Topic 2: Electricity

AQA GCSE Physics 8463 · spec 4.2 · sheets 2.1–2.8

Electricity: circuits, mains and the National Grid

- draw circuit diagrams and calculate **charge**, current, resistance and potential difference;
- investigate how resistance depends on length and how current depends on potential difference;
- apply the rules for series and parallel circuits;

Electricity: circuits, mains and the National Grid (2)

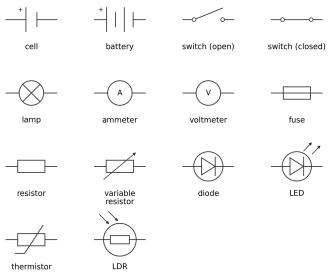
- explain mains electricity, electrical safety, power and the **National Grid**;
- (physics only) explain static electricity and electric fields.

Circuit symbols, charge and current

- Circuit diagrams use standard **circuit symbols** .
- Learn the symbols for a cell, battery, open and closed switch, lamp, fuse, resistor, variable resistor, ammeter, voltmeter, **diode**, LED, **thermistor** and **LDR**.
- An ammeter is always connected **in series** with a component, and a voltmeter **in parallel** across it.
- For charge to flow, there must be a closed circuit with a source of potential difference, such as a cell. **Electric current** is the rate of flow of electrical **charge** :

$$Q = It$$

Figure: Circuit symbols, charge and current



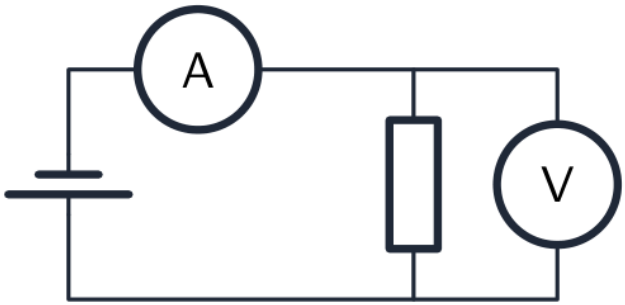
- **Circuit symbols**: light arrows point into an **LDR** and out of an LED.
- Match each part of the diagram to the text.

Current, resistance and potential difference

- The current through a component depends on the potential difference across it and on its **resistance** :
- V is potential difference in volts (V), I is current in amperes and R is resistance in ohms (Ω).
- For the same potential difference, a bigger resistance gives a smaller current.
- **Worked example 4.** A potential difference of 0.45 V drives a current of 0.0075 A through a coin.

$$V = IR$$

Figure: Current, resistance and potential difference



- Required practical 3: the ammeter is **in series** with the wire, and the voltmeter is across the length between the clips.
- Match each part of the diagram to the text.

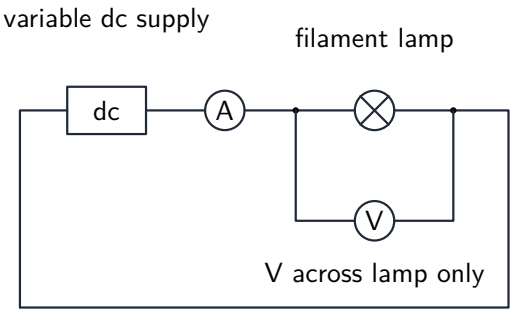
Resistors and I–V characteristics

- An **ohmic conductor** , such as a fixed resistor at constant temperature, has a constant resistance. The current is directly proportional to the potential difference: a straight line through the origin.
- In a **filament lamp** , the filament gets hotter as the current increases. The ions in the metal vibrate more, so the resistance increases and the graph curves.

Resistors and I–V characteristics (2)

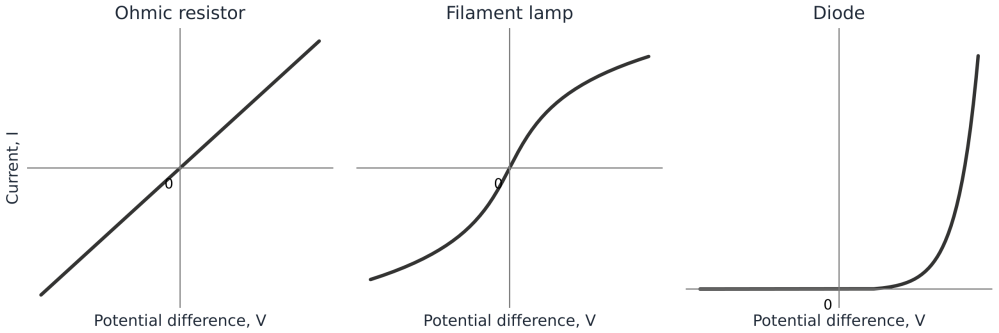
- A **diode** lets current flow in one direction only. In the reverse direction its resistance is very high, so almost no current flows.
- The resistance of a **thermistor** decreases as its temperature increases. It is used in thermostats.
- The resistance of an **LDR** (light-dependent resistor) decreases as light intensity increases. It is used in lights that switch on automatically at night.

Figure: Resistors and I–V characteristics



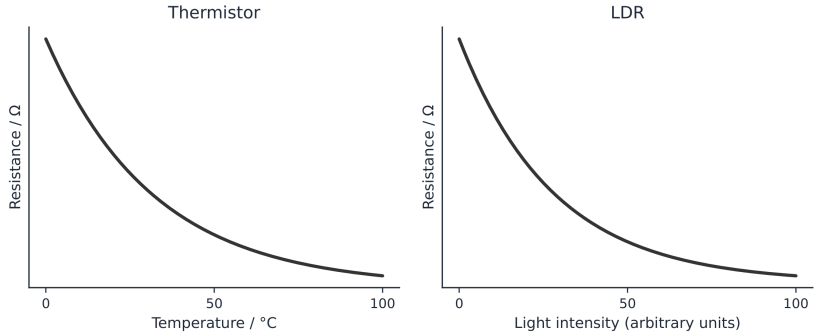
- Required practical 4: the ammeter is **in series** with the lamp, and the voltmeter is across it.
- Match each part of the diagram to the text.

Figure: Resistors and I–V characteristics (2)



- I–V characteristics of a resistor at constant temperature, a **filament lamp** and a **diode**.
- Read the axes and units first.

Figure: Resistors and I–V characteristics (3)

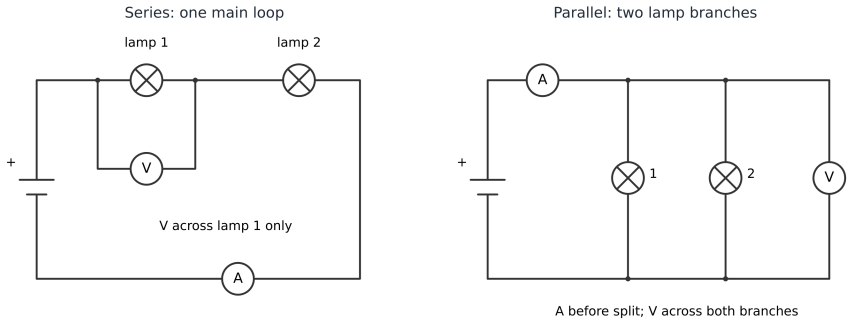


- Resistance against temperature for a **thermistor**, and against light intensity for an **LDR**.
- Read the axes and units first.

Series and parallel circuits

- Total resistance: $12 + 6.0 = 18\ \Omega$.
- Current: $I = \frac{6.0}{18} = 0.33$ A.
- Potential difference across the lamp: $\frac{6.0}{18} \times 12 = 4.0$ V; across the resistor: $\frac{6.0}{18} \times 6.0 = 2.0$ V.

Figure: Series and parallel circuits

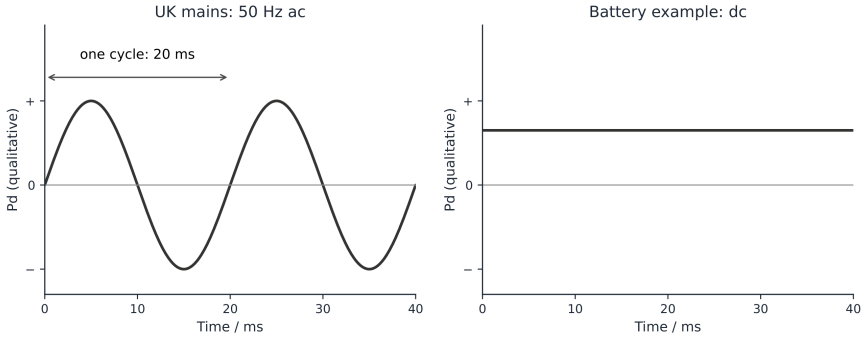


- The same two lamps **in series** and **in parallel**, with the meters in place.
- Match each part of the diagram to the text.

Mains electricity and safety

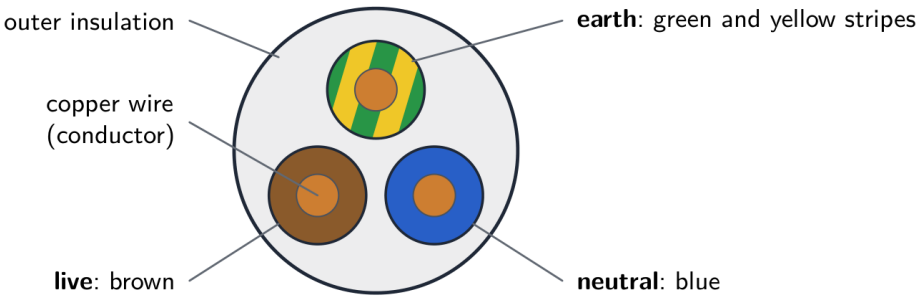
- Mains electricity in the UK is an **alternating** current (ac) supply: the potential difference keeps reversing direction.
- It has a frequency of 50 Hz and a potential difference of about 230 V.
- A battery gives a **direct** potential difference (dc), which always acts in the same direction.
- Most appliances are connected to the mains with a three-core cable.

Figure: Mains electricity and safety



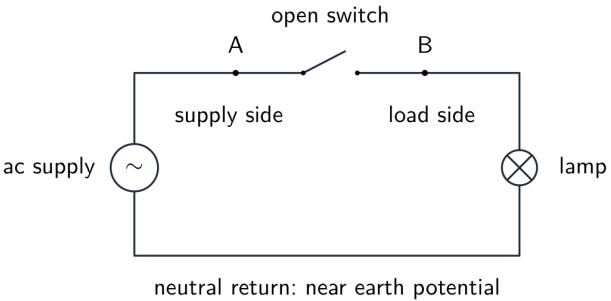
- **Alternating** and **direct** potential difference; one 50 Hz cycle lasts 20 ms.
- Read the axes and units first.

Figure: Mains electricity and safety (2)



- Brown is live, blue is neutral, and green and yellow stripes is earth.
- Match each part of the diagram to the text.

Figure: Mains electricity and safety (3)



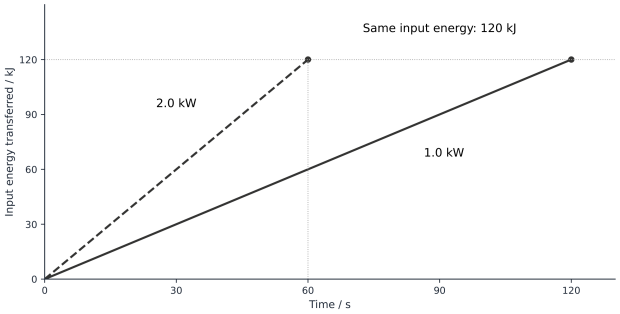
- An open switch in the live wire: point A, on the supply side, is still at about 230 V.
- Match each part of the diagram to the text.

Power and energy in appliances

- Appliances transfer energy from batteries or the mains: a motor transfers energy to a kinetic store, and a heater to a thermal store.
- The power of an appliance is the energy it transfers each second.
- P is power in watts, E is energy in joules and Q is **charge** in coulombs.
- Use time in seconds.

$$P = VI \qquad P = I^2R \qquad E = Pt \qquad E = QV$$

Figure: Power and energy in appliances

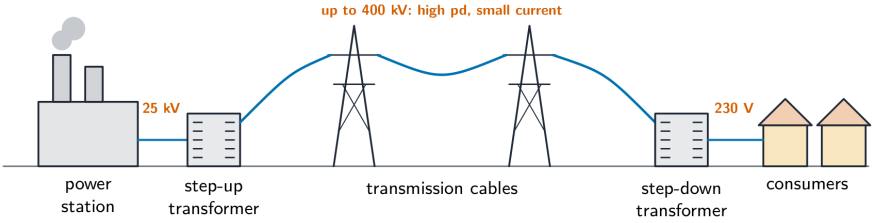


- Energy against time: the 2.0 kW line is twice as steep, so it reaches 120 kJ in half the time.
- Match each part of the diagram to the text.

The National Grid

- A **step-up transformer** increases the potential difference from the power station to a very high value for transmission.
- For the same power, a higher potential difference means a smaller current ($P = VI$).
- A smaller current heats the cables less ($P = I^2R$), so less energy is wasted and the grid is more efficient.
- A **step-down transformer** then decreases the potential difference to about 230 V, a safer value for homes.

Figure: The National Grid



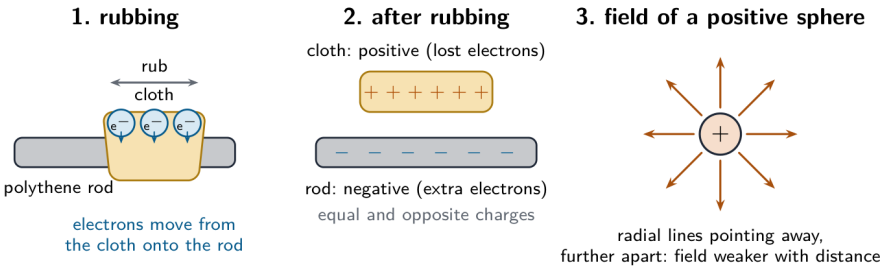
same power, higher pd: smaller current, so less energy wasted heating the cables

- A higher potential difference gives a smaller current for the same power, so less energy is wasted in the cables.
- Match each part of the diagram to the text.

Static electricity (physics only)

- When two insulating materials are rubbed together, electrons are transferred from one to the other.
- The material that gains electrons becomes negatively charged; the material that loses electrons is left with an equal positive **charge**.
- Only electrons move; positive charges do not.
- Charged objects exert a non-contact force on each other: like charges repel and unlike charges attract.

Figure: Static electricity (physics only)



- Rubbing moves electrons onto the rod; the field lines of a positive sphere point radially outwards.
- Match each part of the diagram to the text.

Sources for this lesson

- AQA, *GCSE Physics (8463) specification*, section 4.2 Electricity, and the *Required practical handbook* (practicals 3 and 4).
- G. S. Ohm, *Die galvanische Kette, mathematisch bearbeitet* (Berlin, 1827); Royal Society, Copley Medal award, 1841.
- AQA, *GCSE Physics* Paper 1 Higher, June 2022 to June 2025 (fuse, lamp, **thermistor**, pump, grid and spark questions, adapted).

Common errors

- Saying a lamp uses up current. The current is the same all round a series loop; energy is transferred.
- Putting an ammeter **in parallel** or a voltmeter **in series**.
- Adding parallel resistances as if they were in series. The total is less than the smallest resistance.

Common errors (2)

- Leaving current in mA or time in minutes.
- Using the gradient of a curved I–V graph as the resistance. Use $R = \frac{V}{I}$ at the point.
- Getting sensor trends backwards: **thermistor** resistance falls as temperature rises; **LDR** resistance falls as light increases.

Common errors (3)

- Saying the earth wire carries current all the time.
- Saying positive charges move when objects are rubbed. Only electrons move.

Key terms

- **Current**: the rate of flow of **charge**, in amperes.
- **Potential difference**: what drives charge round a circuit, in volts.
- **Resistance**: opposition to current, in ohms.

Key terms (2)

- **Ohmic conductor**: a conductor whose current is directly proportional to the potential difference at constant temperature.
- **Alternating current**: current that keeps reversing direction.
- **National Grid**: the network of cables and transformers that links power stations to consumers.
- **Electric field**: a region where a charged object feels a force.

Check yourself

- 1. 30 C flows through a lamp in 1 minute.
- Calculate the current. 2.
- A 12 V supply drives 0.40 A through a resistor.
- Calculate its resistance. 3.