oxygen. This is called oxidisation, which results in rust. Another word for rust is corrosion. Ferrous metals are not resistant to corrosion. This reaction happens much faster when there is salt or certain acids in the air as well. For example, metals close to the sea tend to rust a lot quicker than metals inland. Figure 3 shows an example of this.

However, there are ways of protecting metals against oxidisation. The cheapest way of preserving ferrous metals is by painting the exposed surface.

Figure 3: A rusted car by the coast

How do you paint metal? That depends on whether it is a brand new piece of metal or a piece of metal that has already rusted.

Figure 4: Wire brush

Figure 5: Sandpaper

If it is a brand-new, smooth piece of metal that has never been painted before, it is best to first roughen the surface a bit. It is difficult for paint to stick to a very smooth surface. To roughen the surface, you can use wire brush such as the one shown in Figure 4 or sandpaper as shown in Figure 5. Make sure that there is no dust on the surface. You can wipe it with a clean cloth to get rid of dust. Then you must apply one, or preferably two, coats of primer. Primer protects the metal and makes it easier for the top coat of paint to stick to the metal's surface. Finally, you can apply the top coat of paint.

Painting a rusted piece of metal is a bit more difficult. First, you need to get rid of as much rust as possible. If there is old, flaky paint, you must remove that as well. A wire brush and sandpaper work well for this. It is hard to get rid of all the rust, therefore you need to apply a special primer to stop the oxidisation. If you don't use a special primer, the metal will keep rusting underneath the paint, which will make the paint come off after a while.

Certain types of primers meant to stop rusting still require another primer to be painted on top of it, before you can apply the final coat of paint.

Important things to keep in mind when you paint:

1. Always wait till the paint you've applied is completely dry before you apply another coat.
2. Always make sure that the surface is clean before you paint it. There must be no dust or oil on it. Dust and oil prevent paint from sticking to the surface.

You have to read the instructions for the specific product carefully before buying or using it. When you've applied all the relevant primers, you can apply your top coat of paint. Now you know how to fix rusted things and make them beautiful again, instead of just throwing them away!

Preserve metals by painting

Answer the questions below:

1. List the materials you need to use when painting metals.

   ....

2. Write a brief outline explaining why it is important to use a primer coat when painting metals.

   ....

   ....

   ....

   ....

   ....

3. In your own words, briefly explain why boats and ships have to be painted on a regular basis.

   ....

   ....

   ....

   ....

   ....

4. Study the table below. **Column A** describes the process of painting metals. The steps in the process are not in order. Write the number of the correct answer in **Column B**.

A	B
1. Double coat with primer. When metals are exposed to oxygen and they lose hydrogen, it results in rust or oxidisation. Primer helps the top coat of paint to stick to the surface. It also makes the metal less vulnerable to the effects of time, especially rust.	
2. Sand down your metal. Scrape or sand the surface of your metal to ensure an even longer lasting and more durable coat of paint. The rougher your metal, the more it will stick to the surface.	
3. Apply a zinc-chromate primer if you are working with rusted metal. Scrape all the loose rust and residual dust off first, then coat it with this special primer.	
4. Clean off all loose paint, dirt, grease and grime from the surface of your metal. If you miss this step, you will end up with a coat of paint that won't stick to the metal and peels off easily. Even oils on the surface that may not be visible will affect your paint job, so give your metal a thorough rub down even if you don't think it is necessary.	
5. Paint. Acrylic latex paint is usually the best paint to use for metal. A cheap metal paint or a spray paint will probably rub off. This will result in the metal requiring a new coat of paint a lot sooner. Work carefully and apply your paint evenly on the surface.	
6. Read the labels. Make sure your primer and your coat of paint are compatible. If they are not, your paint will not stick to the primer. Check the drying time to ensure that you don't put more primer on than you can paint the next day. Planning ahead is always important when painting.	

7.2 Galvanising

Figure 6

Apart from painting, we can also protect ferrous metals from corrosion by applying a thin coat of zinc. This process is called **galvanisation**.

Zinc also oxidises or rusts, but then the zinc rust reacts with the oxygen, water and carbon dioxide in the air and turns into "zinc carbonate". Zinc carbonate is quite tough and consequently it protects the metal underneath it. If the zinc carbonate layer gets damaged, more zinc carbonate forms. This can repeat until there is no zinc left on the metal. Then the metal will start to rust.

This means that galvanisation only slows down the corrosion of a metal. It doesn't prevent corrosion completely. If you need to protect metal properly for a very long time, it is best to galvanise and paint the metal, which is what people do with cars today.

The word **galvanisation** comes from Luigi Galvani's name. He was an Italian doctor and scientist who did experiments with electric currents in the eighteenth century.

There are two ways of galvanising metal. The one process is called "hot-dip galvanisation". The other process is called "electro-galvanisation".

Hot-dip galvanisation means that the ferrous metal gets dipped into a bath of **molten** zinc at a temperature of 460°C. Water boils more or less at 100°C, so you can imagine how hot that zinc is! Obviously, you need to do this with the right equipment and safety measures.

Molten: a metal or rock that is in liquid form as a result of great heat.

Hot-dip galvanisation has two definite advantages: it is relatively inexpensive and it is also very tough, because the zinc layer resulting from this process is thick. This makes it suitable for outdoor use, even over extended periods of time, such as 20 to 50 years. But there are drawbacks too. Firstly, the metal needs to go through a complex preparation process before it can be dipped into the molten zinc. Figure 7 shows these processes. It also makes the metal look dull and the zinc coating is not the same thickness throughout.

Electro-galvanisation means that the ferrous metal gets coated with zinc through a process called electroplating. You will learn more about electroplating in the next part of this chapter. For now, you only need to know that the zinc layer through electro-galvanisation is thinner than the hot-dip zinc layer and not as tough, but it is the same thickness throughout. The zinc coating is also generally shinier and even small objects can easily be electro-galvanised. This means that electro-galvanised metals are more commonly used indoors. For outdoor use, it will definitely have to be painted to make it last longer.

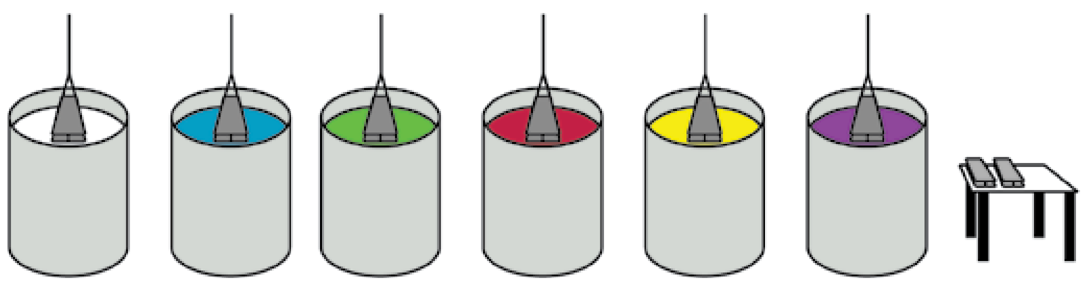


Figure 7: The processes that are followed when hot-dip galvanising metal

What have you learnt?

Galvanising is a process that prevents corrosion. When galvanising metal, the objects are coated with zinc. This is relatively inexpensive and does not react with air and moisture, as iron does. The zinc layer separates the iron from the oxygen and moisture. Objects that have been galvanised are not completely protected from rust. They only take longer to rust. To protect a metal completely, it is best to galvanise and paint it.

Answer the questions below:

1. Briefly discuss the function and purpose of galvanising.

   ....

   ....

   ....

2. What metal is used to coat an object when galvanising it?

....

3. What are the benefits of hot-dip galvanisation?

....

....

....

4. What are the drawbacks of hot-dip galvanisation?

....

....

5. Name two examples of galvanised products.

....

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....

7.3 Electroplating

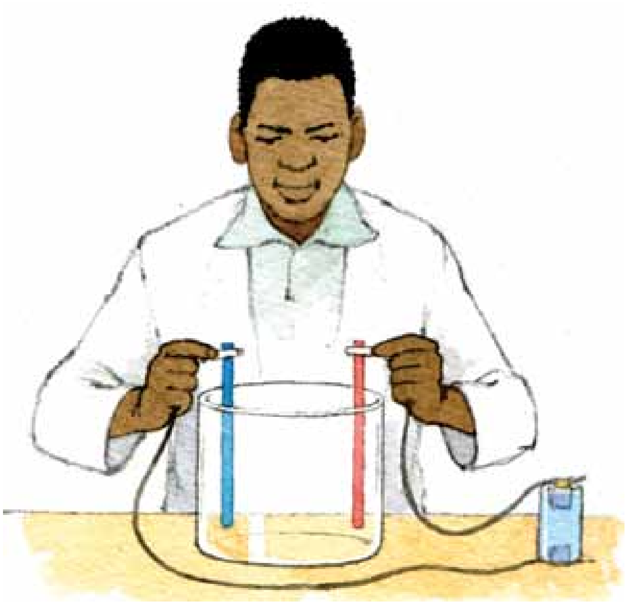

Figure 8

Electroplating is a process whereby one metal is coated with a thin layer of another metal by using electricity and salty water (or an **electrolyte**).

People do electroplating for a number of reasons. One reason could be to protect the metal from corrosion, such as galvanisation. Another reason could be to make an inexpensive metal look better. For example, copper or silver jewellery is often gold plated to make it look more expensive.

An **electrolyte** is a mixture of salt and water that has the ability to conduct electricity.

Look at Figure 8 and 9. In practice, electroplating works like this:

The object that you want coated gets connected to the negative side of an electric cell with a wire. The metal that you want to coat the object with gets connected to the positive side of the cell with a wire. Put the object and the metal, with the wires attached, into a container with the water and salt mixture.

What happens next is that electricity and metal molecules travel from the positive side to the negative side. This means that after a while, a thin layer of metal starts to form on the object. The longer you let this process continue, the thicker the metal layer will be.

Table salt is one example of a salt. Not all salts are edible, but all salts contain a metal as one of their elements. For example, table salt consists of sodium, which is a metal, and chlorine. You can't use table salt for electroplating.

Copper sulphate is also a salt. It contains copper, which is a metal, and sulphur. However, copper sulphate is VERY POISONOUS. You can use it for electroplating, but definitely not for food.

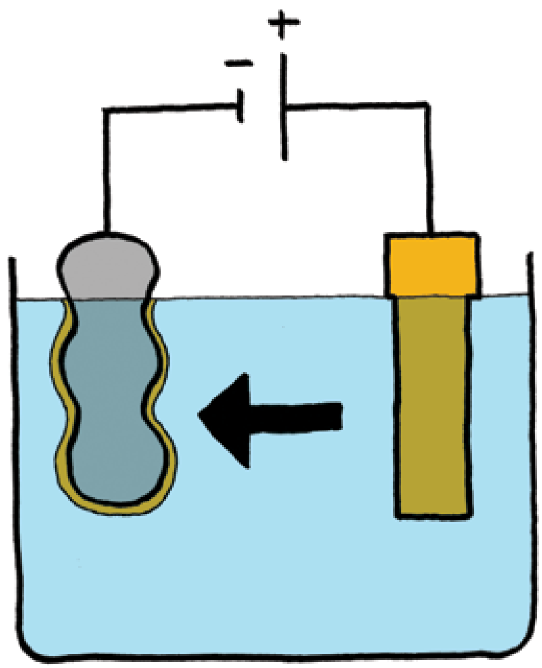

Figure 9: How an electroplating system is assembled

Figure 10: Coins are an example of a less expensive metal that has been electroplated with a more expensive metal for protection and to make it look better.

Work in a group to investigate corrosion

In this experiment, you will observe the effect of salt and water on galvanised and ungalvanised steel. Once you have everything together, it will only take a few minutes to prepare this experiment. But then you have to put your experiment in a safe place where you can observe it for a week or more.

You need the following things for this activity:

- a plastic or glass container that is not made of metal,
- enough water to fill this container,
- a packet of table salt,
- two galvanised metal items, such as a galvanised nail, a tin can or a piece of corrugated iron (hint: look at your last answer on page 102), and
- something rough or sharp that you can use to scratch off the galvanised layer from one of the items, such as a nail or sandpaper or another piece of metal.

Tin cans are made by electroplating tin onto steel.

How to do this experiment:

- Heat the water and dissolve the packet of table salt in the water.
- When it has cooled down, pour the water and salt solution into the glass or plastic container.
- Take your two galvanised metal items and put one directly into the water and salt solution.
- Use the rough or sharp object to scratch off the galvanised layer from the other galvanised object.
- Put the second object into the water as well.
- Keep both items in the water and salt solution for at least a week.
- Take them both out every day to see what has happened.

Answer the questions below:

1. Which item starts to corrode or rust first?

   ....

2. How long does it take for the metal to start corroding?

   ....

   ....

3. Is there a difference in the level of corrosion by the end of the week compared to the beginning of the week?

....

4. Why doesn't the other piece of metal corrode?

....

....

What have you learnt?

You have learnt three methods of protecting ferrous metals against corrosion: painting, galvanisation and electroplating. Protecting metals against corrosion makes the metals last longer, which could reduce the need for mining. You can also easily reuse a rusted piece of metal if you clean the rust off and paint it.

Reducing, reusing and recycling materials will have a positive impact on the environment.

Next week

In the next chapter, you will learn more about processing materials by extending the lifespan of food.

Chapter 8
Extending the shelf life of food

In the last chapter, you learnt about preserving metals by painting, galvanising and electroplating them. In this chapter, you will learn about different ways of preserving food, namely storing grain, pickling, drying and salting.

Figure 1

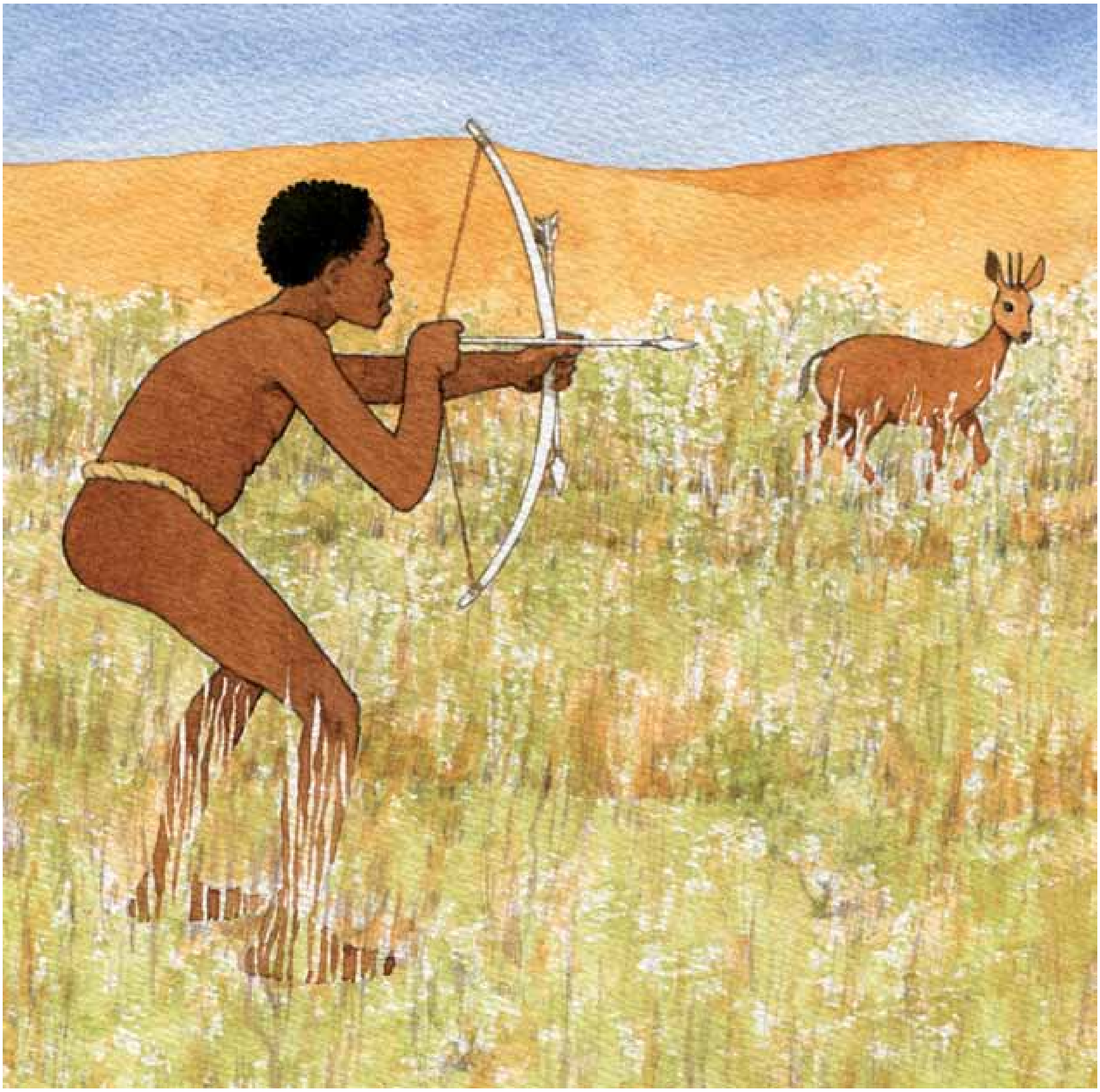

Figure 2


TOMATOES
Whole Peeled
HOME
400g net • 224g drained •
BRILLIANT!
CRISPY
Oven Chips
MANGO ATCHAR
Hot
HOME

Figure 3

8.1 Storing grain

Food begins to spoil the moment it is harvested. Food preservation has been part of all cultures throughout history. Food preservation enabled ancient humans to live in one place and form a community, unlike the Bushmen who had to move from one place to another. The discovery of food-preservation methods meant that ancient humans no longer had to consume hunted animals or harvested food immediately. They could preserve some of their food to eat at a later time.

It is interesting that different cultures preserved their local food sources using the same basic methods of food preservation, for example heating, freezing, pickling, canning, salting, fermenting, drying and refrigerating.

Food preservation is one of the oldest technologies. People ate what they grew on the land and what they hunted. They had to take good care of their food to prevent it from going off and making them ill. They also had to find ways of preserving food so that they would be able to eat even when there were no crops to harvest or when they could not hunt.

> Food preservation is about the treatment, handling and storage of food to ensure that it does not lose its nutritional value or quality. An important part of food preservation is to create conditions that prevent dangerous bacteria from growing.

Grain is a **staple food** for most of the world. Different grains are eaten in different parts of the world, for example in China and Japan, rice is the staple grain that is eaten.

In South Africa, wheat and maize are the main grains that are grown and eaten. Maize is also used to make a fermented drink, a type of beer that some people drink on special occasions.

A **staple food** is a food that is eaten most often by a group of people and forms the main part of the diet.

Structures for storing grain

People have always had some method of storing their grain produce. Improvements in storage methods have also been observed over time and people used the right methods for their situation or need, for example storing grain in sacks. Grains produced by farmers who farm as a business and on a large scale are stored in "silos". These are huge cement or metal structures that hold the grain from many farms in one place until it can be used or exported. The silos keep the grain cool and free from moisture, insects and rodents.

A good storage container should:

- keep grain cool and dry,
- protect grain from insects, and
- protect grain from rats and mice.

Figure 4: A traditional Zulu grain silo

Figure 5: Modern industrial grain silos

The process of storing grain

Firstly, grains need to be harvested. Small-scale or subsistence farmers do this by hand. Figure 6 shows harvesting on a much bigger, industrial scale with a combine harvester and a tractor.

Figure 6: Harvesting on an industrial scale with a combine harvester and a tractor

Secondly, the seed, which is the edible part of the grain, needs to be loosened from the plant's casing that protects the seeds. The casing is inedible and it is called "chaff". This process is called threshing. Figure 7 shows the seeds still in their casing.

The third step is called "winnowing". Winnowing is the process whereby the loosened seed is separated from the chaff. Figure 8 shows the separated, edible seeds, and the inedible chaff in the bucket.

There are various traditional winnowing techniques. Nowadays, people use combine harvesters to harvest, thresh and winnow.

Figure 7: Wheat before harvesting, threshing and winnowing

Figure 8: Grain separated from the chaff

Fourthly, the grain is dried to prevent fungus and bacteria from growing on the seeds. The ideal moisture content for wheat is about 14%.

Nowadays, people use grain-drying machines, but in the old days, people dried grain with the help of the sun. Figure 9 shows a modern grain-drying machine.

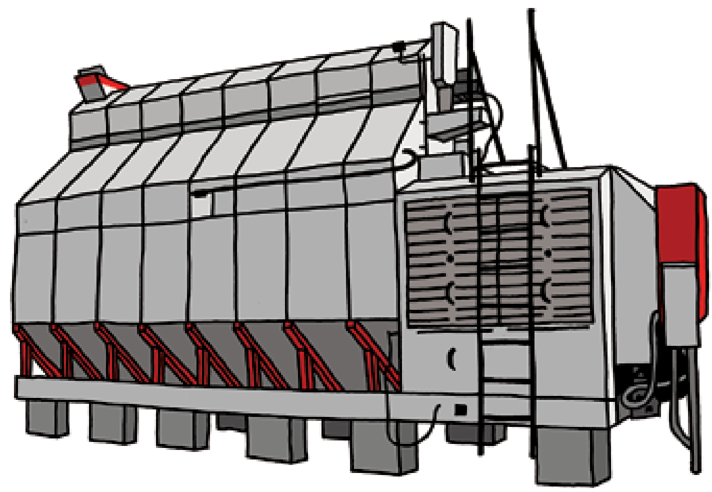

Figure 9: A modern grain-drying machine

Finally, the dried grain is stored. The humidity and temperature of the air are the two most important factors here.

Warm, moist air will encourage bacteria and mould to live on and destroy the grain, even if the grain has been dried beforehand. Cool, dry air will help to keep the grain intact for longer.

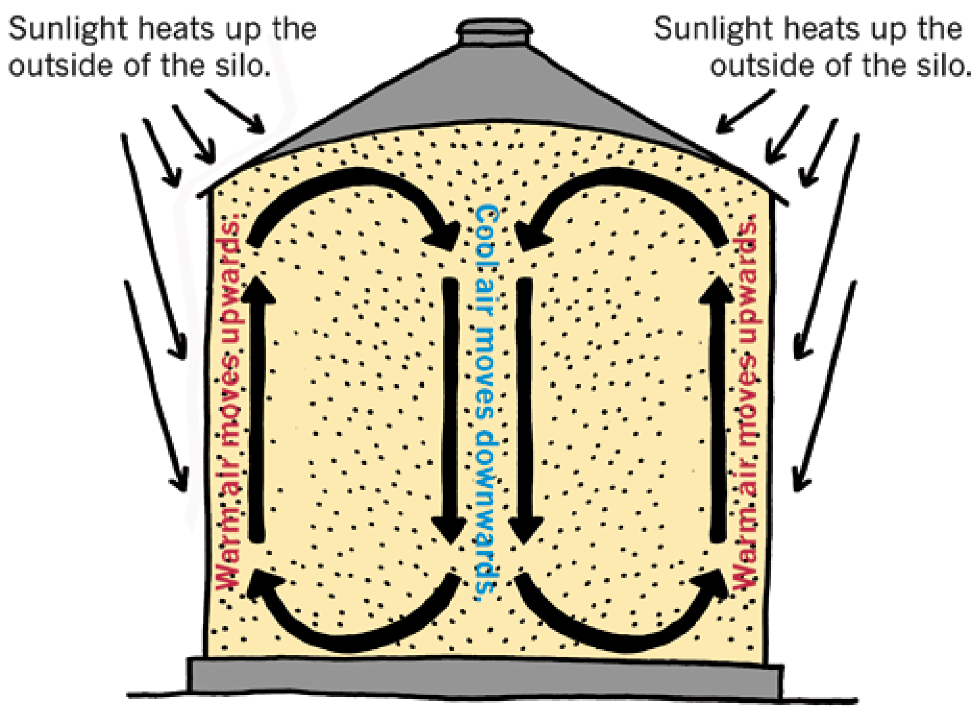

Figure 10: Schematic cross section of the air movement in a grain silo

There are all kinds of insects that damage grains, such as weevils and mites. Mites are very small insects that eat grains. Weevils are small insects that lay their eggs inside the grain. When the **larvae** hatch, they eat the seeds.

Larvae: the stage of an insect's life after it's hatched from the egg, but before it has changed into a mature insect.

Rodents, such as rats and mice, can also cause great damage to grains. They eat large amounts of grain if they're not controlled. Besides that, they carry deadly diseases that can contaminate the grain and spread to humans if consumed.

Now you can imagine that storing very large amounts of grain, for instance in a big, modern silo, is a complicated job, because air flow and temperature, insects and rodents, bacteria and fungi need to be controlled. But luckily, storing small amounts of grain is relatively easy. You need to put the grain into a clean, dry, airtight container and keep it in a cool place that is dry, with no direct sunlight or rodents.

8.2 Pickling

Most food products deteriorate as a result of the presence of micro-organisms, such as bacteria, yeast or mould. Remember that not all bacteria is harmful. We need good bacteria to perform certain functions in our bodies and to make certain food products, such as yoghurt and cheese.

In the past, people had to store fresh food so that it was safe to eat long after it was harvested. There were no fridges or freezers to stop food from going off. Fruit and vegetables were dried, salted, pickled or made into jam so that they could be eaten long after they were picked. Dried, pickled, salted foods and jams meant that people had a bigger variety of food and nutrients in their diet for a longer time.

Pickling possibly originated when food was placed in wine or beer to preserve it. Both wine and beer have a low pH level. People then found many uses for the **brine** that was left over from the pickling process.

Brine is a watery mix of vinegar and salt. Tomato sauce was an oriental fish brine.

South Africa has a few favourite pickles. Achaar is a traditional pickle that was brought to our country by the Malay people more than a century ago. It can be eaten as a side dish or with curry, and is widely enjoyed, especially in the Western Cape. Achaar is made from vegetables such as cauliflower, carrots, cabbage and beans, that have been finely cut and are mixed together with mustard, turmeric, coriander, vinegar and sugar.

What we know today as tomato sauce was originally an oriental pickle sauce for fish. It spread to Europe by the spice route, and eventually to America where someone added sugar to it. Spices were added to these pickling sauces to make tasty recipes.

Chutney is another favourite South African pickled product, normally made with fruit.

For pickling, we can use salt and water or salt, water and an acid, usually vinegar.

Vegetables and fish are the two most common food types that are pickled. Pickling preserves the food because the brine creates an environment where oxygen is not present. Thus the micro-organisms contained in and around the food cannot grow and multiply and, in turn, cause the food to go bad.

The food to be pickled is placed in a clean glass jar. A hot brine mix is poured over the food and covers it completely. The brine is poured until the jar is full. A clean, tight-fitting lid seals the jar. Pickles last for many months, depending on the type of food.

Pickles have become very popular. There are many pickling recipes available, and people often experiment with different combinations of vegetables, herbs and spices.

Figure 11: Examples of pickled foods

Make your own pickles

You will need the following ingredients for this activity:

- 6 pickling cucumbers, sliced in half lengthwise,
- 1 red bell pepper sliced,
- 1 cup water,
- 1 cup white vinegar,
- 1 cup white sugar,
- 2 ½ tablespoons pickling salt,
- 2 cloves garlic, peeled,
- 12 black peppercorns,
- ¼ teaspoon dried dill, and
- 1 pinch crushed red pepper flakes.

A few rules for pickling:

- Use clean jars and lids.
- White vinegar is better to use as it does not discolour the vegetables the way brown vinegar would.
- Use ingredients that are as fresh as possible.

1. Using the ingredients listed above, prepare an instruction sheet for another group of learners to use in preparing their pickles. Write your instructions in point form. Show the flow of activities from start to finish.

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2. Name and briefly discuss three advantages and three disadvantages of this method of food preservation.

   ....

   ....

   ....

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   ....

8.3 Drying and salting

South African **biltong** is a rich inheritance from innovative Dutch settlers from the seventeenth century. They brought recipes for dried meat from Europe. They used the sun to dry meat during their trek across southern Africa.

The word **biltong** is from the Dutch "bil" (rump) and "tong" (strip or tongue).

The basic meat spices were readily available in the Cape Colony. The spices for making biltong include a dramatic blend of vinegar, salt, sugar, coriander and other available spices.

Figure 12: Biltong

Drying is one of the oldest methods of food preservation. Drying preserves food by removing enough moisture from the food to prevent decay and spoilage.

The water content of properly dried food varies from 5% to 25%, depending on the type of food.

> Successful preservation of food depends on inhibiting the growth of micro-organisms such as bacteria, and preventing access to insects.

Answer the following questions:

1. Explain what you understand the purpose of food preservation to be.

   ....

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2. In South Africa, there are many cultures and methods of food preservation. Name one culture and food type they preserve. Briefly explain the process this culture follows in preserving this food type.

   ....

   ....

3. Explain the process of drying food for preservation purposes.

....

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....

4. Briefly discuss why salt is so important in the drying method of preserving food.

....

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....

Dry your own food

Tip:

When drying food, the key is to remove moisture as quickly as possible at a temperature that does not greatly affect the flavour, texture or colour of the food.

Before you touch any food, wash your hands thoroughly to remove dirt and bacteria.

Figure 13

You will need the following things for this activity:

- spinach,
- cold water,
- a knife,
- a large bowl, and
- paper towels.

Follow these steps:

- Find fresh spinach sold loose or in a bunch. Pick spinach that is crisp and green.
- Fill a large bowl with cool water and add the spinach.
- Rinse the spinach in the water to remove any dust or dirt particles.
- Remove the water from the bowl and refill it with fresh, cool water. Continue to rinse out the spinach in fresh water until all of the gritty particles are gone.
- Lift the spinach from the water and place it on a paper towel.
- Roll spinach into sausage shapes, cover it with another paper towel and gently press on it to remove the moisture.
- Replace the paper towel and gently press on the rolled spinach with a dry towel until all the water is removed.
- Place the prepared spinach rolls, covered with paper towel, on a sieve and leave them in the sun to dry for a few days.
- Place the dried spinach in a plastic container for storage until you need to cook it.

Record your observations during this practical activity:

1. Describe what the fresh spinach looked like.

   ....

2. List all the steps you took and explain why you did them.

   ....

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   ....

3. What was the effect of the weather conditions on your drying process?

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....

4. Indicate whether the results of this experiment were a success or not. Motivate your answer.

....

....

....

What have you learnt?

You have learnt how indigenous people long ago thought innovatively to develop ways of preserving food to extend its lifespan.

You have learnt how the principles of grain storage, pickling and drying of food assist in increasing the lifespan of food.

Next week

Next week, you will learn more about reducing, re-using and recycling plastic to reduce its negative impact on the environment.

Chapter 9
Plastics

In this chapter, you will learn about the various types of plastic. You will also learn that plastic can be recycled, and why this is important.

Note to the teacher:

Learners should bring plastic products and containers to school for this week's activities. Figure 1 below suggests a few types of plastic products they can bring.

It is important that learners bring a wide variety of plastic products. They have to bring plastic products with recycling codes at the bottom to identify which type of plastic it was made of.

The selection should include clear, translucent and opaque types of plastic, and hard and soft types of plastic. A few examples of what they can bring are cool drink bottles, milk bottles, peanut butter jars, shampoo bottles, polystyrene cups, margarine tubs, plastic plates, plastic eating utensils, freezer bags, flip-flops (plastic sandals), combs, lunch boxes, and/or geometry triangles.

Figure 1: Bring plastic items such as these to school for this week's lessons.

9.1 What are plastics, and what properties do they have?

Up to about 100 years ago, most clothes as well as many tools and appliances were made of plant or animal materials, such as cotton, wool, wood, animal skin, and bird feathers. But then chemistry scientists invented ways to make synthetic materials with similar properties to natural materials, and sometimes with useful properties that no natural materials have. Most of these synthetic materials are made from mineral oil, and most of them are called plastics. Synthetic materials are usually cheaper and lighter than natural materials with the same properties, and factories can mould the synthetic materials into unique shapes.

Rulers were once made from wood, but are now made from plastic. Buckets were first made from wood, then from galvanised steel, but now they are made from plastic as well. Milk came in heavy glass bottles or steel cans, but now comes in plastic bottles. Ropes were twisted from sisal plant **fibres**, but most ropes are now made from plastic fibres. Cars were made mostly from steel, wood and leather, but now many parts are made from plastics.

All around you, there are objects made of different types of plastic. Look at your shoe soles, your pen and ruler. In winter you may wear a fleecy jacket that feels like wool. That woolly substance is actually made of plastic fibres. Many clothes and most carpets are made from plastic fibres.

There are also disadvantages to synthetic materials. You learnt in Grade 8, Term 3, Chapter 8 that most plastics do no bio-degrade as natural materials do. This means plastic waste lasts a very long time.

When you look at a piece of cloth closely you will see that it is woven from many thin threads, like very thin pieces of rope. If you use a microscope to look even closer, you will see that each thread is made of different long, thin pieces that hook or twist into one another. These long and very thin pieces are called **fibres**. In the close-up photo below you can see the plant fibres from which a specific fabric is made.

Figure 2: Close-up photo of plant fibres that were spun and woven to make a fabric

Figure 3: A "fleece" blanket is made from fibres of a type of plastic called polyester.

Plastics are examples of polymers. A polymer is a material that is made from **molecules** that have carbon atoms, hydrogen atoms and other atoms joined in long chains. Cotton, wool, leather, hair, starch, wood and rubber are examples of natural polymers. The molecule chains join together in different ways, so that there are many different kinds of polymers with different properties.

Plastics are man-made (synthetic) polymers. They are most often made from mineral oil, because the molecules in this oil are chains of carbon atoms, but shorter chains than in plastics.

The word **plastic** was originally used to describe a property that materials such as rubber have, namely that they can be given a new shape. Most synthetic polymers have this property, and therefore they were given the name "plastics".

Molecules are made of atoms that join together. You know from Natural Sciences that molecules are much too small to see, even with a microscope.

Different properties of plastics

Depending on the type of plastic and the form in which it is made, it may have a few of the following properties:

- **Transparent** means you can see clearly through the plastic.
- **Translucent** means light can shine through the plastic even though you can't see through it.
- **Tough** means the plastic will not break or shatter if you hit it or drop it.
- **Elastic** means you can stretch the plastic far and it will still return to its original shape.
- **Flexible** means the plastic can bend without breaking.
- **Rigid** means the plastic will resist bending and stretching, but if you apply a big enough force to bend or stretch it, it will break or even shatter.
- **Heat-resistant** means the plastic will not melt easily.
- **Fire-resistant** means the plastic will not burn easily.
- **Waterproof** means water will not pass through the plastic.
- **Foamed** means the plastic has been processed to fill it with small air bubbles.
- **Electrically insulate**d means the plastic does not allow electricity to conduct through it.
- **Thermally insulated** means the plastic does not allow heat to be conducted through it easily.

In many of these cases, you cannot simply say the plastic has a specific property or does not have a specific property. For example, you cannot simply say a type of plastic is flexible. You need to say how flexible it is, for example very flexible or only slightly flexible.

Investigate properties of plastic objects

Work in teams of three or four.

For this activity, your teacher asked you to bring different plastic objects to school.

Each team should take two of the objects and describe their properties. Write the name of the object and then write its properties next to it.

1. Object 1:

   ....

   ....

   ....

   ....

2. Object 2

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   ....

   ....

   ....

Now swop your two plastic objects with the those of another team that have different objects. Then write down the names and properties of the other team's objects.

3. Object 3:

   ....

   ....

   ....

   ....

4. Object 4:

   ....

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   ....

9.2 Types of plastic, recycling, and identification codes

Thermoplastic and thermosetting plastics

Some plastics are soft or similar to liquid, until you heat them in a specific way, or mix another chemical with them. Then they "set" or become hard and rigid. After they set, you cannot make them soft again by heating them. So you cannot shape them into new products. They will burn, but not turn soft again. Plastic such as this is called thermosetting plastic.

Examples are epoxy-resin glue, shoe soles, car tyres, electrical plugs, pot handles, electronic circuit boards, and kitchen worktops. Thermosetting plastics cannot be recycled by simply reheating them. They can, however, be turned back into oil through a high-temperature chemical process called "pyrolysis".

Other plastics melt when they are heated, and can then be shaped into new products. These are called **thermoplastic plastic**. Cool drink bottles and detergent bottles are thermoplastic. If you pour boiling water into it you can change the shapes.

Safety warning:

Wear protective heat-resistant gloves, protective glasses and fire-resistant clothing if you try to melt plastic, since molten plastic can splatter and cause serious burn injuries.

Never try to melt plastic by using a flame, since the plastic can start to burn, and it can release poisonous gases.

Why we have to recycle plastic

Waste plastic in the environment is a big problem. Most types of plastic will not bio-degrade, but will last for hundreds of years.

Landfills are usually near cities so that garbage trucks don't have to travel too far to dump the waste. But that means people can never build houses on that land or grow crops on it.

Any materials that go into a landfill will never be used again. Instead, people will need to extract more raw materials such as oil, coal, steel, wood or glass from the earth. Then they will burn more coal to generate electricity in order to process the raw materials.

Not all plastics go into landfills, though. A lot of plastic just remains where someone has tossed it, or is dumped into rivers and then goes into the ocean.

Figure 4: Plastic waste on a sea shore. This photo was taken in Hawaii, which is why there is black volcanic rock on the seashore.

In some parts of the ocean, wind causes the water to flow round and round in one place. These areas are much bigger than South Africa. They are called "ocean gyres". Here, millions of floating plastic bottles, bags and little plastic flakes about the size of this block ☐ gather.

Turtles mistake the plastic bags for jelly-fish and swallow them, which kills them. Large and small fish swallow the small plastic flakes. Sea-birds eat these fish and the plastic in the fish kills the sea-birds.

> To **recycle** means to process waste materials to make new products from it.

So plastic being dumped in the environment is a big problem. But many types of plastic can be **recycled**.

1. Write down two reasons why we should recycle plastic items.

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Different types of plastic need different processes to recycle it

Waste of different types of plastic need to be sorted so that each type of plastic can be recycled separately. Manufacturers have agreed on a set of codes to show which type of plastic a product is made of.

Codes and names	**Examples of products**	**Properties**	**Recycled products**
♳ 1 PET polyester	cool drink bottles	clear; tough; good barrier for liquids and gases; heat-resistant	fibres to make fabrics for clothes, bags and carpets; food and drink containers
♴ 2 HDPE high density polyethylene	bottles for milk, juice, water and laundry products	somewhat rigid; tough; resistant to chemicals; good barrier for liquids and gases	bottles; pipes; buckets; crates; flower pots; bins; plastic planks; floor tiles

3 PVC polyvinyl chloride	pipes; coating (sheaves) of electrical wires	resistant to chemicals; electrically insulating; tough; can be rigid or flexible	gutters; floor tiles and mats; electrical boxes; garden hoses
4 LDPE low density polyethylene	thin plastic films, for example to cover food or books; flexible lids and bottles	flexible; tough; good for sealing; barrier to moisture	garbage bags; floor tiles; bins
5 PP polypropylene	large moulded parts, for example car parts	resistant to chemicals; tough; heat-resistant; barrier to moisture	car battery cases; brooms and brushes; bins; trays
6 PS polystyrene	protective packaging; disposable cups; bottles; trays; thermal insulation (especially in roofs)	can be rigid or foamed; low melting point; in foamed form it is an excellent heat insulator	plates for light switches; rulers; thermal insulation; foam packaging
7 OTHER other type of plastic, or more than one type of plastic used in the same product	acrylic or perspex sheets (can be used as a replacement for glass windows); "ABS" for making car bumpers	depends on the type of plastic; "ABS" has very good shock-absorbing properties	plastic planks

9.3 What have you learnt?

Identify the types of plastic on the table

Look at the four plastic products your team looked at in the activity in section 9.1 again. Turn them upside down and try to find a symbol for the recycling code.

1. Complete the table below:

	Code and name of the type of plastic	**Properties**	**What products could be made from this recycled material?**
Object 1			
Object 2			
Object 3			
Object 4			

2. Why do manufacturers often choose to make their products from plastic?

....

....

3. Why do manufacturers put recycling codes on the bottom of containers?

....

....

....

4. Why do they not use the same type of plastic for everything that can be manufactured?

....

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5. Think of three objects that could *not* be made of plastic.

....

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Next week

In the next chapter, you will learn how plastics are recycled to make new products.

Chapter 10
Recycling and manufacturing with recycled plastic

In this chapter, you will learn how plastic waste is recycled to make new products.

10.1 Moulding recycled plastic pellets into products

There are two steps to making plastic bottles, injection moulding and blow moulding.

Step 1: Injection moulding to make preforms from pellets

Injection moulding is used to make plastic "preforms" of bottles. Preforms are like small bottles with very thick walls that already have the neck and screw-thread of the final bottle. Figure 1 shows the preform for a plastic bottle.

Figure 1: A preform of a plastic bottle

Figure 2 shows the injection-moulding machine at different times of the injection-moulding process. In this picture, the plastic is the coloured substance. The raw material going into the machine is small, almost round pieces of plastic called pellets.

They are initially hard since they have not been heated yet, and are shown in blue. The plastic must be soft and hot for the injection process to work.

The pellets are pushed forward by a screw that is turned by a motor. At the same time, the pellets are heated until they melt. The turning force of the screw creates pressure that pushes or injects the molten plastic into the mould. Once the mould has been filled, the opening of the mould where the molten plastic came in is closed, and the mould is left to cool.

The plastic in the mould solidifies as it cools down. Once it has cooled down sufficiently, the two halves of the mould open so that the preform that was made can be taken out.

Answer the following question in connection with Figure 2.

1. Find the mould and label it.
2. Where will you put a heater on the machine to melt the plastic pellets? Draw an extra part or parts for the machine to show where the heater should be, and label it.
3. Look carefully at a plastic bottle. You will find a very thin ridge where the two parts of the mould joined. If you cannot see it, feel around the neck of the bottle with your finger.
   Why is the mould line on both sides of the neck?

   ....

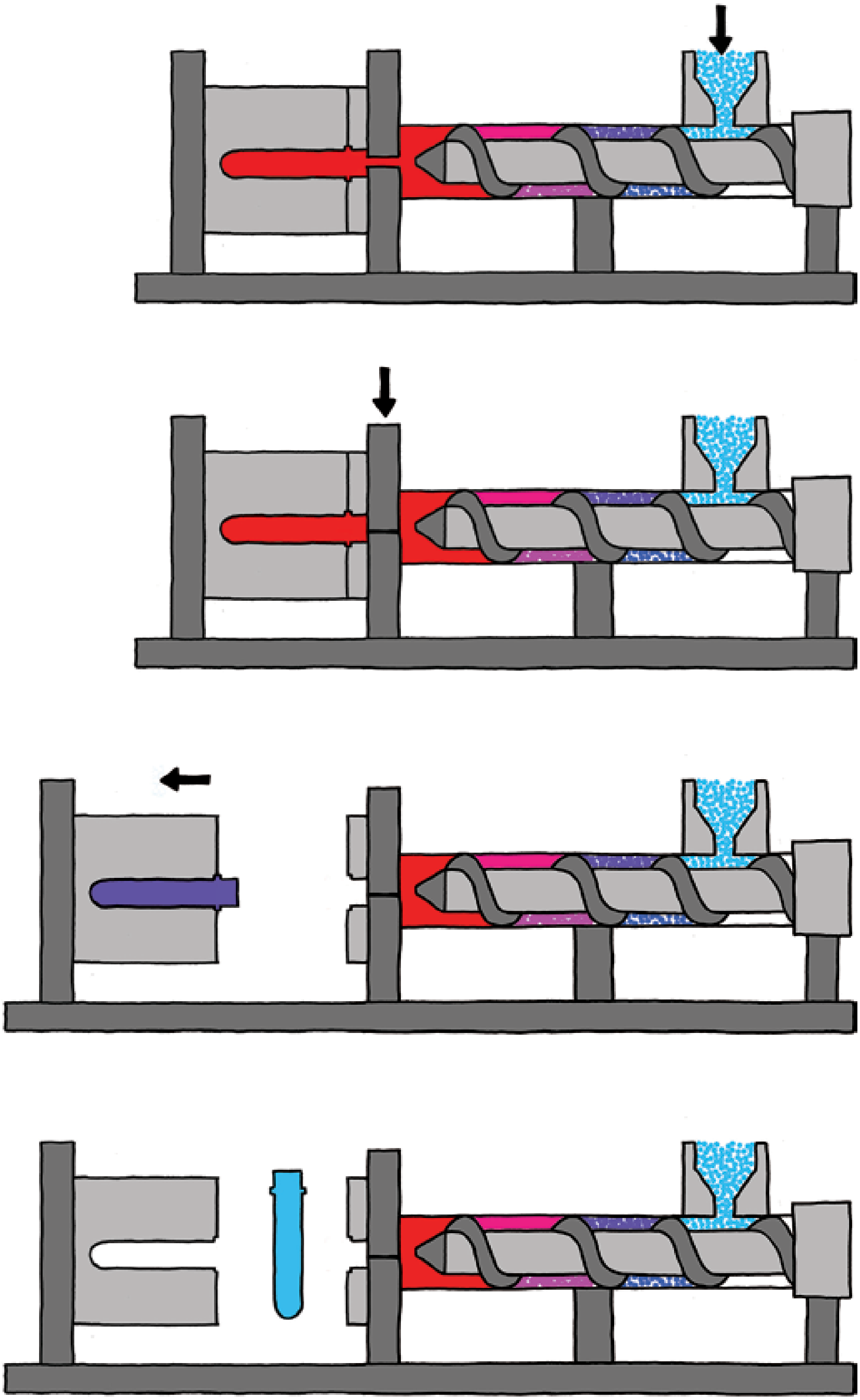

Figure 2: The injection-moulding process

Step 2: Blow moulding to shape preforms into bottles

Next, the preform goes to a blow-moulding machine. This machine blows hot air under high pressure into the preform. This heats the lower part of the preform so that it becomes soft and can change its shape. The high air pressure forces the walls of the preform to expand into the mould, similar to blowing up a balloon.

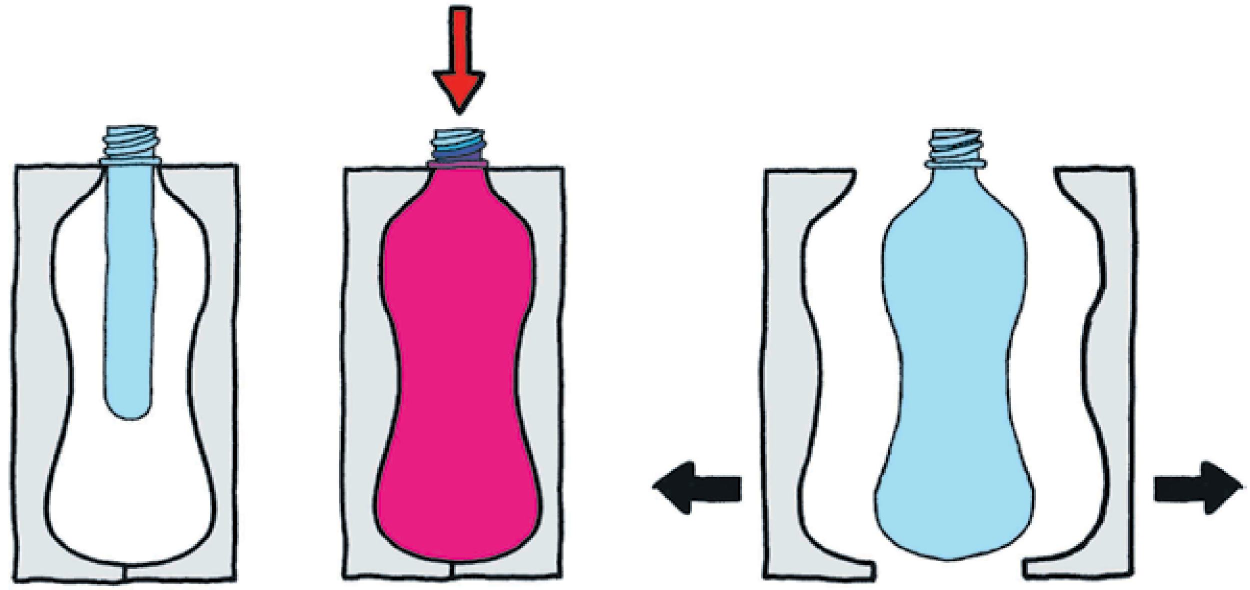

Figure 3: Blow-moulding of a preform to make a plastic bottle

The same type of preform can be made into different shapes of bottles, since it can be blown into different moulds. But all the bottles will have the same screw-on cap.

1. Why will all the different-shaped bottles fit the same cap?

   ....

10.2 Recycling plastic to make new products

In Chapter 9, you learnt why we should recycle plastic containers and other products. In this chapter, you will learn how PET plastic can be recycled and made into a new raw material.

Case study: The cyclical process of recycling plastic

1. Why should plastics be separated into different types before it can be recycled?

   ....

   ....

2. How do the recycling codes on the plastic containers help to sort them?

   ....

   ....

3. The containers are not only plastic. If you look carefully at a container, what other materials can you find? You can look at some of the containers your classmates brought to class.

   ....

   ....

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   ....

4. Are all the plastic containers in the bin clean? Is this important?

   ....

   ....

   ....

5. Plastic bottles and other containers take up a lot of space. Why is this a problem?

   ....

   ....

6. Name four things that need to be done to plastic waste before it will be suitable to turn into new products.

   ....

   ....

   ....

   ....

   ....

The illustration on the next page shows the plastic recycling process.

Each type of plastic waste is pressed into bales that can easily be transported. At the recycling factory, the plastic waste is shredded into small pieces, to make it easier to handle and wash.

7. Complete the systems diagram below by giving descriptions of the different steps of the recycling process. Hint: When something is recycled, it means that the output is also the input, since the process is a cycle or circular.

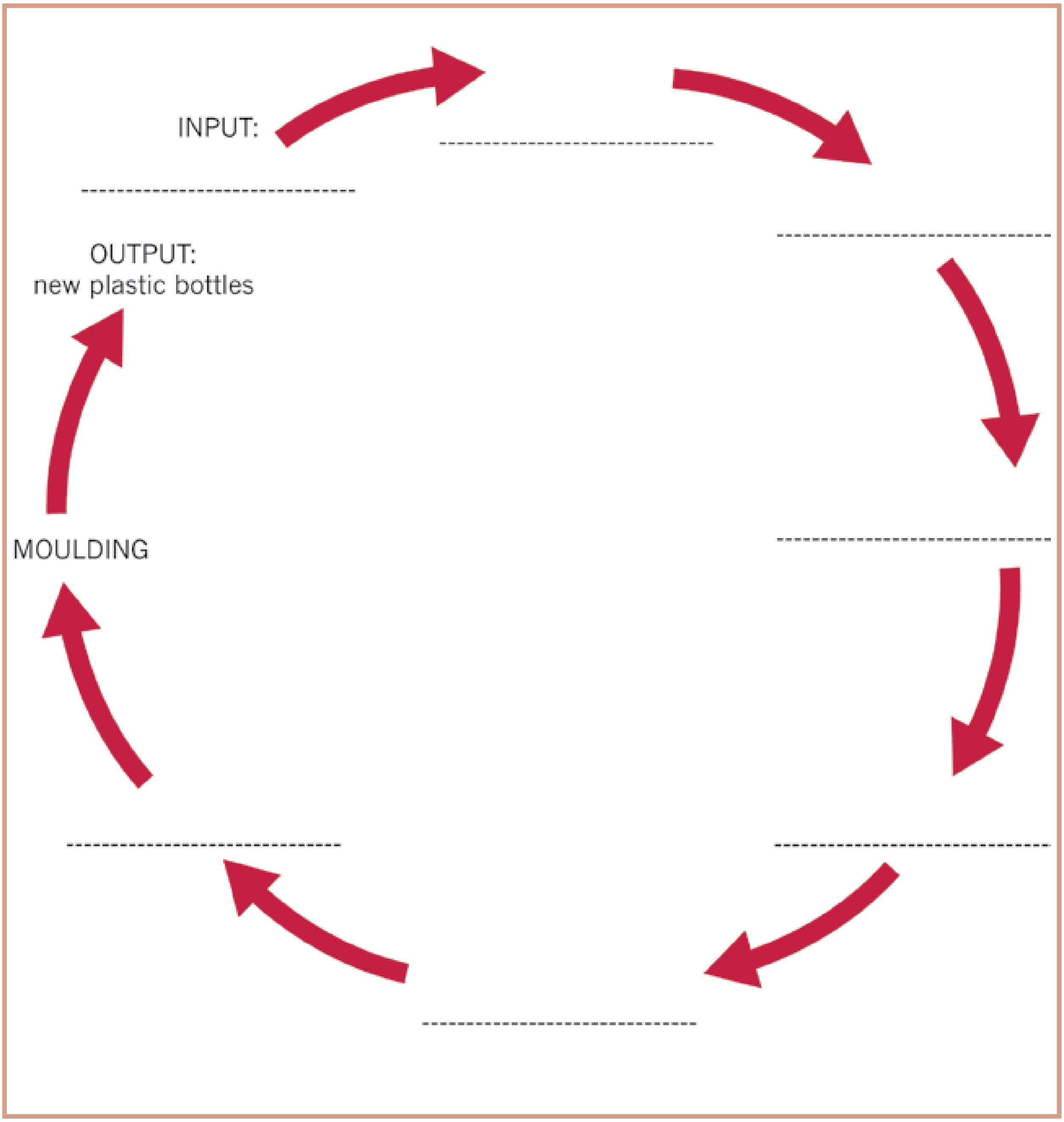

Figure 4: Systems diagram of the plastic bottle recycling process

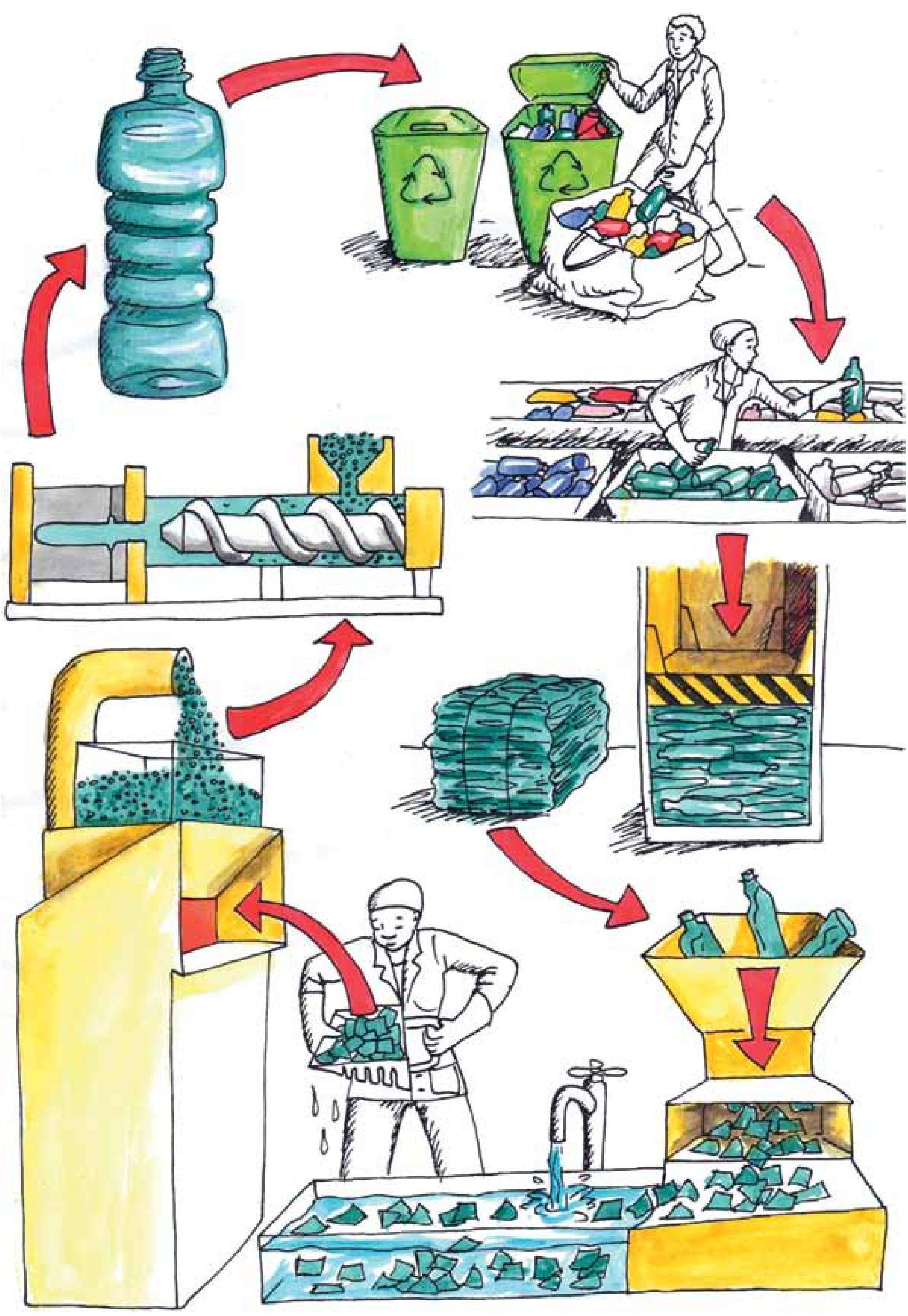

Figure 5: The steps to turn waste plastic into new plastic products

10.3 What have you learnt?

1. What is the raw material for the bottles in this process?

   ....

2. How can consumers and house-owners make it easier for recyclers to process plastic products to make new bottles?

   ....

   ....

   ....

3. A manufacturer can buy one type of preform and then make different-shaped bottles. How can this be done?

   ....

4. Which type of moulding do you think is used to make plastic chairs?

   ....

   ....

5. What is the difference between injection moulding and blow moulding?

   ....

   ....

   ....

   ....

   ....

Next week

Over the next three weeks, you will do your Mini-PAT for this term. You will reuse old plastic bottles for a new purpose. But the bottles will have to be changed, so you will need to design and make new products from the old plastic bottles.

Chapter 11: Mini-PAT
Reduce, re-use and recycle : Working with plastics

In this Mini-PAT you will design and make a useful new product from old plastic bottles. But first you will look at how plastic is used in everyday life.

You will **only do individual work** in this Mini-PAT.

Assessment

Investigate: Different scenarios reusing plastic bottles	[4]
Design brief for the scenario that you chose	[4]
Design: Initial rough sketches	[10]
Make: Final orthographic drawing	[15]
Make the plastic product you designed	[25]
Communicate: What have you learnt during this term?	[12]
	[Total marks: 70]

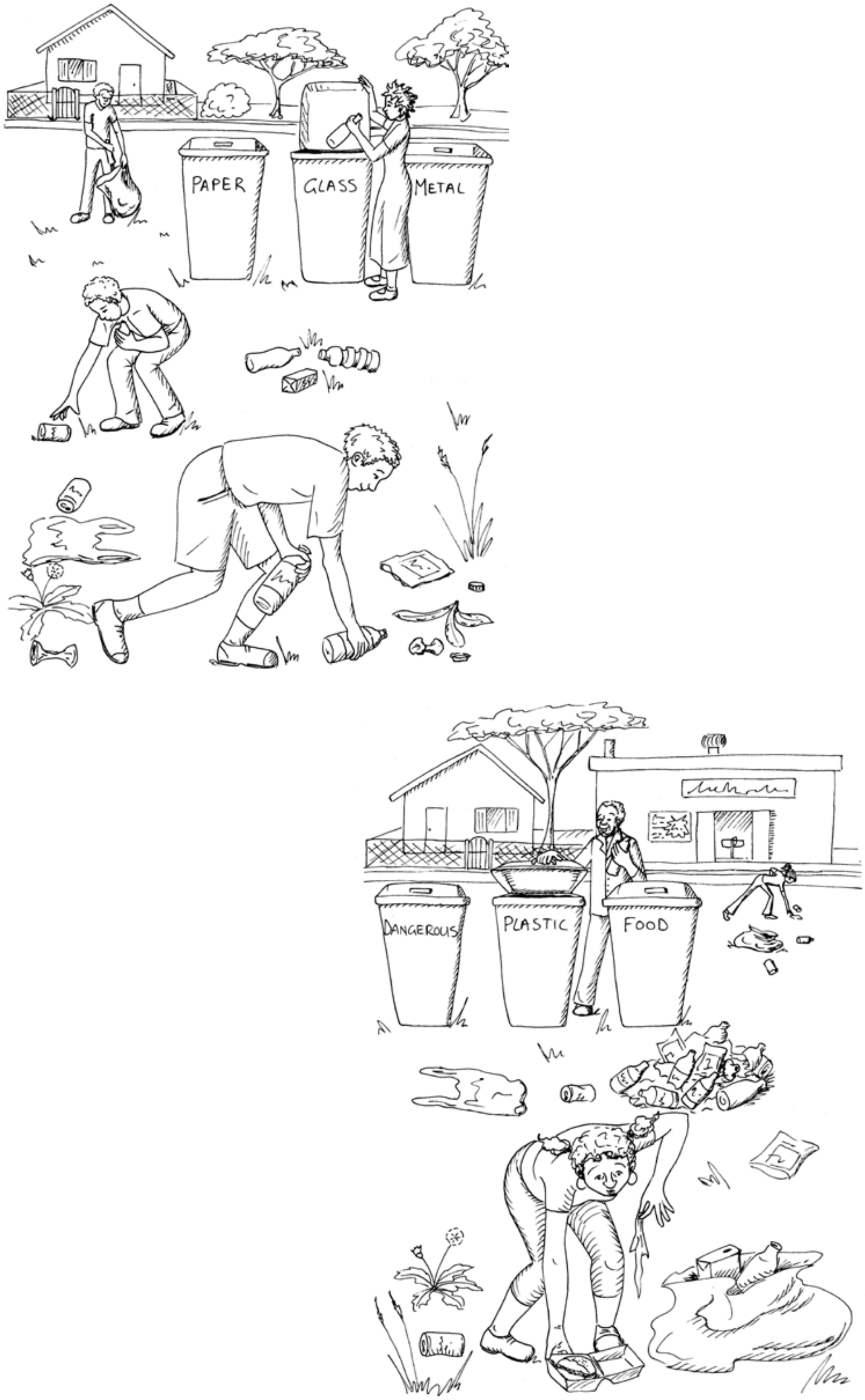

Figure 1: Improving your environment by picking up and sorting waste

Reduce, re-use, recycle

In Grade 8 Term 4, you learnt that the environment is damaged when more and more things are made and thrown away. You learnt that waste is formed in order to make new products, and that the products themselves become waste when they are thrown away. You can reduce the negative impact of this practice on the environment in different ways.

Firstly, you can buy fewer things, which is called reducing your consumption.

Secondly, you can use some things over and over, so that you don't have to buy new things. This is called re-using things. You can also re-use something for a different purpose than it was originally made for. For example, many people use old hot-water tanks (geysers) to make "braai-skottels" in which they can make fire and barbeque food outside.

Figure 2: A "braai-skottel" made from an oil tank cut through the middle

But what if something you own gets broken or you don't have any use for it anymore? Then you have to throw it away. Fortunately, there is a clever way of throwing things away, by separating the different types of waste.

For example, if you and your family collect all your plastic waste separately, then someone can take that plastic to a recycling factory where new plastic is made from the old plastic. At a recycling factory, the old plastic is washed and shredded into very small pieces.

You learnt in the previous chapter how plastic pellets are moulded into new shapes.

It is then melted and "moulded" in the shape of "pellets". The pellets can then be used as the raw material to make new plastic products.

Week 1

Plastics are easy to form into complicated shapes, do not corrode, have high electrical resistance, are tough and can be made in many colours.

Plastics in the classroom and at home (60 minutes)

1. Look around you on your desk, at your clothes and in your school bag. Make a list of all the things you can see that are made of plastic. Also write down whether it is made of hard or soft plastic and thick or thin plastic.

Plastic item	**Hard or soft**	**Thick, thin, or woven**

2. The table below lists different things that you can see in a house. Write "yes" or "no" next to each item to show whether it is made of plastic or not.

floor tiles	
roof plates	
cushions	
windows	
window frames	
paint	
chair backs	
lights	
bottles for washing soap	
sponges	
the outside of a TV or radio	

3. Look at the illustrations of household appliances below. The arrows point to different parts of the appliances, and labels are given to describe the different parts of the appliances. Write a "P" below each label for a part that is made from plastic.

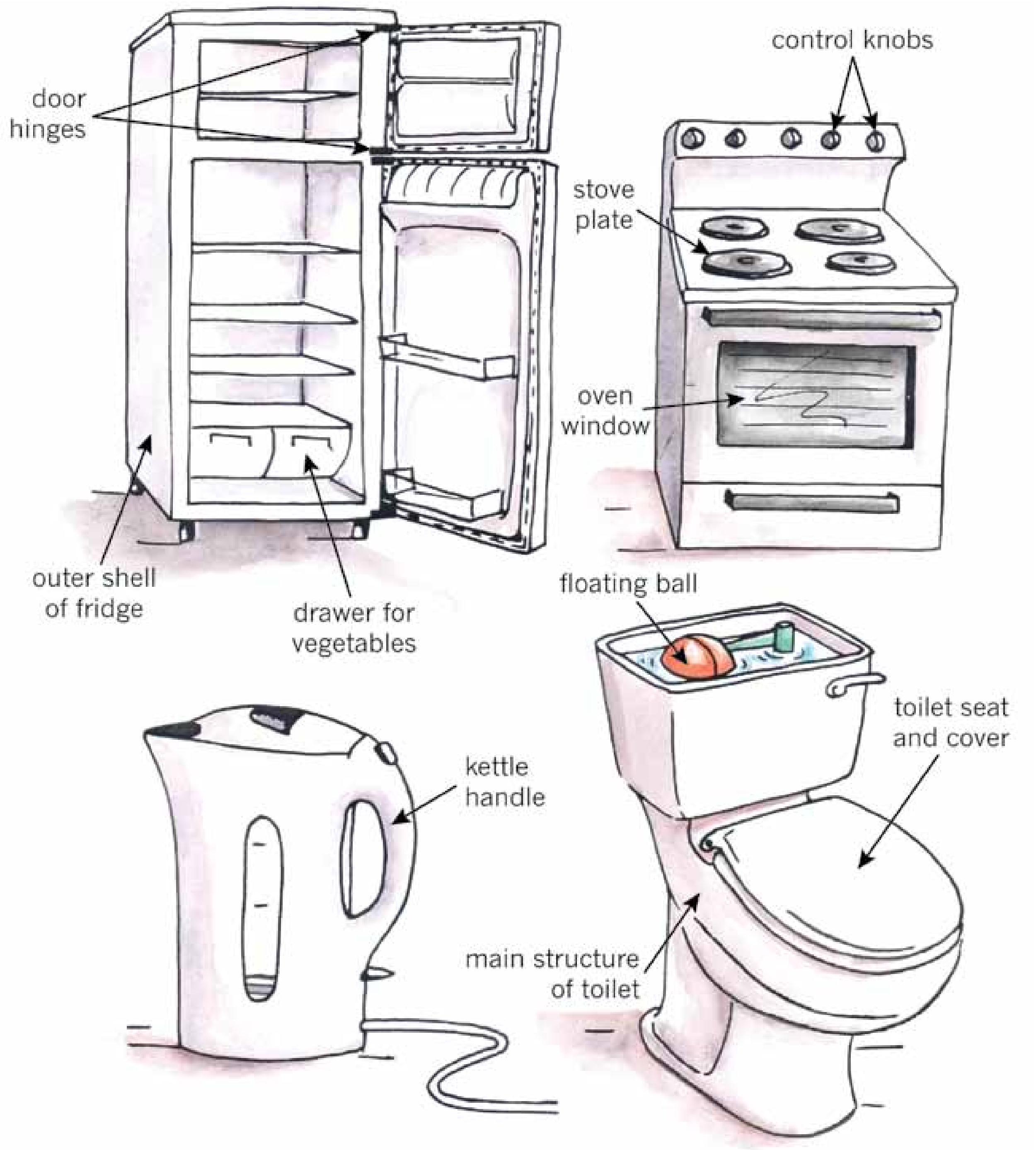

Figure 3: Different parts of typical household appliances

4. A long time ago, cars were heavy because most of their parts were made of steel, cast iron and even wood. Nowadays, cars are much lighter, and therefore they use less petrol to travel each kilometre. One way that was used to make cars lighter is to use more plastic when building them, instead of using metal.
   Look at the illustrations of the inside and outside of a car below. The arrows point to different parts, and labels are given to describe these different parts. Write a "P" below each label for a part that is made from plastic.

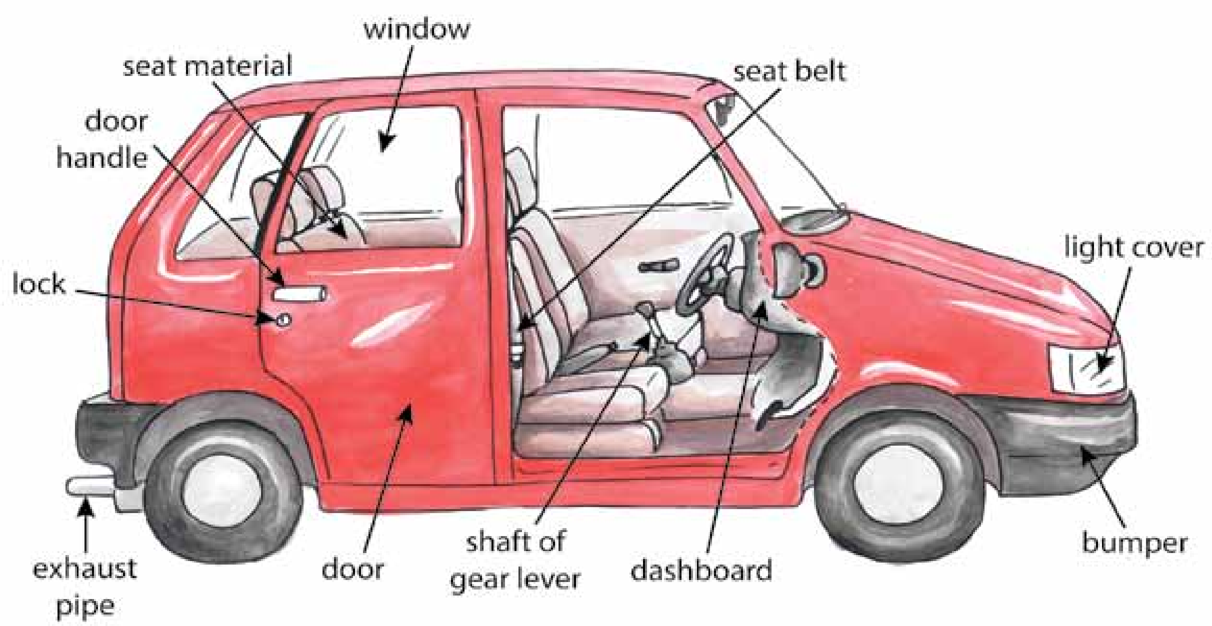

Figure 4: Different parts of a motor car

5. How can you test whether a material is plastic or metal?
   Hints: Think about hardness, strength, magnetism, sound, heat and fire.

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Safety warning:
Burning plastic can start a fire and release poisonous gases. Molten plastic can cause serious burn wounds.

....

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....

Different scenarios for reusing plastic bottles (30 minutes)

On the following pages, you are shown photos of four scenarios in which new products were made from old plastic bottles.

Each of the products solves a certain problem. In other words, it satisfies or addresses a certain need. Answer the questions for each scenario about the problem or need. Then choose one of these scenarios for the product that you will design and make.

Scenario A

Figure 5

1. What is the purpose of the product? (½)

 ....

2. How does this reduce the amount of work that somebody has to do? (½)

 ....

 ....

Scenario B

Figure 6

3. What is the purpose of the product? (½)

....

....

4. Can this product save you money? How? (½)

....

Scenario C

Figure 7

5. What is the purpose of the product? (½)

   ………………………………………………………………………………

6. Can this product save you money or time? How? (½)

   ………………………………………………………………………………

   ………………………………………………………………………………

Scenario D

Figure 8

7. What is the purpose of these products? (½)

....

8. Can this product save you money or time? How? (½)

....

Total [4]

Design brief for the scenario that you chose (30 minutes)

Answer the following questions to identify the specifications and constraints for the scenario that you chose.

1. Give a description of the product you are going to make. (1)

   ....

2. Answer the following questions to identify the *specifications* for your design:

   (a) What is the purpose of your product? (½)

   ....

   ....

   (b) Should your product keep some things inside (contain it) and keep other thing out? What should it keep in and what should it keep out? (½)

   ....

   ....

   (c) Should your product be supported in some way to stay upright? How? (½)

   ....

3. Answer the following questions to identify the *constraints* of your design:

   (a) Make a list of all the materials you will need. (½)

   ....

   ....

   (b) Make a list of all the tools that you will need. (½)

   ....

   ....

   (c) Make a time schedule showing how much time you have to design and make the product. (½)

   ....

Total [4]

Week 2

Initial rough design sketc (30 minutes)

Make rough sketches of your design ideas for the product that you want to make. You can make sketches for different ideas and later decide which one you are going to make.

Try to design and make a product that is slightly different from the photos of the products on the previous pages, to address the need. In other words, try to make an **innovative** design.

The word **innovative** comes from the word "new". An innovative solution to a problem is a solution that nobody else thought of before.

Show notes and labels on your sketches to help to explain your ideas. [10]

Final orthographic drawing (30 minutes)

Choose your final design from your rough sketches. Then draw your product to scale using first angle orthographic projection. Show dimensions. [15]

Practice to mark out, cut and make holes in plastic (60 minutes)

You need the following materials for this activity:

- two or more old plastic bottles that have been cleaned,
- a marker pen or "koki" pen,
- nails of different sizes to make holes in the plastic,
- a strong pair of scissors to cut the plastic,
- sandpaper, and
- sticky tape to join different plastic parts together.

First make sure that the plastic bottles are clean and that all the labels and glue have been removed.

This is how to cut a plastic bottle:

First make a small hole with a thin nail where you want to start cutting. Hint: It will be easier to make the hole if you keep the cap of the bottle on and tightly secured, because then the bottle will not collapse as you press the nail in.

Then make the hole bigger by moving a thick nail around in the hole to make it bigger, as shown in the photo below. You can also use a cutting knife to make a short cut where you can then put the blade of the scissors in.

Figure 9: Making a hole in the bottle

Once the hole is big enough to insert one blade of the pair of scissors, start cutting with the scissors, as shown the photo on the right.

Use sandpaper to make the sharp edges of the hole in the bottle smooth so that it can't cut you.

Safety warnings

A pair of scissors should not be used like a knife. If you do that, it can slip and you can cut yourself.

Do not try to cut the thick, hard parts of the bottle. If you do that, the scissors can slip and you can cut yourself.

Figure 10: Cutting the bottle

Week 3

Make the product you designed (90 minutes)

You can make more sketches if you realise that you need to change some things about your design. [25]

What have you learnt during this term? (30 minutes)

1. What metal is used on the surface of a sheet of corrugated iron to protect it from corrosion? (1)

   ....

2. Give some examples of steel products that have been galvanised. (1)

   ....

3. Painting and galvanising are both methods to stop steel from corroding; each method coats the steel with another substance. Complete the following sentence: The difference between the two methods is that … (4)

   ....

   ....

   ....

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4. How would you protect a steel bridge from rusting? Which of the three processes that you have learnt about in this unit do you think would be most appropriate for this task and why? (2)

   ....

   ....

   ....

5. Give two examples of food that is preserved by the process of drying. (1)

   ....

6. Why do manufacturers print a symbol like this on the bottom of plastic products? (1)

....

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....

Figure 11

7. Why do designers prefer to use plastics instead of steel for certain parts of cars? Give four reasons. (2)

....

....

....

Total [12]

Make a record of the term's work

Go through all your work of this term, and make sure that the following is in your workbook so that your teacher can evaluate it.

You should have the following things in the file, ready to show your teacher. You should be able to show your teacher the place in this workbook where you have:

- answers to the questions about painting, galvanising and electroplating,
- your notes about what you observed when you electroplated a metal object,
- answers to the questions about storing grain, pickling food and drying food to preserve it,
- your notes about how you dried some food to preserve it,
- your records of the kinds of plastic that the class collected and sorted by the codes on the containers,
- a systems diagram for recycling plastic and producing pellets for re-manufacture,
- the investigation of plastics in a car – notes you made,
- the investigation of plastics in a house – notes you made,
- a sample of the material you made from fused plastic bags,
- your sketches and notes of ideas for a product to be made from fused plastic,
- your orthographic drawing of the product, and
- the product that you designed and made by reusing old plastic bottles.

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