Science 5–6

Chapter 9 — Physical sciences

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Contents

Light: sources, paths and what objects do to it

Words to know source · natural source · artificial source · ray · beam · shadow · absorb · transmit · reflect · refract · transparent · reflection · refraction · ray diagram · mirror · prism · periscope

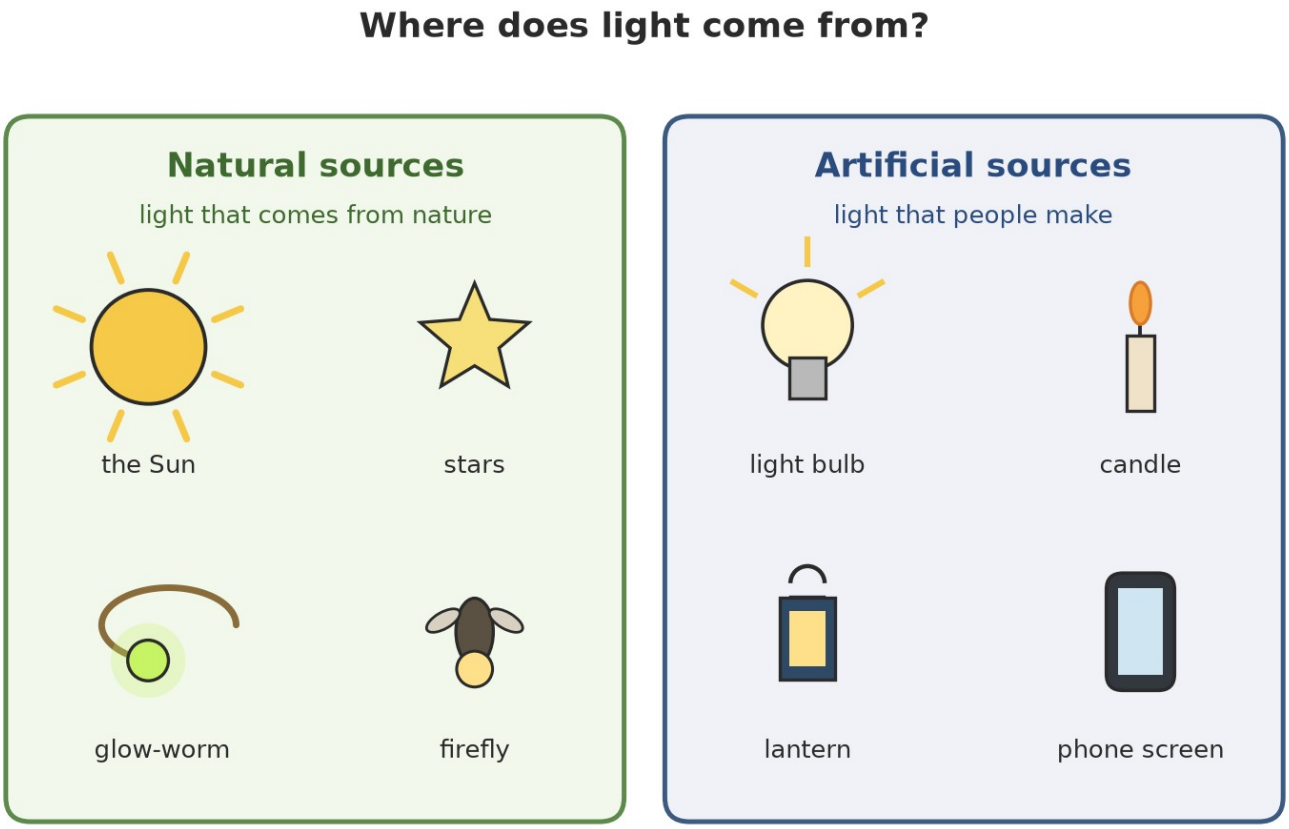
Everything you see, you see because light has travelled into your eyes. Light comes from **sources** such as the Sun, glow-worms and light bulbs. It travels in a straight path, and when it meets an object the light is absorbed, transmitted, reflected or refracted. Those few ideas explain shadows, mirrors, periscopes, prisms and rainbows. In this section we draw ray diagrams to explain what we observe.

Theory

Where does light come from?

A **source** of light is anything that gives out its own light. Sources are either natural or artificial.

- A **natural source** makes light in nature: the Sun, the stars, lightning, and living things such as glow-worms and fireflies.
- An **artificial source** is light that people make: light bulbs, candles, torches, lanterns and phone screens.

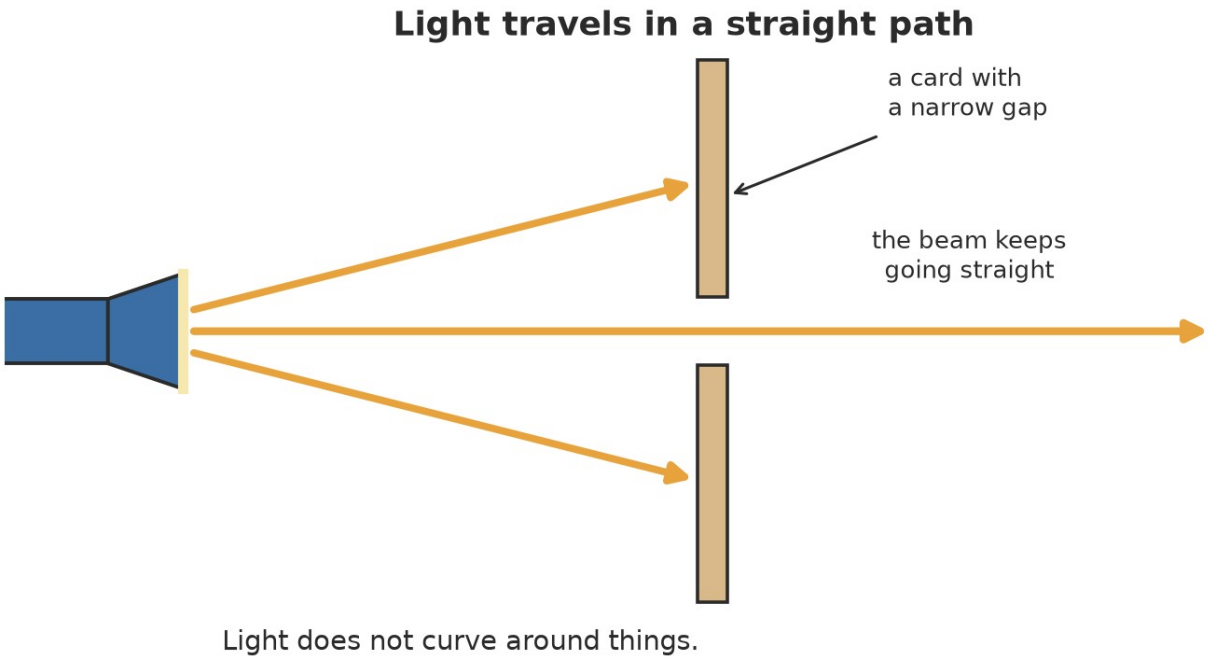


Two boxes sorting light sources. Natural sources: the Sun, stars, a glow-worm and a firefly. Artificial sources: a light bulb, a candle, a lantern and a phone screen.

Most things we see are not sources. We see them because light from a source bounces off them and into our eyes. You can read a page in the Sun because light from the Sun reflects off the page.

Light travels in a straight path

Light travels in a straight **path**. It does not curve around things. A **ray** is a straight line with an arrow showing which way the light travels. A **beam** is many rays together, like the beam of a torch. A **ray diagram** is a drawing of rays that explains what we see.

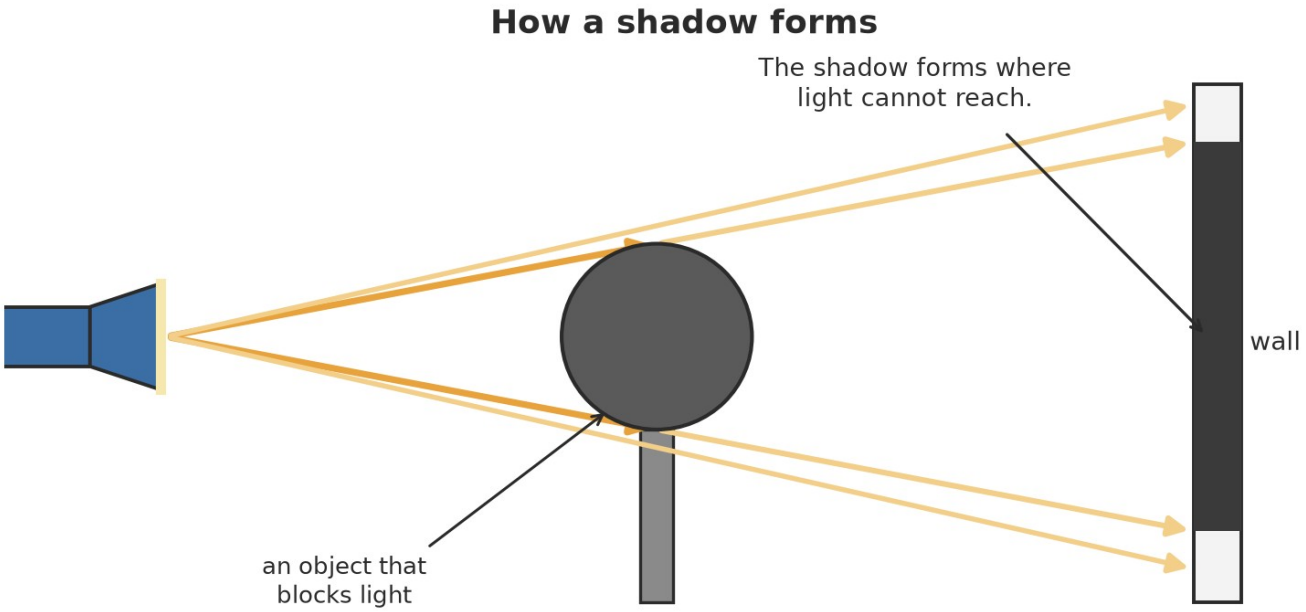


A torch shines three straight rays at a card with a narrow gap. The two rays that hit the card stop there. Only the ray aimed at the gap goes through, and it keeps going straight.

Shine a torch at a card with a narrow gap. The beam is only seen through the gap, and it keeps going straight on the other side. If light could curve, it would travel around the card — but it does not. This is also why you cannot see around a corner.

Shadows

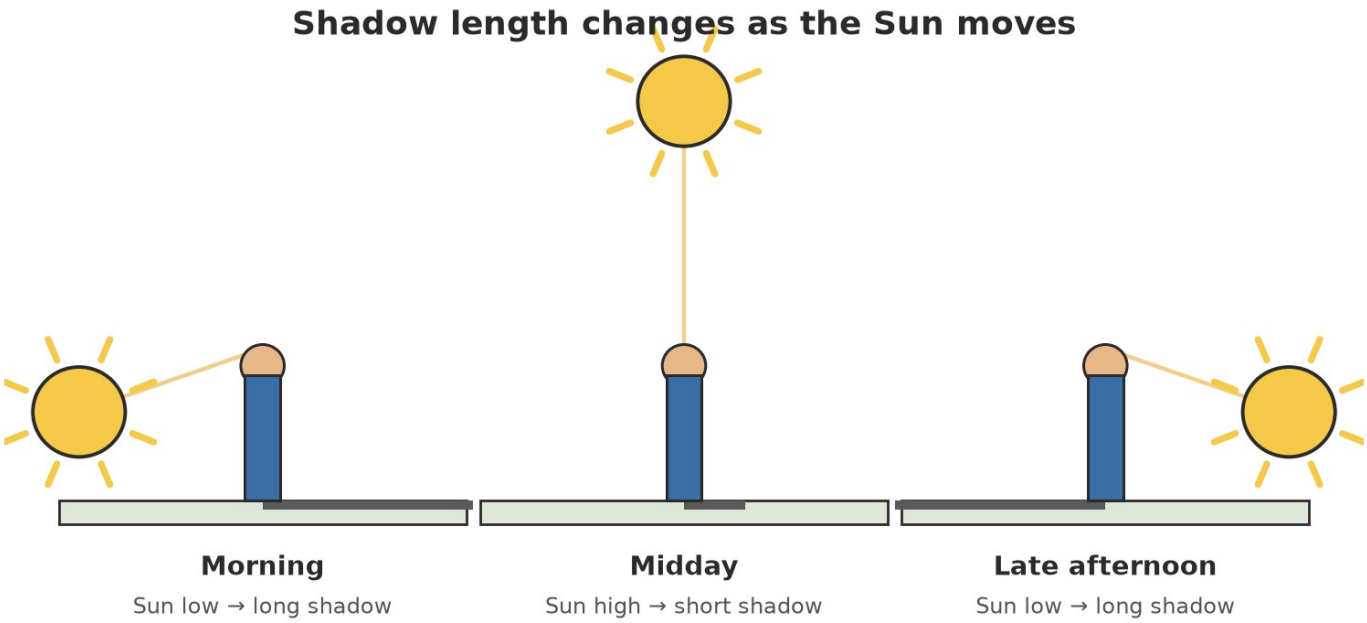
A **shadow** forms where light cannot reach. Put an object that blocks light in a beam, and the light stops at the object. Behind it there is a dark patch: the shadow.



Ray diagram of a torch shining at a ball on a stand in front of a wall. Rays that hit the ball stop, and rays that miss the ball light the wall. A dark band forms on the wall where light cannot reach: the shadow.

Because light travels in a straight path, a shadow has the same shape as the object that makes it. Hold up your hand and the shadow looks like your hand — this is how shadow puppets work. The shadow is large when the object is close to the light source, and small when it is close to the wall.

The Sun moves across the sky through the day, so shadows change too.



Three panels: morning, midday and late afternoon. When the Sun is low in the morning the person's shadow is long; when the Sun is high at midday the shadow is short; when the Sun is low in the late afternoon the shadow is long again.

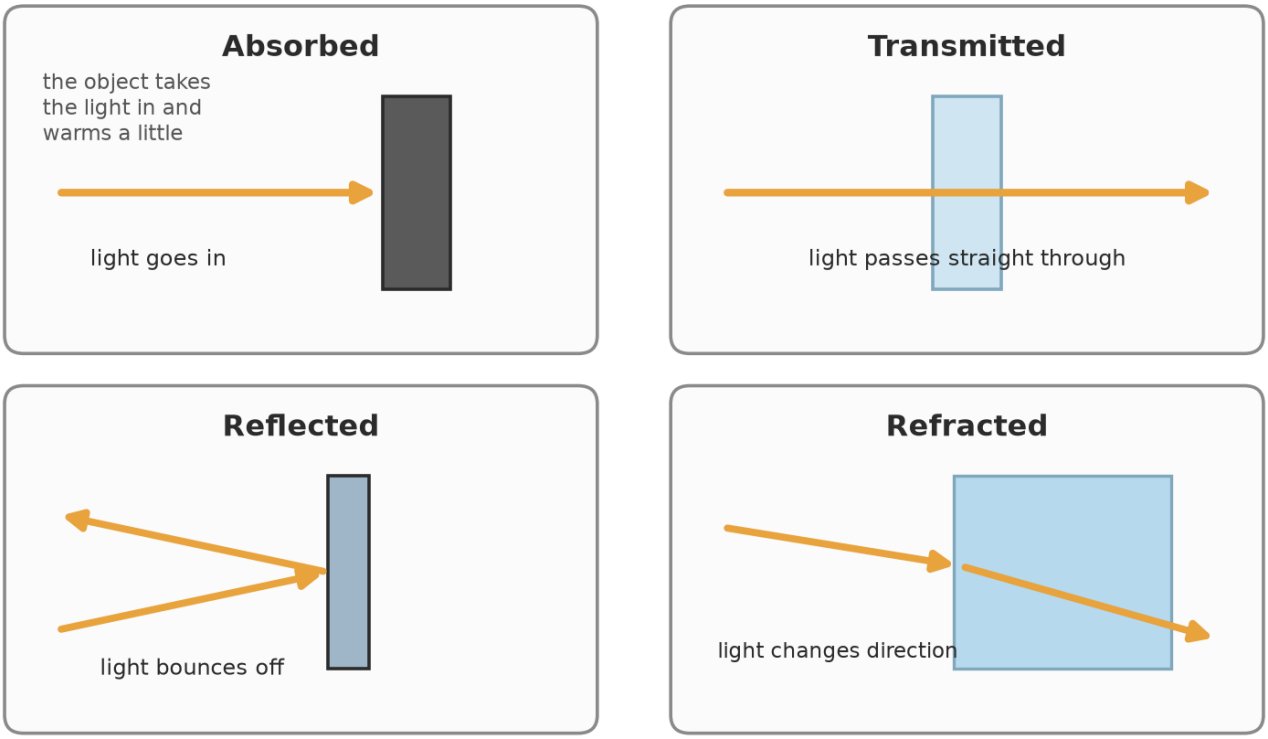
- In the **morning** the Sun is low in the east, so shadows are long and point west.
- At **midday** the Sun is high in the north (in Victoria), so shadows are short and point south.
- In the **late afternoon** the Sun is low in the west, so shadows are long and point east.

A sundial uses this pattern: as the Sun moves, the shadow of a stick moves and changes length, marking the time of day.

Four things an object can do to light

When light meets an object, one of four things happens. We tell which is which by observing what the light does.

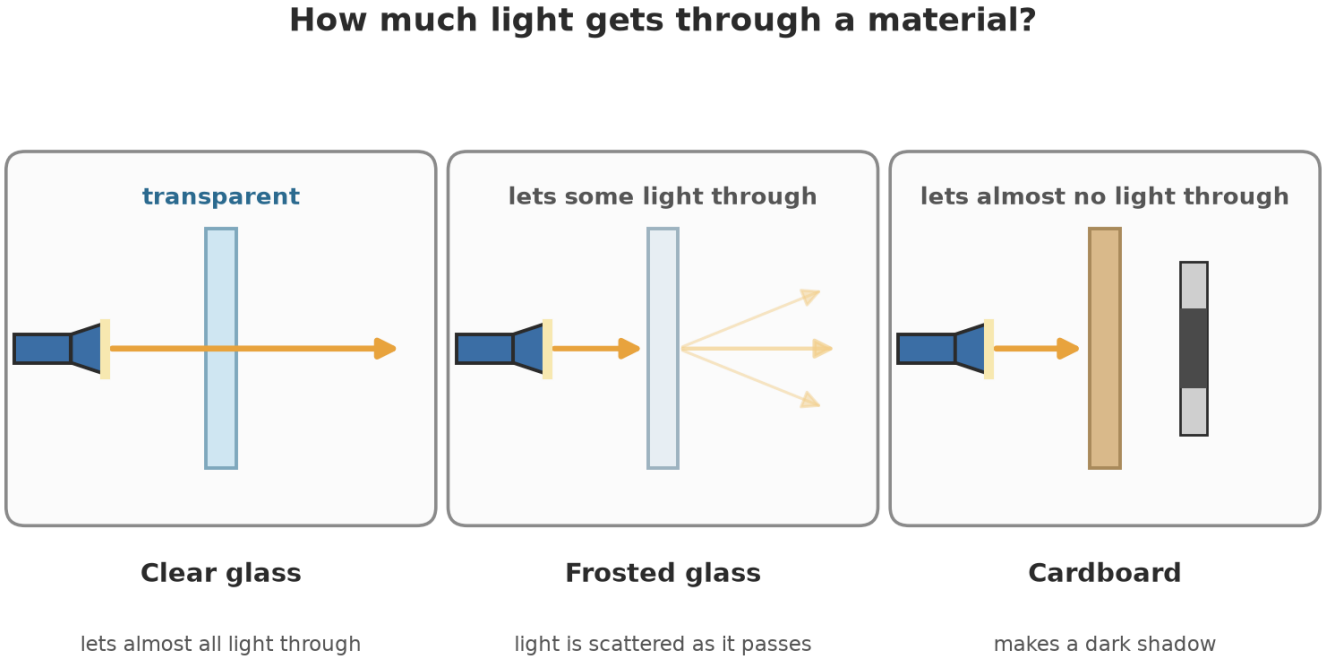
Four things an object can do to light



Four small ray diagrams. Absorbed: a ray goes into a dark object and stops. Transmitted: a ray passes straight through clear glass. Reflected: a ray bounces off a mirror. Refracted: a ray changes direction as it passes into water.

- **Absorbed** — the object takes the light in. It does not pass through and it does not bounce back. The object warms a little. A black road in the Sun gets hot because it absorbs light.
- **Transmitted** — light passes through the object. Clear glass and clear water transmit light.
- **Reflected** — light bounces off the object. Mirrors and shiny metal reflect light well.
- **Refracted** — light changes direction as it passes into or out of the object. This is **refraction**. A pencil in a cup of water looks shifted because light from it is refracted at the water line.

Materials also differ in how much light gets through them.



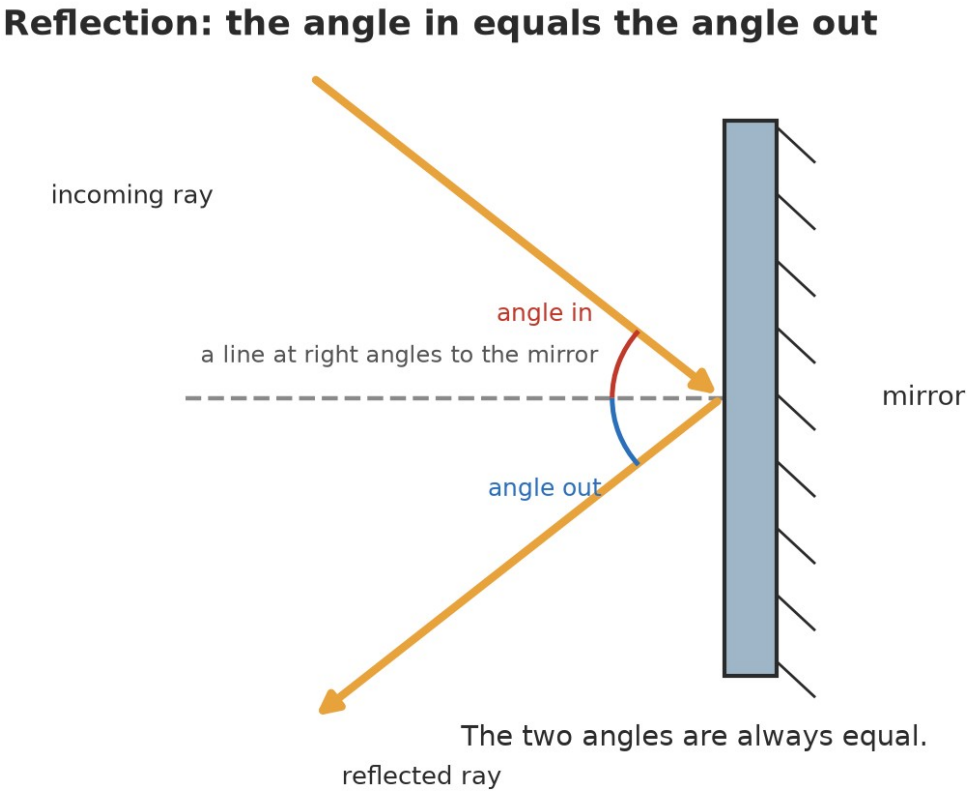
Three panels comparing materials in a torch beam. Clear glass is transparent and lets almost all the light through. Frosted glass lets some light through but scatters it, so you cannot see through it clearly. Cardboard lets almost no light through and makes a dark shadow.

- A **transparent** material lets almost all light through, so you can see through it: clear glass, clear water, clear plastic.
- Some materials let some light through but scatter it, so you cannot see through them clearly: frosted glass, thin cloth.
- Some materials let almost no light through, so they make dark shadows: cardboard, wood, brick, your body.

Most real objects do a mix of these things. A window transmits most of the light that hits it, reflects a little and absorbs a little.

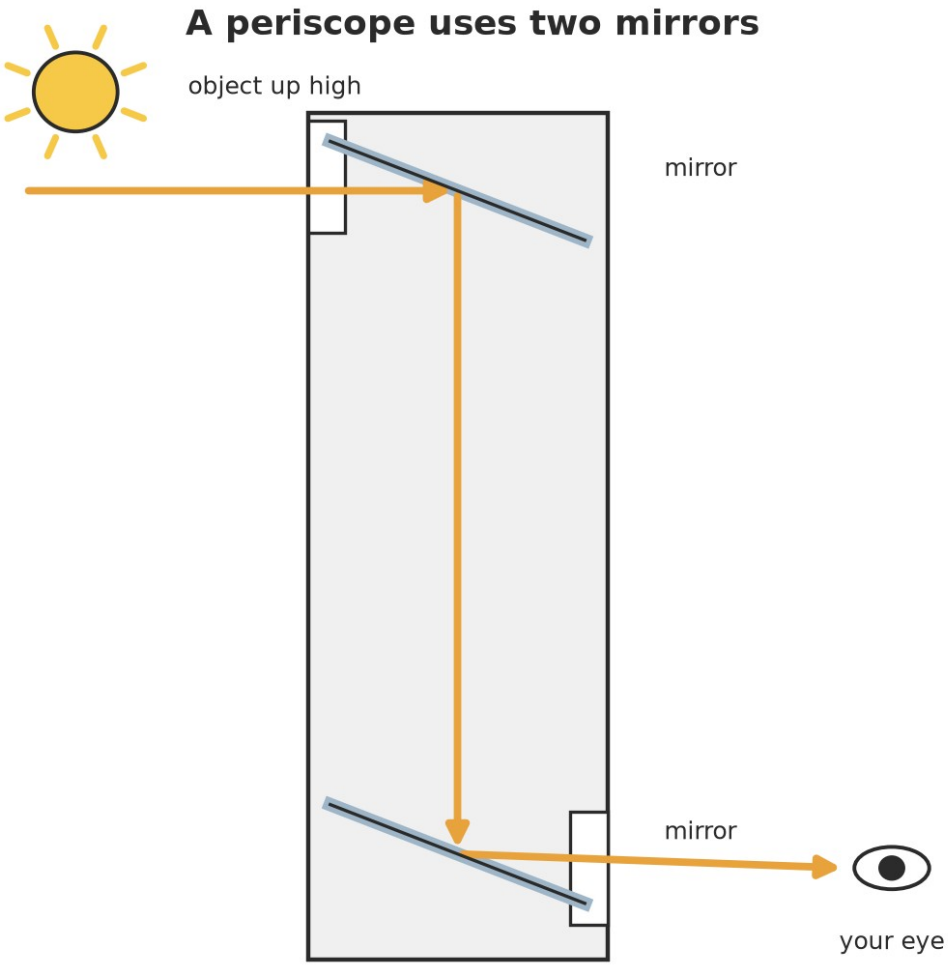
Reflection put to work

A mirror reflects light very well because its surface is smooth and shiny. When a ray hits a mirror, it bounces off. The **angle in** (between the incoming ray and a line at right angles to the mirror) always equals the **angle out**. This is **reflection**.



Ray diagram of a ray hitting a mirror. A dashed line at right angles to the mirror marks the angles. The angle in, between the incoming ray and the dashed line, equals the angle out, between the reflected ray and the dashed line.

Reflection is put to work in mirrors, in mirror mazes, and in a **periscope**. A periscope is a tube with two mirrors set at 45 degrees. Light from an object up high hits the top mirror and reflects down the tube. It hits the bottom mirror and reflects out into your eye. This is how a sailor sees over the water from below deck.

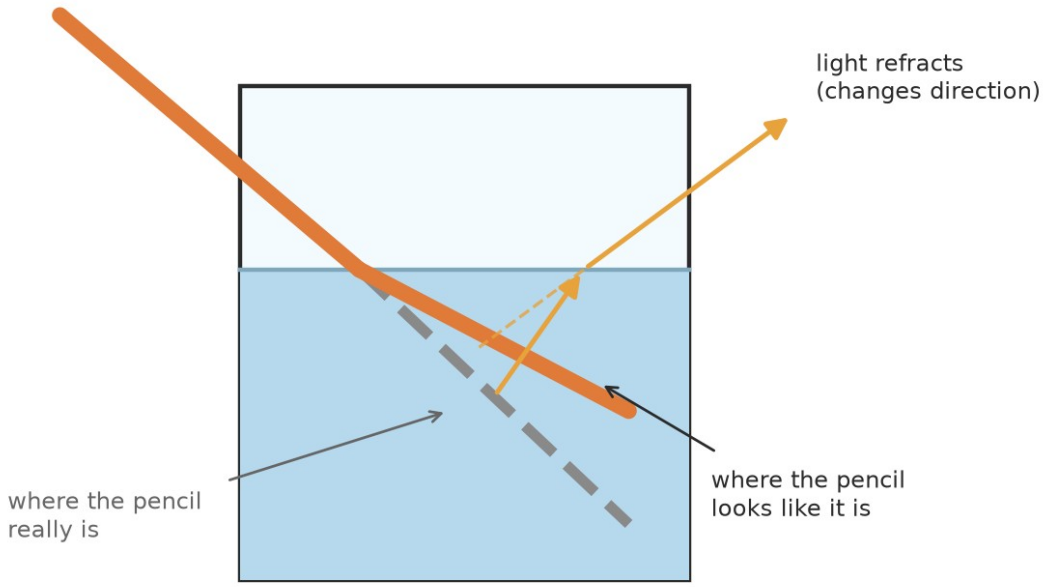


Ray diagram of a periscope. A straight ray from an object up high enters the top window, hits a mirror and reflects straight down the tube, then hits a second mirror and reflects out of the bottom window into your eye.

Refraction observed

Refraction is observed when light passes from one material into another and changes direction.

Refraction makes a pencil look shifted

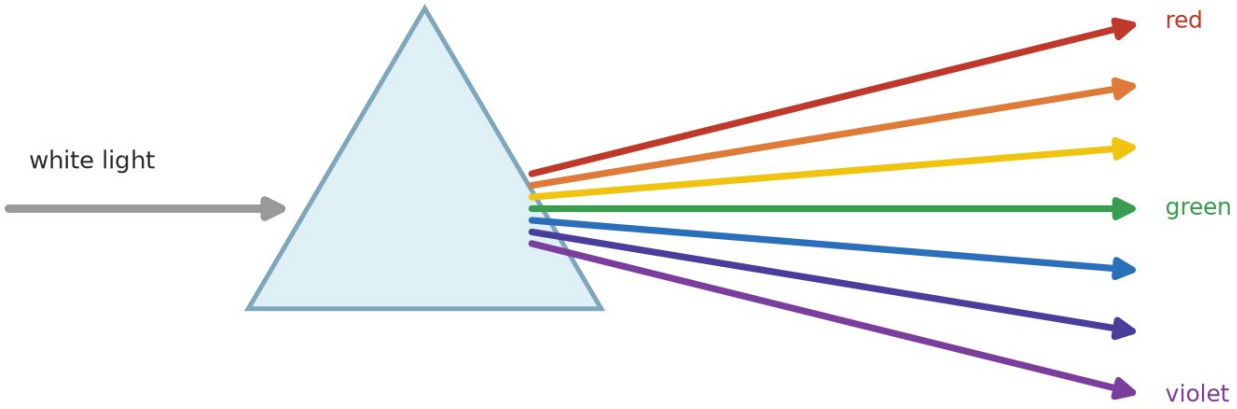


Light from the pencil changes direction as it leaves the water.

A pencil standing in a glass of water. Above the water line the pencil is seen where it really is; below the water line it looks shifted, because light from the pencil changes direction as it leaves the water.

Put a pencil or a straw in a glass of water and it looks shifted or broken at the water line. The pencil has not moved — light from the under-water part changes direction as it leaves the water, so the pencil looks like it is in a different spot.

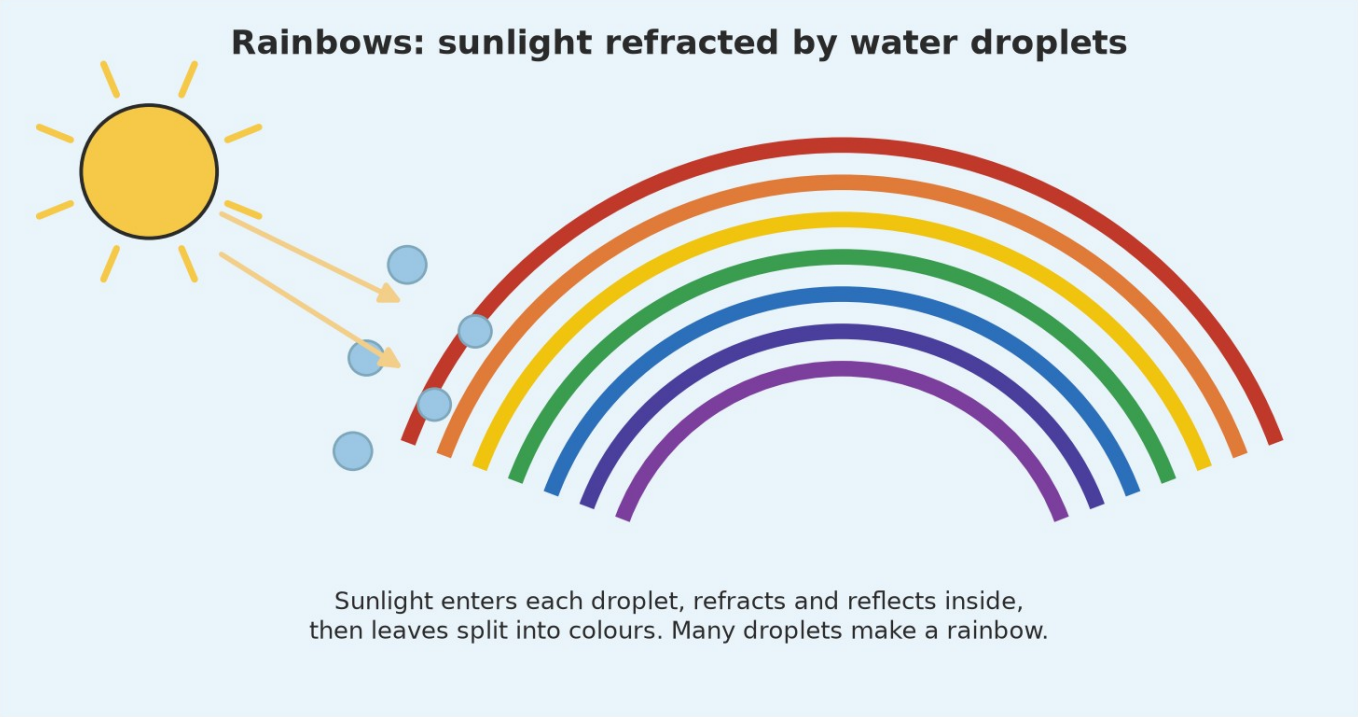
A prism splits white light into colours



White light is a mix of colours. The prism refracts each colour by a different amount, spreading them out.

A beam of white light enters a triangular prism from the left and leaves on the right spread out into seven coloured rays, from red at the top to violet at the bottom.

A **prism** is a piece of clear glass shaped like a triangle. When white light passes through a prism, it is refracted and spreads out into the colours red, orange, yellow, green, blue, indigo and violet. This shows that white light is a mix of colours.



The Sun shines at water droplets in the sky, and a rainbow of seven colour bands curves across the sky, red on the outside and violet on the inside.

A rainbow is refraction in the sky. After rain, the air holds many tiny water droplets. Sunlight enters each droplet, is refracted, reflects inside the droplet, and leaves split into colours. Many droplets together make a rainbow. This is why a rainbow is seen when the Sun is out and rain is falling at the same time.

Worked examples

Example 1 — with support

Match each observation to the word that best fits it: *absorbed, transmitted, reflected* or *refracted*.

(a) Sunlight hits a black road and the road gets hot.
(b) Torch light hits a mirror and a bright spot appears on the wall.
(c) Sunlight passes through a clear window and lights the room.
(d) A straw in a drink looks broken at the surface.

Working	Comment
(a) The light goes into the road and warms it.	Light taken in = absorbed.
(b) The light bounces off the mirror onto the wall.	Light bouncing off = reflected.
(c) The light passes through the glass.	Light passing through = transmitted.
(d) Light from the straw changes direction at the water line.	Light changing direction as it passes out of the water = refracted.
∴ (a) absorbed, (b) reflected, (c) transmitted, (d) refracted.	We tell which of the four is which by observing what the light does.

Example 2 — with support

At 9 am, Mia stands in the Sun and her shadow is long and points west. At midday her shadow is short. Explain both observations, using the idea that light travels in a straight path.

Working	Comment
Light from the Sun travels in a straight path.	Rays do not curve around Mia.
Mia's body blocks the light that hits it.	The light stops at her body.
Her shadow is where that light cannot reach.	A shadow forms where light cannot reach.
At 9 am the Sun is low, so the rays hit her at a shallow angle and the shadow stretches out long, away from the Sun (west).	Low Sun → long shadow.
At midday the Sun is high, so the rays fall almost straight down and the shadow is short.	High Sun → short shadow.
∴ The shadow is long at 9 am and short at midday because the Sun's height changes, and light travels in a straight path.	Same object, same straight rays — only the Sun's position changes.

Example 3 — by yourself

A sailor below deck uses a periscope to see a boat on the water. Light from the boat enters the top window of the periscope. Describe the path of that light through the periscope and into the sailor's eye. In your answer, say what happens at each mirror and why the sailor can see something that is above her.

Practice questions

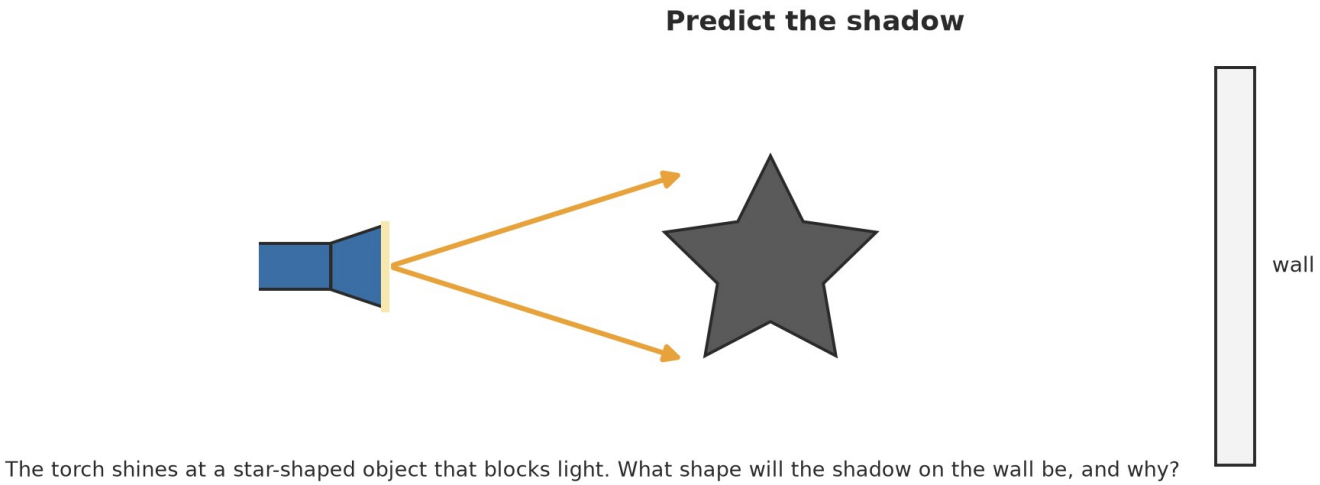
With support

Q1. Sort these sources into natural and artificial: the Sun; a candle flame; a glow-worm; a phone screen. *(2 marks)*

Q2. A torch shines at a card with a narrow gap, as in the second figure. *(2 marks)* (a) Which rays stop at the card, and which ray keeps going? (b) What does this show about the path light travels?

Q3. Match each word to its meaning. *(4 marks)* absorb · transmit · reflect · refract (a) light bounces off an object (b) light changes direction as it passes into or out of an object (c) light passes through an object (d) light is taken in by an object

Q4. A torch shines at a star-shaped object that blocks light, in front of a wall. *(2 marks)*



The torch shines at a star-shaped object that blocks light. What shape will the shadow on the wall be, and why?

A torch shines two straight rays towards a star-shaped object that blocks light, with a wall behind it.

(a) Predict the shape of the shadow on the wall.
(b) Explain your prediction using the path light travels.

Q5. Complete the sentences about a periscope. *(3 marks)* (a) Light from the object hits the top mirror and is _____ down the tube. (b) At the bottom mirror the light is reflected again and travels out into _____. (c) Each mirror reflects the light because the mirrors are smooth and _____.

Q6. White light passes through a prism. *(2 marks)* (a) What comes out of the prism? (b) What does this show about white light?

By yourself

Q7. Name two natural sources and two artificial sources of light that are *not* shown in the first figure. *(2 marks)*

Q8. Explain why you cannot see around a corner, even on a bright day. *(2 marks)*

Q9. Shadow puppets: hold your hand between a torch and a wall and the shadow looks like your hand. Explain why the shadow has the same shape as your hand. *(2 marks)*

Q10. A class puts a 1 m stick in the Sun and measures its shadow. *(3 marks)*

Time	Shadow length
9 am	150 cm
midday	40 cm
3 pm	150 cm

(a) Describe the pattern in the results.
(b) Explain the pattern using the height of the Sun.
(c) The shadow at 9 am points west. Which way does the shadow at 3 pm point, and why?

Q11. A torch shines on three materials in turn, with a white screen behind each one: clear plastic; cardboard; shiny metal. For each material, say what you would see on the screen and which word — *transmit*, *absorb* or *reflect* — best describes what the material mainly does to the light. *(3 marks)*

Q12. A ray hits a mirror. The angle in is 40 degrees. *(2 marks)* (a) What is the angle out? (b) Name the rule you used.

Q13. Explain, in full sentences, how a periscope lets a sailor below deck see a boat on the water. Use the words *reflect* and *mirror* in your answer. *(3 marks)*

Q14. A straight straw is stood in a glass of water. To someone looking in from the side, the straw looks shifted at the water line. Explain why. *(2 marks)*

Q15. A rainbow can appear when the Sun is out and rain is falling. *(3 marks)* (a) What acts like tiny prisms in the sky? (b) What does each one do to the sunlight? (c) What does this show about white light?

Q16. At 9 am a flagpole's shadow is long and points west. Predict the length and direction of its shadow at 3 pm, and give your reason. *(2 marks)*

Practical — which materials transmit, absorb or reflect light?

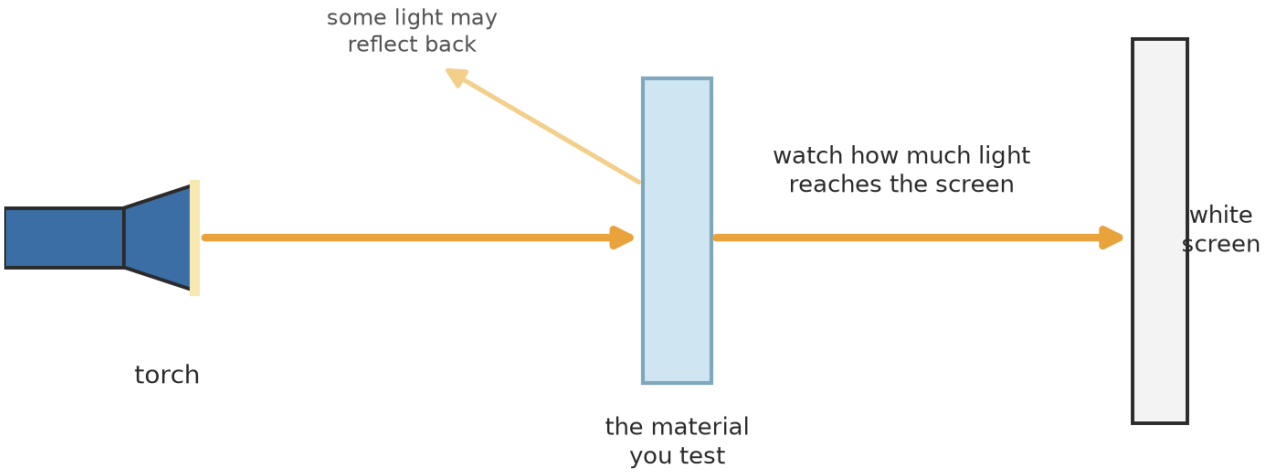
> **PRACTICAL** — this page plans or analyses work done in the classroom, laboratory or field. It is not a substitute for doing it.

Question: What does each material mainly do to light — transmit it, absorb it or reflect it?

Equipment: one torch (battery-powered); a white screen (a sheet of white card); samples of clear plastic, frosted plastic, cardboard, black paper, white paper and shiny metal (such as a clean aluminium lid); a ruler; a dark room.

Safety: Never shine the torch at anyone's eyes or face. Keep the floor clear in the dark room and walk slowly.

Testing what a material does to light



Bright = light gets through. Dim = some gets through. Dark = light is blocked.

Ray diagram of the test: a torch shines a straight beam at the material being tested, and a white screen behind it catches the light that gets through. A faint ray shows light reflecting back from the material.

Risk	How we stay safe
Torch shone at eyes	Shine it at the screen only; never at a person.
Trips in the dark room	Keep the walkway clear; move slowly; leave one light on if needed.

Variables (the things we change, measure and keep the same):

Variable	Choice
The one we change	the material in the beam
The one we measure	how bright the light patch on the screen is (bright, dim or dark), and whether light reflects back
The ones we keep the same	the same torch; the same distances (30 cm torch to material, 30 cm material to screen); the same screen; the same dark room

Method:

1. Darken the room. Set up the torch 30 cm from the material and the screen 30 cm behind the material.
2. Write your prediction for each material before you shine the torch.
3. Shine the torch at the first material. Record how bright the patch on the screen is (bright, dim or dark) and whether you see light reflecting back.
4. Turn the torch off and repeat step 3 a second time for the same material. If the two tries do not match, look again and agree on what you saw.
5. Test each of the other materials the same way.
6. When your group is finished, compare your results with another group's results.

Results: record what you see in a table like this one.

Material	Prediction	Patch on screen (bright / dim / dark)	Light reflected back? (yes / no)
Clear plastic			
Frosted plastic			

Material	Prediction	Patch on screen (bright / dim / dark)	Light reflected back? (yes / no)
Cardboard			
Black paper			
White paper			
Shiny metal			

Thinking about the results:

1. Sort your six materials into three groups: mainly transmits, mainly absorbs, mainly reflects. Say what evidence from your table puts each material in its group.
2. Compare your sorting with another group's. Did the two groups agree? If any material was sorted a different way, suggest one reason why (for example, a different distance or a different torch).
3. A builder wants a window that lets light into a room but does not let people see in clearly. Which material from your test would you choose, and why?

Make a claim and defend it. Finish this writing frame in full sentences:

- I claim that different materials _____ .
- My evidence is _____ .
- If someone claimed that cardboard transmits light, I would answer _____ .

Answers

Q1 Natural: the Sun; a glow-worm. Artificial: a candle flame; a phone screen. **Q2** (a) The rays that hit the card stop; the ray aimed at the gap keeps going. (b) Light travels in a straight path (it does not curve around the card). **Q3** (a) reflect. (b) refract. (c) transmit. (d) absorb. **Q4** (a) A star-shaped shadow, large because the object is close to the torch. (b) Light travels in a straight path, so the object blocks the light in a star shape, and the shadow keeps that shape on the wall. **Q5** (a) reflected. (b) your eye (the sailor's eye). (c) shiny. **Q6** (a) A spread of colours (red to violet). (b) White light is a mix of colours. **Q7** Any sensible answer, e.g. natural: lightning, stars, fireflies, flames in a bushfire; artificial: a light bulb, a torch, a lantern, a TV screen. **Q8** Light travels in a straight path and does not curve around the corner, so no light from behind the corner reaches your eye. **Q9** Light travels in a straight path, so your hand blocks the light in the shape of your hand; the shadow is that blocked shape on the wall. **Q10** (a) The shadow is long in the morning, short at midday and long again in the afternoon. (b) The Sun is low in the morning and afternoon (long shadows) and high at midday (short shadow). (c) East — the shadow always points away from the Sun, and at 3 pm the Sun is in the west. **Q11** Clear plastic: bright patch — mainly transmits. Cardboard: dark patch — mainly absorbs. Shiny metal: dark patch with light seen bouncing back — mainly reflects. **Q12** (a) 40 degrees. (b) The angle in equals the angle out. **Q13** Light from the boat travels in a straight path into the top window and hits the top mirror, which reflects it down the tube; the bottom mirror reflects it out into the sailor's eye, so she sees the boat above her. **Q14** Light from the under-water part of the straw changes direction (refracts) as it leaves the water, so the straw looks like it is in a different spot. **Q15** (a) The water droplets. (b) Each droplet refracts the sunlight, reflects it inside, and lets it leave split into colours. (c) White light is a mix of colours. **Q16** Long, and pointing east. At 3 pm the Sun is low in the west, so the shadow is long and points away from the Sun (east).

Worked solutions

Q1 *(2 marks: 1 per column)* Natural sources give out light made in nature: the Sun and the glow-worm. Artificial sources are light people make: the candle flame and the phone screen.

Q2 *(2 marks: 1 each)* (a) The rays that hit the card stop at the card; only the ray aimed at the gap goes through and keeps going straight. (b) This shows light travels in a straight path — if it could curve, it would go around the card.

Q3 *(4 marks: 1 each)* (a) Reflect — bouncing off. (b) Refract — changing direction as it passes into or out of an object. (c) Transmit — passing through. (d) Absorb — being taken in.

Q4 *(2 marks: 1 each)* (a) The shadow is star-shaped (and large, because the object is closer to the torch than to the wall). (b) Light travels in a straight path, so the star blocks the light in a star shape; the dark patch on the wall keeps that shape.

Q5 *(3 marks: 1 each)* (a) Reflected. (b) Your eye. (c) Shiny — smooth, shiny surfaces reflect light well.

Q6 *(2 marks: 1 each)* (a) The seven colours, spread out from red to violet. (b) That white light is a mix of colours — the prism refracts each colour by a different amount and spreads them out.

Q7 *(2 marks: 1 per correct pair)* Natural sources make light in nature (lightning; the stars; fireflies; a bushfire flame). Artificial sources are made by people (a torch; a lantern; a light bulb; a TV screen). The Moon does not count — it does not give out its own light; it reflects the Sun's light.

Q8 *(2 marks: 1 for the straight path, 1 for the link)* Light travels in a straight path and does not curve around things (1). So no light from behind the corner can travel around the corner and into your eye, and you cannot see what is there (1).

Q9 *(2 marks: 1 for the straight path, 1 for the blocked shape)* Light from the torch travels in a straight path (1). Your hand blocks that light in the shape of your hand, and the wall behind stays dark in exactly that shape — the shadow (1).

Q10 *(3 marks: 1 each)* (a) The shadow starts long (150 cm), becomes short at midday (40 cm), and becomes long again (150 cm). (b) In the morning and afternoon the Sun is low, so the straight rays stretch the shadow out long; at midday the Sun is high, so the rays fall almost straight down and the shadow is short. (c) East. The shadow points away from the Sun; at 3 pm the Sun is low in the west, so the shadow points east.

Q11 *(3 marks: 1 each)* Clear plastic: a bright patch on the screen — light passes through, so it mainly transmits. Cardboard: a dark patch — light is stopped and taken in, so it mainly absorbs. Shiny metal: a dark patch, with light seen bouncing back towards the torch — so it mainly reflects.

Q12 *(2 marks: 1 each)* (a) 40 degrees. (b) The angle in equals the angle out (the rule of reflection).

Q13 *(3 marks: 1 per idea)* Light from the boat travels in a straight path into the top window (1). It hits the top mirror and is reflected down the tube; the bottom mirror reflects it again, out into the sailor's eye (1). Because the light is reflected twice, the sailor sees the boat even though it is above her and behind the deck (1).

Q14 *(2 marks: 1 for refraction, 1 for the shift)* Light from the under-water part of the straw changes direction as it leaves the water — it is refracted (1). Your eye follows the light back in a straight path, so the under-water part looks like it is in a different spot, and the straw looks shifted (1).

Q15 *(3 marks: 1 each)* (a) The tiny water droplets left in the air after rain. (b) Sunlight enters each droplet, is refracted, reflects inside, and leaves split into colours. (c) That white light is a mix of colours.

Q16 *(2 marks: 1 for the prediction, 1 for the reason)* The shadow will be long and will point east (1). At 3 pm the Sun is low in the west; a low Sun makes a long shadow, and the shadow points away from the Sun, so it points east (1).

Circuits: conductors, insulators and energy

Words to know circuit · cell · battery · switch · conductor · insulator · component · electrical energy · transfer · transform · mains electricity · hazard · safety switch

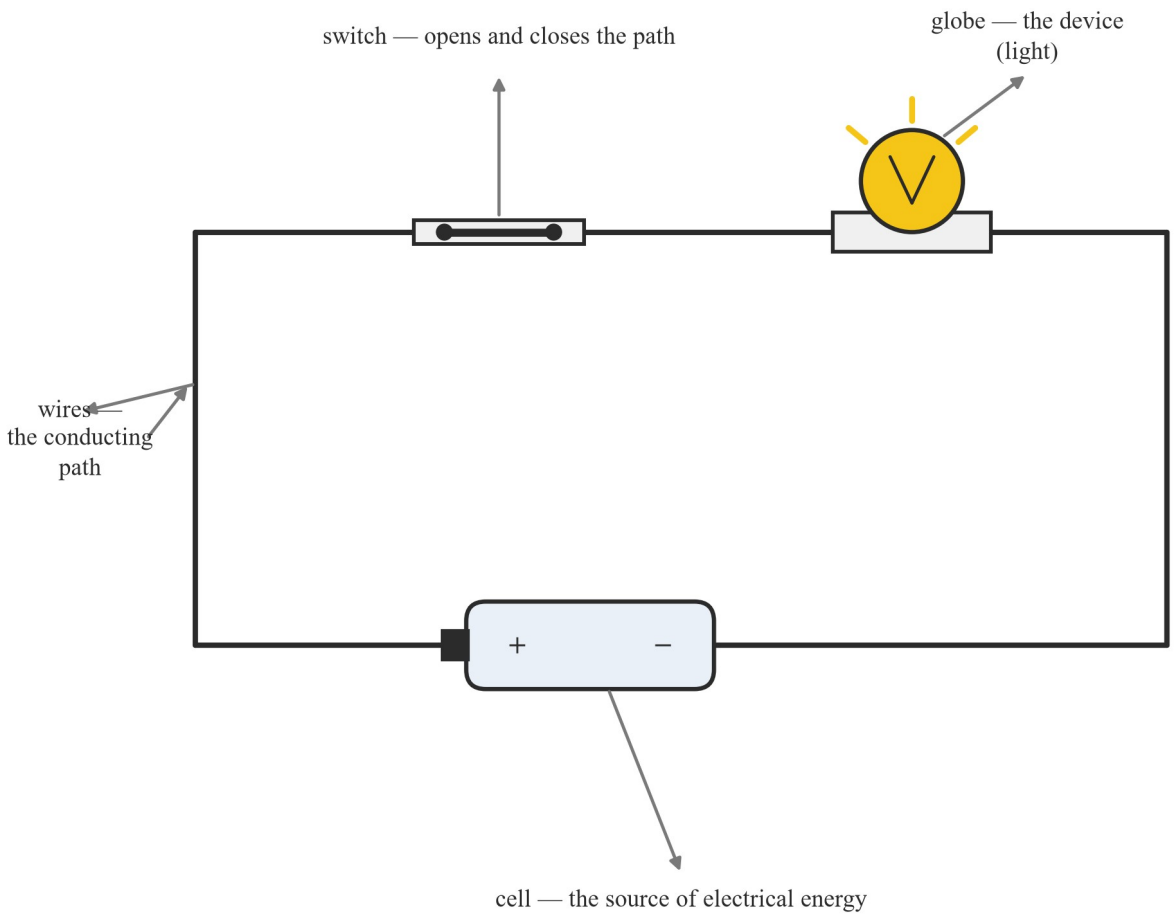
A torch, a doorbell and a television all work because electricity can move through them. Electricity moves along a path called a **circuit**. A circuit is a complete loop of material that electricity can flow through. In this section we look at what a circuit needs to work, which materials let electricity flow and which do not, and what happens to the energy that a circuit carries.

Theory

What a circuit needs to work

A working circuit needs four things. Each part is called a **component**. A component is one part of the circuit, and each component has its own job.

1. **A source of electrical energy.** The source is usually a **cell**. A cell is a small object that stores energy as **chemical energy** and transforms it into **electrical energy**. Electrical energy is the energy carried by flowing electricity. Every cell has two ends, marked + and −. A single cell gives 1.5 volts (1.5 V). The **volt** (V) is the unit we use to measure how much energy a source gives to the flow. Two or more cells joined together make a **battery**.
2. **A conducting path.** The path is made of wire and joins every component into one complete loop with no gaps. The flow of electricity goes out from one end of the cell, around the loop, and back into the other end.
3. **A switch.** A switch is the component that opens and closes the path. When the switch is closed, the loop is complete and electricity flows. When the switch is open, there is a gap, the flow stops, and the circuit is off.
4. **A device.** The device is the component that changes electrical energy into a useful form. A globe changes it into light, a buzzer changes it into sound, and a motor changes it into movement.



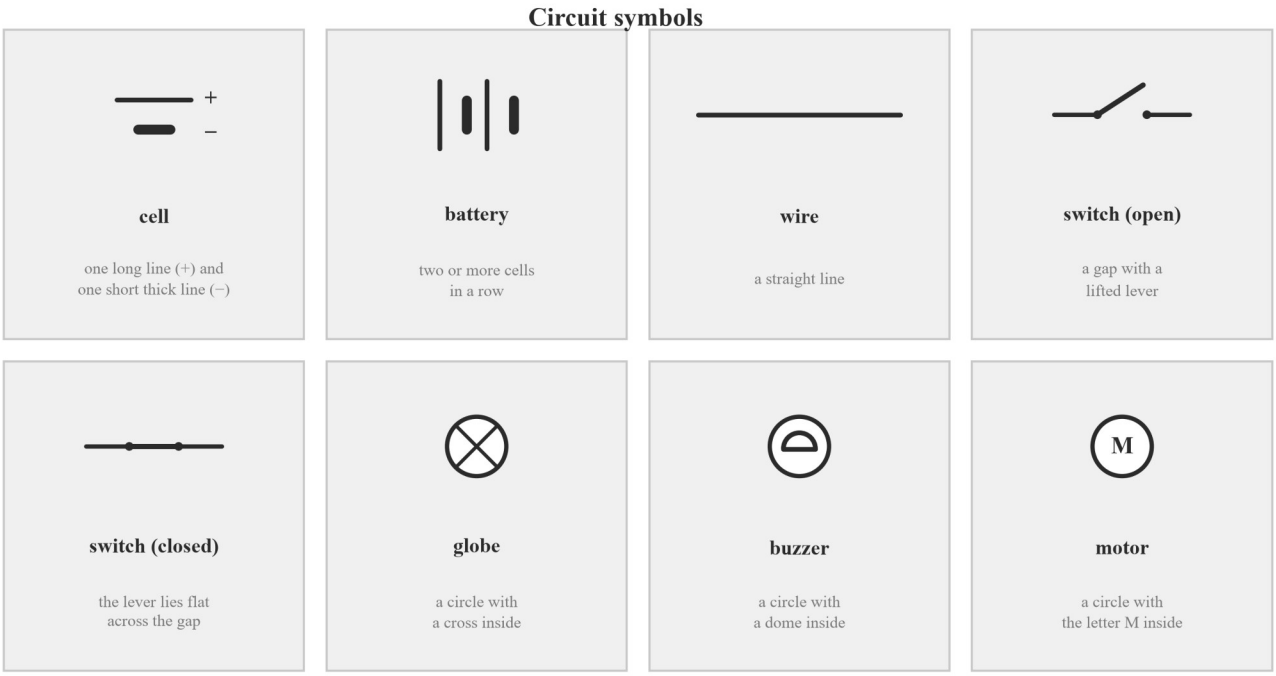
A simple working circuit made of a cell, a switch, a globe and two wires joined in one loop; each of the four parts is labelled with its job: the cell is the source of electrical energy, the wires are the conducting path, the switch opens and closes the path, and the globe is the device.

If there is a gap in any part of the loop, the flow of electricity stops and the device will not work. This is why a globe goes out when a switch is opened: the switch makes a gap in the path.

Drawing circuits with symbols

Scientists draw circuits with **symbols** so that anyone can read them. A symbol is a small, agreed drawing that stands for a component. Here are the symbols used in this book.

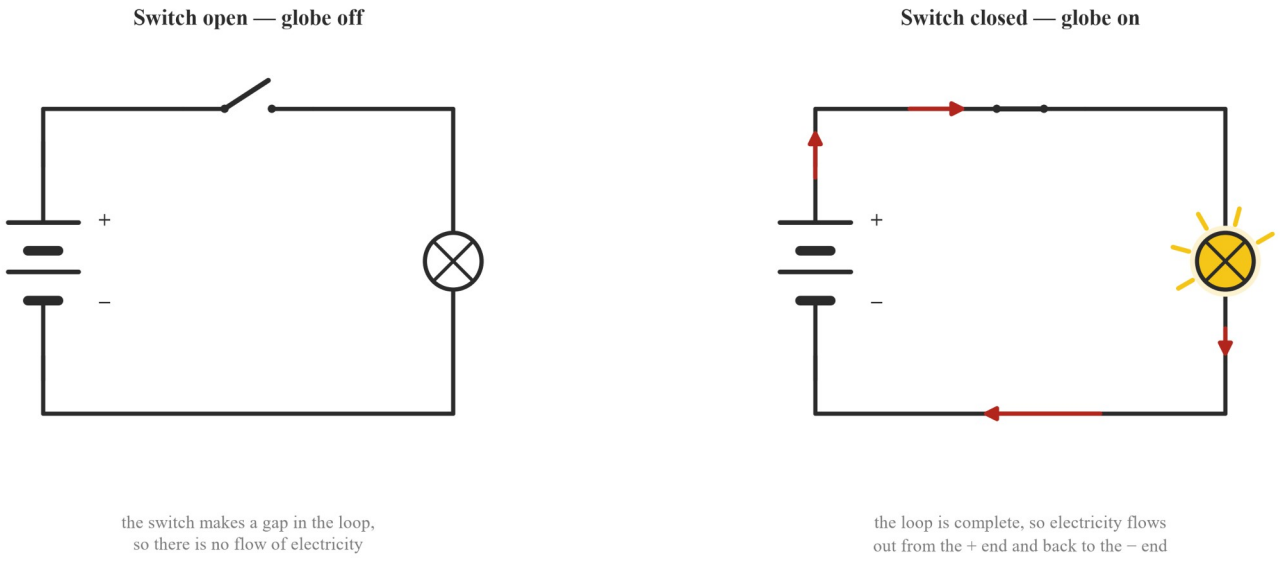
Component	Symbol
cell	one long line and one short thick line; the long line is the + end
battery	two or more cells drawn in a row
wire	a straight line
switch (open)	a line with a gap and a lifted lever
switch (closed)	a line with a lever sitting flat across the gap
globe	a circle with a cross inside
buzzer	a circle with a dome shape inside
motor	a circle with the letter M inside



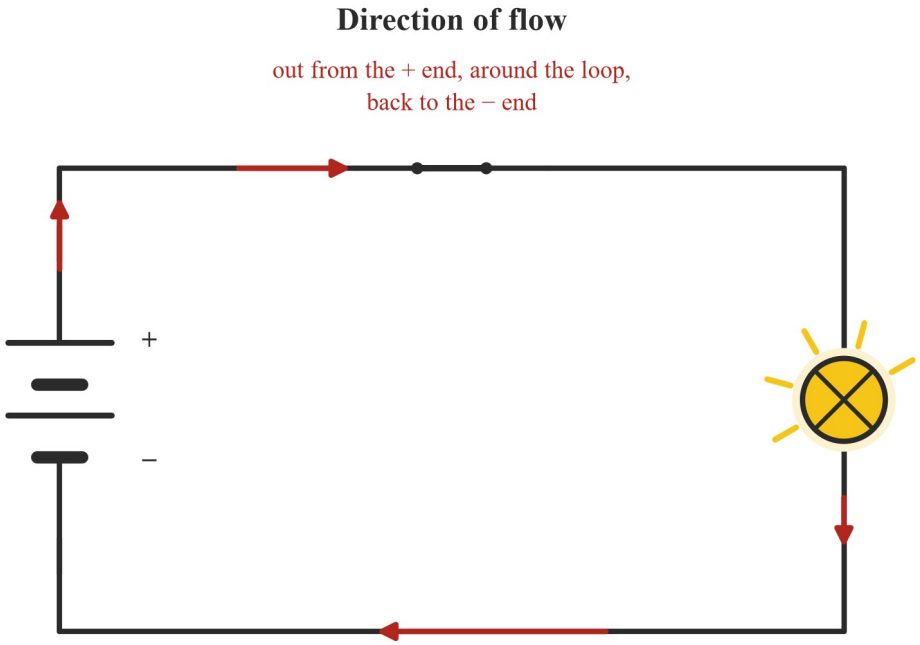
The circuit symbols used in this book, shown side by side with their names: cell, battery, wire, open switch, closed switch, globe, buzzer and motor.

Circuit diagrams follow a few rules. Wires are drawn as straight lines with corners, so the whole circuit makes a neat rectangle. Components are drawn on the straight sides, not at the corners. Lines are not crossed unless the wires really do cross.

When we draw a circuit, we can also show the **direction of flow**. Electricity flows out from the + end of the cell, around the circuit, and back into the − end. We mark this with arrows on the wires.



Two circuit diagrams side by side. In the first, the switch is open, so there is a gap, no flow arrows are shown, and the globe is dark. In the second, the switch is closed, arrows show the flow going out from the + end of the cell and back into the − end, and the globe is glowing.



The arrows are drawn on the wires of the circuit.

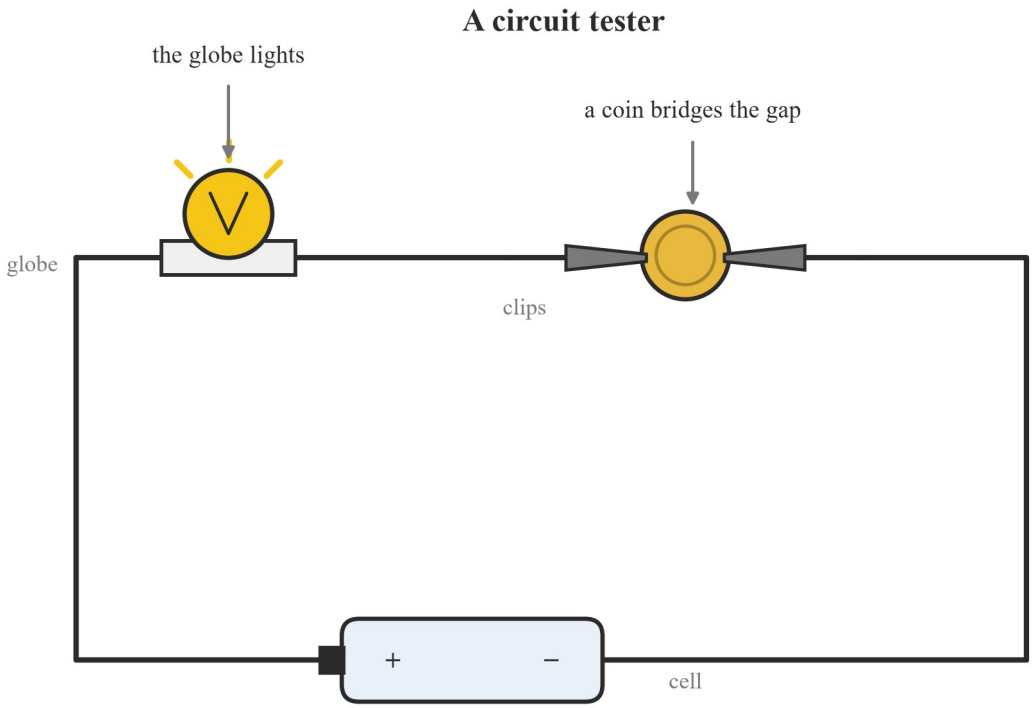
A circuit diagram of a cell, a closed switch and a globe in one loop, with arrows on the wires showing the direction of flow: out from the + end of the cell, through the switch and the globe, and back into the − end.

Conductors and insulators

Not all materials let electricity flow through them.

- A **conductor** is a material that lets electricity flow through it.
- An **insulator** is a material that does not let electricity flow through it.

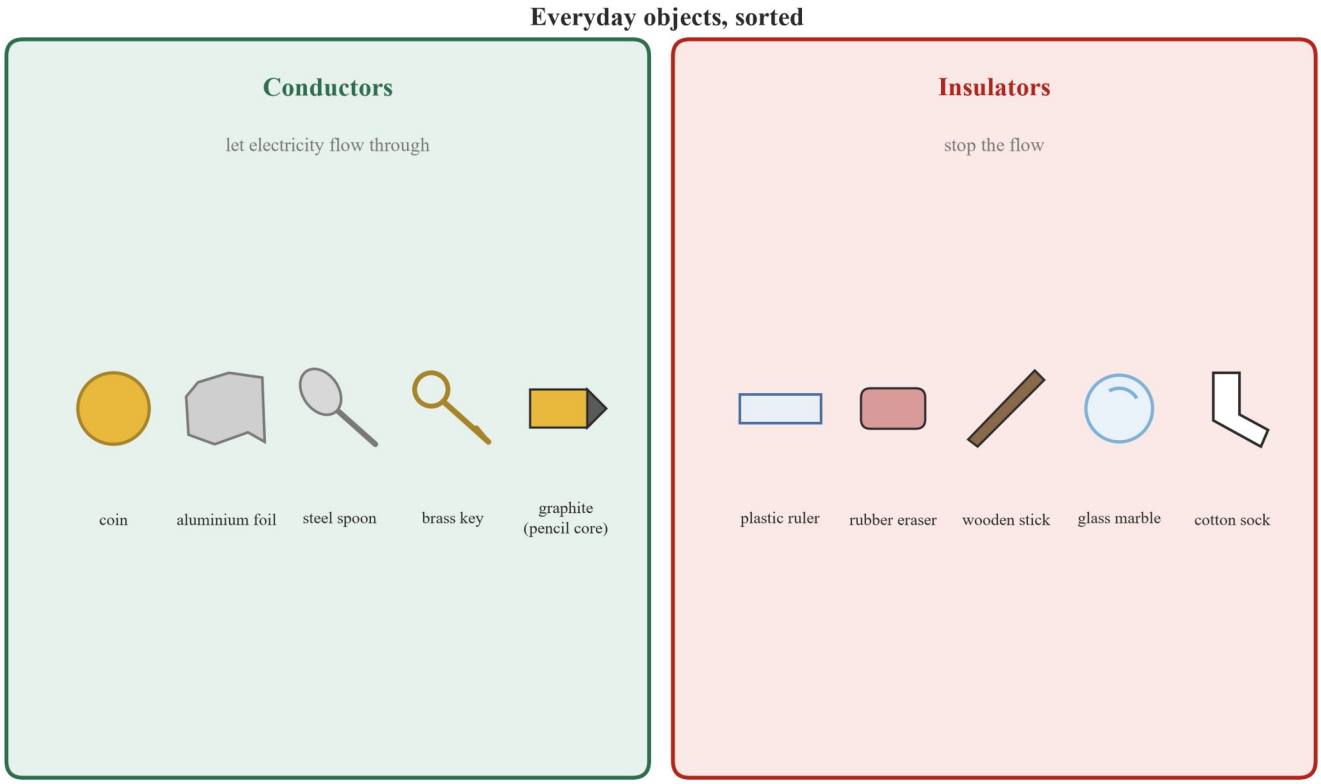
We can test a material with a **circuit tester**. A circuit tester is a circuit with a gap in it. The material is placed across the gap. If the globe lights, electricity has flowed through the material, so the material is a conductor. If the globe stays dark, no electricity has flowed, so the material is an insulator.



The globe lights, so electricity flows through the coin — the coin is a conductor.

A circuit tester: a circuit made of a cell, a globe and two wires that end at two metal clips with a gap between them; a coin is placed across the gap, the globe lights, and the coin is labelled as a conductor because electricity flows through it.

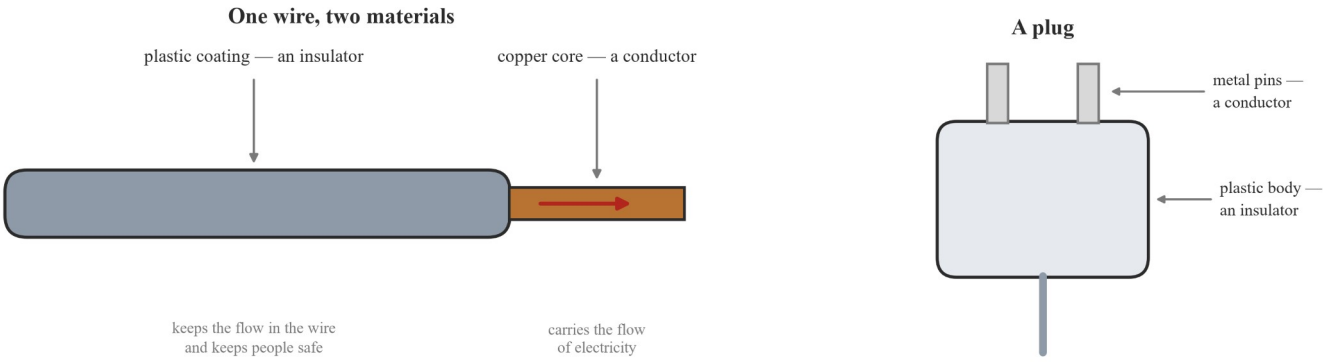
Metals are conductors. Copper, aluminium, iron, steel and brass all let electricity flow. The graphite in a pencil is also a conductor, even though it is not a metal. Most other materials we meet every day are insulators: plastic, rubber, glass, dry wood, paper and fabric all stop the flow. Water is not a conductor like metal, but the water we meet every day — tap water, rain and puddles — can carry enough electricity to be dangerous. That is why electricity and water must be kept away from each other.



Everyday objects sorted into two groups: conductors, including a coin, aluminium foil, a steel spoon, a brass key and a pencil's graphite core; and insulators, including a plastic ruler, a rubber eraser, a wooden stick, a glass marble and a cotton sock.

Why conductors and insulators are both needed

Look at any electrical wire. The inside is a metal, usually copper, because copper is a very good conductor and carries the flow of electricity. The outside is a plastic or rubber coating, because plastic and rubber are insulators. The coating keeps the flow inside the wire, and it keeps anyone who touches the wire safe.



A length of electrical wire drawn with its layers labelled: the inner copper core is a conductor that carries the flow of electricity, and the outer plastic coating is an insulator that keeps the flow in the wire and keeps people safe.

The same idea is used in plugs. The pins of a plug are metal, so electricity can flow into the appliance. The body of the plug is plastic, so the person holding it touches only an insulator. Insulator handles are also put on tools used near electricity. A safe circuit needs conductors and insulators working together.

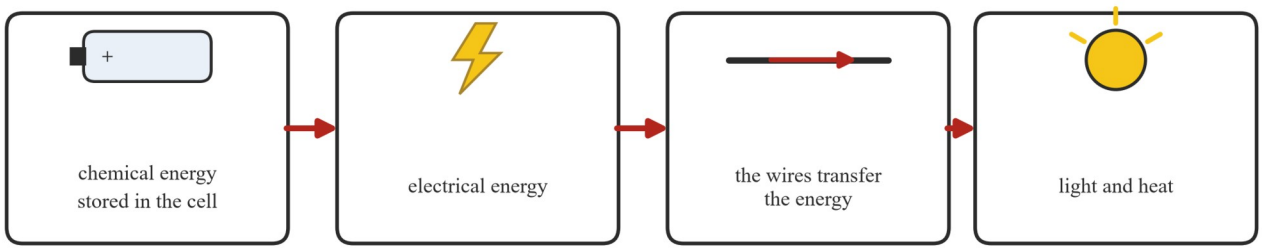
Energy transferred and transformed

Energy is never used up. It is **transferred** from one place to another and **transformed** from one form to another. To transfer energy is to move it from place to place. To transform energy is to change it from one form into another. A circuit is one way to transfer energy.

Here is the energy's journey in a torch.

1. The cell **stores chemical energy**.
2. The cell transforms the chemical energy into **electrical energy**.
3. The wires **transfer** the electrical energy from the cell to the globe.
4. The globe transforms the electrical energy into **light** and **heat**.

The energy journey in a torch

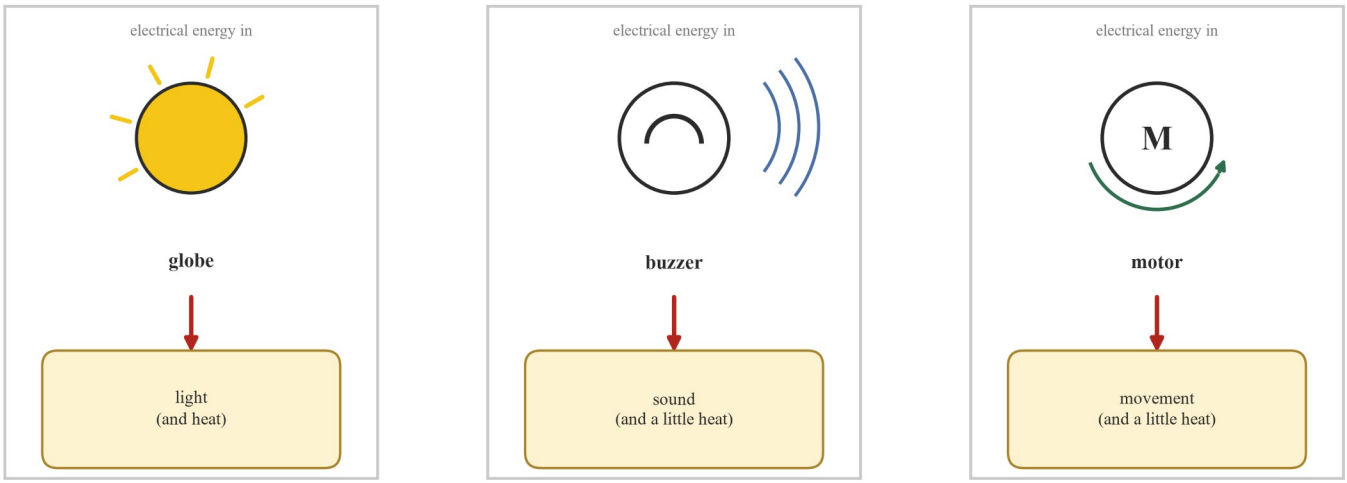


Energy is not used up — it is transferred and transformed.

An energy flow diagram for a torch: chemical energy stored in the cell becomes electrical energy, the wires transfer the electrical energy to the globe, and the globe transforms it into light and heat.

Different devices transform electrical energy into different forms.

Device	Electrical energy is transformed into
globe	light (and heat)
buzzer	sound (and a little heat)
motor	movement (and a little heat)



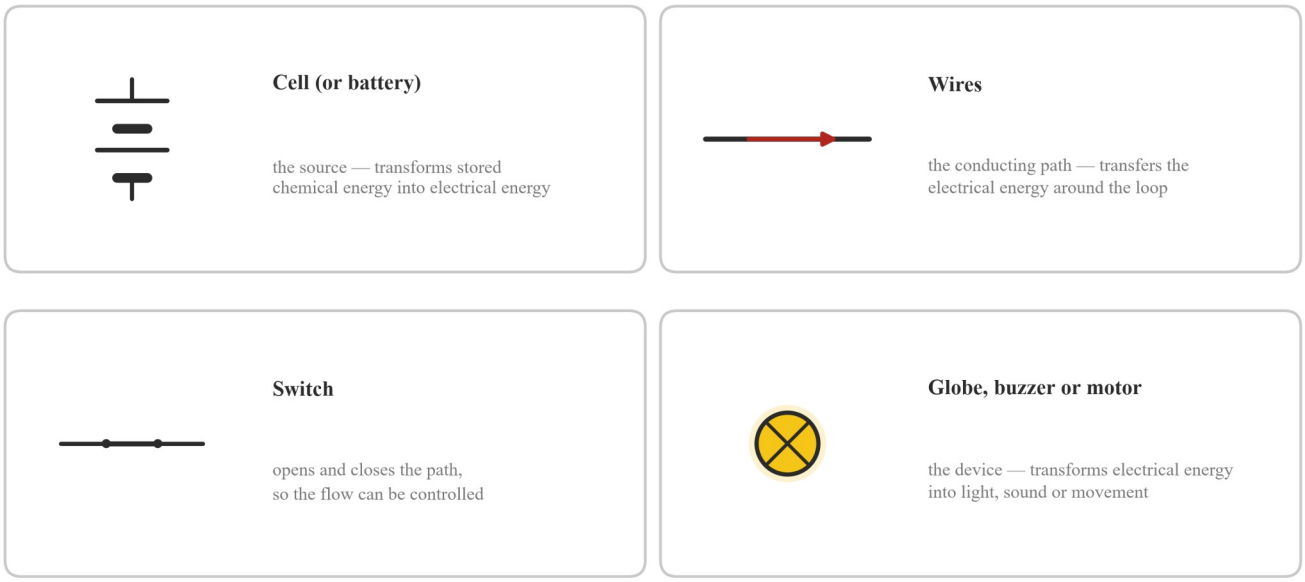
Three devices and the energy transformations they make: a globe transforms electrical energy into light and heat; a buzzer transforms electrical energy into sound; a motor transforms electrical energy into movement.

Notice that every device also makes a little heat. A working globe, buzzer or motor always feels hotter than it did before the circuit was closed.

Now we can state the role of each component in one place.

Component	Its role in the circuit
cell (or battery)	the source — transforms stored chemical energy into electrical energy
wires	the conducting path — transfers the electrical energy around the loop
switch	opens and closes the path so the flow can be controlled
globe, buzzer or motor	the device — transforms electrical energy into light, sound or movement

The role of each component

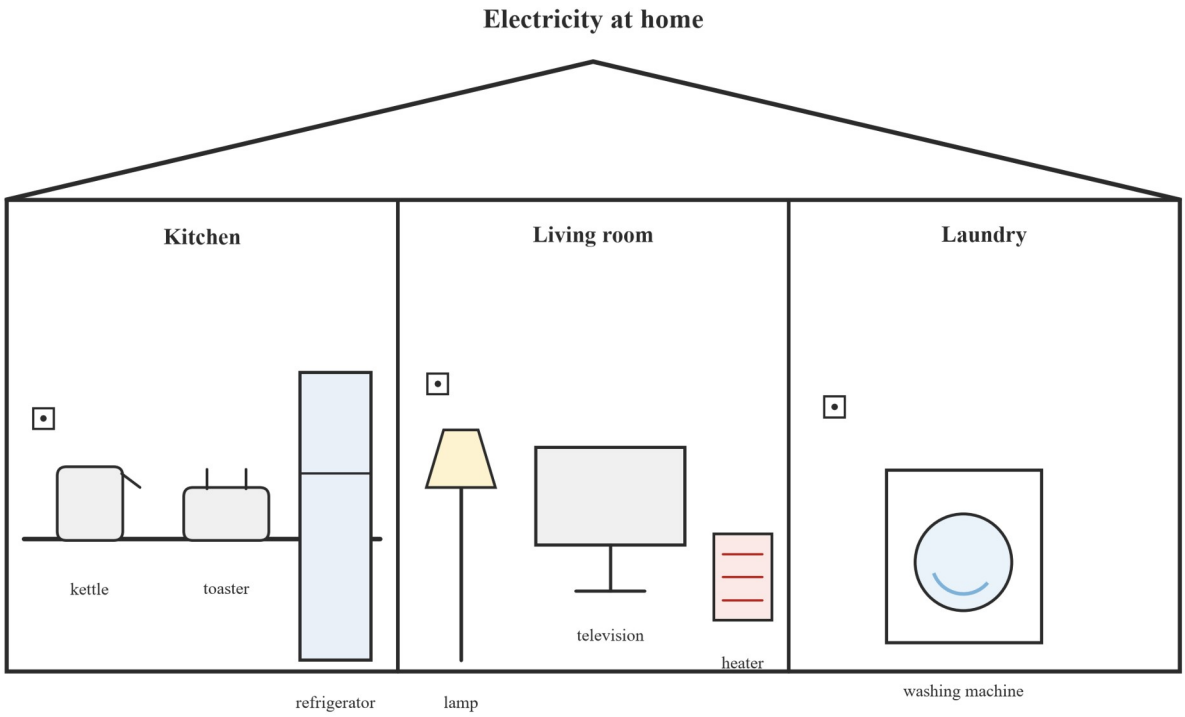


The four main circuit components and the role each one plays: the cell is the source of electrical energy, the wires are the conducting path that transfers the energy, the switch opens and closes the path, and the globe is the device that transforms the energy into light and heat.

When a cell "goes flat", its stored chemical energy has been transformed and sent to the device. The energy has not disappeared — the cell simply has no more stored energy left to give.

Electricity at home

At home, most appliances do not use cells. They are powered by **mains electricity** — the electricity that flows into the house through wires from the power system. Mains electricity is supplied at 230 V. That is far more than the 1.5 V of a cell, and it is far more dangerous. Mains electricity can give a dangerous shock, and it can start fires. Cells used in the classroom are safe to handle; the mains is never safe to touch or play with.

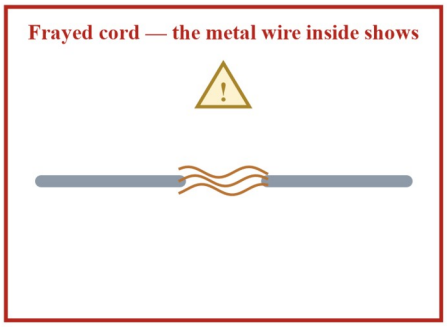


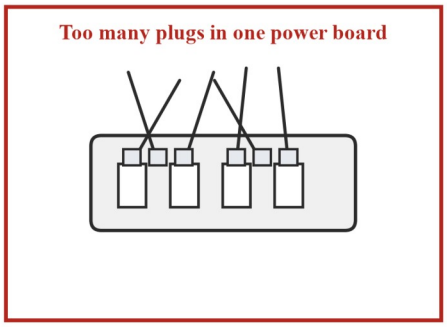
These appliances use mains electricity from power points in the wall.

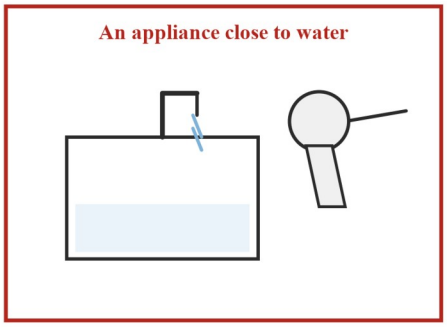
Rooms of a house showing appliances that use mains electricity: a kettle, a toaster and a refrigerator in the kitchen; a lamp, a television and a heater in the living room; a washing machine in the laundry.

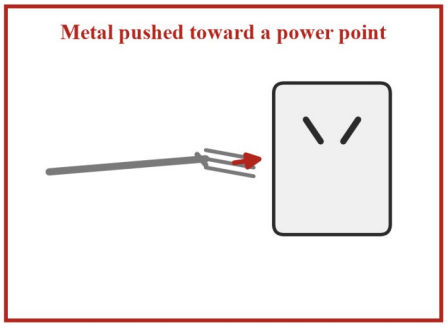
A **hazard** is something that can cause harm. Electrical hazards at home include:

- **damaged cords** — a frayed or cut cord has broken insulation, so the metal wire inside can be touched;
- **overloaded power boards** — too many plugs in one board or power point can make the wires too hot;
- **water near appliances** — because everyday water can carry electricity;
- **objects pushed into a power point** — anything metal pushed into a power point gives the electricity a path through the person touching it.





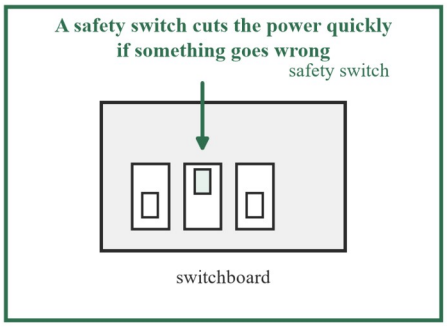


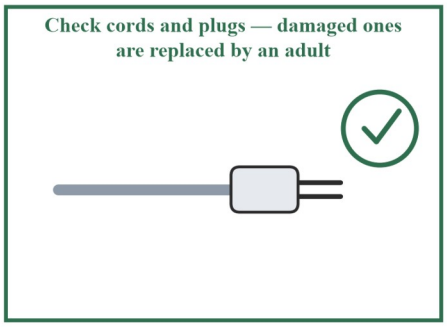


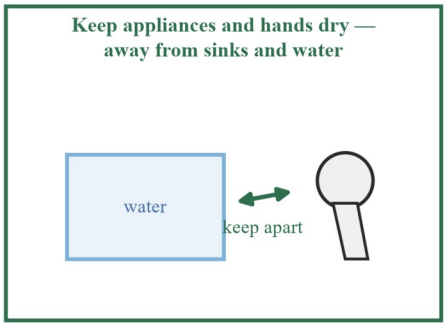
Four electrical hazards drawn as warning panels: a frayed cord with the metal wire showing; a power board crowded with too many plugs; a hair dryer close to water in a sink; and a metal fork being pushed toward a power point.

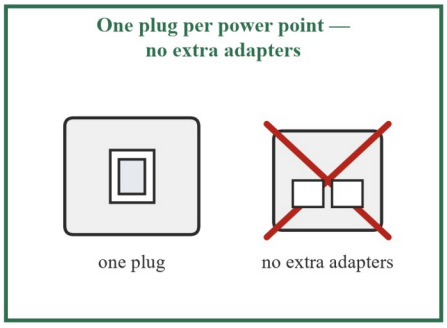
Safety measures reduce these hazards. In Victoria, electrical safety rules come from Energy Safe Victoria, the Victorian government authority for electrical safety.

- **Safety switches** are fitted in the home's switchboard. A safety switch watches the flow of electricity and cuts the power very quickly if something goes wrong, such as electricity flowing through a person.
- **Check cords and plugs.** Damaged cords and plugs must be replaced by an adult, and only a licensed electrician may repair wiring.
- **Keep electricity dry.** Hands and appliances must be kept dry, and appliances are kept away from sinks, baths and puddles.
- **One plug, one power point.** Power boards are not overloaded with extra plugs or adapters.
- **Children tell an adult.** If you see a damaged cord, a sparking plug or a burning smell, do not touch anything — tell an adult at once.









Four safety measures drawn as panels: a safety switch in the switchboard that cuts the power if something goes wrong; an adult checking a cord for damage; a hair dryer kept well away from water; and one plug in each power point, with no extra adapters.

Worked examples

Example 1 — with support

SCENARIO — Mia's torch holds two cells joined together, a switch and a globe, all joined by wires into one loop. Mia closes the switch and the globe lights. She then opens the switch and the globe goes out. (a) Name the part of the torch that is the source of electrical energy. (b) Explain why the globe goes out when the switch is opened. (c) Name the energy transformation that happens in the globe.

Working	Comment
The source of electrical energy is the two cells joined together — a battery.	The source is the component that gives the circuit its electrical energy. Two or more cells joined together make a battery.
Opening the switch makes a gap in the conducting path.	A circuit only works when the loop is complete, with no gaps at all.
With a gap in the loop, electricity cannot flow, so the globe goes out.	No flow means no energy reaches the device.
The globe transforms electrical energy into light and heat.	A globe is a device: it changes electrical energy into useful light, and some heat is always made too.

∴ (a) the battery (the two joined cells); (b) the open switch makes a gap, so the loop is broken and no electricity flows; (c) electrical energy → light and heat.

Example 2 — with support

SCENARIO — A student tests five objects with a circuit tester and records what happens each time.

Object	Material	Globe lights?
coin	metal	yes
steel paper clip	metal	yes
plastic button	plastic	no
graphite pencil core	graphite	yes
rubber band	rubber	no

(a) Sort the five objects into conductors and insulators.

(b) Describe the pattern in the results.

Working	Comment
If the globe lights, electricity flowed through the object, so the object is a conductor.	Use the test result to decide — that is what the tester tells us.
Coin: globe lights → conductor. Paper clip: globe lights → conductor. Pencil core: globe lights → conductor.	Work through the table one row at a time.
If the globe stays dark, no electricity flowed, so the object is an insulator.	The same rule, for the other result.
Plastic button: no light → insulator. Rubber band: no light → insulator.	Both stop the flow.
Pattern: the metal objects and the graphite all conduct, while the plastic and the rubber do not.	A pattern says what is the same across the results. Here, being a metal (or graphite) goes with conducting.

∴ (a) Conductors: coin, paper clip, pencil core. Insulators: plastic button, rubber band. (b) The metals and the graphite are conductors; the plastic and the rubber are insulators.

Example 3 — by yourself

SCENARIO — Noah builds a circuit with a battery, two wires, a buzzer and a switch. He closes the switch, but the buzzer does not sound. Looking carefully, he finds that one wire has pulled out of its clip, leaving a gap at the buzzer. Explain why the buzzer does not sound, say what Noah should do to fix the circuit, and name the energy transformation that will happen in the buzzer once it is fixed.

The buzzer does not sound because the circuit has a gap where the wire pulled out of its clip. A circuit only works when it is one complete loop with no gaps, so the flow of electricity cannot reach the buzzer. To fix the circuit, Noah should push the wire back into its clip so the loop is complete again. When the switch is closed, electricity will flow and the buzzer will sound. The buzzer transforms electrical energy into sound (and a little heat).

Practice questions

With support

Q1. Write a sentence, in your own words, for each word: *(3 marks)* (a) circuit (b) conductor (c) insulator

Q2. Every working circuit needs four things. Name them and give the job of each one. *(4 marks)*

Q3. Sort these materials into conductors and insulators: copper, rubber, glass, aluminium, plastic, steel. *(3 marks)*

Q4. Draw the circuit symbol for each component: *(4 marks)* (a) cell (b) closed switch (c) globe (d) motor

Q5. Name the useful form of energy that each device transforms electrical energy into: *(3 marks)* (a) globe (b) buzzer (c) motor

Q6. A wire has a copper core and a plastic coating. *(3 marks)* (a) Why is copper used for the core? (b) Why is plastic used for the coating?

By yourself

Q7. A student joins a cell, a globe and two wires into a loop, but the globe stays dark. She finds that one wire is not touching the globe, leaving a gap. Explain why the globe stays dark and what she should do. *(2 marks)*

Q8. A switch is used to turn a circuit on and off. *(3 marks)* (a) Describe what a switch does to the circuit when it is opened. (b) The contacts inside a switch are made of metal, and the outside of a switch is made of plastic. Explain why each material is used.

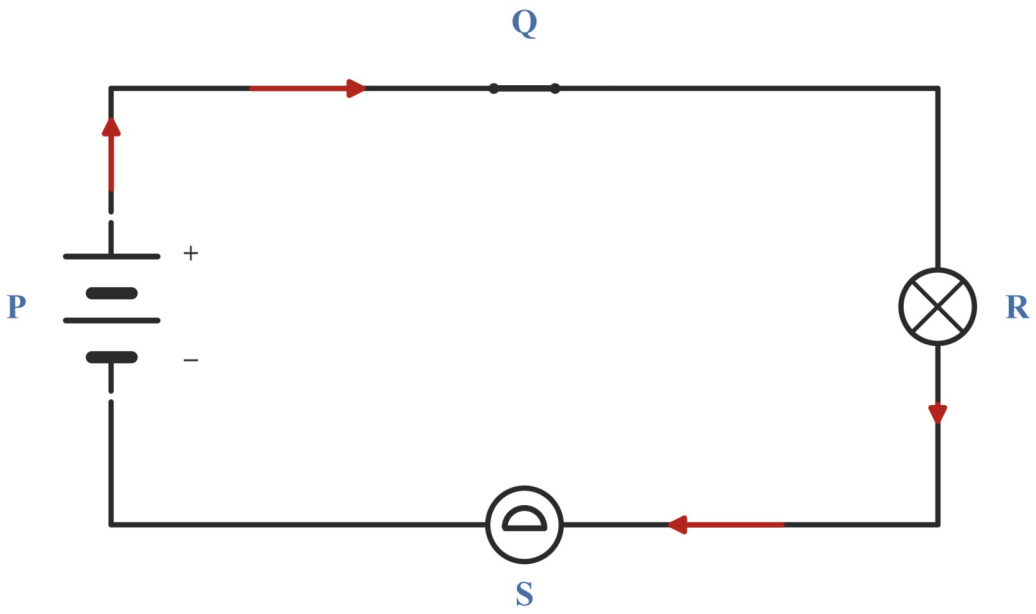
Q9. A circuit is drawn with a cell, a closed switch and a buzzer. *(2 marks)* (a) State the direction of flow of electricity in a circuit, using the + and − ends of the cell. (b) Where would you draw the arrows that show this flow?

Q10. A student says: “Plastic must be a conductor, because the wires in my circuit are covered in plastic and the circuit still works.” Explain why the student is wrong. In your answer, say what the plastic is really doing. *(3 marks)*

Q11. Choose the best material for each job, from this list: *copper, rubber, plastic, aluminium*. Give a reason for each choice. *(3 marks)* (a) the core of a wire (b) the coating of a wire (c) the pins of a plug — choose a metal

Q12. The circuit diagram below is drawn with symbols. Four components are labelled **P**, **Q**, **R** and **S**.

A circuit drawn with symbols



A circuit diagram drawn as a rectangle: a battery on the left side labelled P, a closed switch on the top side labelled Q, a globe on the right side labelled R, and a buzzer on the bottom side labelled S, with arrows showing the direction of flow.

(a) Identify the components labelled **P**, **Q**, **R** and **S**. *(2 marks)*
(b) State the role of component **P** in the circuit. *(1 mark)*
(c) State what happens to the globe and the buzzer when switch **Q** is opened, and explain why. *(2 marks)*

Q13. A cell is joined to a buzzer by wires to make a working circuit. *(3 marks)* (a) Name the form of energy stored in the cell before the circuit is closed. (b) Complete the energy journey: stored energy in the cell → electrical energy in the wires → … (c) Name one other form of energy the buzzer makes besides sound.

Q14. SCENARIO — A group tests four objects with a circuit tester. Each object is tested three times. Their table is below.

Object	Test 1	Test 2	Test 3
brass key	lights	lights	lights
wooden stick	dark	dark	dark

Object	Test 1	Test 2	Test 3
aluminium foil	lights	dark	lights
glass marble	dark	dark	dark

(a) For the brass key, the wooden stick and the glass marble, the three tests agree. What does this tell the group about these results? *(1 mark)*

(b) The results for the aluminium foil do not all agree. What should the group do next? *(1 mark)*

(c) When the foil is tested again carefully, the globe lights every time. Sort all four objects into conductors and insulators, using the corrected results. *(2 marks)*

Q15. List four appliances in your home that use mains electricity. For each one, state the useful form of energy it transforms electrical energy into. *(4 marks)*

Q16. SCENARIO — Kai notices a cord near the television. The plastic coating is split, and some of the metal wire inside can be seen. Kai's little sister is reaching for the cord. *(4 marks)* (a) Name the hazard in this situation. (b) State two things Kai should do. (c) Explain why a split cord is dangerous, using the words conductor and insulator.

Practical — which materials let electricity flow?

PRACTICAL — this page plans or studies work done in the classroom, laboratory or field. It is not a substitute for doing it.

Question: Which everyday materials are conductors, and which are insulators?

Equipment: two 1.5 V cells in a holder (3 V in total — never more than 6 V in this course, and never the mains); a 3 V globe in a holder; three wires with clips; a set of test objects (coin, foil, paper clip, pencil, rubber band, plastic ruler, wooden stick, glass marble); the table below.

Safety: This activity uses cells only. **Never test a power point, a wall socket or any mains appliance — the mains can kill.** A wire joined straight from one end of a cell to the other end, with nothing else in the loop, is a short path that gets hot; always keep a globe or a test object in the loop.

Risk	How we stay safe
A wire touching both ends of a cell at once (a short path) and getting hot	Keep the globe or a test object in the loop at all times; unclip a wire if anything gets warm.
Damaged wires with bare metal showing	Check wires before starting; do not use a wire with broken coating.
Trying to test a power point or a mains appliance	Cells only in this activity. The teacher checks the setup before it is used.

Variables (the things we change, measure and keep the same):

Variable	Choice
The one we change	the material placed across the gap
The one we measure	whether the globe lights (conductor) or stays dark (insulator)
The ones we keep the same	the same cells, globe, wires and clips; clean, dry test objects

Method:

1. Build the circuit tester: join the cells, the globe and two of the wires into a loop, but leave a gap between two clips. Close the clips together to check that the globe lights, then unclip them.
2. Place the first test object across the gap, touching both clips.
3. Record whether the globe lights or stays dark.
4. Take the object out and test it two more times. Record each test.

5. Repeat steps 2–4 for every object.

Results: record your observations in a table like this one.

Object	Test 1	Test 2	Test 3	Conductor or insulator?

Look at your three tests for each object. Do they agree with one another? If one test is different, test that object again and record the new result.

Drawing your circuit: in your notebook, draw the circuit tester you built, using the symbols from this section. Mark the direction of flow with arrows, starting from the + end of the cells.

Thinking about the results:

1. Which objects were conductors? Which were insulators?
2. What do the conductors in your results have in common?
3. Explain why the clips themselves must be made of a conductor.
4. Explain, using the words conductor and insulator, why test wires have metal clips but plastic coatings.

Make a claim and defend it. Finish this writing frame in full sentences:

- I claim that metals are _____ .
- My evidence is _____ .
- The graphite pencil core conducted even though it is not a metal. This shows that _____ .
- If someone claimed that rubber is a conductor, I would answer _____ .

Answers

Q1 (a) A complete loop of conducting material that electricity can flow through. (b) A material that lets electricity flow through it. (c) A material that does not let electricity flow through it. **Q2** A source of electrical energy (a cell or battery) — gives the energy; a conducting path (wires) — carries the flow around the loop; a switch — opens and closes the path; a device (globe, buzzer or motor) — changes the electrical energy into a useful form. **Q3** Conductors: copper, aluminium, steel. Insulators: rubber, glass, plastic. **Q4** (a) one long line and one short thick line; (b) a line with a lever sitting flat across a gap; (c) a circle with a cross inside; (d) a circle with the letter M inside. **Q5** (a) light (and heat); (b) sound (and a little heat); (c) movement (and a little heat). **Q6** (a) Copper is a conductor, so it lets electricity flow through the wire. (b) Plastic is an insulator, so it keeps the flow in the wire and keeps people safe. **Q7** The gap breaks the loop, so no electricity flows and the globe stays dark; she should join the wire back onto the globe so the loop is complete. **Q8** (a) It makes a gap in the conducting path, so the flow stops. (b) Metal contacts are used because metal is a conductor and lets the flow pass when the switch is closed; the plastic outside is used because plastic is an insulator and keeps people safe. **Q9** (a) Out from the + end of the cell, around the circuit, and back into the − end. (b) On the wires of the circuit. **Q10** The flow travels through the metal core of the wire, not through the plastic. Plastic is an insulator; its job is to keep the flow inside the wire and keep people safe — it does not carry the flow itself. **Q11** (a) copper — it is a very good conductor; (b) plastic (or rubber) — it is an insulator; (c) copper or aluminium — metals are conductors, so the flow can pass into the appliance. (Any metal from the list earns the mark.) **Q12** (a) P = battery, Q = switch, R = globe, S = buzzer. (b) It is the source of electrical energy (it transforms stored chemical energy into electrical energy). (c) Both stop working, because opening the switch makes a gap, the loop is broken, and no electricity can flow. **Q13** (a) chemical energy. (b) …→ sound (and a little heat). (c) heat. **Q14** (a) The results can be trusted — repeated tests agree. (b) Test the foil again, checking that it touches both clips, and record the new result. (c) Conductors: brass key, aluminium foil. Insulators: wooden stick, glass marble. **Q15** Any four appliances with a correct useful energy form, e.g. kettle → heat; lamp → light; speaker or doorbell → sound; fan → movement. **Q16** (a) A damaged cord with exposed wire — a shock hazard. (b) Any two: keep his sister away from the cord; do not touch the cord; tell an adult at once; have the cord replaced. (c) The plastic coating is an insulator that keeps the flow in the wire and away from people; when it splits, the metal wire inside — a conductor — can be touched, so electricity can flow through a person.

Worked solutions

Q1 *(3 marks: 1 each)* (a) A circuit is a complete loop of conducting material that electricity can flow through. *1 mark* (b) A conductor is a material that lets electricity flow through it, such as copper. *1 mark* (c) An insulator is a material that does not let electricity flow through it, such as plastic or rubber. *1 mark*

Q2 *(4 marks: 1 per part with its job)* A source of electrical energy, such as a cell or battery, which gives the circuit its energy. *1 mark* A conducting path made of wires, which carries the flow of electricity around the loop. *1 mark* A switch, which opens and closes the path so the circuit can be turned on and off. *1 mark* A device, such as a globe, buzzer or motor, which transforms the electrical energy into a useful form. *1 mark*

Q3 *(3 marks: 1 for each correct group)* Conductors: copper, aluminium and steel — all metals, which let electricity flow. *1 mark* Insulators: rubber, glass and plastic — they do not let electricity flow. *1 mark* Award the third mark when both groups are completely correct. *1 mark*

Q4 *(4 marks: 1 per symbol)* (a) A cell is drawn as one long line (the + end) next to one short thick line (the − end). *1 mark* (b) A closed switch is drawn as a line with a lever sitting flat across the gap, so the path is complete. *1 mark* (c) A globe is drawn as a circle with a cross inside. *1 mark* (d) A motor is drawn as a circle with the letter M inside. *1 mark*

Q5 *(3 marks: 1 each)* (a) A globe transforms electrical energy into light, and also heat. *1 mark* (b) A buzzer transforms electrical energy into sound, and a little heat. *1 mark* (c) A motor transforms electrical energy into movement, and a little heat. *1 mark*

Q6 *(3 marks)* (a) Copper is used for the core because copper is a conductor, so it lets electricity flow through the wire. *1 mark* (b) Plastic is used for the coating because plastic is an insulator. *1 mark* The coating keeps the flow of electricity inside the wire and keeps anyone who touches the wire safe. *1 mark*

Q7 *(2 marks)* The gap where the wire is not touching the globe breaks the loop, and electricity only flows in a complete loop with no gaps, so the globe stays dark. *1 mark* She should join the wire back onto the globe so the loop is complete again. *1 mark*

Q8 *(3 marks)* (a) When a switch is opened, it makes a gap in the conducting path, so the flow of electricity stops and the device turns off. *1 mark* (b) The contacts inside are metal because metal is a conductor, so electricity can flow through them when the switch is closed. *1 mark* The outside is plastic because plastic is an insulator, so anyone touching the switch is kept safe from the flow. *1 mark*

Q9 *(2 marks)* (a) Electricity flows out from the + end of the cell, around the circuit, and back into the − end of the cell. *1 mark* (b) The arrows showing the direction of flow are drawn on the wires of the circuit. *1 mark*

Q10 *(3 marks)* The student is wrong because the electricity flows through the metal core of the wire, not through the plastic covering. *1 mark* Plastic is an insulator, which means it does not let electricity flow through it. *1 mark* The plastic's real job is to keep the flow inside the wire and to keep anyone who touches the wire safe. *1 mark*

Q11 *(3 marks: 1 per choice with a reason)* (a) Copper (or aluminium) for the core, because it is a metal and metals are conductors that let electricity flow. *1 mark* (b) Plastic (or rubber) for the coating, because it is an insulator that keeps the flow in the wire and keeps people safe. *1 mark* (c) Copper or aluminium for the pins, because the pins must be a conductor so the flow can pass into the appliance. *1 mark*

Q12 *(5 marks)* (a) P is a battery (two or more cells joined together), Q is a switch, R is a globe and S is a buzzer. *2 marks for all four; 1 mark for three.* (b) P is the source of electrical energy: it transforms stored chemical energy into electrical energy for the circuit. *1 mark* (c) When Q is opened, both the globe and the buzzer stop working. *1 mark* This is because opening the switch makes a gap in the loop, so electricity can no longer flow around the circuit. *1 mark*

Q13 *(3 marks)* (a) Chemical energy — the cell stores energy as chemical energy before the circuit is closed. *1 mark* (b) The cell transforms the chemical energy into electrical energy, the wires transfer the electrical energy to the buzzer, and the buzzer transforms it into sound (and a little heat). *1 mark* (c) Heat — every device makes a little heat as well as its useful energy form. *1 mark*

Q14 *(4 marks)* (a) Repeated tests that agree mean the results for those objects can be trusted. *1 mark* (b) The group should test the foil again, making sure it touches both clips, and record the new result. *1 mark* (c) With the corrected result, the foil is a conductor: conductors are the brass key and the aluminium foil, and insulators are the wooden stick and the glass marble. *2 marks for both groups correct; 1 mark for one group.*

Q15 *(4 marks: 1 per appliance with its useful energy form)* Any four correct appliance–energy pairs, for example: a kettle or toaster transforms electrical energy into heat; a lamp transforms it into light; a speaker, radio or doorbell transforms it into sound; a fan or washing machine transforms it into movement. *1 mark each*

Q16 *(4 marks)* (a) The hazard is a damaged cord with the metal wire showing — a shock hazard. *1 mark* (b) Any two correct actions, such as: keep his sister away from the cord; do not touch the cord himself; tell an adult at once; have the cord replaced by an adult or an electrician. *2 marks* (c) The plastic coating is an insulator that keeps the flow of electricity in the wire and away from people; when the coating splits, the metal wire inside, which is a conductor, can be touched, so electricity could flow through a person who touches it. *1 mark — award it when the answer gives both halves: the insulator's role and the exposed conductor.*

Test

Topic 5 test — Physical sciences · Chapter 9 · Subtopics 9A and 9B

> This is a school-designed paper. It is not a VCAA instrument. Achievement at Levels 5 and 6 is reported against the Victorian Curriculum achievement standard on teacher judgement; the marks here are one source of evidence towards that judgement.

About this test

Covers	Chapter 9 — subtopics 9A and 9B
Content descriptions	`VC2S6U08` (9A) · `VC2S6U09` (9B)
Total marks	**30** — Section A 12 marks, Section B 12 marks, Section C 6 marks
Inquiry marks	**11 of 30** — inquiry is examined in its own right (paper minimum: 8)
Suggested time	35 minutes

How to run this test

- No calculator. No formula sheet. No reading time.
- **Untimed completion** — the suggested time is a guide only. A student may take all the time they need.
- **Reading support** — any item may be read aloud to a student who asks. Reading is not being assessed.
- Answer every question in the spaces provided.

What this paper assesses

> *light can be produced from many sources; light travels in a straight path, can form shadows, and can be absorbed, transmitted, reflected or refracted by objects* — VC2S6U08
>
> *materials may be electrical insulators or conductors; energy can be transferred and transformed in electrical circuits where the components of a circuit play particular roles in the function of the circuit* — VC2S6U09

Section A — Multiple choice — 12 marks

Choose the best answer for each question. Each question is worth 1 mark.

Q1. Which is a NATURAL source of light? *(1 mark)*

A. Light bulb

B. Candle

C. Sun

D. Lamp

Q2. Which is an ARTIFICIAL source of light? *(1 mark)*

A. Stars

B. Lightning

C. Sun

D. Light bulb

Q3. Why is the Moon NOT a light source? *(1 mark)*

A. It is too far from Earth to count as a light source

B. It reflects sunlight; it does not make its own light

C. It produces its own light but only during the night

D. It glows only because its surface is white

Q4. A shadow forms because: *(1 mark)*

A. Light bends around the object

B. Light disappears when it hits the object

C. The object soaks up all the colours nearby

D. Light travels in straight lines and is blocked by an object

Q5. Move an object CLOSER to a light source. Its shadow: *(1 mark)*

A. Gets smaller

B. Gets bigger

C. Disappears

D. Stays the same size

Q6. Why does a sundial work? *(1 mark)*

A. The Sun appears to move across the sky, so shadows change direction in a predictable way

B. The sundial spins on its base to track the time

C. The Sun heats different parts of the sundial at each hour

D. Magnets inside the sundial point to the correct time

Q7. A simple closed circuit needs at MINIMUM: *(1 mark)*

A. Just a wire

B. A device only, with no source of electrical energy

C. A source of electrical energy, a conducting path and a device

D. Just a battery

Q8. Which is an electrical CONDUCTOR? *(1 mark)*

A. Copper wire

B. Rubber

C. Plastic

D. Glass

Q9. Why must a circuit be CLOSED for electricity to flow? *(1 mark)*

A. Electricity is stored inside the wire and leaks out

B. Electricity needs a complete loop with no gaps to flow

C. An open gap lets the electricity escape into the air

D. The cell only works when the wire ends are apart

Q10. A globe is connected to a battery by a switch. The switch is OPEN. Does the globe light? *(1 mark)*

A. Yes

B. No

C. Sometimes

D. Cannot tell

Q11. Replacing a wire with a rubber band in a circuit results in: *(1 mark)*

A. The globe glows more brightly

B. Nothing changes in the circuit

C. No electricity can flow

D. Less electricity flows, but the globe still glows dimly

Q12. SCENARIO — A group builds a circuit with a cell, wires, a switch and a globe. The switch is closed, but the globe stays dark. The group tests the cell and the globe separately, and both work. What is the most likely reason the globe stays dark? *(1 mark)*

A. There is a gap somewhere in the loop

B. Copper wires stop the flow of electricity

C. The cell and the globe must be joined with no wires at all

D. The switch must be opened to let the electricity through

Section B — Short response — 12 marks

Write your answers in the spaces provided.

Q13. A class investigates this question: *Does the colour of an object change how much light it absorbs?* They place a square of black card and a square of white card, the same size, under a lamp. After 10 minutes they measure the temperature of each card. They do a **fair test**. *(3 marks)*

(a) Name the variable the class **changes**. *(1 mark)*

(b) Name the variable the class **measures**. *(1 mark)*

(c) Name one variable the class **keeps the same**. *(1 mark)*

Q14. A group tests a piece of aluminium foil with a circuit tester three times. Their results are: *(2 marks)*

lights · dark · lights

(a) The results do not all agree. What should the group do next? *(1 mark)*

(b) The group tests the foil once more, carefully, and the globe lights every time. Is the aluminium foil a **conductor** or an **insulator**? *(1 mark)*

Q15. A cell is joined to a buzzer with wires to make a working circuit. *(3 marks)*

(a) Name the form of energy stored in the cell before the circuit is closed. *(1 mark)*

(b) Name the useful form of energy the buzzer transforms electrical energy into. *(1 mark)*

(c) Name one other form of energy the buzzer makes. *(1 mark)*

Q16. Draw the circuit symbol used in this book for: *(2 marks)*

(a) a cell *(1 mark)*

(b) a closed switch *(1 mark)*

Q17. A straight straw stands in a glass of water. Seen from the side, the straw looks shifted at the water line. *(2 marks)*

(a) Name what happens to light as it leaves the water. *(1 mark)*

(b) After rain, a rainbow can appear while the Sun is shining. What does a rainbow show about white light? *(1 mark)*

Section C — Extended response — 6 marks

Q18. Use the table to answer this question. *(6 marks)*

SCENARIO — A group stands a 1 m stick upright on flat ground in the school yard. On a sunny day they measure the length of the stick's shadow every hour from 9 am to 3 pm. Their results are:

Time	Length of shadow (cm)
9 am	140
10 am	100
11 am	65
Midday	45
1 pm	65
2 pm	100
3 pm	140

(a) From the table, at what time is the shadow (i) shortest and (ii) longest? *(2 marks)*

(b) Describe the pattern the results show. Quote the figures in your answer. *(1 mark)*

(c) Explain why the shadow is shortest at midday. Use the idea that light travels in a straight path in your answer. *(2 marks)*

(d) Predict whether the shadow at 4 pm will be longer or shorter than at 3 pm, and give your reason. *(1 mark)*

Marking guide

This guide is written so a teacher without a science background can mark the paper. Accept the student's own words wherever the meaning matches the answer given here. Spelling and grammar are not marked. There are no half-marks: each mark point is either earned or not earned. Every item traces to the achievement-standard extract of 9A (VC2S6U08) or 9B (VC2S6U09) in §4.1; inquiry items also name the inquiry code they rehearse, per §4.3.

Inquiry-strand marks on this paper: 11 of 30 (Q13 × 3, Q14 × 2, Q16 × 2, Q18(a) × 2, Q18(b) × 1, Q18(d) × 1). The paper minimum is 8.

Section A — answers

The question bank holds six items keyed to VC2S6U08 and six keyed to VC2S6U09, all at those codes' E01 and E02 elaborations. Section A uses all twelve: eleven are bank items (the option order has been changed from the bank order, and the answer letters below are the letters as printed on the paper), and five of those carry a vocabulary repair in the book's own words, noted below; a repair changes no key and no code. The twelfth bank item, VC2S6U09.E02.S01.D3.V01, cannot be used at this band — it needs the ideas of series wiring and resistance, which VC2 Levels 5 and 6 and this book do not teach — so it is replaced by a new item written against the same code, VC2S6U09, drawing on VC2S6U09.E02. No item in this paper draws on any other content code.

Q	Answer	CD	Bank item
1	**C** — Sun	VC2S6U08	VC2S6U08.E01.S01.D1.V01
2	**D** — Light bulb	VC2S6U08	VC2S6U08.E01.S01.D2.V01
3	**B** — It reflects sunlight; it does not make its own light	VC2S6U08	VC2S6U08.E01.S01.D3.V01
4	**D** — Light travels in straight lines and is blocked by an object	VC2S6U08	VC2S6U08.E02.S01.D1.V01
5	**B** — Gets bigger	VC2S6U08	VC2S6U08.E02.S01.D2.V01 (option D tidied for print)
6	**A** — The Sun appears to move across the sky, so shadows change direction in a predictable way	VC2S6U08	VC2S6U08.E02.S01.D3.V01
7	**C** — A source of electrical energy, a conducting path and a device	VC2S6U09	VC2S6U09.E01.S01.D1.V01 (repaired)
8	**A** — Copper wire	VC2S6U09	VC2S6U09.E01.S01.D2.V01
9	**B** — Electricity needs a complete loop with no gaps to flow	VC2S6U09	VC2S6U09.E01.S01.D3.V01 (repaired)
10	**B** — No	VC2S6U09	VC2S6U09.E02.S01.D1.V01 (repaired)
11	**C** — No electricity can flow	VC2S6U09	VC2S6U09.E02.S01.D2.V01 (repaired)
12	**A** — There is a gap somewhere in the loop	VC2S6U09	New item — replaces VC2S6U09.E02.S01.D3.V01, draws on

Q	Answer	CD	Bank item
			VC2S6U09.E02

Each correct answer earns 1 mark. There is no working required for Section A and no part-credit.

Repairs. Q5: the bank's option D reads "Stays same"; it is printed as "Stays the same size". Q7: the bank's correct option reads "Power source, conductors, and a load" and its option D reads "A load only, with no power source"; they are printed in the book's own words — *device* and *source of electrical energy* — because *load* and *power source* are not words this book teaches. Q9: the bank's stem and options use *current* and *charge*; they are printed with *electricity* and *the flow of electricity*, the words 9B teaches, because electric charge is not a term at this band. Q10 and Q11: the bank's *bulb* is printed as *globe*, the word this book uses throughout, and Q11's correct option "No current flow" is printed as "No electricity can flow". All repairs follow the word-level policy's rewrite channel; the items stay keyed to their codes.

Section B — answers and marking

Q13 *(3 marks: 1 each)* — inquiry: planning a fair test (rehearses VC2S6I02, anchored at 9A); content VC2S6U08 (absorbed light warms an object). (a) The colour of the card — accept "which card, black or white". *1 mark* (b) The temperature of each card — accept "how hot each card gets". *1 mark* (c) Any one of: the size of the cards; the kind of card; the distance from the lamp; the time under the lamp (10 minutes); the same lamp; the same starting temperature. Do not accept "the colour" (that is the changed variable) or "the temperature" (that is the measured variable). *1 mark*

Q14 *(2 marks: 1 each)* — inquiry: repeat measurements (rehearses VC2S6I03, anchored at 9B); content VC2S6U09. (a) Test the foil again — accept "repeat the test" or "test it once more, checking that it touches both clips". Do not accept "ignore the dark result" with nothing further. *1 mark* (b) Conductor. *1 mark*

Q15 *(3 marks: 1 each)* — content VC2S6U09 (energy transferred and transformed; the role of the components). (a) Chemical energy. *1 mark* (b) Sound. *1 mark* (c) Heat. *1 mark*

Q16 *(2 marks: 1 each)* — inquiry: constructing a representation to accepted conventions (rehearses VC2S6I04, anchored at 9B); content VC2S6U09. (a) One long line next to one short thick line; the long line is the + end. Accept any recognisably correct cell symbol. *1 mark* (b) A line with a lever sitting flat across the gap, so the path is complete. Do not accept the open-switch symbol (a lifted lever with a gap). *1 mark*

Q17 *(2 marks: 1 each)* — content VC2S6U08 (refraction, and white light as a mix of colours). (a) It is refracted — accept "it changes direction" or "it bends as it leaves the water". *1 mark* (b) White light is a mix of colours. *1 mark*

Section B subtotal: 12 marks.

Section C — answers and marking

Q18 *(6 marks)* — content VC2S6U08 (straight path of light, shadows and the Sun's position); parts (a), (b) and (d) are inquiry: reading a supplied data table and describing its pattern (rehearses VC2S6I04) and a reasoned prediction (rehearses VC2S6I01). The stimulus is a SCENARIO built on the real parameters of the 9A shadow work; the figures are the group's own measurements, not a published data set.

(a)

(i) Midday. *1 mark* (ii) 9 am and 3 pm — accept either time or both; both readings are 140 cm. *1 mark*

(b) The shadow is long in the morning, becomes shortest at midday, and becomes long again through the afternoon, quoting at least two figures — for example "it falls from 140 cm at 9 am to 45 cm at midday, then rises back to 140 cm at 3 pm". Do not award the mark for a statement with no figures, such as "it goes down then up". *1 mark*

(c) At midday the Sun is highest in the sky. *1 mark* Because light travels in a straight path, light from the high Sun falls almost straight down onto the stick, so the patch where light cannot reach — the shadow — is short. *1 mark* Accept any response that links the high midday Sun to a short shadow through straight-travelling light.

(d) Longer, because the Sun is lower in the sky as the afternoon goes on (a lower Sun makes a longer shadow). *1 mark* Award the mark only when both the prediction and a fitting reason are given.

Mark summary and curriculum map

Section	Marks	Inquiry-strand marks
A — Multiple choice	12	0
B — Short response	12	7 (Q13: 3, Q14: 2, Q16: 2)
C — Extended response	6	4 (Q18(a): 2, Q18(b): 1, Q18(d): 1)
Total	**30**	**11** (required minimum: 8)

Evidence towards the achievement-standard extracts (§4.1 of the plan of record):

Items	Code	Achievement-standard extract
Q1–Q6, Q17, Q18(c)	VC2S6U08	"They identify sources of light and model different pathways of light to explain observed phenomena."
Q7–Q12, Q14(b), Q15	VC2S6U09	"They distinguish between electrical insulators and conductors, and identify the role of circuit components in the transfer and transformation of electrical energy."
Q13	VC2S6I02	"They plan different scientific investigations including fair tests, describe how risks and ethical issues associated with investigations have been managed, and identify cultural considerations when planning fieldwork." (evidenced here by the fair-test variables)
Q14(a)	VC2S6I03	"They use equipment to generate and record data, including repeat trials."
Q16, Q18(a), Q18(b)	VC2S6I04	"They construct representations to organise and process data and information, and describe patterns, trends and relationships." (evidenced here by drawing circuit symbols to accepted conventions and by reading the supplied table and quoting figures)
Q18(d)	VC2S6I01	"Students make reasoned predictions, describe patterns and test relationships when investigating observable phenomena."