

Light It Up

Wire up a house so every lamp lights: from complete circuits and switches to Ohm's law, fuses and cable losses.

UK Years 8–13

Ages 12–18

US grades 7–12

Physics · Electricity

Levels

LEVEL 2 · YEAR 8

Two Rooms

☆☆☆

Numbers

Brief

Hint

Kitchen lamp lit

Bedroom lamp lit

Wire £1

Eraser remove

COST

£12

3 stars at £12 · budget £16

✓ Check circuit

Inside this pack

1. Overview: learning outcomes, curriculum links, key words
2. How the game works (teacher background)
3. Level-by-level guide with 3-star solutions
4. Lesson 1: Series, parallel and switches (Years 8–9)
5. Lesson 2: Resistance, power and safety (Years 10–13)
6. Worksheet 1 and Worksheet 2 (photocopiable)
7. Answers and mark scheme

Play it free

dowplay.com/games/light-it-up

Runs in any browser on Chromebooks, iPads, laptops and phones. No accounts, no ads, nothing to install. Progress is saved only on the device being used.

A separate PDF has the worksheets on their own, ready to print for students.

1 · OVERVIEW

What students learn

Light It Up turns circuit-building into a puzzle. Students wire up the rooms of a house so the lamps, appliances and gadgets work, within a budget. The game solves every circuit the way an electrical engineer would (nodal analysis), so the voltages and currents are real: lamps in series really do glow dimmer, and too much current really does blow the fuse. Its eight levels run from Year 8 to Year 13.

By the end, students can

- explain why a circuit needs a **complete loop**, and what a switch does
- compare **series and parallel** circuits: how voltage and current are shared
- use $V = I \times R$ to choose a resistor, and add resistances in series
- use $I = P \div V$ to work out currents, and explain what a **fuse** does
- design a **potential divider** and explain loading
- explain why big currents need thick cables ($P = I^2 \times R$)

You will need

- One device per pair (any browser)
- A projector for the starters
- Worksheet 1 or 2 for each student

Timing

Each lesson plan fills 60 minutes. The levels also work as a homework or a club activity: each takes 5–15 minutes.

Curriculum links

Course	Content	Levels
KS3 Science (England)	Current in series and parallel circuits; currents add where branches meet; potential difference in volts; battery and bulb ratings; resistance as the ratio of potential difference to current	1–5
GCSE Physics / Combined Science	Circuit symbols; $V = I R$; series and parallel circuits; power ($P = I V$, $P = I^2 R$); domestic electricity, fuses and safety; why the National Grid transmits at high voltage	2–8
A-level Physics	Potential dividers and loading; resistance of wires and power losses	7–8
US (NGSS)	MS-ETS1-1, MS-ETS1-2, HS-ETS1-3: designing solutions within criteria and constraints, such as cost and safety	All

Safety note. The game uses low-voltage batteries. Remind students that mains electricity (230 V in the UK) is dangerous and must never be experimented with.

2 · TEACHER BACKGROUND

How the game works

The board is a real circuit:

1. Every part sits between two junctions on the grid, and everything touching a junction is connected.
2. The game works out the voltage at every junction and the current in every part, the way engineers analyse circuits.
3. If a battery gives more current than its fuse allows, the **fuse blows**. If a lamp or appliance gets more than 135% of its rated voltage, it **burns out**.

A lamp or appliance counts as **working** when its voltage is within 20% of its rating (within 10% on levels 5, 6 and 8). Below 10% of its rating, it's off.

The parts

Part	What it does	Notes
Battery or supply	A fixed voltage: 6, 9 or 12 V	Each has a fuse (5 A, 3 A, 2 A, 100 mA...) and a tiny internal resistance (0.05 Ω)
Lamp, appliance	Rated voltage and power, e.g. 6 V, 3 W	Resistance = $V^2 \div P$, so a 6 V, 3 W lamp is 12 Ω
Doorbell	Needs 2.8–3.2 V	A fixed 1 k Ω resistance
Wire	£1 per grid section	0.01 Ω per section (Power to the Shed: thin wire 0.1 Ω ; thick cable 0.01 Ω at £3)
Resistor	£3 each	2, 4, 10, 12, 22, 47 or 100 Ω , depending on the level
Switch	Tap to open or close	Part of the level; circuits are tested both ways

2 · TEACHER BACKGROUND (CONTINUED)

Reading the screen

Dots flow along the wires where current runs, and each dark room lights up when its lamps work. Turning on **Numbers** labels every lamp, appliance and resistor with its voltage, current and circuit symbol, and the battery with the current it gives. The figures on the worksheets are taken straight from that view.

Stars

1 star for a working circuit, 2 for staying within the budget, 3 for matching the cheapest design we know. Students sometimes match it with a different layout.

What the model leaves out

Real lamp filaments get hotter and their resistance rises; in the game it's fixed. Real batteries run down, fuses take time to blow, and homes use alternating current (AC) at 230 V. Good discussion points with older students.

Key words

Current (A)	The flow of charge, measured in amps.	Series	Components on one path, one after another. They share the voltage.
Voltage (V)	Potential difference: the push from the battery, in volts.	Parallel	Components on separate branches. Each gets the full voltage.
Resistance (Ω)	How much a component opposes current. $R = V \div I$.	Fuse	Melts and breaks the circuit if the current is too big.
Power (W)	Energy transferred each second. $P = I \times V$.	Potential divider	Two resistances in series that share a voltage to give a smaller one.

3 · LEVEL GUIDE

Level by level

"3 stars" is the cheapest design we know. Keep it to yourself until students have had a go: the fun is in the search.

1 Lights On

Year 8 · A complete loop

Watch for A single wire from the battery to the lamp, or a gap at a corner.
3 stars, £8 A loop of 8 wire sections: one along the top and one along the bottom.
Ask "If you cut the bottom wire, what happens, and why?"

2 Two Rooms

Year 8 · Series vs parallel

Watch for The lamps in a chain (series): both glow dimly at 3 V each.
3 stars, £12 Each lamp joined straight to both battery wires (parallel). The battery then gives 0.98 A, about 0.49 A to each lamp.
Ask "Why does the battery give twice as much current now?"

3 The Hall Switch

Years 8–9 · Switches in branches

Watch for The switch in the main loop, so it turns both lamps off.
3 stars, £16 The kitchen lamp on its own loop; only the hall lamp's return wire goes through the switch.
Ask "Where would you put a master switch that turns everything off?"

4 Twelve Volts

Year 9 · Voltage shared in series

Watch for The lamps in parallel straight across 12 V: each gets twice its rating and burns out.
3 stars, £15 The two lamps in series, 6 V each. The 12 Ω resistor isn't needed.
Ask "What would three of these lamps in series on 12 V get?" (4 V each: too dim.)

5 Pick the Resistor

Year 10 · Ohm's law; resistors in series

Watch for No resistor (the lamp gets 9 V and burns out), or a 10 Ω or 22 Ω resistor (too dim).
3 stars, £14 A 2 Ω and a 4 Ω resistor in series with the lamp: 5.96 V and 0.50 A for the lamp.
Ask "How much power does the resistor waste?" (About 1.5 W.)

6 Two Fuses

Years 10–11 · $I = P \div V$; currents add

Watch for The heater and fridge on one circuit (3.5 A blows the 3 A fuse), or circuits A and B joined together.
3 stars, £16 The heater alone on circuit A (2 A); the fridge, TV and lamp on circuit B (2.75 A).
Ask "Why would fitting a bigger fuse be dangerous?"

7 Smart Doorbell

Years 11–13 · Potential dividers; loading

Watch for Small resistors, which draw too much current and blow the 100 mA fuse; forgetting that the doorbell pulls the output voltage down.

3 stars, £21 Two $47\ \Omega$ resistors in series on top and one $47\ \Omega$ below: the doorbell gets 2.91 V and the battery gives 65 mA.

Ask "Why is the output 2.91 V and not exactly 3 V?"

8 Power to the Shed

Years 12–13 · Cable resistance and losses

Watch for Thin wire on the heater's long loop (the heater gets well under 10.8 V), or thick cable everywhere (over budget).

3 stars, £76 Thick cable for the heater's loop (23 sections) and thin wire for the lamp's short loop (7): heater 10.9 V, lamp 11.3 V.

Ask "Why does the heater's loop need thick cable when the lamp's doesn't?"

4 · LESSON PLAN · YEARS 8–9 · 60 MINUTES

Lesson 1: Series, parallel and switches

Objectives

- Explain why a circuit needs a complete loop.
- Compare series and parallel circuits.
- Explain where to put a switch to control one lamp.

Resources

- Worksheet 1 (one each)
- Devices, one per pair
- Light It Up on the projector

Time	Activity
Starter 10 min	Open Level 1, Lights On . Lay one wire from the battery to the lamp: nothing happens. Ask why. Complete the loop and it lights. Then open Level 2, Two Rooms and ask: "If I chain the two lamps one after the other, how bright will they be?" Build it: both are dim. Then wire them in parallel: both are bright.
Main 1 15 min	Worksheet 1, Part A: which circuits work, series and parallel voltages, and why a 6 V lamp burns out on 12 V.
Main 2 25 min	Pairs play levels 1–4 and fill in the record table (Part B). Before pressing Check, one partner predicts what will happen. Circulate and ask: "Is that part in series or in parallel?"
Plenary 10 min	Part C together: the Two Rooms numbers. Currents add where branches meet ($0.49\text{ A} + 0.49\text{ A} = 0.98\text{ A}$). Exit ticket: <i>why are the lights in a house wired in parallel?</i>

Support

Use the in-game hints. For Two Rooms, ask students to trace each lamp's loop with a finger: does each lamp have its own path to both sides of the battery?

Stretch

Turn on Numbers and explain every value. Try Level 5, Pick the Resistor. Go for 3 stars on The Hall Switch (£16).

Misconceptions to listen for

- "The lamp uses up the current." In series, the same current flows all the way round; the lamp transfers energy, not current.
- "A battery always gives the same current." It gives whatever the circuit draws: two lamps in parallel draw twice as much.
- "A switch must be next to the lamp it controls." It just has to be in that lamp's branch.

Homework: Worksheet 1, Part D, and get 3 stars on Level 2.

5 · LESSON PLAN · YEARS 10–13 · 60 MINUTES

Lesson 2: Resistance, power and safety

Objectives

- Use $V = I R$ and $I = P \div V$ in circuit design.
- Explain how fuses protect circuits.
- Design a potential divider; explain why thick cables carry big currents.

Resources

- Worksheet 2 (one each)
- Devices, one per pair
- Light It Up on the projector

Time	Activity
Starter 10 min	Show Level 5, Pick the Resistor . "The lamp needs 6 V and 0.5 A, and the battery gives 9 V. What resistor do we need?" Take answers, then show that the box has no 6 Ω resistor. How can 2 Ω and 4 Ω help? Build it with Numbers turned on.
Main 1 15 min	Worksheet 2, questions 1–3 : Ohm's law, reading the game's numbers, and fuse currents.
Main 2 25 min	Pairs play levels 5–8 (Years 10–11 mainly levels 5–6; Years 12–13 levels 7–8). Use questions 4–5 to guide Smart Doorbell and Power to the Shed.
Plenary 10 min	Plan question 6 together: how house wiring is made safe and efficient. Finish it as homework.

Support

Give students the formula triangle for $V = I R$. In Two Fuses, have them write each appliance's current next to it before wiring anything.

Stretch

Smart Doorbell: calculate the loaded output before building. Power to the Shed: find the most thin wire the heater's loop can have and still get 10.8 V.

Misconceptions to listen for

- "A bigger fuse is safer." A fuse must blow before the cable overheats, so it must be only just above the normal current.
- "Resistors use up current." The current is the same all round a series loop; the resistor takes some of the voltage.
- "Thick wire has more resistance because there's more of it." Thicker wire has *less* resistance.

Homework: Worksheet 2, question 6 (6 marks).

Series and parallel

Name: _____ Class: _____ Date: _____

A circuit only works if there is a **complete loop** from one side of the battery to the other.

Series: one path. Components share the battery's voltage. **Parallel:** separate paths. Each component gets the full voltage.

Part A · Circuits

A1 Which of these circuits will light the lamp? Explain your answer. [2]



(a)



(b)



(c)

A2 Two identical 6 V lamps are connected to a 6 V battery.

a) In series, what voltage does each lamp get? [1]

b) In parallel, what voltage does each lamp get? [1]

c) Which way are the lamps brighter? [1]

A3 In **Twelve Volts**, two 6 V lamps must work on a 12 V supply.

a) How should the lamps be connected? Explain why. [2]

b) What would happen to a 6 V lamp connected straight across 12 V? [1]

A4 A 6 V, 3 W lamp takes 0.5 A from a 6 V battery.

a) Two of these lamps are connected in parallel to the battery. How much current does the battery give? [1]

b) Why does adding a lamp in parallel make the battery give more current?

[1]

Part B · Play levels 1 to 4

Before you press **Check circuit**, predict what will happen. Record your best design for each level.

Level	What I built	Cost	Stars	What went wrong, and how I fixed it
1		£		
2		£		
3		£		
4		£		

Part C · Read the numbers

This is **Two Rooms** with both lamps in parallel and **Numbers** turned on. Each label shows the voltage and the current.



C1 What current does each lamp take?

[1]

C2 What current does the battery give? How does it compare with the lamps' currents?

[2]

C3 The lamps get 5.89 V and 5.86 V, not quite 6 V. Suggest why.

[2]

C4 Where would you put a switch to turn off only the bedroom lamp?

[1]

Part D • Explain

D1 The lights in a house are wired in parallel, not in series. Give three reasons why.

[3]

Resistance, power and safety

Name: _____ Class: _____ Date: _____

$V = I \times R$ · $P = I \times V$ · $P = I^2 \times R$ · resistors in series: $R = R_1 + R_2$ · resistors in parallel: $1/R = 1/R_1 + 1/R_2$
Potential divider: $V_{\text{out}} = V_{\text{in}} \times R_2 \div (R_1 + R_2)$

1 Pick the Resistor. A desk lamp needs 6 V and takes 0.5 A. The battery gives 9 V.

a) What voltage must a resistor in series with the lamp take? [1]

b) What resistance does it need? [2]

c) The box has 2 Ω , 4 Ω , 10 Ω and 22 Ω resistors. How can you make the resistance you need? [1]

d) How much power does the resistor waste as heat? [2]

2 Read the numbers. This is the finished Pick the Resistor circuit, with Numbers turned on.



a) Add up the voltages across the two resistors and the lamp. Compare the total with 9 V, and explain any difference. [2]

b) Use the numbers to work out the lamp's resistance. Check it against its rating (6 V, 3 W). [2]

3 Two Fuses. Two 12 V circuits each have a 3 A fuse. The appliances are a 24 W heater, an 18 W fridge, a 12 W TV and a 3 W lamp.

a) Work out the current each appliance takes. [2]

b) Explain why the heater and the fridge can't share a circuit. [1]

c) Suggest a way to share the four appliances between the two circuits. [1]

d) Why is it dangerous to replace a 3 A fuse with a 13 A fuse? [2]

4 Smart Doorbell. A 9 V battery feeds a potential divider: $R_1 = 94\ \Omega$ (two $47\ \Omega$ in series) on top and $R_2 = 47\ \Omega$ below. The battery has a 100 mA fuse.

a) With nothing connected, what is the output voltage across R_2 ? [2]

b) What current flows through the divider? Is it safe for the fuse? [2]

c) The 1 k Ω doorbell is connected across R_2 . Work out the combined resistance of R_2 and the doorbell, and the new output voltage. [3]

d) Why wouldn't a 22 Ω resistor on top and a 10 Ω resistor below work? [2]

5 Power to the Shed. The shed heater is rated 12 V, 36 W. Assume its current stays the same.

a) What current does the heater take? [1]

b) Its loop is 20 sections of thin wire, 0.1 Ω each. What is the loop's resistance, and how much voltage is lost in it? [2]

c) Repeat (b) for thick cable at $0.01\ \Omega$ per section. [1]

d) Use $P = I^2 \times R$ to work out the power wasted in each loop. [2]

e) Explain why the National Grid sends electricity at very high voltages. [2]

6 Evaluate. Evaluate how the wiring of a house is designed to be safe and efficient. Refer to parallel circuits, fuses and cable thickness, and use evidence from Light It Up. [6]

Continue on lined paper if you need more space.

7 · ANSWERS

Worksheet 1 answers

Part A

A1 (a) only (1). (b) has no complete loop: the lamp isn't joined back to the battery; in (c) the open switch breaks the loop (1).

A2 a) **3 V** each (they share the 6 V).

b) **6 V** each.

c) **In parallel.**

A3 a) **In series** (1): the lamps share the 12 V, so each gets the 6 V it needs (1).

b) It gets 12 V, twice its rating, and **burns out**.

A4 a) $0.5 + 0.5 = 1 \text{ A}$.

b) Each branch takes its own current, and the currents add where the branches meet.

Part C

C1 0.49 A each.

C2 0.98 A (1): the sum of the two lamp currents, because currents add where branches meet (1).

C3 The wires and the battery have a small resistance (1), so a little of the voltage is lost in them before it reaches the lamps; the bedroom lamp is further away, so it loses slightly more (1).

C4 In the bedroom lamp's own branch, between the lamp and the point where its wires join the main loop.

Part D

D1 Any three: every lamp gets the full voltage, so all are bright; each lamp can be switched on and off on its own; if one lamp breaks, the others stay on; adding more lamps doesn't make the others dimmer.

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Worksheet 2 answers

- 1 a) $9 - 6 = 3 \text{ V}$.
 b) $R = V \div I = 3 \div 0.5 = 6 \Omega$.
 c) **2 Ω and 4 Ω in series** ($2 + 4 = 6 \Omega$).
 d) $P = I \times V = 0.5 \times 3 = 1.5 \text{ W}$.
- 2 a) $0.99 + 1.99 + 5.96 = 8.94 \text{ V}$ (1). The other 0.06 V is lost in the wires and the battery's internal resistance (1).
 b) $R = 5.96 \div 0.50 = 11.9 \Omega$ (1); the rating gives $V^2 \div P = 36 \div 3 = 12 \Omega$, which matches (1).
 3 a) $I = P \div V$: heater **2 A**, fridge **1.5 A**, TV **1 A**, lamp **0.25 A**.
 b) Together they take 3.5 A, more than the 3 A fuse.
 c) For example, the heater alone on one circuit (2 A) and the fridge, TV and lamp on the other (2.75 A). Any split with no circuit over 3 A.
 d) The fuse must blow before the cable overheats (1); a 13 A fuse would let a fault current flow that could overheat the wiring and start a fire (1).
- 4 a) $9 \times 47 \div (94 + 47) = 3.0 \text{ V}$.
 b) $9 \div 141 = 0.064 \text{ A} = 64 \text{ mA}$, under the 100 mA fuse, so safe.
 c) $1 \div (1/47 + 1/1000) = 44.9 \Omega$ (1); $V_{\text{out}} = 9 \times 44.9 \div (94 + 44.9) = 2.91 \text{ V}$ (2), inside the 2.8–3.2 V range. (The game shows 2.91 V.)
 d) $9 \div (22 + 10) = 0.28 \text{ A}$, which blows the 100 mA fuse (1); small resistors draw too much current (1). (With the doorbell connected its output would also be too low: 2.79 V.)
- 5 a) $36 \div 12 = 3 \text{ A}$.
 b) $20 \times 0.1 = 2 \Omega$; $3 \times 2 = 6 \text{ V}$ lost.
 c) 0.2Ω ; **0.6 V** lost.
 d) Thin: $3^2 \times 2 = 18 \text{ W}$; thick: $3^2 \times 0.2 = 1.8 \text{ W}$.
 e) For the same power, a higher voltage means a smaller current (1); the power wasted in cables is $I^2 R$, so a smaller current wastes far less (1).

Question 6 mark scheme (6 marks)

Level	Description
3 (5–6 marks)	A detailed evaluation of parallel wiring, fuses and cable thickness, linking each to safety or efficiency with evidence from the game (numbers or levels). Reaches a justified conclusion.
2 (3–4 marks)	Explains at least two features with some evidence. The conclusion is partial or not fully justified.
1 (1–2 marks)	Simple statements about one or two features, with little explanation.
0	Nothing worthy of credit.

Indicative content

Parallel circuits

- Every appliance gets the full voltage
- Each can be switched on its own
- One fault doesn't stop the others (Two Rooms, The Hall Switch)

Fuses

- Break the circuit if the current is too big
- Rated just above the normal current (Two Fuses: 3 A for 2.75 A)
- Protect the cables from overheating and fire

Cable thickness

- Thick cable has less resistance
- Big currents need it: losses are $I^2 R$ (Power to the Shed: 18 W vs 1.8 W)
- Thicker cable costs more, so it's used only where needed

Credit references to earth wires, circuit breakers and RCDs, and to the National Grid's high transmission voltages.