

Ages 12–15 · Science

LESSON SLIDES

Electric Circuits

Physics · Current, voltage, resistance, and series vs parallel

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Electric Circuits

SPEAKER NOTES

Show a torch or a desk lamp and ask: what has to happen inside for the bulb to light? Collect ideas. Many students will say electricity 'flows into the bulb and gets used up'. Tell them the lesson will test that idea.

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By the end of this lesson you can

- 🎯 Explain why a circuit must be a complete loop
- 🎯 Describe current, potential difference and resistance
- 🎯 Calculate with $V = IR$
- 🎯 Compare series and parallel circuits
- 🎯 Explain how homes are wired

By the end of this lesson you can

SPEAKER NOTES

Point out that 'voltage' and 'potential difference' mean the same thing in this lesson; some courses prefer one term, some the other. Ask which objective students think will be hardest.

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A circuit is a complete loop

- Charge flows only around a complete, unbroken loop
- The cell or battery pushes the charge round
- Opening a switch breaks the loop and the current stops
- Conventional current flows from + to – outside the cell
- Electrons actually drift the other way, from – to +

A circuit is a complete loop

SPEAKER NOTES

Draw a cell, a switch and a lamp in a loop using standard circuit symbols. Ask what happens if one wire is disconnected anywhere in the loop: everything stops. The direction convention was chosen before electrons were discovered, which is why the two directions differ.

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Current and potential difference

Current (I)

- The rate of flow of charge
- Unit: ampere (A); 1 A = 1 coulomb per second
- Measured with an ammeter
- Ammeter goes in series, in the loop

Potential difference (V)

- Energy transferred per unit of charge
- Also called voltage; unit: volt (V)
- Measured with a voltmeter
- Voltmeter goes in parallel, across a component

Current and potential difference

SPEAKER NOTES

A useful picture: current is how much charge passes a point each second; potential difference is how much energy each unit of charge gives up in a component. Ask students where the ammeter and voltmeter must go in a circuit and why: the ammeter must have all the current pass through it, the voltmeter compares two points.

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Resistance and Ohm's law

- Resistance opposes the current in a component
- Unit: ohm (Ω); $1 \Omega = 1$ volt per ampere
- $V = I \times R$
- For a fixed resistance, more voltage means more current
- Copper wires have low resistance; lamp filaments have high resistance

Resistance and Ohm's law

SPEAKER NOTES

Show the rearrangements $I = V \div R$ and $R = V \div I$. Components that keep the same resistance as the current changes are called ohmic; a filament lamp is not, because its resistance rises as it heats up. Older students can sketch a current-voltage graph for each.

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 Example

Worked example: a torch lamp

- 1 A lamp is connected to a 3.0 V battery
- 2 The ammeter reads 0.25 A
- 3 $R = V \div I$
- 4 $R = 3.0 \div 0.25$
- 5 $R = 12 \, \Omega$

Worked example: a torch lamp

SPEAKER NOTES

Write each line on the board and ask students to check the units: volts divided by amperes gives ohms. Follow-up: if the same $12 \, \Omega$ lamp were connected to a 6.0 V battery and its resistance did not change, the current would be 0.5 A. In reality the filament gets hotter, so the current would be a little less.

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Series circuits: one path

- All components sit in one loop
- The current is the same at every point
- Supply voltage is shared between components
- Total resistance = $R_1 + R_2 + \dots$
- If one lamp breaks, the whole circuit stops

Series circuits: one path

SPEAKER NOTES

Add a second lamp in series and the lamps get dimmer, because the total resistance goes up and the current goes down. Show ammeter readings before and after each lamp: they are the same. Current is not used up; energy is transferred to the lamps.

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Parallel circuits: several paths

- Each component has its own branch to the supply
- Each branch gets the full supply voltage
- Branch currents add up to the total current
- Adding a branch lowers the total resistance
- Each branch can be switched on or off separately

Parallel circuits: several paths

SPEAKER NOTES

Add a second lamp in parallel and both stay as bright as a single lamp, because each gets the full supply voltage. The battery now supplies more current in total, so it runs down faster. For ages 14–15, introduce $1/R = 1/R_1 + 1/R_2$ as an extension.

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Series vs parallel at a glance

Series

- One path for the current
- Same current everywhere
- Voltage shared between components
- More lamps: each lamp dimmer
- One break stops everything

Parallel

- Two or more paths
- Current splits, then rejoins
- Same voltage across each branch
- More lamps: each stays bright
- One break stops only that branch

Series vs parallel at a glance

SPEAKER NOTES

Ask students to copy this table and add a sketch of each circuit. Then ask a hinge question: a string of decorative lights goes out completely when one bulb fails. Is it wired in series or parallel? Series.

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 Example

Worked example: two $6\ \Omega$ resistors, $6\ \text{V}$ battery

- 1 Series: total $R = 6 + 6 = 12\ \Omega$
- 2 Series: $I = 6 \div 12 = 0.5\ \text{A}$; each resistor gets $3\ \text{V}$
- 3 Parallel: each resistor gets the full $6\ \text{V}$
- 4 Parallel: each branch $I = 6 \div 6 = 1\ \text{A}$
- 5 Parallel: total current $= 1 + 1 = 2\ \text{A}$

Worked example: two $6\ \Omega$ resistors, $6\ \text{V}$ battery

SPEAKER NOTES

Same parts, very different results. In parallel the total resistance is $6\ \text{V} \div 2\ \text{A} = 3\ \Omega$, less than either resistor on its own. Check with older students: $1/R = 1/6 + 1/6 = 1/3$, so $R = 3\ \Omega$. Ask why the battery would run down four times faster in the parallel circuit (four times the current).

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Why homes are wired in parallel

- Every appliance gets the full mains voltage
- Each light or socket can be switched on its own
- One appliance failing does not switch off the rest
- Mains electricity can kill: never experiment with it
- Fuses and circuit breakers cut off dangerous currents

Why homes are wired in parallel

SPEAKER NOTES

Mains voltage differs between countries, for example about 230 V in many countries and about 120 V in others, so avoid quoting one figure as universal. Make the safety message explicit: classroom experiments use low-voltage cells or power packs only.

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Series and parallel on one page

- Series: one path, current the same everywhere, voltage shared. Parallel: several paths, voltage the same across each branch, currents add up.

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Series vs Parallel Circuits

Two ways to connect the same components, with very different results for current, voltage and brightness.

Series circuit VS **Parallel circuit**

PATHS FOR THE CURRENT

- One loop: every component is on the same path.
- Two or more branches, each connected across the supply.

CURRENT

- The same at every point in the circuit.
- Splits between the branches: branch currents add up to the total.

POTENTIAL DIFFERENCE

- Shared between the components; the parts add up to the supply voltage.
- Each branch gets the full supply voltage.

TOTAL RESISTANCE

- Add them up: $R = R_1 + R_2 + \dots$
- Less than the smallest single resistance.

ADD ANOTHER LAMP

- Every lamp gets dimmer.
- Each lamp stays as bright; the battery runs down faster.

ONE LAMP BREAKS

- The circuit is broken, so every lamp goes out.
- Only that branch stops; the others stay on.

WHERE YOU FIND IT

- A switch, which must break the loop it controls.
- Lights and sockets in a home, so each works on its own.

Same parts, different results

Two 6 Ω resistors on a 6 V battery. Series: 12 Ω, 0.5 A, 3 V each. Parallel: 6 V and 1 A each, 2 A in total. Check with $V = IR$.

Stay safe

Mains electricity can kill. Do circuit experiments only with low-voltage cells or a school power pack, and never short-circuit a cell.

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Series and parallel on one page

SPEAKER NOTES

Use the poster as a recap or print it for the classroom wall. Ask students to cover one column and recall it from memory, then swap with a partner.

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 Quick check

**Two identical lamps are in series with a 6 V battery.
What is the potential difference across each lamp?**

A 6 V

B 12 V

C 3 V

D 0 V

Quick check

SPEAKER NOTES

Answer: C, 3 V. In series the supply voltage is shared, and identical lamps share it equally. Students who chose A are thinking of a parallel circuit; ask them to explain what would change if the lamps were in parallel.

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Key takeaways

- ✓ Current flows only in a complete circuit and is not used up
- ✓ Current in amperes, potential difference in volts, resistance in ohms
- ✓ $V = IR$ links all three
- ✓ Series: same current, shared voltage
- ✓ Parallel: same voltage, currents add up

Key takeaways

SPEAKER NOTES

Return to the opening question about the torch and ask students to answer it again with the words current, potential difference and energy. Then move to the five-question quiz. Homework idea: find three things at home that are switched independently and explain how that shows parallel wiring.