

Materials: Conductors & Insulators

What lets electric current through, and what stops it?

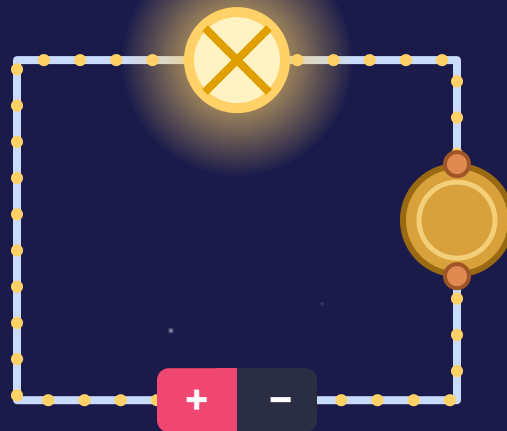
1 Testing a material

2 Conductors

3 Insulators

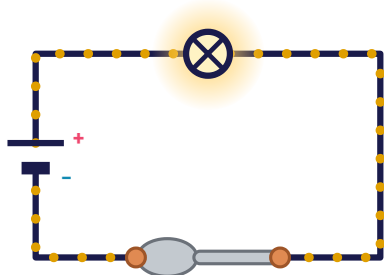
4 In between

5 The right material

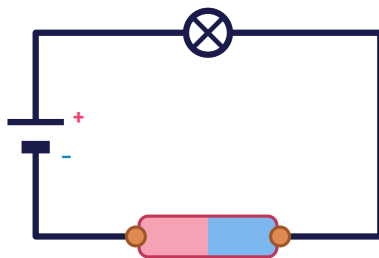


The Conductivity Tester

To find out whether a material conducts, make it part of a circuit and watch the lamp.



METAL SPOON: LAMP ON



ERASER: LAMP OFF

- Build a circuit with a battery, a lamp and three wires. Leave a **gap** between two bare wire ends.
- Touch both bare ends to the object you want to test.
- The lamp lights: the object closes the loop. It is a **conductor**.
- The lamp stays off: the loop is still open. It is an **insulator**.

💡 Try it in the Tester

The object becomes a piece of the loop: the current has to go through it.

Predict, Test, Write It Down

A scientist guesses first, then checks, and keeps a record of what really happens.

OBJECT	MY PREDICTION	LAMP	RESULT
 Key	CONDUCTOR	 lit	CONDUCTOR ✓
 Plastic ruler	INSULATOR	 off	INSULATOR ✓
 Metal spoon	CONDUCTOR	 lit	CONDUCTOR ✓
 Pencil lead	INSULATOR	 dim	CONDUCTOR ✗
 Glass jar	INSULATOR	 off	INSULATOR ✓
 Coin	CONDUCTOR	 lit	CONDUCTOR ✓

A fair test

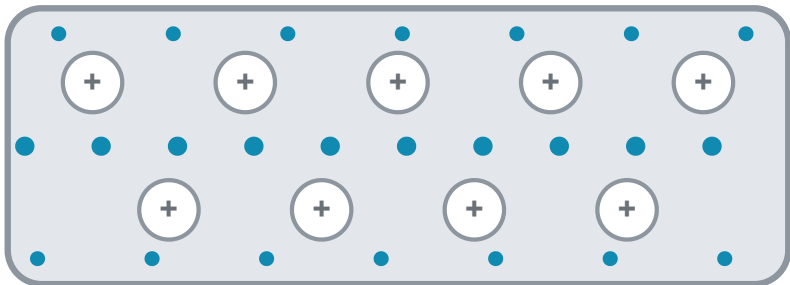
Same battery, same lamp, same wires: change only the object. Then the lamp tells you about the object, not about the rest.

A surprise is good news

A wrong prediction teaches you something. Pencil lead is not a metal, and yet it conducts!

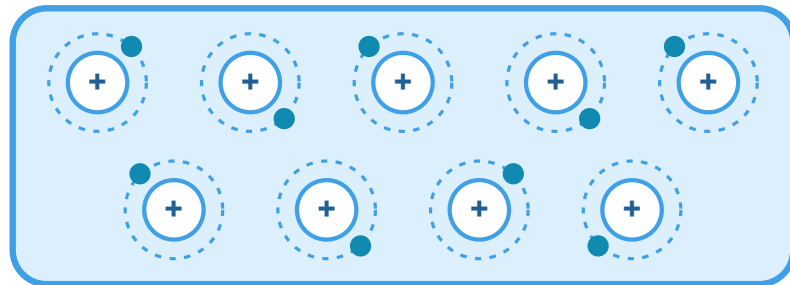
Free Electrons Make the Difference

Every material contains electrons. What matters is whether they can travel.



METAL: CONDUCTOR

Some electrons belong to no atom in particular. They wander between the atoms, and the push of a battery sends them all along the wire.



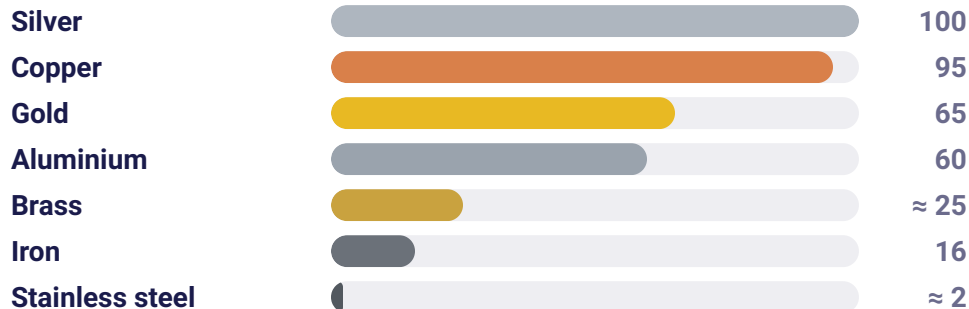
PLASTIC: INSULATOR

Each electron stays tied to its atom. It can wiggle on the spot but not travel: the battery pushes, and no current flows.

Colour, shape and size don't matter: only what the object is made of.

All Metals Conduct, But Not Equally

How well each metal conducts, compared with silver (100).



*Graphite would hardly show here: it conducts hundreds of times less well than copper.
Still enough to light a lamp!*

Silver: the champion

But it's too expensive for wires. Copper is almost as good and much cheaper: it's in nearly every cable in your house.

Gold never rusts

A very thin layer protects the contacts of connectors and computer chips.

Aluminium is light

Big high-voltage lines use it: for kilometres of wire, it is lighter and cheaper than copper.

Surprising Conductors

Metals are not the only conductors. These conduct too, only less well.



GRAPHITE

The “lead” of a pencil is made of carbon, not metal. Draw a thick, dark pencil line on paper: a tester with an LED lights up through it!



SALT WATER

Salt dissolved in water splits into tiny charged particles called **ions**. They carry the current.



LEMONS

Their juice is full of ions. Push a copper wire and a galvanized nail into a lemon: you’ve made a battery!

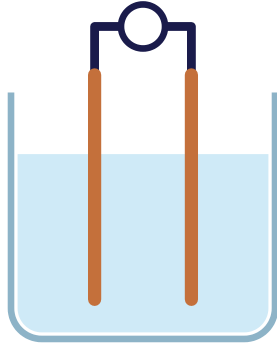


YOUR BODY

It’s full of salty water, so it conducts. Too weakly for a small battery to light a lamp through your hand, but a wall socket pushes hard enough to hurt you.

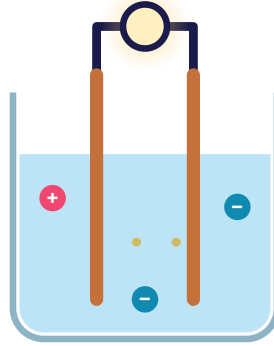
An LED is more sensitive than a lamp: it can show a weak conductor that leaves a lamp dark. Try both in the Tester!

Water: It Depends What's in It



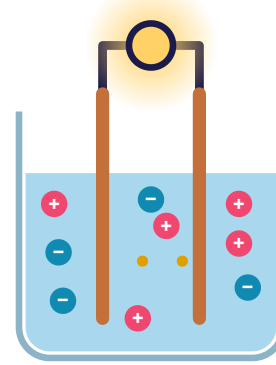
Distilled water

Pure water: almost no ions. The LED stays off.



Tap water

A few dissolved salts: the LED glows faintly.



Salt water

Lots of ions: the LED shines brightly.

Near electricity, all water conducts

Bath water, puddles, rain and sweat always contain salts and dirt. Never touch anything electric with wet hands or with your feet in water.

The Insulator Families

Their electrons are held tight. Here are the main families.

Plastics & rubber

- cable sheaths, plugs, switches
- electricians' gloves and boots
- erasers, balloons, toys

Glass & ceramics

- insulators on power poles
- the glass of light bulbs
- plates, mugs, tiles

Natural materials

- dry wood, paper, cardboard
- cotton, wool, leather
- cork, wax

Gases

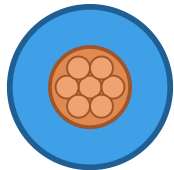
- air: it keeps the bare wires of power lines apart
- it only gives way at very high voltage, like lightning

Watch out: dry wood and paper insulate, but **wet** wood and paper let a little current through.



Sort them fast in Quick Sort

Insulators Keep Us Safe



Electric cable

The plastic sheath keeps the current inside the copper.



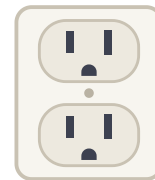
Gloves and boots

Electricians wear thick rubber gloves and boots to work near live wires.



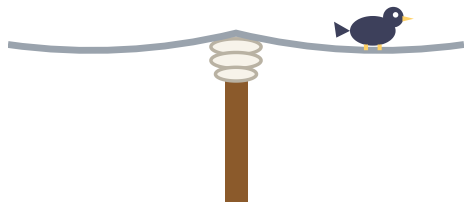
Electrician's screwdriver

A plastic handle, and even the shaft is covered: only the tip is bare metal.



Wall socket

The metal contacts hide deep inside a plastic cover, out of reach of fingers.



A bird on a wire

Power lines are bare: **air** insulates them, and **ceramic or glass insulators** hold them away from the pole. A bird can sit on one wire because the current has no loop through its body. Touching two wires, or a wire and the pole, would close a loop: danger!

When Insulators Give Up

An insulator only protects you if it is dry, clean and in one piece.



WATER

A film of water and dirt on an insulator conducts. Wet wood, wet skin and wet gloves no longer protect you.



HIGH VOLTAGE

Push hard enough and the current forces its way through. Lightning crosses kilometres of air, and a spark jumps from your finger to a doorknob.



DAMAGE

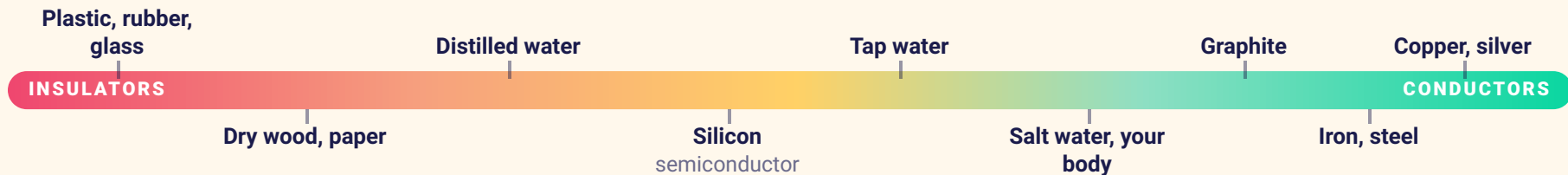
A cracked plug or a cable with its plastic worn through leaves the copper bare. Don't use it: tell an adult.

A fallen power line

Never go near a wire on the ground, or a branch touching a power line, even if it looks harmless. Stay at least **10 metres** away and tell an adult, who will call for help.

From Insulator to Conductor

Materials don't just say "yes" or "no": each one lets current through more or less easily.



Not to scale: the best conductors let current through billions of billions of times more easily than the best insulators.

Semiconductors

Silicon sits in the middle. Add a pinch of other atoms and it conducts exactly when we want: that's how computer chips, LEDs and solar panels work.

Guess, Then Check

Make your guess first, then tap a card to see the answer.



A soda can is covered with paint. Test the painted side: does the lamp light?

Check

No! Paint is an insulator. Scratch off a little paint and touch the bare aluminium: now it lights.



A sock: dry, then soaked in salty water.

Check

Dry: insulator. Wet: weak conductor. The salty water in the fabric makes a path for the current.



A pencil sharpened at both ends: the wires touch the two points.

Check

The lamp glows dimly. The graphite core carries the current from one point to the other. On the wooden sides: nothing.



Sugar water or salt water: which one lights the LED?

Check

Salt water. Sugar dissolves too, but it doesn't split into charged particles, so sugar water hardly conducts.



Scissors with plastic handles: conductor or insulator?

Check

Both! The steel blades conduct, the plastic handles insulate. It depends where you test.



A gold ring: conductor or insulator?

Check

Conductor. Gold is a metal, and one of the best conductors, just behind silver and copper.



Test them yourself in the Tester

One Object, Several Materials

Conductors where the current must flow, insulators where hands touch.



A plug

CONDUCTOR brass blades carry the current

INSULATOR plastic body, safe to hold

CONDUCTOR copper wires inside the cord



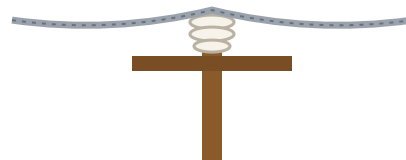
A light bulb

CONDUCTOR tungsten filament glows white-hot

INSULATOR glass bulb around the filament

CONDUCTOR metal base and tip bring the current

INSULATOR black glass ring keeps them apart



A power line

CONDUCTOR aluminium wires, with a steel core for strength

INSULATOR glass or ceramic insulators

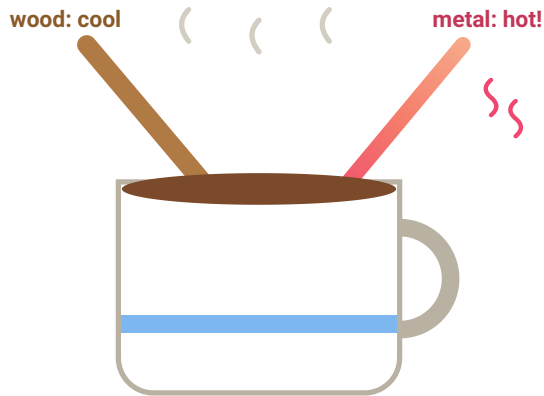
INSULATOR the air around the bare wires



Build them in the Electrician's Workshop

Heat Takes the Same Road

Good conductors of electricity are usually good conductors of heat too.



- The free electrons of metals carry **heat** as well as current.
- A metal spoon in hot chocolate is soon hot all the way up. A wooden or plastic spoon stays cool.
- Saucepans are metal, so the heat reaches the food quickly, with handles of plastic or wood so you can hold them.
- In winter, metal feels colder than wood at the same temperature: it carries the heat away from your hand faster.

The odd one out

Diamond carries heat even better than copper, and yet it is an electrical insulator!

What You've Learned

1

Test it in a circuit

If the object closes the loop and the lamp lights, it's a conductor. If not, it's an insulator.

2

Free electrons or ions

Metals and graphite have free electrons; salty water has ions. Plastic, rubber, glass, ceramic, dry wood and air hold theirs tight.

3

The right material

Conductors carry the current. Insulators keep it on its path and protect us, as long as they stay dry and whole.

Play the Materials Lab!

[Tester](#)

[Quick Sort](#)

[Electrician's Workshop](#)

[Quiz](#)

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