Science 7–8

Chapter 17 — Physical sciences C: electric circuits

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Contents

Building a circuit for a purpose: components and circuit symbols, series against parallel, and designing for a stated job

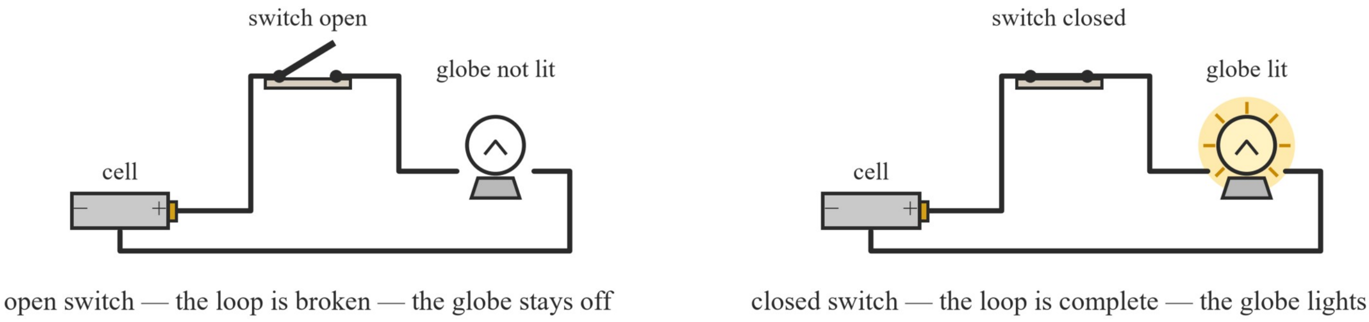
What we teach here — `VC2S8U17` (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *“electrical circuits transfer energy when current flows and can be designed for diverse purposes using different components; the operation of circuits can be explained using the concepts of voltage and current”* **This subtopic owns the first clause only**: circuits transfer energy when current flows, and circuits are designed for diverse purposes using different components — the components and their symbols, series against parallel arrangements, what happens when a part fails or a switch opens, how household wiring compares, and how a circuit is designed for a stated job, including sensors in control devices. The second clause — explaining the operation of circuits using the concepts of voltage and current, and measuring both — belongs to the partner subtopic **17B** († split delivery, D6). **In our words:** a circuit is a loop, and its one job is to carry energy from a source to the parts that do something with it. Current is the flow that carries that energy, and it only flows when the loop is complete. The two great arrangements of the loop are series (one path for the current) and parallel (a path of its own for each part), and choosing between them — plus picking the right components and the right places for switches and protection — is what designing a circuit for a purpose means. **Achievement-standard extract served here (D13):** *“They design and construct series and parallel circuits, and observe and make predictions about voltage and current and about energy transfer in the circuits.”* 17A serves the designing and constructing of series and parallel circuits, the predictions about energy transfer, and the observing of what series and parallel circuits do; the observing and predicting of voltage and current themselves is 17B’s share of the extract. **Elaborations drawn on:** `VC2S8U17.E01` (investigating parallel and series circuits — here the building and observing; the measuring of voltage drops and currents is shared with 17B, D6), `VC2S8U17.E02` (the properties of components such as LEDs and temperature and light sensors), `VC2S8U17.E03` (comparing electrical circuit design to household wiring — common components, arrangement, and the safety role of fuses and circuit breakers; the voltage-and-current limb of this elaboration is 17B’s, D6) and `VC2S8U17.E04` (the use of sensors in robotics and control devices). **Authored from the CD text and the elaboration contexts (D12):** the CD names the two arrangements nowhere, so series and parallel are authored from the CD’s own claim — one loop transferring energy, designed with different components for diverse purposes — and from the achievement standard, which names series and parallel circuits directly. E01 supplies the hands-on comparison, E02 the component properties, E03 the household comparison and the protection devices, and E04 the sensor-and-control context that makes “designed for a purpose” concrete. Scope is capped by D9: no Ohm’s law, no resistance as a taught concept, no voltage or current calculations — those belong to VCE Physics Unit 1 Area of Study 3 and to 17B’s explaining. Circuits here are read, built, compared and designed, never computed.

Word watch — *current* and *circuit*. In everyday talk, *current* means now (“the current term”) or a flow of water (“an ocean current”). In this subtopic, an electric **current** is a flow of charge around a loop, and it is the flow that carries energy from the source to every component. And *circuit*: in everyday talk it is a lap — a runner does circuits of the track. Here a **circuit** is a complete loop of components joined by conducting wire, and the lap idea is still alive in it: the current goes right around the loop and back to where it started. Break the loop at any point and the current stops, the way a broken track stops the runner. Keep the everyday and scientific meanings apart: the circuit is the loop itself, not the diagram drawn of it, and a current is not something a wire “has” — it is something that flows, or does not.

Theory

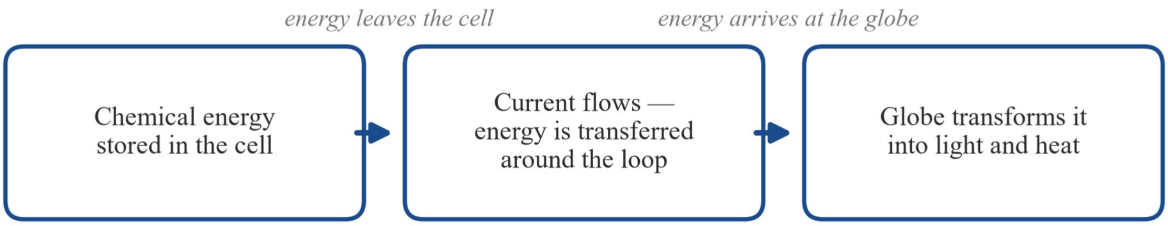
A circuit is a loop that transfers energy

Pick up any device that runs on electricity — a torch, a doorbell, a battery toy — and inside it there is a loop. A circuit is a complete loop of components joined by conducting wire, and while the loop is complete, a current flows around it. The current is the flow that carries energy from the source to every component in the loop. Break the loop at any point — an open switch, a cut wire, a globe missing from its holder — and the current stops everywhere at once.



Two bench views of the same circuit of a cell, a knife switch and a globe on leads: with the switch open the loop is broken and the globe is dark, and with the switch closed the loop is complete and the globe glows.

The source in a school circuit is a cell or a battery of cells. A cell stores energy in chemical form, and when the loop is complete that stored energy is handed to the current, carried around the loop, and handed over again at each component. A globe changes the energy it receives into light and heat; a motor changes it into motion; a buzzer changes it into sound. So the one sentence that holds this whole subtopic together is: **electrical circuits transfer energy when current flows** — no current, no transfer, nothing happens.



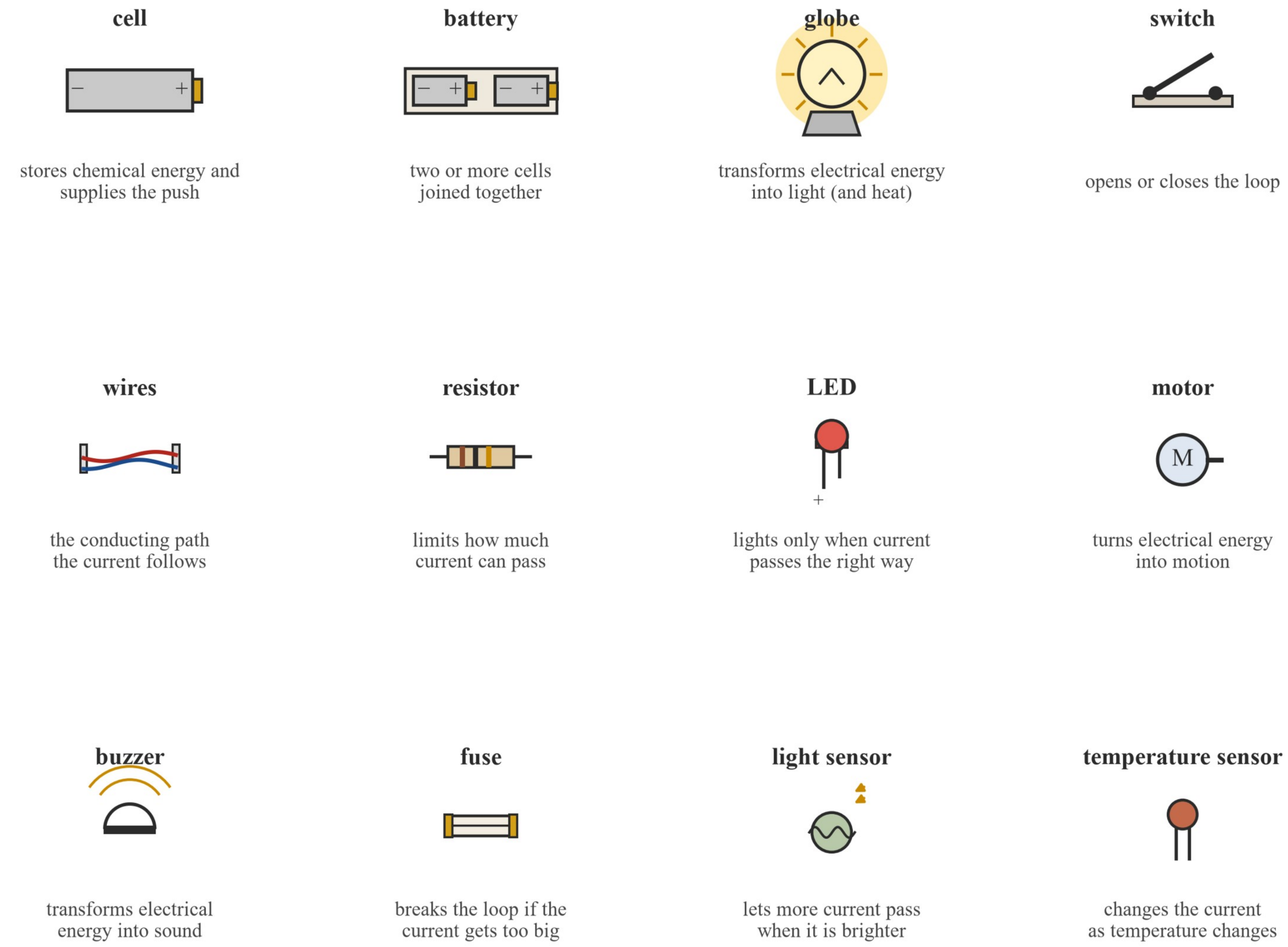
A circuit transfers energy from the source to every component in the loop — the energy is transformed where the components are.

Energy chain in three boxes: chemical energy stored in the cell, then current flows so energy is transferred around the loop, then the globe changes it into light and heat.

Energy is not used up like fuel in a tank; it is transferred — moved from the store in the cell to the components, and changed in form where the components are. That is why the word *transfer* does so much work in this chapter, and why 16A's energy ideas and this subtopic fit together: the circuit is the delivery route.

Components and the job each one does

Every part of a circuit is called a **component**, and components fall into a small number of jobs: the source that supplies the push, the path that carries the current, the parts that do something with the energy, the parts that control the loop, and the parts that notice things.



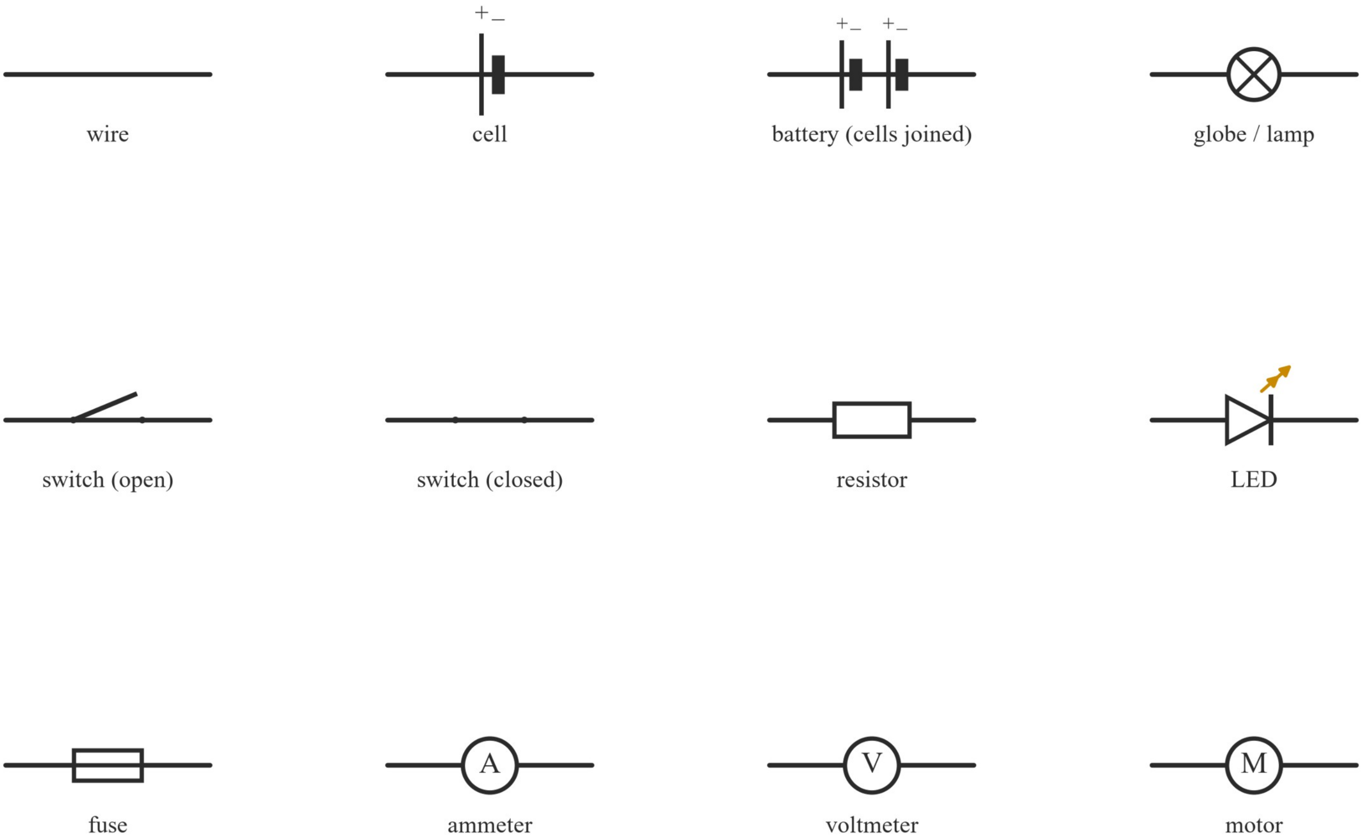
Grid of twelve physical components with the job of each: cell, battery, globe, switch, wires, resistor, LED, motor, buzzer, fuse, light sensor and temperature sensor.

- **Cell and battery.** A cell stores chemical energy and supplies the push that drives the current. A single AA cell supplies 1.5 V (Wikipedia, “AA battery”, retrieved 2026-08-21). A battery is two or more cells joined together, nose to tail, so the push adds up.
- **Globe (lamp).** Changes electrical energy into light and heat.
- **LEDs (light-emitting diodes).** Tiny lights with a property a globe does not have: an LED lights only when the current passes through it the right way around (`VC2S8U17.E02`). Turn it around and it stays dark. This is why an LED has a longer lead marked as the positive side.
- **Motor and buzzer.** Change electrical energy into motion and into sound.
- **Switch.** Opens or closes the loop. Open means a gap — no current; closed means a bridge — current flows. A closed switch is therefore the “on” position, which is the opposite of what the everyday word suggests.
- **Resistor.** Limits how much current can pass. Resistors are used to protect small components such as LEDs.
- **Fuse.** A deliberate weak link: if the current gets too big, the thin wire inside it melts and the loop is broken on purpose, before anything else is damaged.
- **Sensors.** Components that notice a change in the world around them. A **light sensor** lets more current pass when it is brighter; a **temperature sensor** changes the current as the temperature changes (`VC2S8U17.E02`). Sensors are how a circuit notices that it is getting dark, or that a room is getting hot.
- **Wires (leads).** The conducting path the current follows.

Two more symbols — a circle lettered A and a circle lettered V — are the measuring instruments you will meet in 17B, where voltage and current are measured and used to explain what a circuit does. Here they are worth recognising as symbols only.

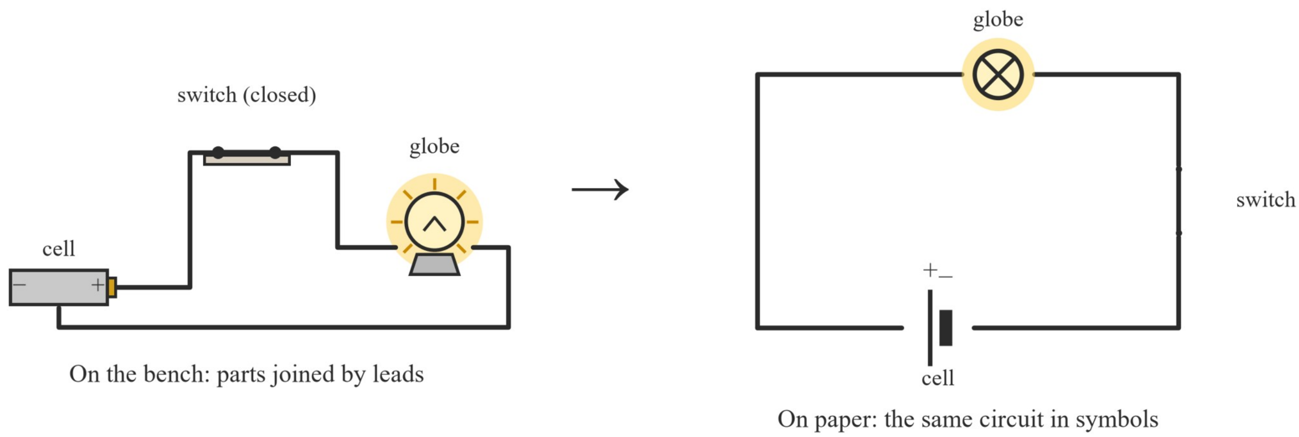
Drawing circuits in symbols

A photograph of a bench circuit is hard to read: leads curve, parts lie at angles, and two circuits that are electrically the same can look completely different on the bench. So circuits are drawn as **circuit diagrams**, in which every component is replaced by its symbol and every wire is a straight line. The diagram does not show what the bench looks like; it shows what is joined to what.



Grid of the school-standard circuit symbols: wire, cell with plus and minus plates marked, battery of two cells, globe as a circle with a cross, open and closed switch, resistor as a rectangle, LED as a triangle and bar with two light arrows, fuse as a rectangle with a line through it, and circles lettered A, V and M.

The symbols are the same in every Australian classroom and in most of the world, which is the point of them: a circuit diagram is a shared language. In the cell symbol the long thin line is the positive terminal and the short thick one is the negative terminal. By convention, the current is drawn leaving the positive terminal, going once around the loop through the components, and returning to the negative terminal.

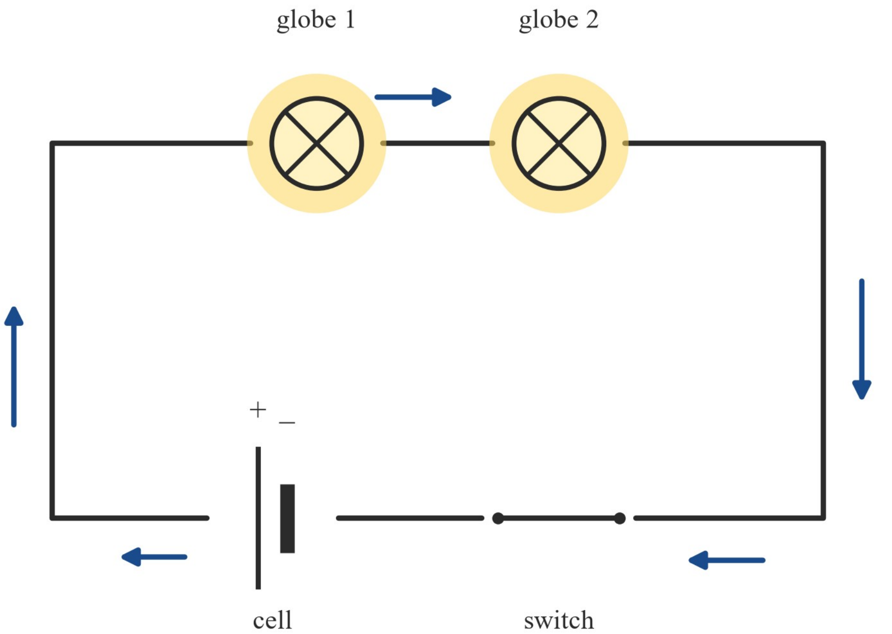


The same circuit of cell, closed switch and lit globe shown twice: on the left as parts joined by leads on a bench, on the right translated into a neat rectangular circuit diagram in symbols.

Translating a bench circuit into a diagram is a skill worth practising slowly: follow the loop one wire at a time from the positive terminal back to the negative one, and draw each component as you pass it. Corners in a diagram mean nothing — only the connections mean something.

Series — one path for the current

A **series** circuit is a loop in which the components sit one after another, so the current has exactly one path to follow. The same current that leaves the cell must pass through globe 1, then globe 2, then the switch, on its way home.



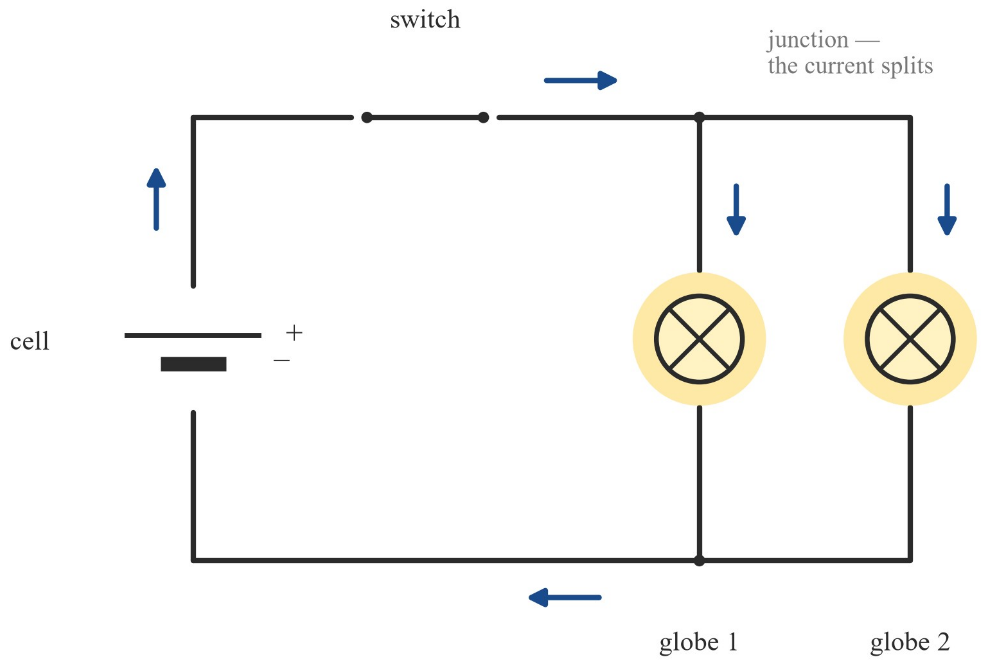
A series circuit — one loop, one path for the current.

Circuit diagram of a series loop: a cell and a closed switch on the bottom wire and two lit globes one after the other on the top wire, with arrows showing the single current path around the loop.

The whole behaviour of a series circuit follows from that one fact. There is only one path, so a break at any point — an open switch, a failed globe, a loose wire — stops the current everywhere, and every component goes dead at once. Series is the right arrangement when you want one thing to control everything, and the wrong arrangement when you want parts to work independently.

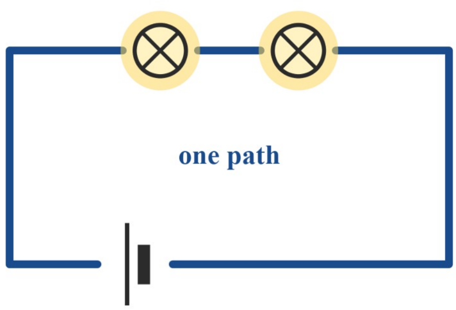
Parallel — a path of its own for each branch

A **parallel** circuit gives the current more than one path. At a **junction** the current splits, some going down each **branch**, and the branches rejoin before the current returns to the cell. Each branch is itself a complete loop with the source.

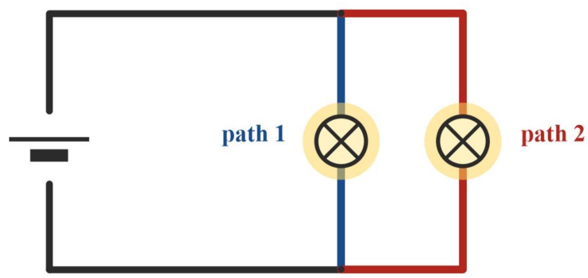


A parallel circuit — two branches, each globe on its own path.

Circuit diagram of a parallel circuit: a cell and a closed main switch, then two branches between the same two junction dots, each branch carrying one lit globe, with arrows showing the current splitting at the junction.



Series: the current can only go one way



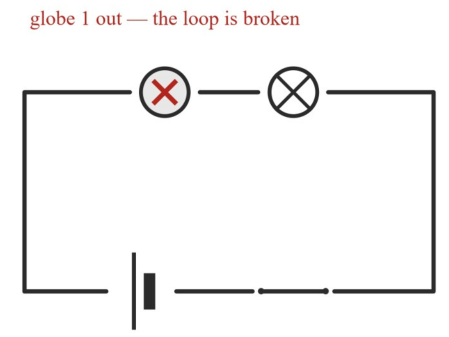
Parallel: the current splits at the junction

The series loop and the parallel circuit redrawn with the current paths coloured: series has one path all the way around, while parallel has two paths — the current splits at the junction and rejoins at the other one.

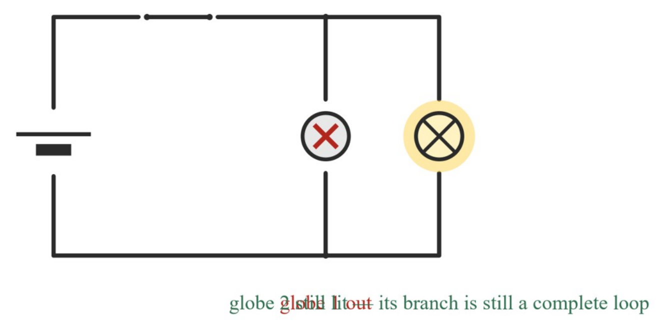
Because each branch is its own loop with the source, a break in one branch leaves the other branches working. That single difference — one shared path against separate paths — is the difference between series and parallel, and it is the first thing to ask about any circuit you are given: *how many paths does the current have?*

When a globe fails, and where the switch goes

The series–parallel difference shows up most clearly when something fails. Take one globe out of its holder in a series circuit and the loop is broken, so every globe goes dark. Take one globe out of a parallel circuit and only that branch stops; the other branches keep complete loops with the cell, so they stay lit.



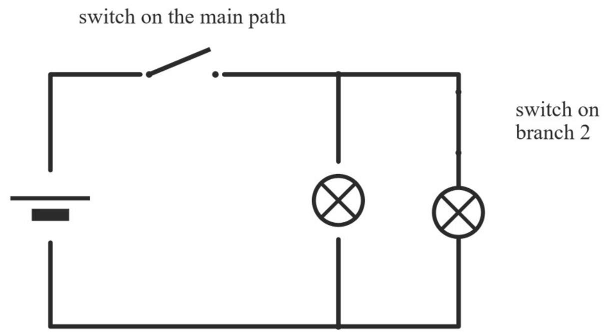
Series: one globe out, all globes go dark



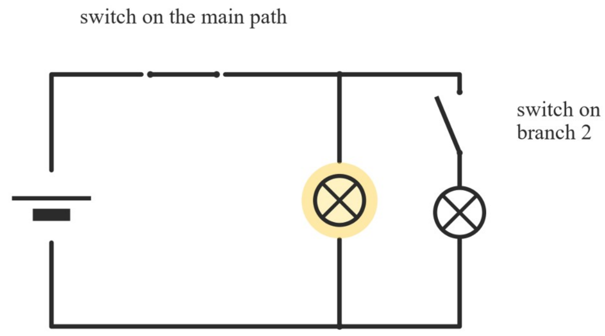
Parallel: the other branch keeps working

Two circuits with globe 1 removed from its holder: in the series circuit both globes are dark because the loop is broken, while in the parallel circuit globe 2 stays lit because its branch is still a complete loop.

The same logic tells you where a switch will reach. A switch on the main path — before the junction — controls every branch at once. A switch on one branch controls only that branch. So a circuit can have a master switch that turns everything off and individual switches that turn single branches off, and the two jobs are done by putting the same component in two different places.



Main switch open — every branch is off



Branch switch open — only that globe is off

Two parallel circuits: with the switch on the main path open, both globes are off; with the main switch closed and a second switch on branch 2 open, only globe 2 is off while globe 1 stays lit.

Safety and risk assessment — Every practical in this subtopic is carried out under a risk assessment written to Science ASSIST (ASTA) guidance (both pages retrieved 2026-08-21; see Sources [S2] and [S3]). The standing controls are: **low voltage only** — cells or a school power pack on a low setting, never the mains; leads and components checked for damage before use; the cell or power pack connected last and disconnected when finished; the two terminals of a cell never joined by a single bare wire (a short circuit makes cells hot); circuits not left connected longer than the activity needs; and anything that gets hot, smells, or a cell that leaks, disconnected and reported to the teacher at once. **PPE:** none beyond normal classroom practice for low-voltage work; safety glasses if leads are being cut or a broken globe is being handled.

Try it — build series against parallel and test your predictions (`VC2S8U17.E01`)

You will need: two globes in holders, one cell in a holder (1.5 V) or a school power pack on low voltage, one switch, connecting leads, and one LED with a resistor in series if your kit has them.

1. Build a series loop: cell, switch, globe 1, globe 2, all in one path. Close the switch and note what you see.
2. Predict, *before* you do it: what will happen to globe 1 if globe 2 is unscrewed a turn from its holder? Then unscrew globe 2 and check.
3. Rebuild the same parts as a parallel circuit: two branches between the same two junctions, one globe per branch, the switch on the main path. Close the switch and note what you see.

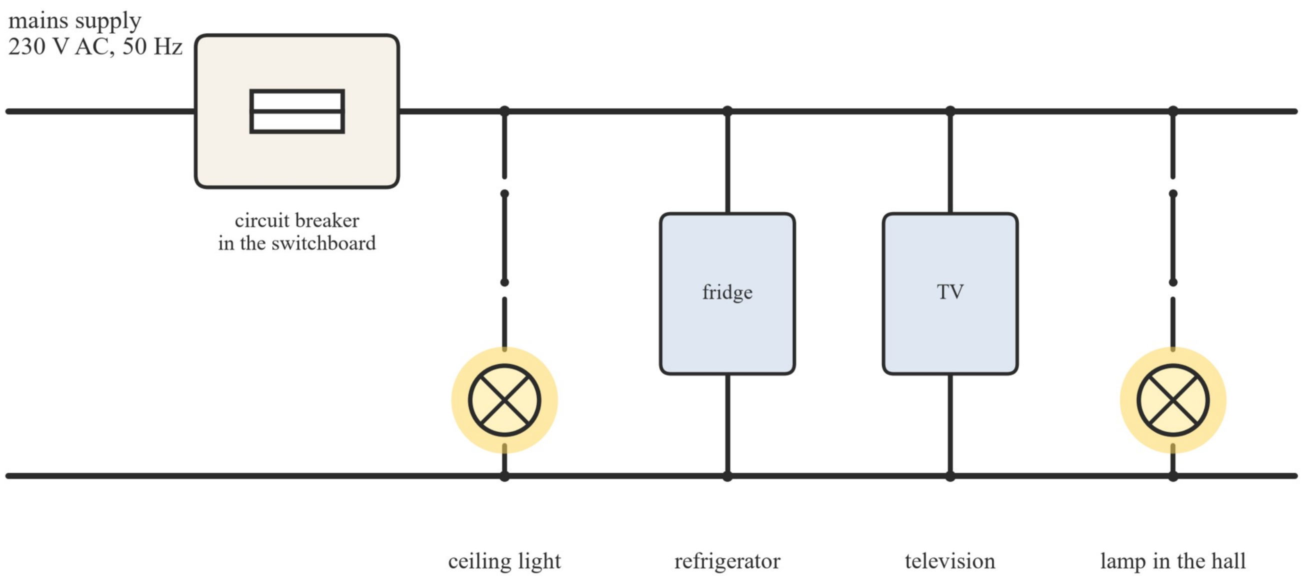
4. Predict again: what will happen to globe 2 if globe 1 is unscrewed? Check.
5. Predict: what does the main switch do in each circuit? Check.
6. If your kit has an LED: put it in a simple loop with the cell and the resistor. If it does not light, turn the LED around. Note when it lights (`VC2S8U17.E02`).

What you did	What you predicted	What you observed
Unscrewed a globe in the series loop		
Unscrewed a globe in the parallel loop		
Opened the main switch in each loop		
Turned the LED around		

Then answer: which arrangement would you choose for the lights in a house, and which single observation from the table tells you why?

How a house is wired — and why

The mains supply in Australia is 230 V AC at 50 Hz (Wikipedia, "Mains electricity" and "Mains electricity by country", retrieved 2026-08-21). That is a very different source from a 1.5 V cell — two hundred and thirty volts, alternating current, enough to be dangerous — which is why school circuits stay on cells and low-voltage power packs, and why nobody in a school laboratory touches the mains. The *design*, however, is the same family of thinking you have just learned.

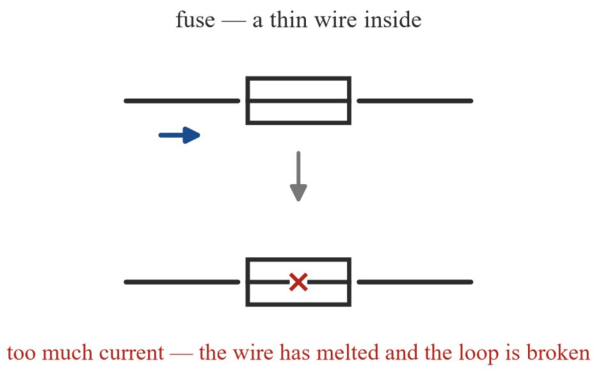


Every light and appliance is wired in parallel across the mains — each on its own path, so one can be switched off while the others keep working.

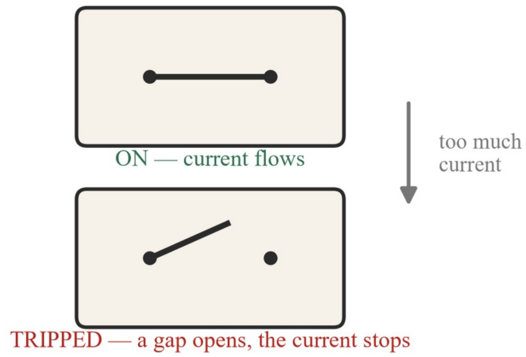
Simplified household wiring diagram: the 230 V AC 50 Hz mains enters through a circuit breaker in the switchboard, then two rails run past four parallel branches — a ceiling light with its own switch, a refrigerator, a television, and a hall lamp with its own switch.

Every light and appliance in a house is wired **in parallel** across the mains (Wikipedia, "Mains electricity", retrieved 2026-08-21). Run the series–parallel test on your own kitchen: when the refrigerator is switched off, the lights stay on; when one globe fails, the television keeps working. Each light and appliance is on its own branch, with its own switch where a switch is wanted, so each works independently of the others — exactly the behaviour you observed in the parallel circuit on the bench. And comparing components, the house and the bench circuit use the same families of parts: a source, switches, conducting path, and components that do the work (`VC2S8U17.E03`).

The one extra component the house carries is protection. Because the mains can supply a very large current, every house has a switchboard holding **fuses or circuit breakers**, wired in the main path so that everything passes through them. If a fault makes the current too big — a damaged appliance, a worn lead — the fuse wire melts, or the breaker trips, and the loop is broken before the wiring gets hot enough to start a fire. That is the importance of circuit protection in one sentence: fuses and circuit breakers are designed to fail first, on purpose, to prevent electrical hazards (`VC2S8U17.E03`).



A fuse works once, then must be replaced



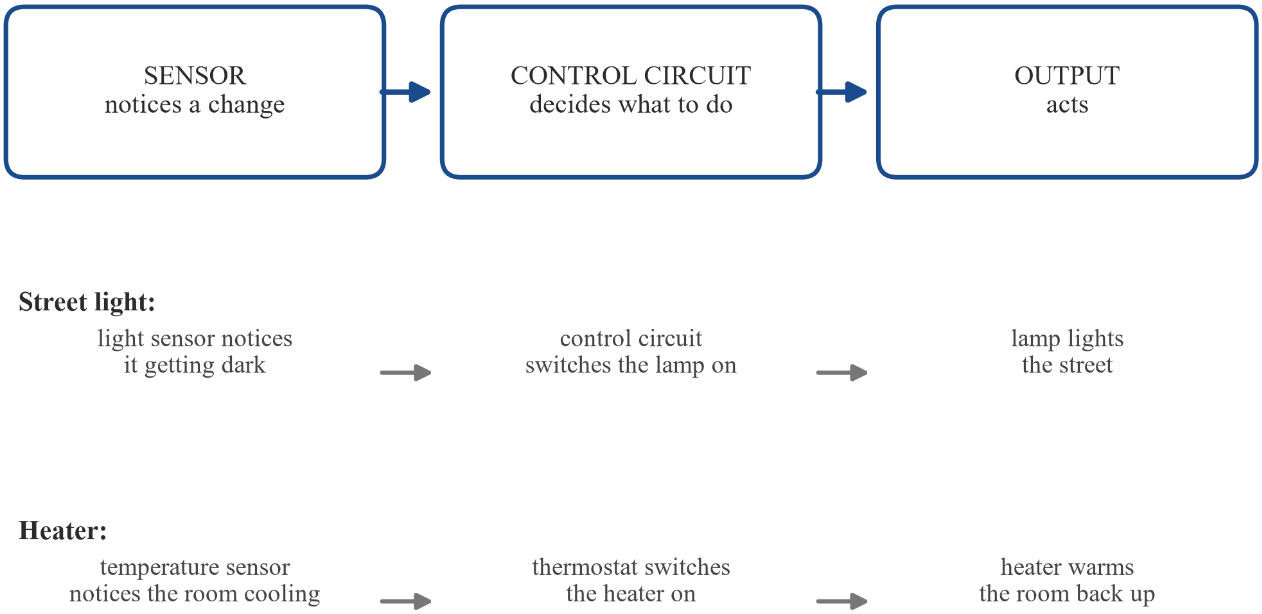
A circuit breaker is a switch that trips — flip it back on to reset

A fuse and a circuit breaker shown before and after too much current: the fuse's thin wire melts and the loop is broken, and the fuse must be replaced, while the circuit breaker trips open like a switch and is reset by flipping it back on.

A fuse works once and is replaced; a circuit breaker is a switch that trips, and is reset by flipping it back on. Notice where both sit: on the main path, before the branches — the only place where one small component can guard the whole circuit.

Sensors — circuits that notice and act

A circuit becomes a control device when it can notice something. The pattern is always the same three steps: a **sensor** notices a change, a **control circuit** decides what to do, and an **output** acts.



Control devices use sensors to watch for a change, then switch an output on or off.

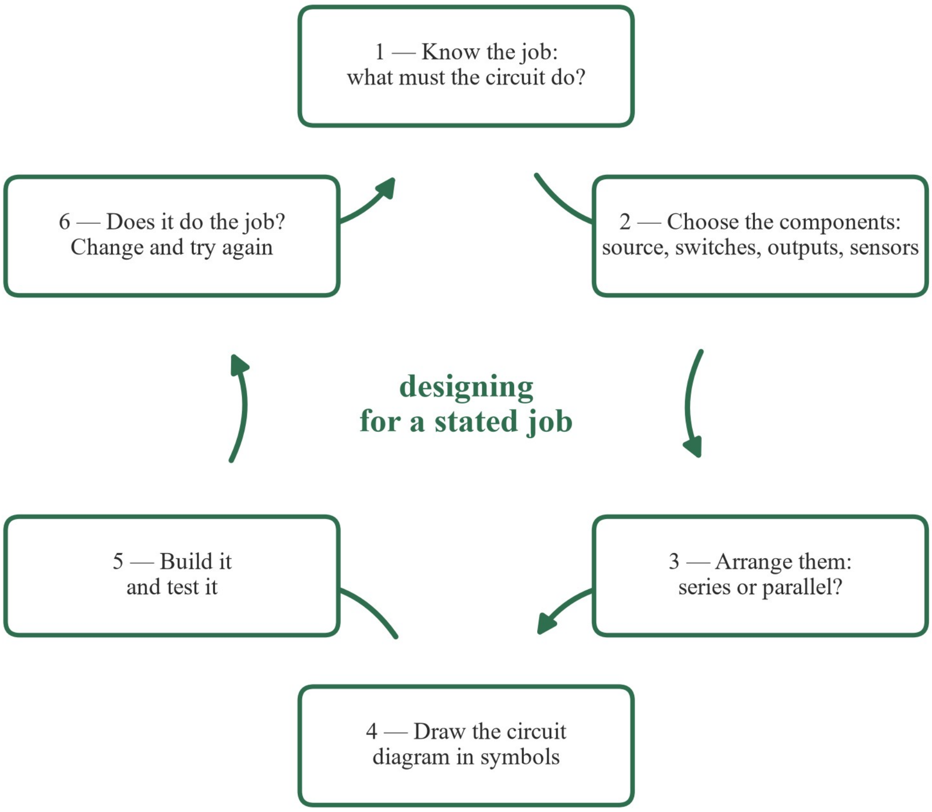
Flow of sensor, control circuit and output, with two examples beneath it: a street light whose light sensor notices it getting dark so the control circuit switches the lamp on, and a heater whose temperature sensor notices the room cooling so the thermostat switches the heater on.

A street light is the cleanest example. Its light sensor notices the daylight fading; the control circuit then switches the lamp on, without anyone climbing a ladder at dusk. A heater with a **thermostat** works the same way: the temperature sensor notices the room cooling below the set temperature, the control circuit switches the heater on, and when the room is warm again the same sensor has the heater switched off (Wikipedia, “Thermostat” and “Photoresistor”, retrieved 2026-08-21).

The same pattern runs through robotics. A mobile robot stays on its path with sensors — light sensors and cameras to follow a line, distance sensors to notice an obstacle — feeding a control circuit that drives the motors (Wikipedia, “Mobile robot”, retrieved 2026-08-21). A line-following robot is nothing more mysterious than the street-light pattern repeated very fast: sensor notices, control decides, output acts. That is `VC2S8U17.E04`, and it is also the reason “designed for a purpose” is the heart of this subtopic: once components can notice the world, a circuit can be designed to look after something on its own.

Designing a circuit for a stated job

Design is the achievement standard’s verb — *they design and construct series and parallel circuits* — and it is a loop of its own, just like the circuits.



The design loop as a six-step cycle: know the job, choose the components, arrange them in series or parallel, draw the circuit diagram in symbols, build it and test it, and check whether it does the job before changing and trying again.

1. **Know the job.** Not "build a circuit" but "the two hall lights must work independently, and one master switch must turn everything off". The job statement decides everything that follows.
2. **Choose the components.** A source with enough push; an output for each job the circuit must do; a switch for each thing someone must control; a sensor if the circuit must notice something; a resistor or fuse where something needs protecting.
3. **Arrange them — series or parallel?** This is the designer's first big fork. Things that must work independently go on separate branches (parallel); things that must be controlled or protected together sit in the one path (series, or the main path of a parallel circuit). Houses are wired in parallel for exactly this reason; old strings of decorative lights were wired in series and failed as a string.
4. **Draw the circuit diagram** in symbols, before building. The diagram is where mistakes are cheap.
5. **Build it and test it** against the job statement, one requirement at a time.
6. **Does it do the job?** If not, change one thing and test again — that is the loop closing.

Worked Example 2 and Example 4 below walk this loop on two stated jobs, and the second Try it hands you one.

Try it — design and build for a stated job (`VC2S8U17.E03`)

You will need: a model board or box with two "rooms", two globes in holders, one cell or low-voltage power pack, three switches, leads.

The job: *each room's light must be able to be on while the other is off, and one master switch must be able to turn both rooms off at once.*

1. From the job statement, decide the arrangement: series or parallel? Write one sentence of reason.
2. Decide where the three switches go: which one is the master switch, and where do the other two sit?
3. Draw the circuit diagram in symbols and have it checked before you build.
4. Build it and test all three requirements: room 1 alone, room 2 alone, master off.
5. If a test fails, change one thing and retest. Record the change you made and why.

The whole story in five sentences

A circuit is a complete loop, and when the loop is complete a current flows that transfers energy from the source to every component. Components have jobs — source, path, output, control, protection, sensing — and each has a symbol, so any circuit can be drawn as a diagram that shows the connections and nothing else. In series the current has one path and one break stops everything; in parallel each branch has its own path and keeps working when another branch fails. Houses use parallel wiring with switches on each branch and protection on the main path, because independence and safety are the job a house needs done. And designing a circuit is choosing components and arrangement to fit a stated job — including sensors, which let a circuit notice the world and act on it by itself.

Worked examples

Example 1 — scaffolded

A circuit diagram shows, in one loop: a cell, a switch drawn with its arm lifted off the contact, and two globes drawn as circles with a cross inside, all joined one after the other by straight lines.

(a) Name the three components from their symbols, and the arrangement. **(b)** Will the globes light as drawn? Explain in one sentence. **(c)** Predict what happens to each globe when the switch is closed, and then what happens to both globes if globe 1 is later taken from its holder.

Working	Comment
(a) Cell; switch; two globes. One loop, one after another → series.	The circle-with-cross is the globe; the lifted arm is an *open* switch; "one after another" is the series test.
(b) No. The open switch is a gap, so the loop is broken and no current flows.	Current flows only in a complete loop. The globes are fine; the loop is not.
(c) Switch closed: the loop is complete, current flows, both globes light. Globe 1 removed: the loop is broken again, so globe 2 goes dark too.	In series, one path means one break stops everything — the observation from the first Try it.

Example 2 — scaffolded

A school is building a bike shed with two globes. The job statement reads: *each globe must keep working if the other fails, and one switch at the door must turn both globes on and off.* Design the circuit: choose the arrangement, place the switch, and give the reason for each choice.

Working	Comment
Requirement 1 — one globe failing must not stop the other. A series loop would let one failed globe break the whole circuit, so the globes go on separate branches: **parallel**.	This is exactly the globe-out observation: in parallel, the other branch keeps its loop.
Requirement 2 — one switch controls both. A switch on a branch controls only that branch, so the switch goes on the **main path**, before the junction.	The switch-position rule: main path reaches every branch; a branch switch reaches only its own.
Design: cell (or low-voltage supply), main switch on the path before the junction, two branches, one globe per branch.	Draw it in symbols before building — mistakes are cheaper on paper.

Example 3 — unscaffolded

A parallel circuit is built with a cell, a main switch, and two branches: branch 1 holds globe 1, and branch 2 holds a switch of its own and globe 2. The main switch is closed and the branch-2 switch is open. Predict, with a reason each time: (i) which globes are lit now; (ii) what changes when the branch-2 switch is closed; (iii) what changes when the main switch is then opened.

Solution. (i) Globe 1 is lit and globe 2 is dark. Branch 1 is a complete loop with the cell through the closed main switch, so current flows in it; branch 2 has a gap at its own switch, so no current flows there. (ii) Closing the branch-2 switch completes branch 2's loop, so globe 2 also lights — and globe 1 is unchanged, because closing a switch on one branch does not break the other branch's loop. (iii) Opening the main switch puts a gap in the main path, through which both branches' current must pass, so both globes go dark at once. One branch switch reaches one globe; the main switch reaches everything.

Example 4 — unscaffolded

A parent wants a night light for a child's room: *the light must come on by itself when the room gets dark, and it must change electrical energy into light the child can sleep by.* Design the circuit in outline — name the sensor, the control and the output, say how they are arranged, and trace the energy transfers once the light is on.

Solution. The sensor is a light sensor, which notices the room darkening. The control circuit takes the light sensor's change and, when it is dark, closes the loop to the output; the output is a small globe or an LED that gives a soft light (an LED with a resistor in series is a good choice — the resistor limits the current and protects the LED). The arrangement follows the sensor loop: light sensor and control circuit in the control path, the globe as the output they switch on — the three-step pattern of the street light, shrunk to a bedroom. Test step: cover the sensor with a cup and check the light comes on; uncover it and check the light goes off. Energy trace once the loop is closed: chemical energy stored in the cell is handed to the current, the current transfers it around the complete loop, and the globe changes it into light (and a little heat) — energy transfer happening only because current flows, which is the clause this subtopic is built on.

Practice questions

Scaffolded

Q1. Name the component each symbol describes: (a) a circle with a cross inside; (b) a long thin line beside a short thick one; (c) a rectangle with the circuit line running through it; (d) a triangle pointing at a bar, with two small arrows leaving it.

Q2. A series circuit holds a cell, a closed switch and two globes. (a) How many paths does the current have? (b) Predict what both globes do when the switch is opened. (c) Predict what globe 1 does when globe 2 is unscrewed from its holder.

Q3. A parallel circuit holds a cell, a closed main switch and two branches with a globe in each. (a) Why do both globes light? (b) Predict what happens to globe 2 when globe 1 fails. (c) Predict what happens to both globes when the main switch is opened.

Q4. Copy the chain and fill the gaps: *The cell stores ______ energy. When the loop is complete, ______flows and transfers the energy around the loop. The globe changes it into ______ and ______.*

Q5. (a) State the voltage and frequency of the Australian mains supply. (b) Give the reason house lights are wired in parallel. (c) Name one protection device found in a switchboard, and what makes it act.

Q6. (a) Name the sensor a street light uses. (b) State the change it notices at dusk. (c) Name the output, and the two steps in between, in the order they happen.

Unscaffolded

Q7. *(2 marks)* A circuit diagram shows a cell, a globe and a switch drawn with its arm lifted off the contact, joined in one loop. Will the globe light? Explain your answer using the words *loop* and *current*.

Q8. *(3 marks)* A model house has two rooms. The job: each room's light must work while the other is off, and a failed globe must not put out the other light. State the arrangement you would build and where any switches go, and give one observation from a bench circuit that supports your choice.

Q9. *(3 marks)* A fuse protects a circuit by breaking the loop when the current is too big. Explain why the fuse must sit on the main path rather than on one branch of a parallel circuit, and describe what happens inside the fuse when it acts.

Q10. *(3 marks)* Old strings of decorative lights were wired in series. Explain why one failed globe put the whole string out, and state which arrangement a house uses instead and the everyday observation that tells you so.

Q11. *(3 marks)* A greenhouse needs a fan (a motor) that runs only when the day gets hot. Name the sensor, the control and the output for this job, and describe the sequence of events as a cold morning turns into a hot afternoon.

Q12. *(2 marks)* A student builds a loop with a cell, a resistor and an LED. Every part works, the loop is complete, yet the LED stays dark while a globe in the same loop lights. Suggest the cause and the fix.

Q13. *(3 marks)* Trace the energy transfers in a working parallel circuit with two lit globes, from the cell to the globes. State clearly where energy is transferred and where it is changed in form.

Q14. *(3 marks)* A caravan owner wants one light that is on whenever the master switch is on, and a second light that can be switched on and off without ever affecting the first. Choose the arrangement and the switch positions for this job, and explain why your design meets both halves of the job statement.

Answers

Q1. (a) globe/lamp. (b) cell. (c) fuse. (d) LED.

Q2. (a) one path. (b) both go dark. (c) globe 1 goes dark too.

Q3. (a) each branch is its own complete loop with the cell. (b) globe 2 stays lit. (c) both go dark.

Q4. chemical; current; light; heat.

Q5. (a) 230 V AC at 50 Hz. (b) so each light and appliance works independently — one failing or switching off does not stop the others. (c) a fuse (or circuit breaker); a current that is too big melts the fuse wire (or trips the breaker), breaking the loop.

Q6. (a) a light sensor. (b) it notices the daylight fading (it getting dark). (c) output: the lamp; order — sensor notices, control circuit decides, output acts.

Q7. No — the open switch is a gap, the loop is broken, and current flows only in a complete loop, so no energy reaches the globe.

Q8. Parallel, one globe per branch, with a switch on each branch (a master switch, if wanted, on the main path). Support: unscrewing a globe in a parallel bench circuit left the other globe lit, while in series both went dark.

Q9. On the main path, all of the circuit's current passes through the fuse, so one fuse guards everything; on a branch it would guard only that branch. Inside the fuse, the too-big current heats the thin wire until it melts, leaving a gap that breaks the loop.

Q10. In series the string is one path, so one failed globe broke the loop and stopped the current through all the globes. A house is wired in parallel; the observation: switching off or failing one light or appliance at home does not stop the others.

Q11. Sensor: temperature sensor. Control: the control circuit (thermostat). Output: the motor/fan. Sequence: on a cold morning the sensor keeps the loop to the motor open and the fan is off; as the greenhouse heats past the set temperature the sensor's change has the control circuit close the loop, current flows, and the fan runs.

Q12. The LED is in the wrong way around — it lights only when current passes one way. Fix: turn the LED around (long lead to the positive side).

Q13. Chemical energy stored in the cell is handed to the current; the current transfers it around the loop, splitting at the junction so both branches carry energy; at each globe the energy is changed in form into light and heat. Transfer happens around the loop; change of form happens at the globes (and a little at the wires).

Q14. Parallel: light 1 on one branch, light 2 with its own switch on the other branch, and the master switch on the main path. Light 1's branch has no branch switch, so it is on whenever the master switch is closed; light 2's branch switch reaches only light 2, so using it never affects light 1; and each branch keeps its own loop, so a failed globe cannot put out the other light.

Fully-worked solutions

Q7 (2 marks). No *(1)*: the lifted arm is an open switch, a gap in the loop, and a current flows only in a complete loop, so no current flows and no energy is transferred to the globe *(1)*.

Q8 (3 marks). Arrangement: parallel, one globe on each branch *(1)*; a switch on each branch so each room is controlled alone *(1)*; support: on the bench, a globe removed from a parallel circuit left the other globe lit — each branch keeps its own loop with the cell *(1)*.

Q9 (3 marks). Main-path reason: the main path carries the current of every branch, so a fuse there can break the whole circuit when any fault makes the current too big; on one branch it would protect only that branch *(1)*. Inside the fuse: the too-big current heats the thin wire *(1)*; the wire melts, leaving a gap, and the loop is broken before the wiring can overheat *(1)*.

Q10 (3 marks). Series string: one path, so one failed globe broke the loop and the current stopped through every globe on the string *(1)*. House arrangement: parallel *(1)*. Observation: at home, one light or appliance switching off or failing leaves all the others working *(1)*.

Q11 (3 marks). Sensor: temperature sensor; control: control circuit/thermostat; output: motor driving the fan *(1)*. Cold morning: the loop to the motor is open, no current, fan off *(1)*. Hot afternoon: the sensor notices the temperature rise, the control circuit closes the loop, current flows and transfers energy to the motor, and the fan runs *(1)*.

Q12 (2 marks). Cause: an LED lights only when the current passes through it the right way, so it has been placed the wrong way around *(1)*. Fix: turn the LED around, long (positive) lead towards the cell's positive terminal *(1)*.

Q13 (3 marks). Store to loop: chemical energy in the cell is handed to the current when the loop is complete *(1)*. Around the loop: the current transfers the energy, splitting at the junction so both branches are supplied *(1)*. At the globes: each globe changes the energy it receives into light and heat — changed in form at the components, transferred everywhere else *(1)*.

Q14 (3 marks). Arrangement and switches: parallel, master switch on the main path, light 1 on a branch with no switch of its own, light 2 on a branch with its own switch *(1)*. First half of the job: with the master switch closed, light 1's branch is a complete loop, so light 1 is on *(1)*. Second half: the branch-2 switch sits after the junction, so it can break or complete only light 2's loop and never touches light 1's *(1)*.

Sources

Web sources below were retrieved 2026-08-21.

- **[S1]** Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description `VC2S8U17` and its elaborations, 2026. vcaa.vic.edu.au
- **[S2]** Science ASSIST (ASTA), "Risk management", 2026. asta.edu.au
- **[S3]** Science ASSIST (ASTA), "Science safety essentials: risk assessment in science", 2026. asta.edu.au
- **[S4]** Wikipedia, "Mains electricity", 2026. en.wikipedia.org
- **[S5]** Wikipedia, "Mains electricity by country", 2026 — Australia: 230 V, 50 Hz, plug type I. en.wikipedia.org
- **[S6]** Wikipedia, "AA battery", 2026 — nominal voltage 1.5 V. en.wikipedia.org
- **[S7]** Wikipedia, "Photoresistor", 2026 — light-dependent resistor; used in street-light control. en.wikipedia.org
- **[S8]** Wikipedia, "Thermostat", 2026 — senses temperature and switches heating or cooling to hold a set temperature. en.wikipedia.org
- **[S9]** Wikipedia, "Mobile robot", 2026 — robot sensors including light sensors, cameras and distance sensors used to follow a path and avoid obstacles. en.wikipedia.org

All bench scenarios, circuit diagrams and design briefs in this subtopic — including the bike shed, the model house, the caravan and the night light — are **simulated examples for practice**: made-up situations to design and argue about, not records of real installations. The real-world datums (mains 230 V AC 50 Hz, the AA cell's 1.5 V, the street-light, thermostat and robot sensor facts) are sourced to [S4]–[S9] as listed.

Elaboration contexts used: `VC2S8U17.E01` (building and observing series and parallel circuits; the measuring limb shared with 17B), `VC2S8U17.E02` (LED one-way behaviour and light and temperature sensor properties), `VC2S8U17.E03` (the household-wiring comparison, common components, and the safety role of fuses and circuit breakers; the voltage-and-current limb shared with 17B) and `VC2S8U17.E04` (sensors in robotics and control devices — the street light, the thermostat and the line-following robot).

Teacher-facing note — split-CD delivery and the D9 ceiling (not student text). `VC2S8U17` is delivered †-split: 17A owns the energy-transfer, components-and-design clause; 17B owns the explanation of circuit operation with voltage and current, including the measuring in E01 and the "how voltage and current are managed" limb of E03. Accordingly this section names current as the flow that transfers energy (the CD's own words) and names voltage only as a quoted real-world datum (the mains' 230 V, the AA cell's 1.5 V); it never defines voltage or current as explanatory quantities, never places a meter, and never computes — all of that is 17B's. The D9 ceiling is held absolutely: no Ohm's law, no resistance as a concept (the resistor appears only as a component that limits current, as E02/E03 name it), and no power or energy calculations — that material is VCE Physics Unit 1 Area of Study 3. No Aboriginal and Torres Strait Islander content is required here: `VC2S8U17` carries no Indigenous elaboration, and this book's First Nations content follows the TOC's D10/ICIP decision for the CDs that do carry it.

Voltage and current: measuring both, predicting what a circuit will do, and tracing the energy transferred when current flows

What we teach here — `VC2S8U17` † (Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8): *"… electrical circuits transfer energy when current flows and can be designed for diverse purposes using different components; the operation of circuits can be explained using the concepts of voltage and current."* **This subtopic owns the second clause only** — explaining the operation of circuits using the concepts of voltage and current: how voltage and current are measured, how they behave in series and parallel circuits, what they let us predict, and where the energy goes when a current flows. The first clause — circuits transferring energy and being designed for diverse purposes — belongs to the owner subtopic **17A** († split delivery, D6). **In our words:** a circuit is a loop that delivers energy. Voltage tells you how hard the supply pushes the charge and how much energy each bit of charge carries; current tells you how much charge is flowing. Put those two ideas together and you can measure a circuit, predict what it will do, and trace the energy it transfers — before you ever switch it on. **Achievement-standard extract served here (D13):** cited by reference to the header of the owner subtopic 17A, where the extract appears in full. This subtopic leans on the part that reads *"They design and construct series and parallel circuits, and observe and make predictions about voltage and current and about energy transfer in the circuits."* **Elaborations drawn on:** `VC2S8U17.E01` — *"investigating parallel and series circuits and measuring voltage drops across and currents through various components"* — and `VC2S8U17.E03` — *"comparing electrical circuit design to household wiring, for example identifying common components used in both electrical circuit design and household wiring (such as resistors, switches and power sources), considering the arrangement of electrical components within devices, considering how voltage and current are managed in both electrical circuits and household wiring, or analysing the safety features and precautions in circuits and household wiring, recognising the importance of circuit protection devices such as fuses and circuit breakers in preventing electrical hazards."* Both are dual-listed by design with 17A (D6): 17A uses them for designing and building, this subtopic uses them for measuring, explaining and predicting. **ICIP (D10):** no Aboriginal or Torres Strait Islander content is taught here. `VC2S8U17` carries no Indigenous elaborations in the curriculum, and this subtopic is not one of the book's 16 allocated Indigenous-content subtopics; the reserved items stay reserved. **Maths interlocks (D11):** `VC2M7N06` — the four operations with decimals — covers every sum in this subtopic: adding branch currents, adding cell voltages, adding voltage shares, and splitting a supply voltage into equal shares. Nothing beyond that is assumed or taught.

Word watch — *voltage*, *current* and *charge*. These three words get mixed up more than any others in electricity. **Charge** is the stuff that moves around the loop — it is carried by the wires, and it is never used up. **Current** is how much charge is flowing past a point in the circuit — a big current means a lot of charge flowing. **Voltage** is the push a supply gives to the charge — and it tells you how much energy each bit of charge carries as it moves. Current is measured in amperes (A); voltage is measured in volts (V). A circuit can have a big voltage and a small current, or a small voltage and a big current: they are two different questions about the same loop. When you write about circuits here, say *the current through* a component and *the voltage across* it — those little words keep the two ideas straight.

Theory

A loop that delivers energy

Switch on a torch and the lamp glows. Where does the light's energy come from, and how does it get to the lamp? The answer is the big idea of this whole subtopic: a circuit is a **loop that delivers energy**, and the moving charge is the delivery service.

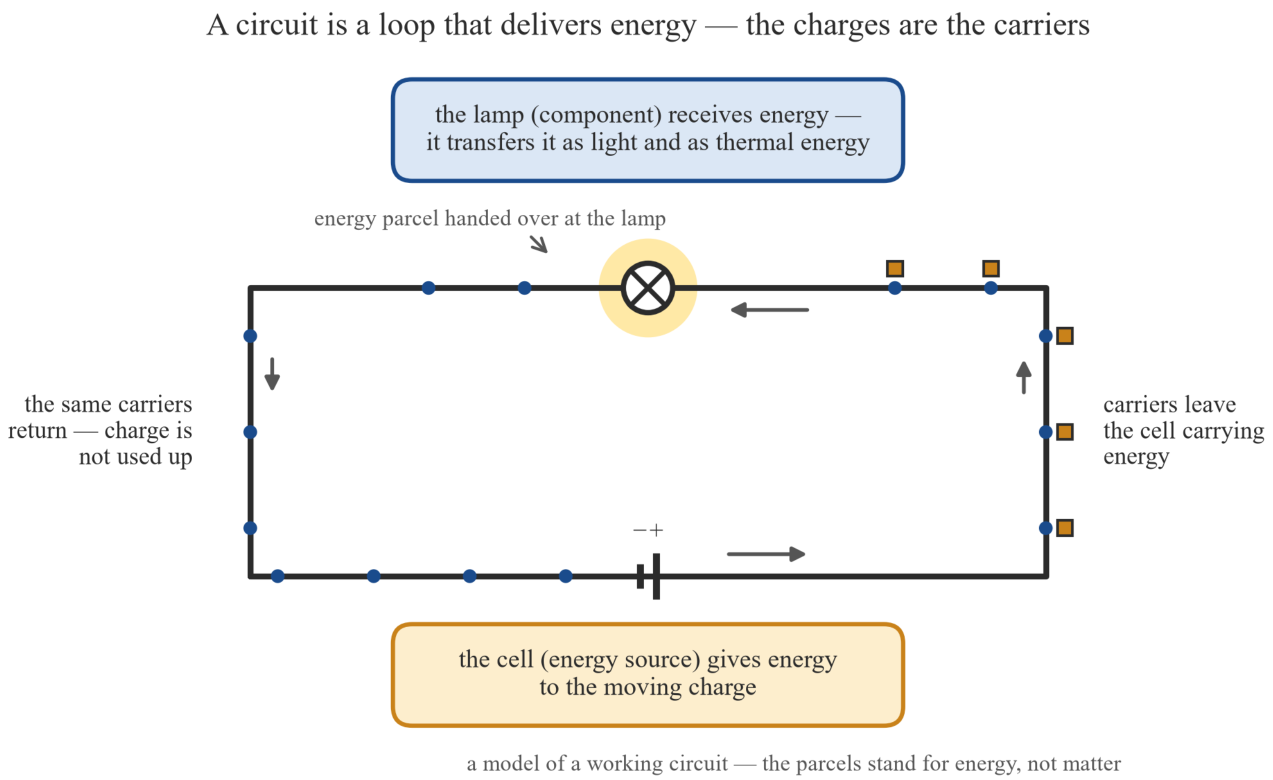


Figure 17B.1 — A circuit is a loop that delivers energy. The charge carries the energy from the cell to the lamp; the charge itself comes back round, ready to be loaded again.

Follow one trip around the loop in Figure 17B.1. The **cell** is the energy source: it hands energy to the charge. The charge carries that energy around the wires to the **lamp**, and the lamp takes the energy in and transfers it out — as light, and as thermal energy warming the surroundings. The charge then returns to the cell *empty*, but still there: **charge is not used up**. Only the energy is handed over. That single sentence explains most of what circuits do.

Two words name the two halves of this story. **Current** says how much charge is moving. **Voltage** says how much energy each bit of charge carries. Measure both, and you can explain — and predict — everything in this subtopic.

Current: how much charge is flowing

The **current** in a wire is the amount of charge flowing past a point each second. Its unit is the **ampere** (A), usually shortened to "amp". A small torch lamp carries a current of about 0.25 A; a household kettle draws about 10 A — a lot more charge flowing.

Current is measured with an **ammeter**, and there is only one way to connect it: **in the loop**, so that all of the charge has to flow through it. A component connected in the loop like this — with the charge flowing through it — is said to be connected **in series**.

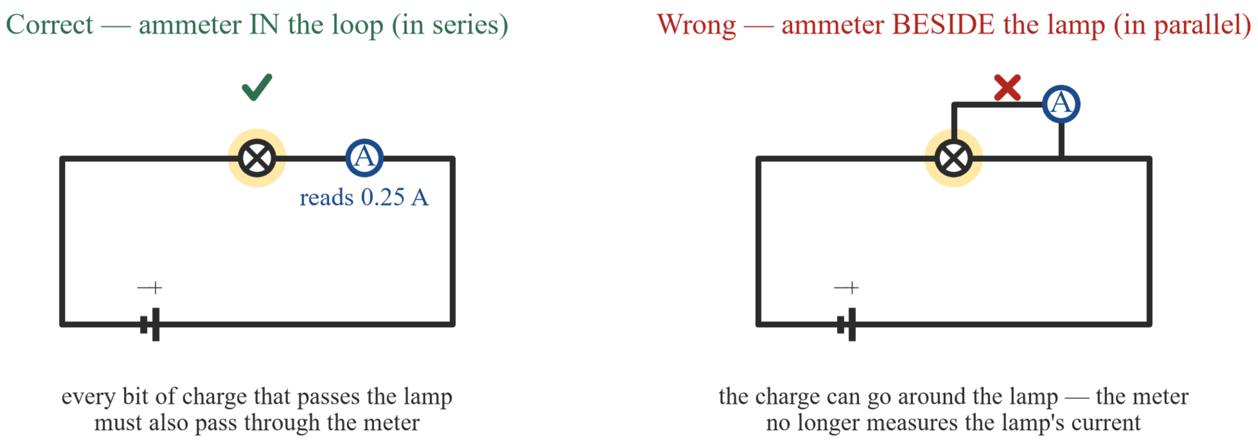


Figure 17B.2 — The ammeter must sit in the loop (in series) so the charge flows through it. Connected beside the lamp (in parallel) it no longer measures the lamp's current.

Digital meters make reading easy — the number is on the display. Analogue meters have a needle and a scale, and you read them to the smallest mark on the scale, exactly the measurement habit built in subtopic 3C.

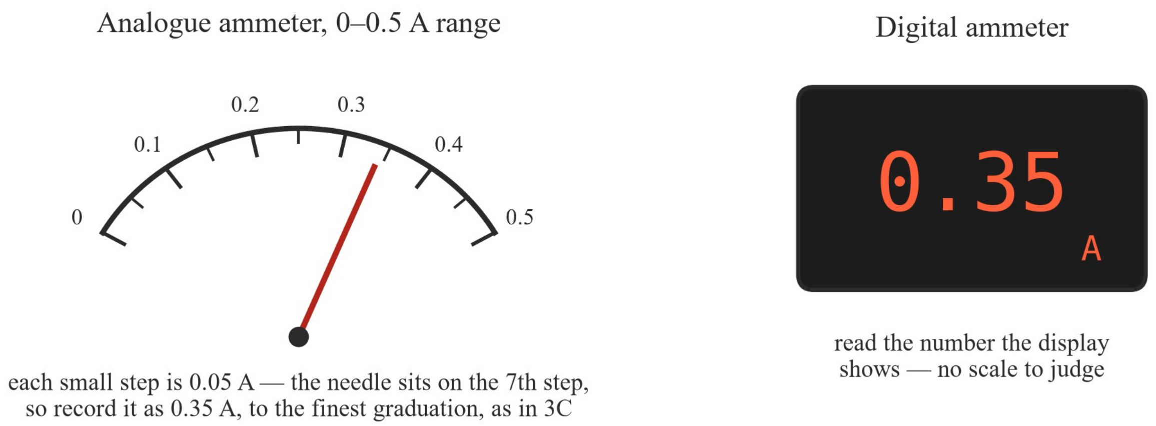


Figure 17B.3 — The same current read two ways. On the analogue scale each small step is 0.05 A and the needle sits on the seventh step, so the reading is recorded as 0.35 A.

Try it 1. A student connects an ammeter beside a lamp, like the right-hand panel of Figure 17B.2. In one sentence, say what is wrong with the connection and how to fix it.

Voltage: the push behind the charge

The **voltage** of a supply tells you how hard it pushes the charge — which means how much energy each bit of charge carries away from it. A bigger voltage means each bit of charge carries more energy to the components. Voltage is measured in **volts** (V), and the meter that measures it is a **voltmeter**.

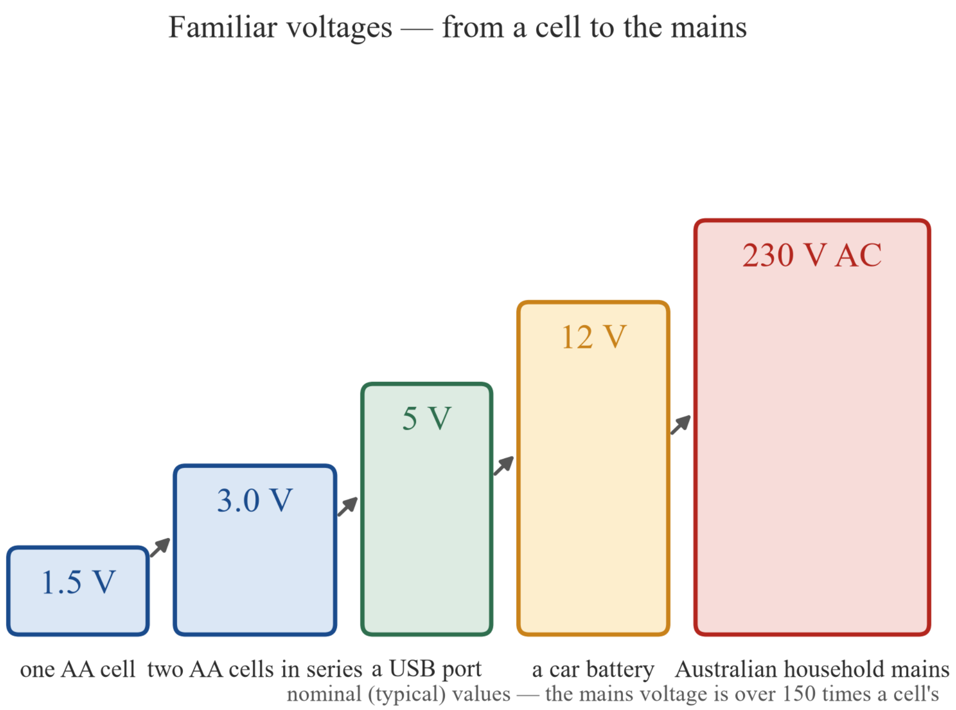


Figure 17B.4 — Familiar voltages. In Australia the mains supply is 230 V AC at a frequency of 50 Hz — over 150 times the voltage of a single cell (Sources).

Cells are the supplies you will use in class, and they are labelled with their voltage: a single AA cell is 1.5 V. Connect cells **in series** — the + end of one to the − end of the next — and their voltages **add**:

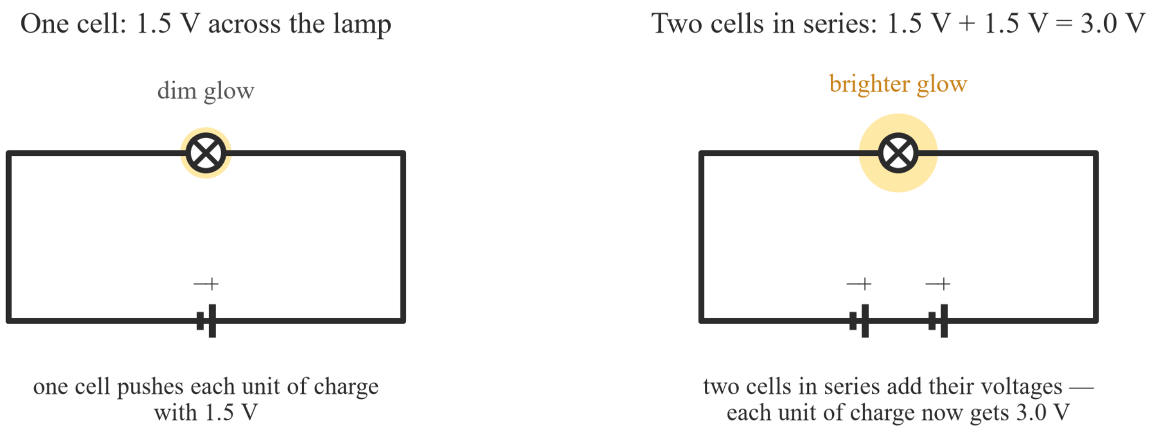


Figure 17B.5 — Cells in series add their voltages, and the lamp glows more brightly because each bit of charge now carries more energy.

That is why a torch that takes two cells is brighter on two fresh cells than on one: each bit of charge arrives at the lamp carrying more energy.

A voltmeter connects the other way from an ammeter: **across** the component you are interested in — one lead each side — so it compares the energy the charge carries *into* the component with the energy it carries *out*. A component connected across another like this is said to be connected **in parallel**.

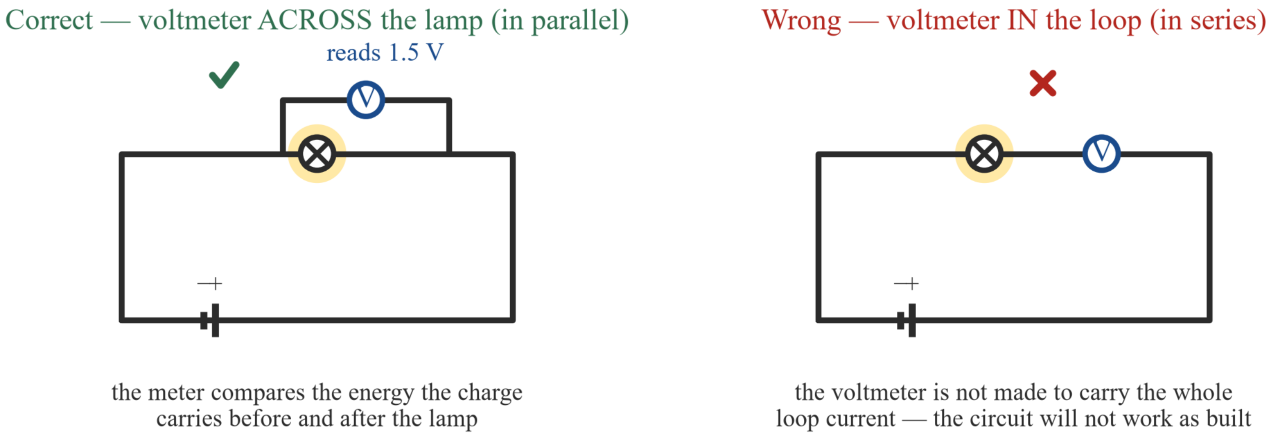


Figure 17B.6 — The voltmeter connects across the component (in parallel). In the loop, where an ammeter belongs, it is connected wrongly.

So: **ammeter in series, voltmeter in parallel** — current *through*, voltage *across*. Two meters, two connections, no exceptions.

Series circuits: one loop, same current, shared voltage

A **series circuit** is a single loop: every bit of charge must travel through every component in turn. That fact alone predicts both meter readings.

Because charge is not used up and there is nowhere else for it to go, **the current is the same at every point of a series circuit**. Two ammeters placed at any two points of the loop read the same.

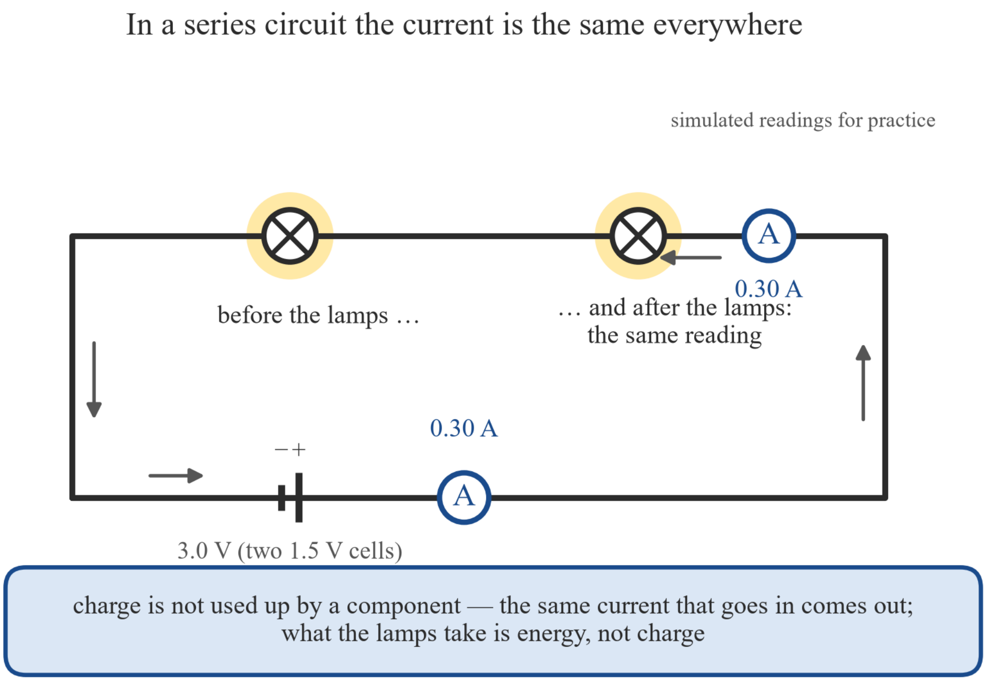


Figure 17B.7 — The same current at every point of a series loop (simulated readings for practice).

Because each bit of charge hands over, by the time it returns to the cells, all of the energy it was given, **the voltages across the components add up to the supply voltage**. The components *share* the supply voltage between them — and if the components are identical, they share it equally.

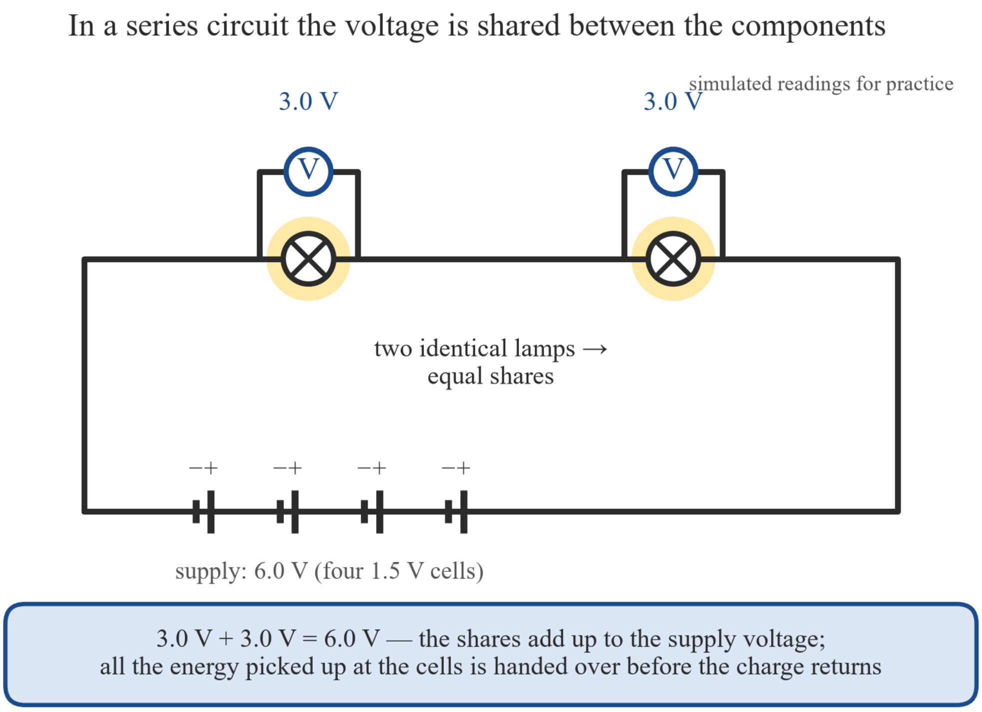


Figure 17B.8 — Two identical lamps share the supply voltage equally (simulated readings for practice).

Read Figures 17B.7 and 17B.8 together and you have the whole series story: **same current everywhere; voltage shared so the shares add up to the supply**. Add a third identical lamp to Figure 17B.8 and the 6.0 V would be shared three ways — 2.0 V each — so each lamp glows dimmer. You have just made a prediction without touching a wire. That is the habit this subtopic builds.

> **Try it 2.** A series circuit holds a 4.5 V supply and three identical lamps. Predict the voltage across each lamp, and say what the lamps would do to the brightness if a fourth identical lamp were added in series.

Parallel circuits: branches share the current, not the voltage

A **parallel circuit** gives the charge more than one path. At a **junction** the current splits between the branches, and the branch currents add back together when the branches rejoin. So the rule is: **the branch currents add up to the current in the main loop**.

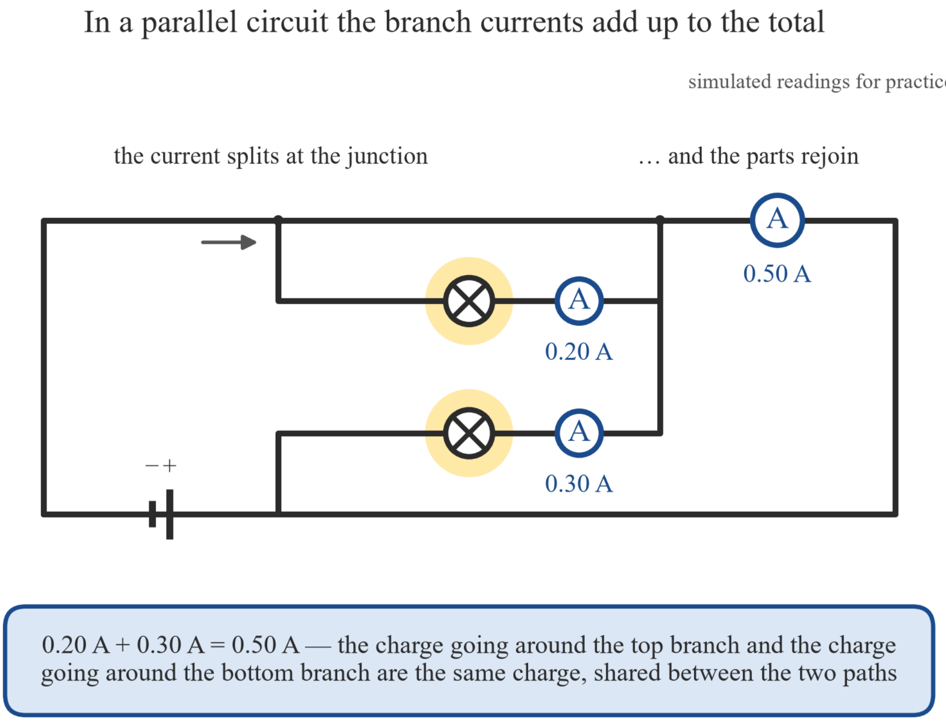


Figure 17B.9 — The branch currents add up to the main-loop current: 0.20 A + 0.30 A = 0.50 A (simulated readings for practice).

Voltage does the opposite of what it did in series. Each branch is connected straight across the supply, so **every branch gets the full supply voltage** — no sharing.

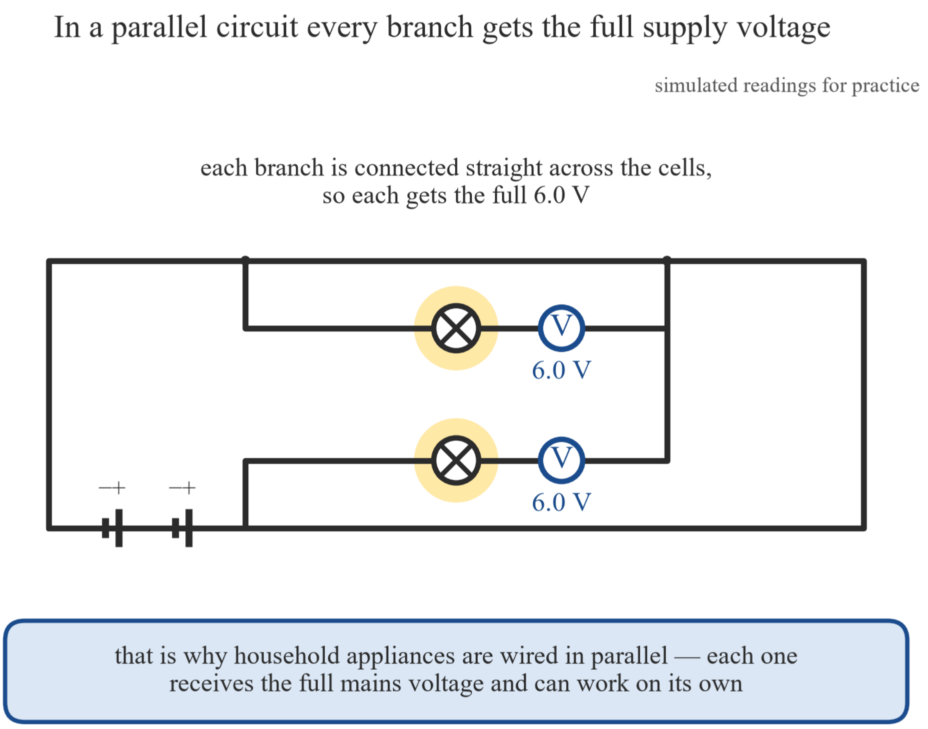


Figure 17B.10 — Every parallel branch gets the full supply voltage (simulated readings for practice).

Those two rules explain the most familiar fact about circuits at home: unscrew one lamp and the rest stay on. In series, a broken or removed lamp breaks the one loop and everything stops; in parallel, the other branches are still complete loops.

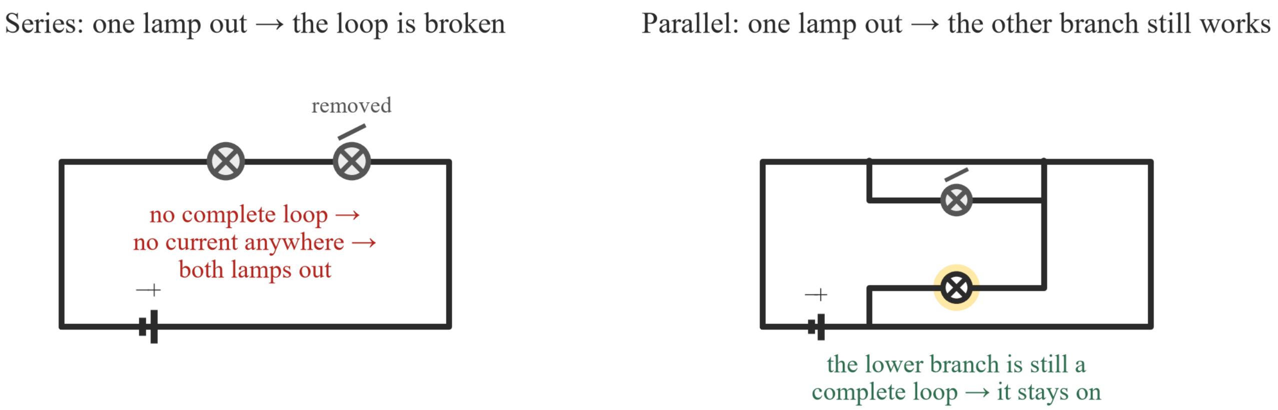


Figure 17B.11 — One lamp out: the series circuit stops completely; the parallel circuit keeps working on its other branches.

Tracing the energy when a current flows

Voltage and current together answer the energy question of this subtopic — *where does the energy go when a current flows?* Start at the store, follow the charge, end at the surroundings.

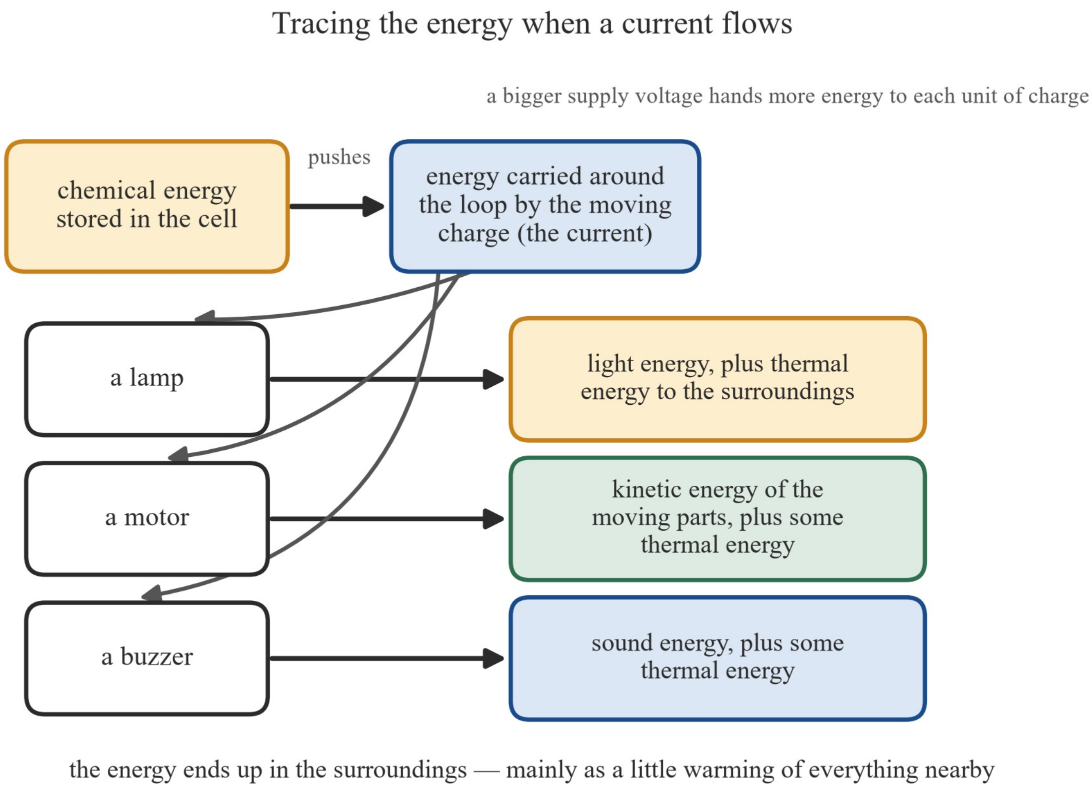


Figure 17B.12 — Tracing the energy: from the chemical store in the cell, by way of the moving charge, to the component, and out to the surroundings. In every case some energy ends up warming the surroundings a little.

Notice the middle box. The charge is *the carrier*, not the source and not the destination — which is exactly why the charge comes back round unchanged while the energy does not. Notice too what a bigger supply voltage means in this picture: each bit of charge is handed more energy to carry, so the component receives more.

From the lab bench to the house

The circuits on your bench and the wiring in your walls are the same idea at different scales. Household wiring is a **parallel** circuit on a 230 V AC supply: every appliance sits on its own branch, so each one gets the full mains voltage and can be switched on or off without affecting the others. The switch for an appliance is in **series** with it — a switch has to be in the path to stop the current. And between the supply and the branches sit the protection devices: a **fuse** or **circuit breaker** in series with the whole supply, which cuts the current off if it ever grows too large, before wires overheat. Your bench circuits have the same parts in miniature — a source, switches in series, components on branches — just at 1.5–6 V instead of 230 V.

A house circuit — parallel branches from the 230 V AC mains

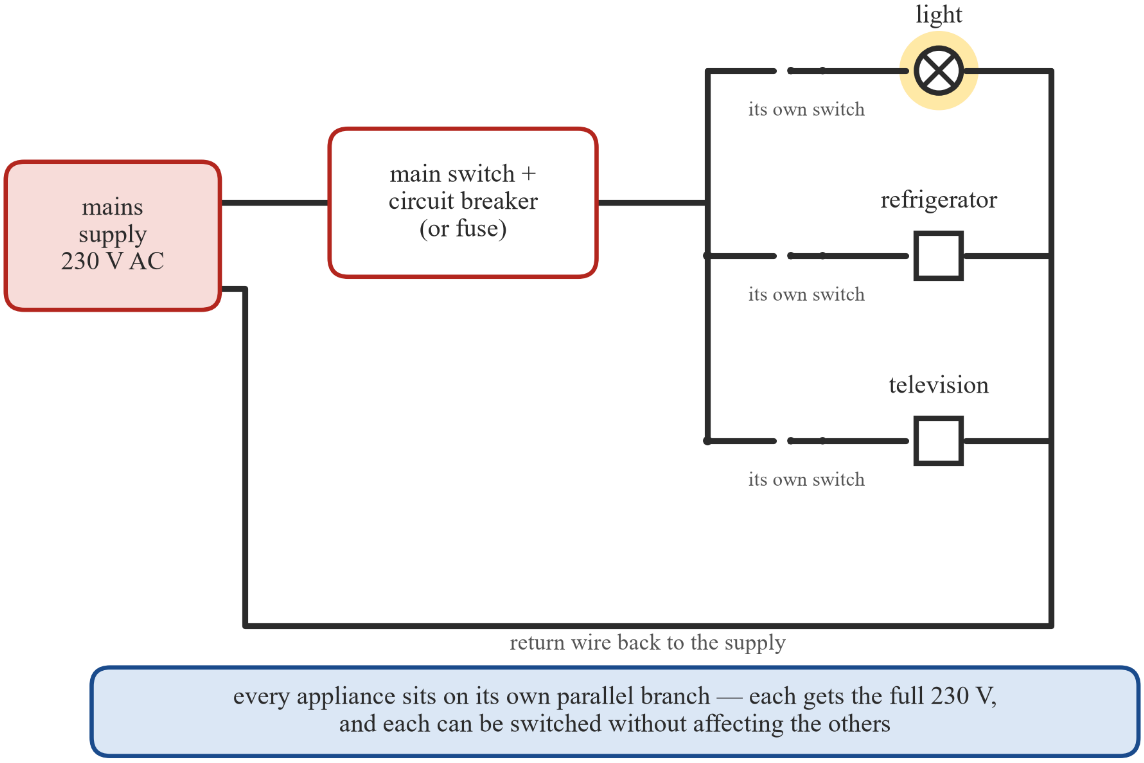


Figure 17B.13 — Household wiring: parallel branches from the 230 V AC mains, each appliance with its own series switch, and a circuit breaker guarding the whole supply.

One difference matters above all others: the mains is **230 V AC at 50 Hz** — alternating current, reversing direction 100 times a second — while your bench supplies and cells are **low-voltage DC**, direct current flowing one way. At 230 V, each bit of charge carries over 150 times the energy it carries from a single cell, and the currents available are large enough to stop a heart. **The mains is never a classroom experimental supply.** Everything you measure and predict in this subtopic happens on cells and low-voltage packs; the house circuit is there to compare, not to touch.

Predict before you build

Every rule in this subtopic is a predicting tool. Before you connect anything, ask: is this one loop, or branches? Then apply the matching rules.

Predict before you build — the series and parallel rules

SERIES — one loop	
current	the same at every point
voltage	shared between the components; the shares add up to the supply
adding lamps	each gets a smaller share of the voltage → dimmer
lamp removed	the loop breaks → no current anywhere

PARALLEL — branches	
current	splits at each junction; the parts add up to the total current
voltage	every branch gets the full supply voltage
adding lamps	each still gets the full voltage, but the supply current grows
lamp removed	the other branches stay complete loops → they stay on

Figure 17B.14 — The predicting rules for series and parallel circuits, side by side.

> **Try it 3.** Without building anything, predict: two identical lamps on a 3.0 V supply, connected in parallel. State the voltage across each lamp, and say which arrangement — this one, or the same lamps in series on the same supply — draws the bigger current from the supply, and why.

Investigation 17B.1 — Build, measure, predict

Equipment: a low-voltage DC supply or up to four 1.5 V cells in holders; two identical lamps in holders; one ammeter; one voltmeter; a switch; connecting leads.

Method: 1. Before building, write down your predictions for each of the four readings below (this is the point of the investigation — the predictions come first). 2. Build the two lamps in **series** with the supply and the switch. With the switch closed, read the current at two different points of the loop, and the voltage across each lamp. 3. Rebuild the lamps in **parallel**. Read the current in the main loop and in each branch, and the voltage across each branch. 4. Compare every reading with your prediction, and account for any difference.

Risk assessment: this investigation uses cells and low-voltage DC packs only — **never** a wall socket or any mains appliance. Check leads and holders for damage before use, keep the bench dry, and have the teacher check the circuit before the switch is closed. Lamps in holders can crack if dropped, so handle globes by the holder and wear **safety glasses** while globes are being fitted or removed. A completed **Science ASSIST (ASTA) risk assessment** must be in place before the practical is scheduled (see Sources).

Worked examples

Example 1 (scaffolded) — predicting a series circuit

A series circuit is built from a 4.5 V supply (three 1.5 V cells in series) and two identical lamps. An ammeter in the loop reads 0.30 A. Predict (a) the reading of a second ammeter placed after the lamps, and (b) the voltmeter reading across each lamp.

Working	Comment
(a) second ammeter reads 0.30 A	A series circuit is one loop; the current is the same at

Working	Comment
	every point. Charge is not used up by the lamps.
(b) 4.5 V ÷ 2 = 2.25 V	Identical lamps share the supply voltage equally.
Check: 2.25 V + 2.25 V = 4.5 V	The shares must add back up to the supply voltage — they do.

Example 2 (scaffolded) — predicting a parallel circuit

A 3.0 V supply drives two lamps in parallel. The main-loop ammeter reads 0.50 A and one branch ammeter reads 0.20 A. Predict (a) the current in the other branch, and (b) the voltmeter reading across each branch.

Working	Comment
(a) 0.50 A − 0.20 A = 0.30 A	At the junction the current splits; the branch currents must add back to the main-loop current.
(b) 3.0 V across each branch	Every parallel branch is connected straight across the supply, so each gets the full supply voltage.

Example 3 (unscaffolded) — cells in series and brightness

A lamp on one 1.5 V cell glows dimly. A second 1.5 V cell is added in series. Predict what happens to the lamp's brightness and explain it in terms of energy.

Adding the cell in series makes the supply voltage 1.5 V + 1.5 V = 3.0 V. A bigger voltage means each bit of charge is handed more energy at the cells, so the lamp receives more energy and the glow gets brighter. The prediction — brighter — follows from the voltage, and the explanation is the energy story of Figure 17B.1: same carriers, bigger parcels.

Example 4 (unscaffolded) — the bench and the house

Compare your bench circuit with the wiring of a room at home: name the components the two have in common, say how the appliances are connected and why, and state what the circuit breaker does.

Both circuits have a source, wires, switches and components that transfer the energy — the house versions are simply bigger and safer-looking. The appliances are connected in parallel, so each one gets the full 230 V and works independently: switching off the television does not darken the light. The circuit breaker (or fuse) sits in series with the whole supply and cuts the current off if it grows too large, protecting the wiring from overheating. The one thing that never carries across from bench to house is the experimenting: at 230 V AC the mains is dangerous, and it is compared in class, never touched.

Practice questions

Q1. Name the meter that measures current, and state how it must be connected in a circuit. *(2 marks)*

Q2. In a series circuit with two lamps, an ammeter next to the cells reads 0.25 A. Predict the reading of a second ammeter placed after the second lamp, and give the reason for your prediction. *(2 marks)*

Q3. The circuit of Q2 uses a 3.0 V supply and two identical lamps. Predict the voltmeter reading across each lamp. *(2 marks)*

Q4. Three 1.5 V cells are connected in series. Predict the voltage of the supply they make. *(1 mark)*

Q5. In a parallel circuit the two branch currents are 0.20 A and 0.30 A. Predict the current in the main loop. *(2 marks)*

Q6. A cell drives a buzzer. Trace the energy transfers, from the store in the cell to the surroundings. *(2 marks)*

Q7. Explain why an ammeter is connected in series while a voltmeter is connected in parallel. *(3 marks)*

Q8. Two lamps in series are glowing normally. One lamp is now removed from its holder. Predict what happens to the other lamp and explain your prediction. *(3 marks)*

Q9. The same two lamps are connected in parallel across the same supply, both glowing. One lamp is removed. Predict what happens to the other lamp and explain your prediction. *(3 marks)*

Q10. A 6.0 V supply drives two identical lamps in series. (a) Predict the voltage across each lamp. (b) A third identical lamp is added in series. Predict the new voltage across each lamp. *(3 marks)*

Q11. The analogue ammeter of Figure 17B.3 is on its 0–0.5 A range, with smallest marks of 0.05 A, and the needle sits on the seventh mark from zero. State the reading the student should record. *(2 marks)*

Q12. A toy car runs on a cell that drives a small motor. Trace the energy transfers when the car moves, ending with what happens to the energy in the surroundings. *(3 marks)*

Q13. Explain why the appliances in a house are connected in parallel rather than in series, and state the job of the circuit breaker in the same circuit. *(3 marks)*

Q14. State two ways in which the Australian mains supply differs from a single AA cell. *(2 marks)*

Answers

Q1. An ammeter; connected in series — in the loop, so all of the charge flows through it.

Q2. 0.25 A — the current is the same at every point of a series loop.

Q3. 1.5 V each (3.0 V shared equally between two identical lamps).

Q4. 4.5 V.

Q5. 0.50 A.

Q6. Chemical energy (cell) → energy carried by the moving charge → sound energy from the buzzer, plus some thermal energy to the surroundings.

Q7. The ammeter measures the charge flowing, so it sits in the loop and all the charge passes through it (in series). The voltmeter compares the energy the charge carries into and out of a component, so it connects across the component (in parallel).

Q8. It goes out: removing one lamp breaks the single loop, so no current flows at all.

Q9. It stays on, just as bright: its branch is still a complete loop across the full supply voltage.

Q10. (a) 3.0 V each. (b) 2.0 V each.

Q11. 0.35 A.

Q12. Chemical energy in the cell → energy carried by the current → kinetic energy of the moving car, plus some thermal energy; the energy ends up warming the surroundings a little.

Q13. In parallel each appliance gets the full 230 V and can be switched independently; in series, switching one off would break the loop for all. The circuit breaker sits in series with the supply and cuts the current off if it grows too large, stopping wires overheating.

Q14. Any two of: the mains is 230 V while a cell is 1.5 V; the mains is AC (alternating current, 50 Hz) while a cell is DC; the mains is dangerous to touch while a cell is safe to handle.

Fully-worked solutions

Q1. Current is the flow of charge, so to measure it the meter must have all of the charge flowing through it. That meter is the **ammeter**, and it is connected **in series** — in the loop itself — so the charge that passes the component also passes the meter. *(2 marks: name 1, connection 1.)*

Q2. A series circuit is one loop, and charge is not used up by components, so the current is the same at every point. The second ammeter therefore reads **0.25 A**, the same as the first. *(2 marks: prediction 1, reason 1.)*

Q3. Identical lamps in series share the supply voltage equally. 3.0 V ÷ 2 = **1.5 V** across each lamp; check 1.5 V + 1.5 V = 3.0 V. *(2 marks: value 1, equal-share reason or check 1.)*

Q4. Cells in series add their voltages: 1.5 V + 1.5 V + 1.5 V = **4.5 V**. *(1 mark.)*

Q5. At the junction the current splits, and the parts rejoin, so the branch currents add to the main-loop current: 0.20 A + 0.30 A = **0.50 A**. *(2 marks: value 1, add-at-junction reason 1.)*

Q6. The chain starts at the store and ends at the surroundings: **chemical energy** stored in the cell is handed to the charge; the **moving charge carries it** around the loop; the buzzer transfers it to **sound energy**, plus some **thermal energy** warming the surroundings. *(2 marks: store and carrier 1, outputs 1.)*

Q7. The ammeter counts charge flowing past a point, so it must sit **in the loop (series)**: then every bit of charge passes through it and the reading is the component's current. The voltmeter measures the energy handed over **across** a component — energy in per bit of charge minus energy out — so it connects **in parallel**, one lead each side of the component, without carrying the loop's current. *(3 marks: ammeter reason 1, voltmeter reason 1, series/parallel naming 1.)*

Q8. Prediction: the other lamp **goes out**. Reason: a series circuit is a single loop; removing one lamp leaves a gap, the loop is no longer complete, and **no current flows at all** — so the remaining lamp cannot glow. *(3 marks: prediction 1, loop broken 1, no current 1.)*

Q9. Prediction: the other lamp **stays on, just as bright**. Reason: in parallel each branch is its own complete loop across the supply; removing one lamp leaves the other branch **still a complete loop with the full supply voltage across it**, so its current and brightness are unchanged. *(3 marks: prediction 1, branch still complete 1, full voltage unchanged 1.)*

Q10. (a) Two identical lamps share 6.0 V equally: 6.0 V ÷ 2 = **3.0 V** each. (b) Three identical lamps share 6.0 V equally: 6.0 V ÷ 3 = **2.0 V** each. Check: 2.0 V + 2.0 V + 2.0 V = 6.0 V. Each lamp now gets a smaller share, so the lamps glow dimmer — a prediction you could test. *(3 marks: (a) 1, (b) 1, equal-share reason or check 1.)*

Q11. Each small mark is 0.05 A, so the seventh mark is 7 × 0.05 A = **0.35 A**. Recording to the smallest mark is the reading habit of subtopic 3C; a digital meter beside it would show the same number. *(2 marks: value 1, method 1.)*

Q12. Start at the store: **chemical energy** in the cell is handed to the charge; the **current carries it** to the motor; the motor transfers it to **kinetic energy** of the moving car, plus some **thermal energy**. In the surroundings, all of it ends up as a little warming of everything nearby. *(3 marks: store 1, carrier and kinetic 1, thermal/surroundings 1.)*

Q13. Parallel connection gives every appliance the **full mains voltage** and lets each be switched **independently** — in series, one switch (or one failed appliance) would break the loop and stop everything, and the voltage would be shared instead. The **circuit breaker** is in series with the supply and **cuts the current off if it grows too large**, protecting the wiring from overheating and preventing electrical hazards. *(3 marks: full voltage 1, independence 1, breaker's job 1.)*

Q14. Two differences: the mains is **230 V** while a single AA cell is **1.5 V**; and the mains is **AC at 50 Hz** (the current alternates) while a cell supplies **DC** (one direction). Equally acceptable: the mains is dangerous to touch while a cell is safe to handle. *(2 marks: one per valid difference.)*

Sources

- Victorian Curriculum and Assessment Authority, *Victorian Curriculum F–10 Version 2.0, Science, Levels 7 and 8*, content description `VC2S8U17` and elaborations `E01` and `E03`, 2026. vcaa.vic.edu.au — retrieved 2026-08-21.
- Standards Australia, *AS/NZS 60038 — Standard voltages* (the Australian standard voltage of 230 V at 50 Hz), catalogue search page. standards.org.au — retrieved 2026-08-21.
- Science ASSIST (ASTA), *Science safety essentials — risk management in science* (published 2022-10-26, modified 2025-12-15). asta.edu.au — retrieved 2026-08-21; and *Science safety essentials — risk assessment in science* (published 2022-10-25, modified 2025-12-15). asta.edu.au — retrieved 2026-08-21.

All meter readings drawn in the circuit figures are **simulated readings for practice**, labelled as such in each figure: they are teaching values chosen to make the series and parallel rules visible, not measurements. The voltages in Figure 17B.4 are the standard nominal values — 1.5 V for a AA cell, 5 V for a USB port, 12 V for a car battery, and 230 V AC at 50 Hz for the Australian mains (AS/NZS 60038, above).

Elaboration contexts used: `VC2S8U17.E01` (measuring voltages across and currents through components in series and parallel circuits, Figures 17B.2–17B.11 and Investigation 17B.1) and `VC2S8U17.E03` (the bench-to-household comparison, Figure 17B.13, Example 4 and Q13–Q14).

Teacher-facing note (not student text). 17B owns the partner clause of `VC2S8U17` — the explanation of circuit operation using voltage and current — under the † split (D6); 17A owns the design clause and serves the achievement-standard extract (D13). Ceilings held per D9: no resistance and no rule-of-three reasoning over voltage, current and resistance — the student text never uses the concept (the single token *resistors* occurs only inside the verbatim E03 quotation in the header); no power or energy calculations (energy transfer is traced qualitatively); and no story about what carries the charge inside the wire — current is taught as a flow of charge, with the model of the charge carriers themselves held back for `VC2S10U06`. D10: no Indigenous content is taught here and the reserved items remain reserved. D11: all arithmetic is `VC2M7N06` (four operations with decimals) — adding and subtracting currents and voltages and splitting equal shares; every sum in the examples, questions and solutions is machine-checked. Mains facts (230 V AC, 50 Hz) are cited to AS/NZS 60038 in Sources and appear as comparison only; all student practicals are low-voltage DC under a Science ASSIST (ASTA) risk assessment. **Where this leads:** the quantitative circuit model — resistance and the rule linking voltage, current and resistance, plus power and energy calculations — is VCE Physics Units 1–2 territory and is not pre-taught here.

Test A

Topic 7 test — Physical sciences · Chapter 17 · Covers Chapter 15, Chapter 16 and Chapter 17 (subtopics 15A, 15B, 15C, 16A, 16B, 16C, 17A and 17B)

> This is a school-designed paper. It is not a VCAA instrument. Levels 7 and 8 carry no VCAA examination and no external assessment (D14); this paper is a school-based assessment instrument of this book's own design, graded against the achievement-standard extracts of `VC2S8U13`, `VC2S8U14`, `VC2S8U15`, `VC2S8U16` and `VC2S8U17`, with the inquiry-strand marks attached to the chapters' own practical work (`VC2S8I02`, `VC2S8I04` and `VC2S8I06`) per D7. Achievement at Levels 7 and 8 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 15 — Physical sciences A: forces and simple machines, Chapter 16 — Physical sciences B: energy, transfer and efficiency, and Chapter 17 — Physical sciences C: electric circuits; subtopics 15A, 15B, 15C, 16A, 16B, 16C, 17A and 17B
Content descriptions	`VC2S8U13` (15C) · `VC2S8U14` (15A and 15B) · `VC2S8U15` (16A and 16B) · `VC2S8U16` (16C) · `VC2S8U17` (17A and 17B)
Total marks	**40** — Test A 10 marks, Test B 30 marks
Inquiry marks	**6 of 40** — Q16(a)–(c) (paper minimum: 5)
Suggested time	45 minutes

How to run this test

- A scientific calculator is permitted for this paper. 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. Show your working wherever you calculate.

Choose the best answer for each of the 10 questions. Each question is worth 1 mark.

Q1. The mechanical advantage of a simple machine is defined as: *(1 mark)*

A. Effort force ÷ load force

B. Distance ÷ time

C. Load force ÷ effort force

D. Effort force × load force

Q2. Which simple machine helps lift a heavy load by trading distance for a reduced force? *(1 mark)*

A. An inclined plane

B. A wheel and axle with the wheel the same size as the axle

C. A wedge used to split wood

D. A hammer used to drive a nail

Q3. Balanced forces on a stationary object cause the object to: *(1 mark)*

A. Speed up

B. Slow down

C. Reverse direction

D. Remain stationary

Q4. The same force is applied to a heavier object and to a lighter object. Compared with the lighter object, the heavier object: *(1 mark)*

A. Changes its motion more

B. Changes its motion less

C. Changes its motion by the same amount

D. Does not change its motion at all

Q5. At the top of a roller coaster, energy is mostly: *(1 mark)*

A. Gravitational potential

B. Kinetic

C. Chemical

D. Sound

Q6. Why does a Newton's cradle eventually stop swinging? *(1 mark)*

A. Energy is created inside the balls and then used up

B. Pendulums do not lose energy, so the cradle must stop suddenly

C. The balls gain mass each time they collide

D. Its energy is gradually transferred to the surroundings as thermal energy and sound because of friction and air resistance

Q7. Two fridges of the same size: one rated 2 stars and one rated 5 stars. Over a year, the 5-star fridge will likely: *(1 mark)*

A. Use more energy, because more stars need more power

B. Use less energy and cost less to run

C. Use the same energy but cost more to buy

D. Cool food faster while using the same energy as the 2-star fridge

Q8. Star ratings allow for an appliance's size or capacity, not just its total energy use. Why is this done? *(1 mark)*

A. Larger appliances should automatically receive more stars

B. Total energy use cannot be measured accurately

C. It allows a fair comparison between appliances of different capacities

D. Capacity does not affect how much energy an appliance uses

Q9. If one globe in a SERIES circuit burns out: *(1 mark)*

A. All the globes go out

B. The other globes stay lit

C. The voltage doubles

D. The current doubles

Q10. Why does adding more globes in PARALLEL not reduce the brightness of each globe (assuming the supply stays the same)? *(1 mark)*

A. The voltage is shared equally between the branches, as in a series circuit

B. Each branch is connected directly across the full voltage of the supply

C. Adding globes makes the total current smaller

D. The current is the same in every branch, no matter how many globes are added

Test B

Answer every question in the spaces provided. Show your working wherever you calculate. Questions 11–16 are worth 30 marks.

The questions are worth 30 marks in total:

Question	Assesses	Marks
11	Force diagrams, net force and change of motion (`VC2S8U14`)	5
12	Levers, mechanical advantage and the distance rule (`VC2S8U13`)	4
13	Sankey diagrams, efficiency and waste energy (`VC2S8U15`)	6
14	Series and parallel circuits, and household wiring (`VC2S8U17`)	6
15	Energy audits and passive solar design (`VC2S8U16`)	3
16	Inquiry: variables, sources of error, and strengths and limits of a model, from the chapters' practical work (`VC2S8I02`, `VC2S8I06`, `VC2S8I04`)	6
	Total	**30**

Q11. A student pushes a box across the floor with a force of 8 N to the right, while friction pushes back with 3 N to the left. *(5 marks)*

(a) Draw a force diagram of the two horizontal forces acting on the box: one arrow per force, each arrow starting on the box and pointing the way the force acts, the lengths drawn to match the sizes of the forces, and each arrow labelled with the name of the force and its size in newtons. *(2 marks)*

(b) Calculate the net force on the box. Show your working. *(1 mark)*

(c) Are the forces on the box balanced or unbalanced? *(1 mark)*

(d) State what happens to the box's motion. *(1 mark)*

Q12. A gardener uses a wheelbarrow to lift a load of soil. A wheelbarrow is a class 2 lever: the wheel is the fulcrum, the load sits in the middle, and the hands supply the effort at the handles. The load arm is 0.4 m, the effort arm is 1.6 m, and the load force is 200 N. *(4 marks)*

(a) Calculate the mechanical advantage of the wheelbarrow. Show your working. *(1 mark)*

(b) Calculate the effort needed to lift the 200 N load. Show your working. *(1 mark)*

(c) The handles move four times as far as the load rises. Explain why a machine that multiplies force always makes the effort move further. *(1 mark)*

(d) Name one other simple machine, and state the change it makes to a force. *(1 mark)*

Q13. The Sankey diagram of an LED globe shows 100 J of electrical energy going in, 35 J of light energy coming out as the useful output, and the rest wasted as thermal energy. *(6 marks)*

(a) On a Sankey diagram, what does the width of each arrow represent? *(1 mark)*

(b) Calculate the energy wasted by the LED globe. Show your working. *(1 mark)*

(c) Calculate the efficiency of the LED globe. Show your working. *(2 marks)*

(d) A filament globe has an efficiency of about 5%. Which globe — the LED or the filament — transfers the greater share of its input energy into light? *(1 mark)*

(e) Name one pathway by which the wasted thermal energy moves from the globe to the surrounding air. *(1 mark)*

Q14. A student has one cell in a holder, one switch, two identical globes in holders, and connecting leads. *(6 marks)*

(a) In the space below, draw a circuit diagram, using the correct symbols, that shows the two globes connected in series with the cell and with the switch closed. *(2 marks)*

(b) In the series circuit, globe 2 is removed from its holder. State what happens to globe 1, and give the reason. *(1 mark)*

(c) The student rebuilds the circuit with the two globes in parallel, then removes globe 1 again. State what globe 2 does this time. *(1 mark)*

(d) The lights in a house are wired in parallel. Use your answer to (c) to state one reason why. *(1 mark)*

(e) Student circuits always use cells or a low-voltage power pack, and never a wall socket. State one reason why. *(1 mark)*

Q15. A household in Melbourne wants to decrease the energy it uses. *(3 marks)*

(a) State what a household energy audit lists. *(1 mark)*

(b) Suggest one change the household could make to decrease its energy consumption. *(1 mark)*

(c) The house is being renovated to use passive solar design. In Victoria, on which side of the house should the main windows face to catch the winter Sun? *(1 mark)*

Q16. The chapters' practical work. *(6 marks)*

In 15B's trolley investigation, a student pulls a dynamics trolley along a bench with a force meter held at a steady reading, and measures how far the trolley travels in the first 2 s. To test the effect of the trolley's mass on its change of motion, the student runs trials with the light trolley and with the trolley loaded with slotted masses, keeping the pull the same.

(a) State (i) the independent variable and (ii) the dependent variable in these trials. *(2 marks)*

In 16B's spoon race, one bead is stuck with a dot of butter on each of a metal, a wooden and a plastic spoon of similar size, the beads are placed at the same height, and the spoons stand in a beaker of hot water while the class records the order the beads drop.

(b) State one source of error in the spoon race, and one change to the method that would fix that error. *(2 marks)*

In 16C's model, two identical shoeboxes stand in for two houses: each box has a "north" window and a small black-painted jar of water inside, and one box carries a cardboard eave above its window. A lamp stands in for the Sun and is shone low (the winter angle) and then high (the summer angle), and the temperatures are recorded.

(c) State one thing this model shows well about a real house, and one limit of the model. *(2 marks)*

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. Test A (the multiple-choice paper) is marked in "Section A — answers" below; Test B (the short and structured response paper) is marked in "Section B — answers and marking". Every item traces to the achievement-standard extracts of the five CDs in §4's rows for `VC2S8U13`, `VC2S8U14`, `VC2S8U15`, `VC2S8U16` and `VC2S8U17`; the inquiry-strand marks attach to the chapters' own practical work per D7.

Inquiry-strand marks on this paper: 6 of 40 — Q16(a) (`VC2S8I02`), Q16(b) (`VC2S8I06`) and Q16(c) (`VC2S8I04`). The paper minimum is 5.

Section A — answers

Every multiple-choice item is drawn from the MCQ bank keyed to this paper's content descriptions (`mcq-system/data/output/questions/L7-8_Science.csv`); the bank item ids keep the §4 join. The bank holds six items at each of the paper's codes (two at each difficulty); this paper draws ten — two per code — at a difficulty mix of three easy (D1), four medium (D2) and three hard (D3). One presentational normalisation applies to all ten items: the bank stores every item with its correct option in position A, so the options are redistributed across the letters and the key is not uniform. No stem, option text, code or difficulty was changed except the vocabulary and scope repairs listed below, each rewritten in the book's own words without changing what the item tests:

- Q1: the bank's option D "Mass x acceleration" becomes "effort force × load force" — F = ma is out of band (D9); the division signs are normalised to ÷, and the bank's "input/output force" is written as the book's "effort/load force".
- Q2: the bank's "at equal radii" becomes "with the wheel the same size as the axle".
- Q4: the bank's "accelerates" becomes the book's "changes its motion" — acceleration is not a taught term in this band (D9).
- Q6: the bank's "dissipated as heat" becomes the 16A and 16B transfer language: "transferred to the surroundings as thermal energy and sound".
- Q8: the bank's "normalised" becomes "allow for".
- Q10: the bank's "(ideal source)" becomes "(assuming the supply stays the same)", and option C is rewritten to remove "resistance" — resistance is not a taught concept in this band (D9).
- Q9 and Q10: "bulbs" becomes "globes", the book's standard term.

Q	Answer	CD	Bank item
1	**C** — Load force ÷ effort force	`VC2S8U13`	`VC2S8U13.E01.S01.D1.V01` (options reordered; option D rewritten and terms put in the book's words — see repairs)
2	**A** — An inclined plane	`VC2S8U13`	`VC2S8U13.E02.S01.D2.V01` (options reordered; "equal radii" put in the book's words)
3	**D** — Remain stationary	`VC2S8U14`	`VC2S8U14.E02.S01.D1.V01` (options reordered)
4	**B** — Changes its motion less	`VC2S8U14`	`VC2S8U14.E01.S01.D2.V01` (options reordered; "accelerates" put in the book's words)
5	**A** — Gravitational potential	`VC2S8U15`	`VC2S8U15.E01.S01.D1.V01` (options reordered)

Q	Answer	CD	Bank item
6	**D** — Its energy is gradually transferred to the surroundings as thermal energy and sound because of friction and air resistance	`VC2S8U15`	`VC2S8U15.E01.S01.D3.V01` (options reordered; “dissipated as heat” put in the book’s words)
7	**B** — Use less energy and cost less to run	`VC2S8U16`	`VC2S8U16.E02.S01.D2.V01` (options reordered)
8	**C** — It allows a fair comparison between appliances of different capacities	`VC2S8U16`	`VC2S8U16.E02.S01.D3.V01` (options reordered; “normalised” put in the book’s words)
9	**A** — All the globes go out	`VC2S8U17`	`VC2S8U17.E01.S01.D2.V01` (options reordered; “bulbs” → “globes”)
10	**B** — Each branch is connected directly across the full voltage of the supply	`VC2S8U17`	`VC2S8U17.E01.S01.D3.V01` (options reordered; “(ideal source)” and the resistance option put in the book’s words; “bulbs” → “globes”)

Section B — answers and marking

Q11 *(5 marks)* — understanding: force diagrams, net force and change of motion (`VC2S8U14`; rehearses 15A’s four rules of force diagrams and the net-force subtraction, and 15B’s change-of-motion language). This is the paper’s required force-diagram item.

(a) *2 marks.* One mark for the two arrows drawn and labelled correctly — an 8 N push to the right and a 3 N friction force to the left, each arrow starting on the box and pointing the way the force acts, each labelled with the name of the force and its size in newtons *(1 mark)*; one mark for the lengths drawn to match the sizes, so the 8 N arrow is clearly longer than the 3 N arrow (about two-and-a-half times as long — accept any roughly-to-scale drawing in which the right arrow is plainly the longer) *(1 mark)*. A box or a dot for the object is enough. The vertical forces (gravity pulling down and the floor’s support pushing up) are not required; do not penalise a student who draws them equal and opposite.

(b) 8 N − 3 N = 5 N to the right. *1 mark* Accept “5 N rightwards” or “5 N in the direction of the push”. Do not award the mark for an answer without working, or for a correct number with no direction.

(c) Unbalanced. *1 mark*

(d) The box’s motion changes in the direction of the net force — it speeds up, to the right. *1 mark* Accept “it accelerates to the right” or “it moves faster and faster to the right”.

Q12 *(4 marks)* — understanding: simple machines (`VC2S8U13`; rehearses 15C’s lever maths and the distance rule, with the ratio work carried by `VC2M7N09`).

(a) mechanical advantage = effort arm ÷ load arm = 1.6 ÷ 0.4 = 4. *1 mark*

(b) effort = load force ÷ mechanical advantage = 200 ÷ 4 = 50 N. *1 mark*

(c) *1 mark.* Accept any answer carrying the idea that energy is never used up, so you cannot get more energy out of a machine than you put into it — with a smaller force, the same energy transfer needs a longer distance. For example: “The same energy is transferred, and a smaller force can only do that over a longer distance.”

(d) *1 mark* for any one of the other five simple machines named in 15C with a matching change. Accept: a pulley changes the direction of the force (pull down to lift up), or a moving pulley halves the effort; a ramp (inclined plane) lifts a load with a smaller force over a longer distance; a wedge turns one push into two sideways forces, or concentrates a force onto a small area; a screw turns a small turning force into a strong straight pull; a wheel and axle multiplies a force applied at the wheel's rim. The machine and the change must match. A lever is not accepted here — the wheelbarrow already is one.

Q13 *(6 marks)* — understanding: Sankey diagrams, efficiency and waste energy (`VC2S8U15`; rehearses 16B's Sankey anatomy and the efficiency formula, with the percentage work carried by `VC2M7N07`). This is the paper's required Sankey/efficiency item.

(a) The amount of energy that arrow carries — a wider arrow carries more energy. *1 mark*

(b) 100 J − 35 J = 65 J. *1 mark* Do not award the mark for an answer without working.

(c) *2 marks.* efficiency = useful energy output ÷ total energy input = 35 ÷ 100 *(1 mark for the substitution)* = 0.35, or 35% *(1 mark for the answer)*. Accept 35% shown with correct working.

(d) The LED globe. *1 mark*

(e) Any one of: radiation (energy sent out in straight rays), convection (the warmed air rises and carries the energy away), conduction (energy handed to the air touching the globe). *1 mark* — the name of the pathway is enough; an explanation earns the mark provided it matches the pathway named.

Q14 *(6 marks)* — understanding: circuits (`VC2S8U17`; rehearses 17A's symbols, series and parallel, and the household-wiring comparison of `.E03`). This is the paper's required circuit item.

(a) *2 marks.* One mark for one complete loop containing the cell, the closed switch and both globes one after the other (series) *(1 mark)*; one mark for the symbols drawn correctly — the cell shown with its long and short lines, the globes as circles with a cross inside, and the switch drawn closed *(1 mark)*. Straight lines with neat corners are the convention; corners mean nothing. Accept either the single-cell symbol or a battery symbol; the switch must be shown closed.

(b) Globe 1 goes out, because the single loop is broken and the current stops everywhere in a series circuit. *1 mark* Award the mark only when both the effect and the reason are given.

(c) Globe 2 stays lit. *1 mark*

(d) *1 mark.* Accept: if one light fails (or is switched off) the others keep working; each light works on its own branch, independently of the others. The answer must rest on the behaviour in (c) — one branch breaking leaves the other branches complete.

(e) *1 mark.* Accept: the mains supply is 230 V — large enough to electrocute a person, or stop their heart — while cells and low-voltage power packs are safe to handle. Award the mark for any answer that names the risk (electric shock, electrocution, the heart stopping) or the size of the mains voltage (230 V is dangerous). "Because it is dangerous" with no reference to voltage or shock earns no mark.

Q15 *(3 marks)* — understanding: household energy (`VC2S8U16`; rehearses 16C's audit and passive solar design).

(a) *1 mark.* Accept: where a household's energy goes; the appliances and devices that use energy in the home, and how much each uses; the home's biggest energy users.

(b) *1 mark* for any one proposal taught in 16C: choose a higher-star appliance of the right size when one needs replacing; switch standby devices off at the wall; line-dry washing on the days the weather allows; insulate the ceiling; seal the draughts; let the eave and the north-facing windows do the heating and cooling. A general "use less electricity" earns no mark — the change must be a named action.

(c) North. *1 mark* Accept "the north side" or "facing north".

Q16 *(6 marks)* — inquiry, from the chapters' own practical work (D7). Part (a) rehearses 15B's trolley investigation (`VC2S8I02`: variables in a planned investigation); part (b) rehearses 16B's spoon race (`VC2S8I06`: sources of error and the improvements that fix them); part (c) rehearses 16C's shoebox passive-solar model (`VC2S8I04`: strengths and limits of a representation).

(a)

(i) The independent variable is the trolley's mass — the light trolley or the loaded trolley. *1 mark* (ii) The dependent variable is the distance the trolley travels in the first 2 s — how much its motion changes. *1 mark* The steady pull (the force meter reading), the 2 s timing and the same start line are controlled variables — not credited either way.

(b) *1 mark* for any one source of error in the spoon race, *1 mark* for a change that fixes the error named. Accept errors: the spoons are only "of similar size", so their thickness or shape may differ; the dots of butter are not the same amount; the beads are not identical; the beads are not all at exactly the same height; the water cools during the test, so later spoons sit in cooler water; the order of the drops is judged by eye. Accept matching fixes: choose spoons of exactly the same size and shape; measure out equal amounts of butter; use identical beads; mark one height on all three handles; put all three spoons into the water at the same moment; film the drops and play them back. The fix must match the error named.

(c) Shows well (any one): at the low lamp angle (winter), the light shines through the window and warms the box, as the low winter Sun warms a north-facing house; at the high lamp angle (summer), the cardboard eave shades the window and the box stays cooler, as a well-sized eave blocks the high summer Sun; the black jar of water holds warmth, as thermal mass holds warmth in a real house. *1 mark* Limit (any one): the lamp is not the Sun — it is close, still, and its beam does not sweep across the sky; the shoeboxes are nothing like real houses — their walls, windows and insulation are not a real house's; the test takes minutes, while a real house warms and cools over a day and through the seasons; the model has no wind, draughts or clouds. *1 mark*

Section B subtotal: 30 marks.

Data provenance and sources. Every multiple-choice item is drawn from the MCQ bank keyed to `VC2S8U13`–`VC2S8U17`, with the vocabulary and scope repairs listed in the Section A note; the bank item ids above keep the §4 join. This paper carries no real data objects — Q11's pushed box, Q12's wheelbarrow and Q13's LED globe are worked values chosen for practice — so no source lines are printed on the paper. The inquiry items attach to practicals named in the chapters: 15B's trolley investigation (simulated results), 16B's spoon race and 16C's shoebox passive-solar model. Elaboration contexts drawn on: `VC2S8U13.E01` and `.E02` (mechanical advantage; machines that trade distance for force), `VC2S8U14.E01` and `.E02` (force, mass and change of motion; balanced and unbalanced forces), `VC2S8U15.E01` and `.E02` (roller coaster and Newton's cradle; Sankey diagrams and efficiency), `VC2S8U16.E01`–`.E03` (audits; star ratings; passive solar design), and `VC2S8U17.E01` and `.E03` (series and parallel; household wiring).

Teacher-facing note (not student text). Marking is strictly point-based per §7: every mark above is tied to a stated point, and no holistic judgement is applied at any level. This paper carries no Aboriginal and Torres Strait Islander content (CONTENT_POLICY Rule 1): the elaborations that carry that content (`VC2S8U13.E04`, `VC2S8U14.E06`, `VC2S8U15.E05`) are contexts only and are not drawn on. The scope ceiling (D9) is held throughout: no Ohm's law, no resistance as a taught concept, no F = ma, no named Newton's laws, and no quantitative motion — Q11's net force is the single-line subtraction taught in 15A, and "change of motion" stands in for acceleration wherever the bank's wording used it. The only calculations on the paper are Q11(b), Q12(a)–(b) and Q13(b)–(c), for which a scientific calculator is permitted; no graphing is required. Q11(a) and Q14(a) are drawing items — accept a dot or a simple box for the object in Q11(a), and accept either the cell symbol or a battery symbol in Q14(a) provided the arrangement is series.

Traceability

Item	Marks	CD	Achievement-standard evidence	Inquiry
Q1, Q2	2	`VC2S8U13`	simple machines demonstrated for a purpose	0
Q3, Q4	2	`VC2S8U14`	effects of forces represented and explained	0
Q5, Q6	2	`VC2S8U15`	forms of energy compared; transfers and transformations	0

Item	Marks	CD	Achievement-standard evidence	Inquiry
			represented	
Q7, Q8	2	`VC2S8U16`	household energy consumption analysed	0
Q9, Q10	2	`VC2S8U17`	series and parallel circuits predicted	0
Q11	5	`VC2S8U14`	forces represented on a diagram; effect on motion explained	0
Q12	4	`VC2S8U13`	simple machine used for a purpose (mechanical advantage)	0
Q13	6	`VC2S8U15`	energy transfer represented (Sankey) and efficiency analysed	0
Q14	6	`VC2S8U17`	circuits designed and constructed; predictions about series and parallel	0
Q15	3	`VC2S8U16`	energy audit undertaken; ways to decrease consumption proposed	0
Q16(a)	2	`VC2S8I02`	variables identified in a planned investigation	2
Q16(b)	2	`VC2S8I06`	source of error identified; method improved	2
Q16(c)	2	`VC2S8I04`	strengths and limits of a representation	2
Total	**40**			**6**

Achievement-standard extracts served (D13), verbatim from the authority file: `VC2S8U13` — *"They demonstrate how simple machines can be used for a purpose."*; `VC2S8U14` — *"They represent and explain the effects of forces acting on objects."*; `VC2S8U15` — *"They compare different forms of energy and represent energy transfers and transformations in simple systems."*; `VC2S8U16` — *"They undertake a household energy audit and propose ways to decrease energy consumption."*; `VC2S8U17` — *"They design and construct series and parallel circuits, and observe and make predictions about voltage and current and about energy transfer in the circuits."* Inquiry extracts: `VC2S8I02` — *"They plan a range of reproducible scientific investigations, document procedures…"*; `VC2S8I04` — *"They select and construct appropriate representations to organise and process data and information."*; `VC2S8I06` — *"They identify assumptions and sources of error in methods and analyse conclusions and claims with reference to conflicting evidence and unanswered questions."*