Electricity: quantities and laws

Printable revision sheet — Galaxscia

LEVEL 1

What is a conducting material?

Electricity does not travel everywhere: it needs a path made of materials that let it through.

We call this electrical conductivity.

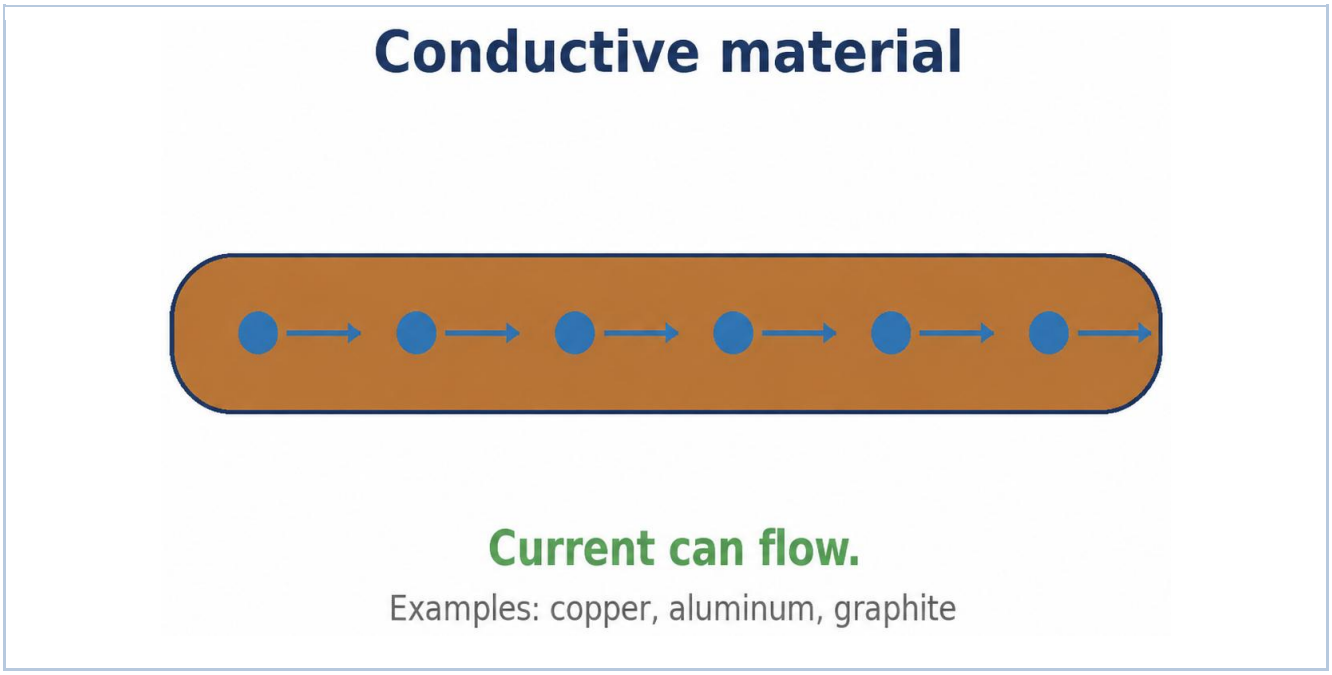
Definitions:

A conductor is a material that lets the electric current through.

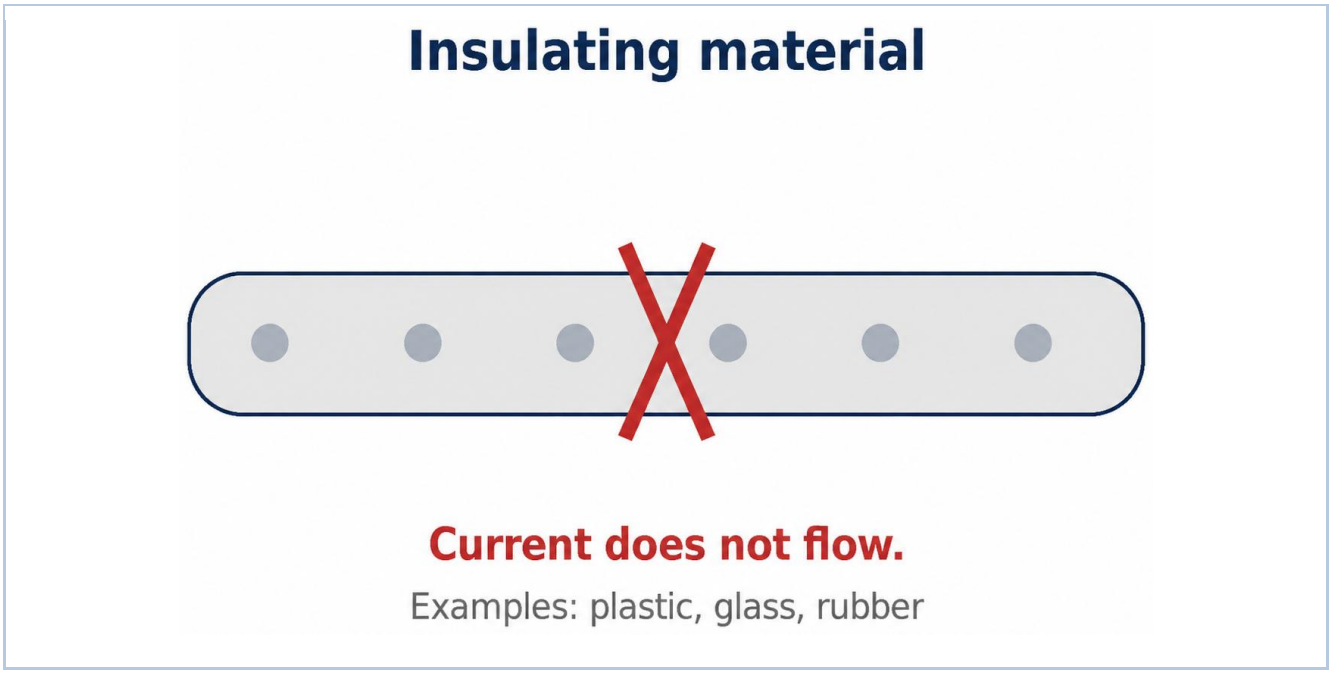
An insulator is a material that stops the current getting through.

Examples:

Metal is a conductor: a stainless steel spoon, a copper wire...



Plastic is an insulator: it surrounds cables to prevent shocks.



An analogy (wrong, but helpful!): Electricity can be pictured as cars on a road: the road (conductor) lets the cars through, a wall (insulator) blocks them.

Key points — revision questions

- What is a conductor?
- What is an insulator?
- Can you name two examples of conductors? Two insulators?

LEVEL 2

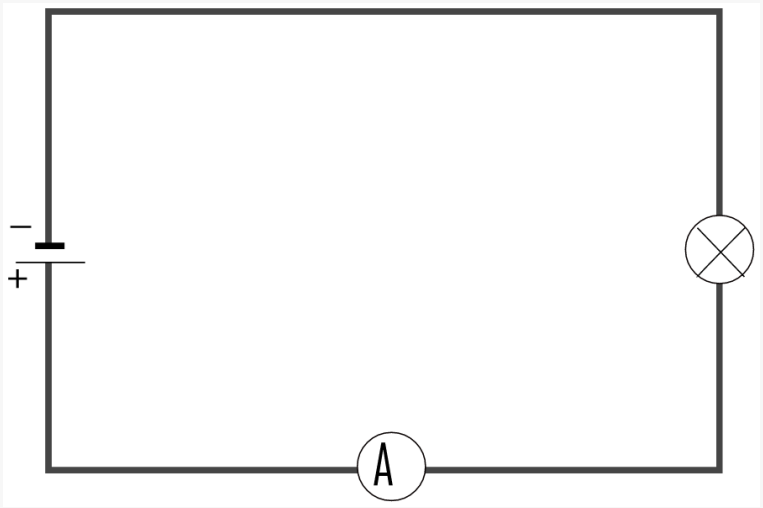
What is an electrical quantity?

Some effects of electricity in a circuit can be measured using quantities: it is like taking the "vital signs" of the current.

Current (intensity)

The current measures how much electricity flows in a circuit at each instant. Its symbol is I.

It is measured in amperes, written A, with an instrument called an ammeter (whose symbol is shown on the diagram). The ammeter must always be connected in series with the component, so as to measure the current flowing through that component.



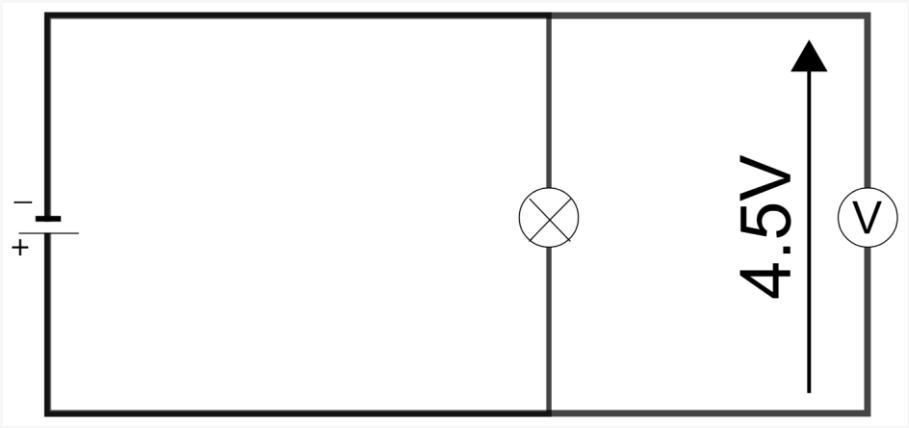
Voltage

Voltage is the difference in electric charge between two terminals. It is what sets the current moving. Its symbol is U.

The greater the voltage, the more "push" the current has to flow.

It is measured in volts, written V, with an instrument called a voltmeter.

The voltmeter must always be connected in parallel with the component, so as to measure the voltage across the terminals of that component.



An analogy (wrong, but helpful!): The current is the number of cars driving on the road; the voltage is, for example, the difference between where the cars live during the summer holidays. Cars living in the middle of the country travel to the coast, because that is where the sea is!

Key points — revision questions

- What is the current in a circuit? What is its unit?
- How is the current measured in a circuit?
- What is voltage? What is its unit?
- What is the difference between an ammeter and a voltmeter?
- Why are voltage and current linked?

LEVEL 3

The junction rule — in a series circuit

When the current is measured in a circuit where the components are connected one after another (a series circuit), we notice that the current is the same at every point of the circuit.

Example: in a circuit with a battery cell, two lamps and a motor in series:

Leaving the cell, the current is IP

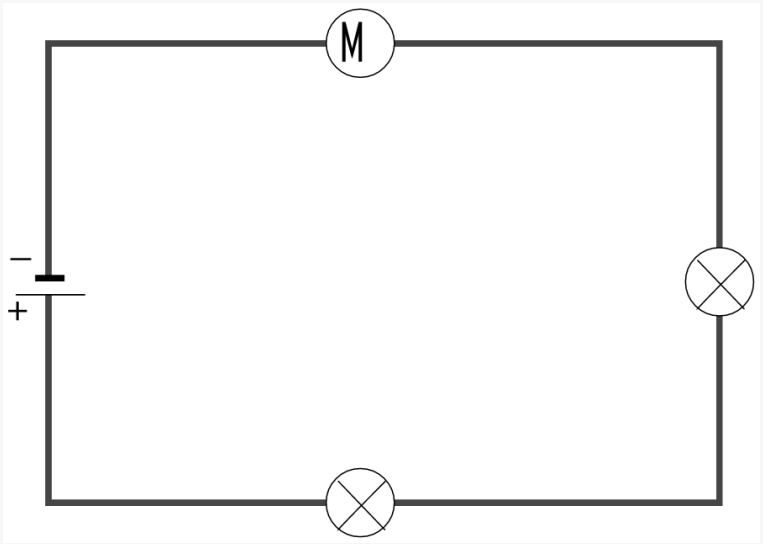
After lamp 1, the current is I_1

After lamp 2, the current is I_2

After the motor, the current is IM

We observe that: $IP = I_1 = I_2 = IM$

➞ With no junction, there is a single current: this is the junction rule in series (also called the rule of a single current).



The junction rule — in a parallel circuit

In a parallel circuit (several possible paths), the current in the main branch is equal to the sum of the currents in the side branches.

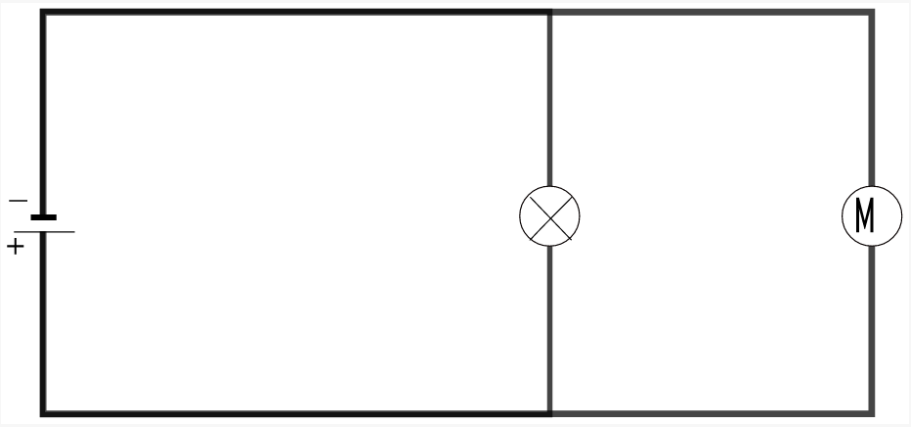
Example: a circuit with a battery cell and two lamps in parallel:

In the main branch (with the cell), the current is IP

In branch 1: I_1, in branch 2: I_2

We observe that: $IP = I_1 + I_2$

➞ All the current entering a junction comes back out of it: this is the junction rule (also called the rule of adding currents).



Key points — revision questions

- What happens to the current in a series circuit?
- How does the current vary in a parallel circuit?
- Which formula sums up the current rule in each type of circuit?

LEVEL 4

The loop rule — in a series circuit

In a series circuit, the voltage of the cell is shared between the receivers.

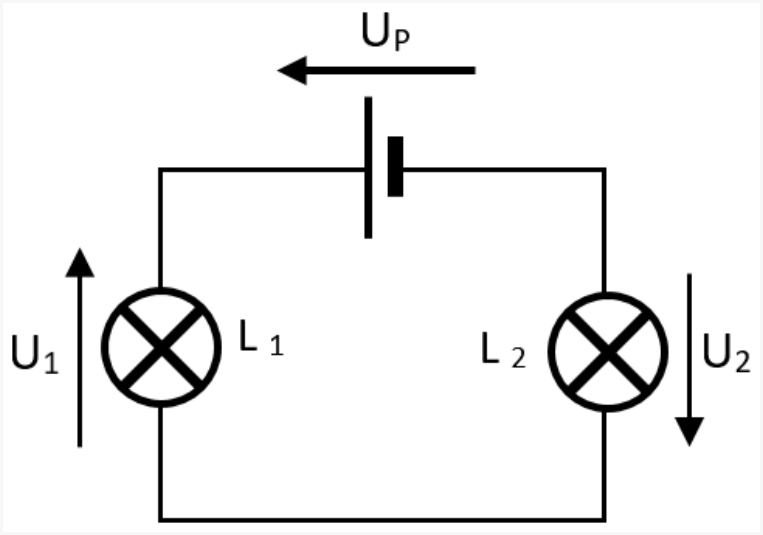
Example: a cell and two lamps in series:

Voltage across the cell: UP

Voltage across lamp 1: U_1, across lamp 2: U_2

We observe that: $UP = U_1 + U_2$

➞ A single loop, and the voltage of the cell is shared out: this is the loop rule (also called the rule of adding voltages).

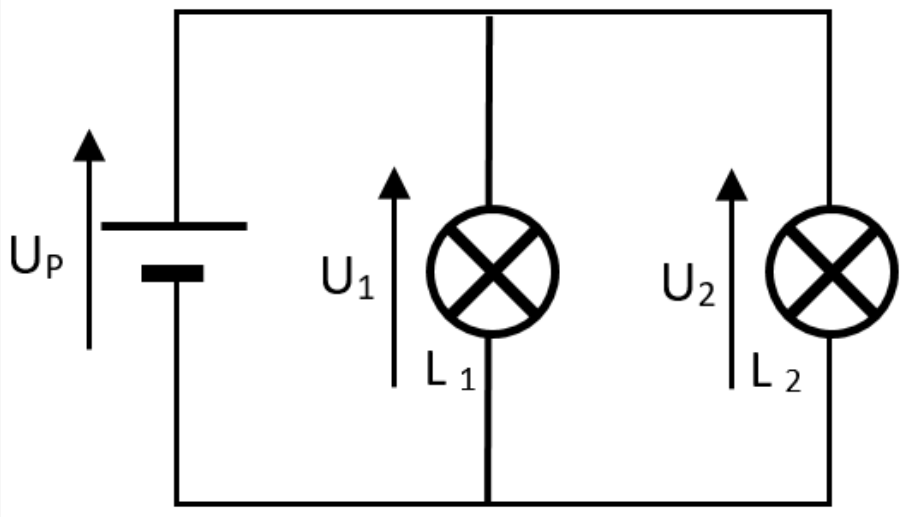


The loop rule — in a parallel circuit

In a parallel circuit, the voltage across the cell is the same in every branch.

We observe that: Up = U_1 = U_2

➞ Each loop contains the cell and a single receiver: this is the loop rule (also called the rule of a single voltage).



Key points — revision questions

- What happens to the voltage in a series circuit?
- What is the voltage in each branch of a parallel circuit?
- Which formula sums up the voltage rule in the two cases?

LEVEL 5

Electrical resistance

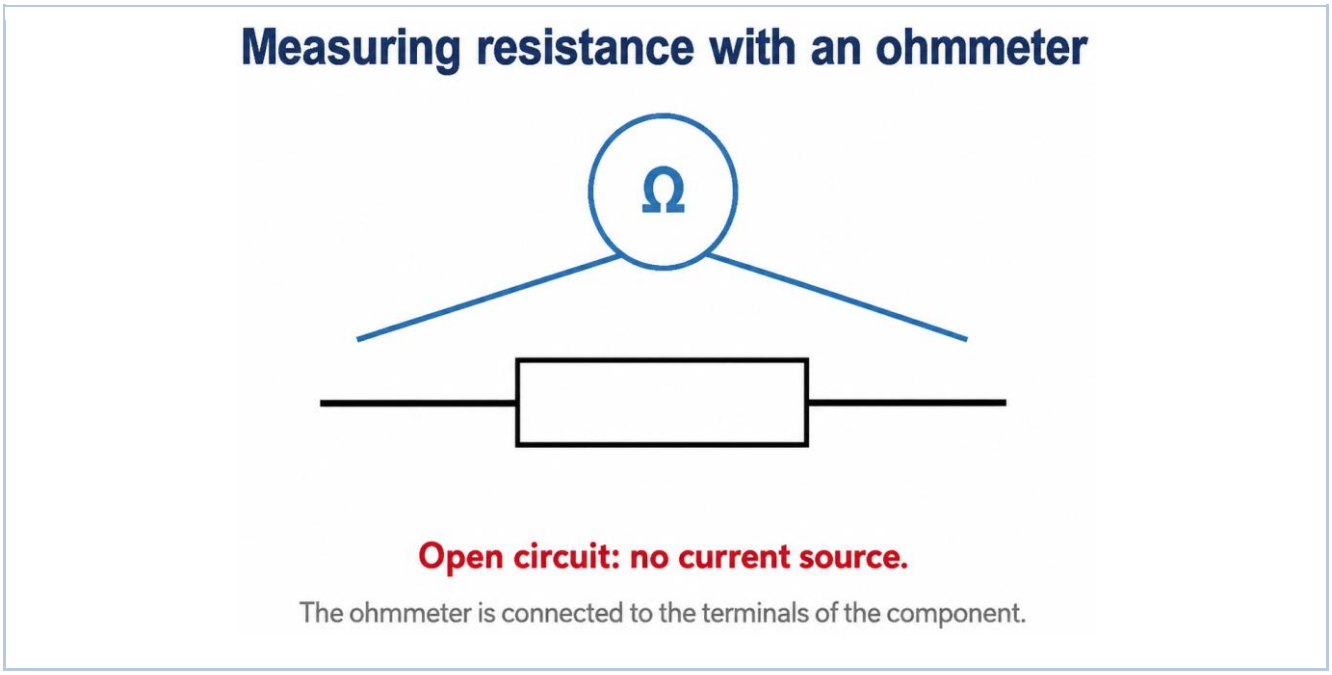
Resistance is the ability of a component or of a material to oppose the flow of the current. It is written R.

The more resistant an object is, the less current gets through. Conversely, if it has little resistance, it lets the current through easily.

Resistance is measured in ohms (Ω).

Measuring resistance

We use an ohmmeter. This instrument must be used out of circuit! So with no source of current at all. Its circuit symbol is shown opposite.



Ohm's law

There is a mathematical relation linking voltage (U), current (I) and resistance (R).

If we plot the voltage against the current for a resistive component, we obtain a straight line through the origin, which shows a relation of proportionality:

$$U = R \times I$$

It can also be written:

$R = U/I$

$I = U/R$

Key points — revision questions

- What is electrical resistance?
- What happens if the resistance is very high?
- Which relation links U, R and I?
- How do you work out R if you know U and I?

LEVEL 6

Power: energy per unit of time

Power is the amount of energy used (or supplied) per second.

It is written P and is expressed in watts (W).

Example: a 100 W lamp uses more energy than a 40 W one over the same time.

Power and energy

Power can be linked to energy and time by the formula:

$$P = E/t$$

P: power in watts

E: energy in joules

t: time in seconds

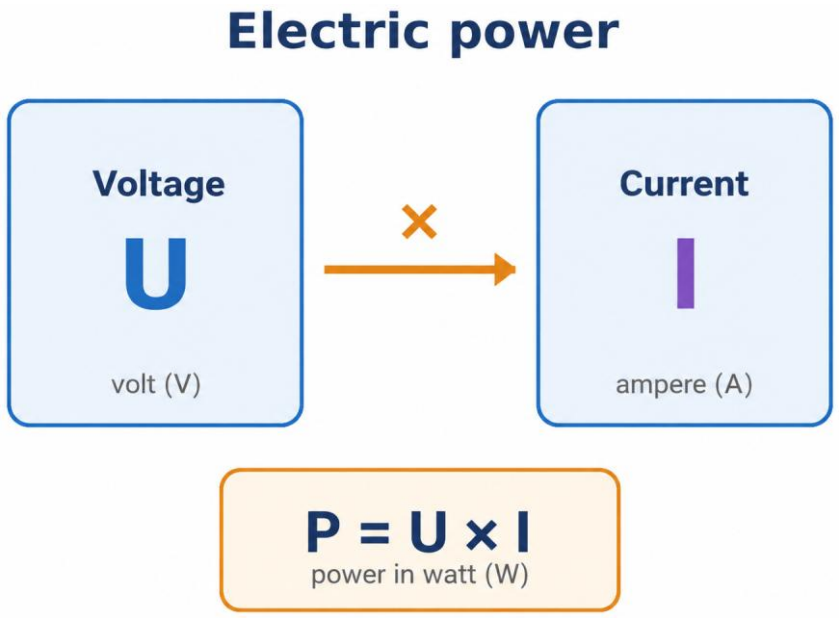
Electrical power in a circuit

In an electric circuit, the power can be worked out from the voltage (U) and the current (I):

$$P = U \times I$$

U: voltage in volts

I: current in amperes



Key points — revision questions

- What does power correspond to?
- What is the unit of power?
- Which formula links power, voltage and current?