ELECTRICITY MATTERS 1

CP7325

Inspiring The Next Generation Of Engineers

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Contents

WORKSHEETS

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Worksheet 1 - Conductors and Insulators

We are surrounded by many kinds of materials. They all behave in different ways.

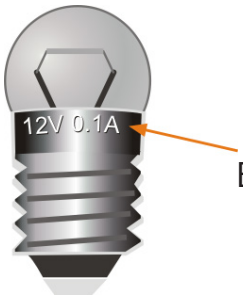
One way in which they are different is that some pass electricity, and others do not.

Materials which pass electricity are called **conductors.**
Materials which do not pass electricity are called **insulators.**

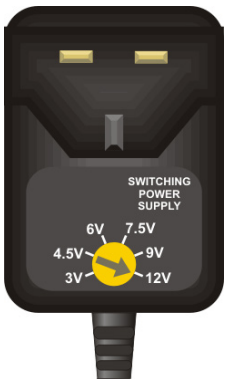
Over to you

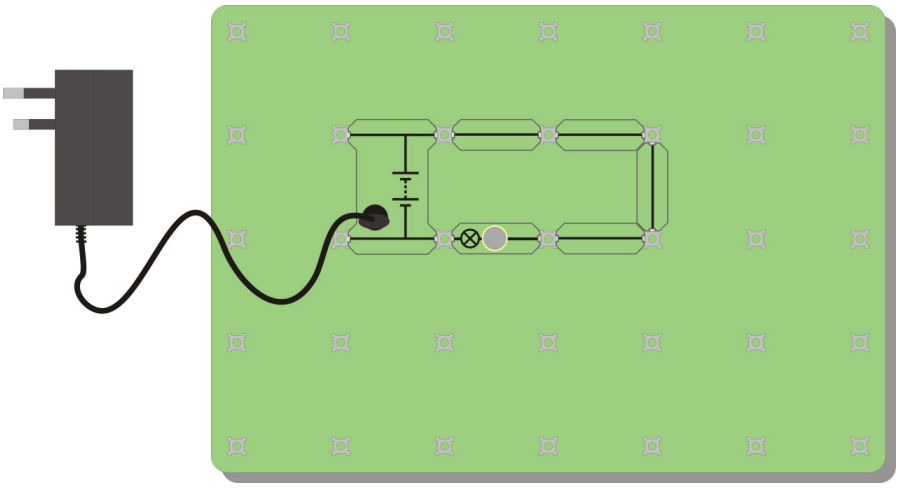
Build a circuit that makes a bulb light. The picture shows one way to do this.

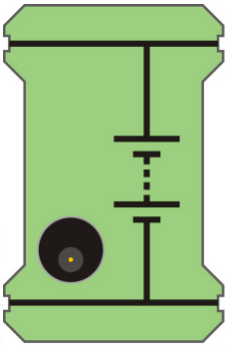
Set the power supply to 12V. Use a 12V 0.1A bulb. (See the picture!)



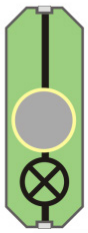
Bulb rating





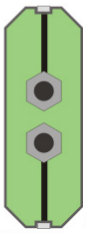


Battery



Bulb

Link



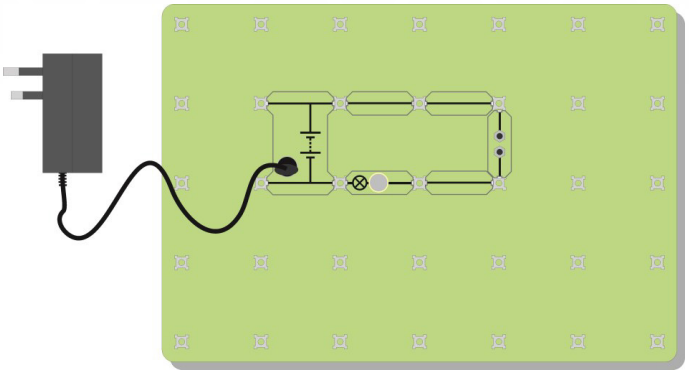
Sampler

Here are the names of some of the components that you will use on the board.

WORKSHEETS

Worksheet 1 - Conductors and Insulators

Swap one link for the carrier with the sampler. Your board now looks like the picture.



Put different materials across the gap, in turn. See if the bulb lights.

Try the following:
kitchen foil (aluminium), a rubber, paper, polythene, copper, air, lead, pencil lead (graphite), glass, wood, a coin, a piece of cloth, a plastic pen any other handy items.

Sort the materials into two groups – **conductors and insulators.**

Fill in a table, like the one shown here, with the findings from your experiment.

Materials that conduct	Materials that insulate

So What?

- Look at the materials that let electricity pass.
- Which class of substance do they all belong to?
- If you had a hard, shiny object that felt cold to touch, would you expect it to be a conductor? Explain your answer to your partner or to your teacher.
- Think of a way to test whether water is a conductor or an insulator. Check your idea with the teacher, and if you get the go-ahead, try your idea out.
- Test pure water, tap water (they are not the same thing!) and salty water. Is there a difference?

For your records:

- Most of the conductors belong to the class of substances called .....
- I think that the hard shiny object that felt cold would ..... electricity, because it is probably made of a .....
- Pure water is an ..... However, if there are any impurities in it, such as salt, or chlorine, then the water is a .....
- Air is an ..... which explains why we do not get an electric shock when we stand near a mains electricity socket.

A roller coaster goes round a circuit. It finishes at the same place as it starts.

Electricity is the flow of invisible particles called electrons. They go round a track of wire.

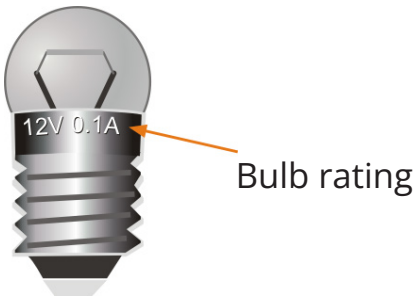
We call electric pathways **- circuits.**

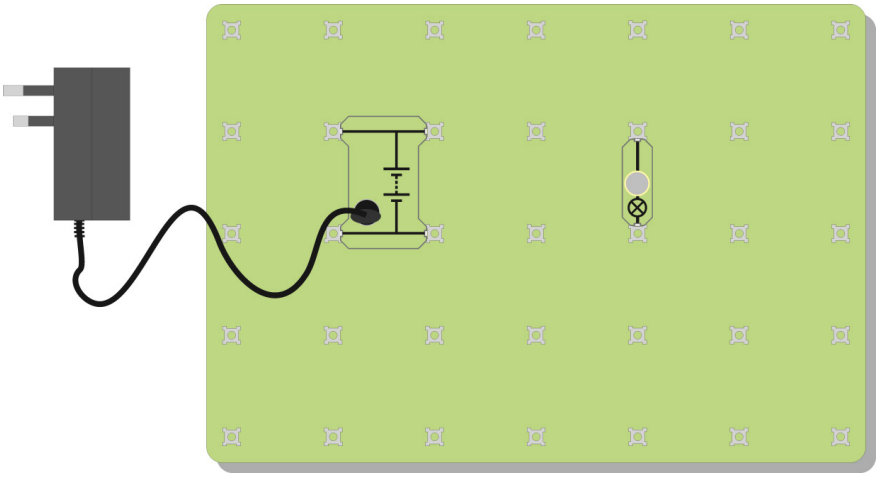
Over to you

Set up the arrangement shown, using a 12V 0.1A bulb.

Make sure that the power supply is set to 12V.

Add connecting links to make the bulb light.





You have just used two circuit symbols, one standing for a battery, or group of batteries, and the other for a lamp, or sometimes any kind of indicator.

We will look at more of these symbols in later worksheets.

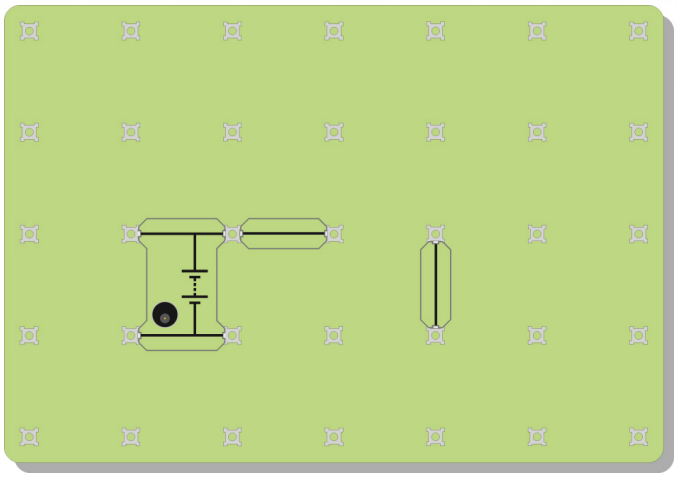
You should try to learn them as you use them.

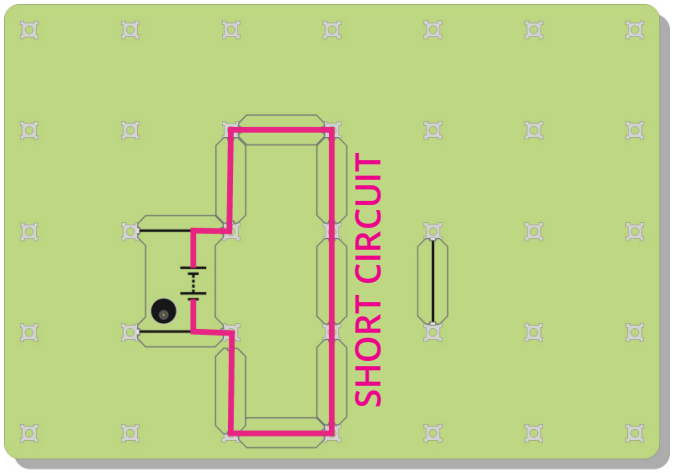
Battery

Bulb

Make other shapes with the links to make the bulb light.

You could try to complete the arrangement shown here.





BE CAREFUL!

Don't create a **short circuit**, where the electricity can get from one side of the power supply to the other without going through the bulb.

This might damage the power supply! The diagram opposite shows an example of a short-circuit.

So What?

- You need a complete circuit to make the bulb light. There must be an unbroken path of conductors going from the power supply to the bulb and then back to the power supply.
- The actual shape of the circuit makes no difference.
- Can you set up a circuit to make two bulbs light? There are two ways to do this. One way makes the bulbs dimmer than when there was just one bulb. The other way keeps roughly the same brightness as in the one-bulb circuit. Can you make both of these circuits?

For your records:

For a bulb to light, there must be:

- A source of ....., such as a battery or power supply;
- Wires of metal to ..... the electricity;
- Wires which are insulated by a ..... coating to stop the metal conductors touching each other;
- A complete ....., with no gaps in it.



We use electricity in many ways, not just for lighting bulbs.

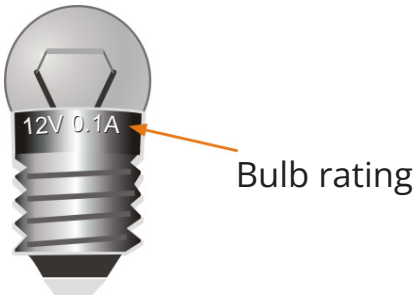
It heats our homes, drives our washers, driers and vacuum cleaners, and powers our computers, games and phones.

Electric currents warm up the wires that they flow through.

Over to you

Set up the arrangement shown in the diagram below, using a 12V 0.1A bulb.

Make sure that the power supply is set to 12V.

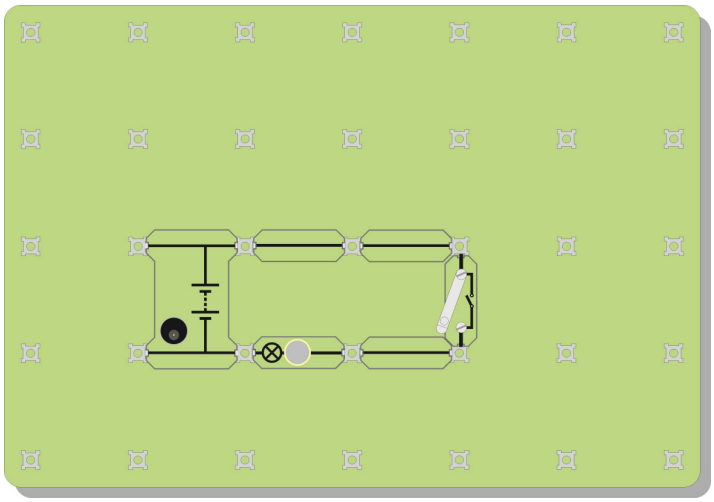


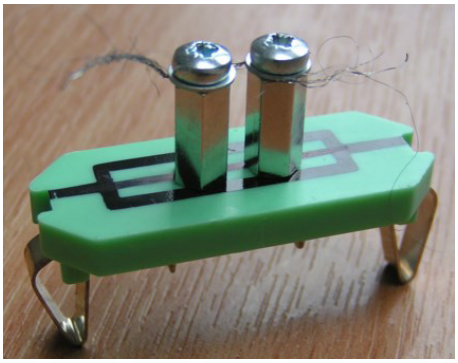
Switch on by closing the switch.

Look at the lamp filament. It should be glowing yellow-hot.

Take hold of the glass envelope of the lamp.

Does it feel warm?
Switch off.





Tease out one or two strands of wire wool from the pack.

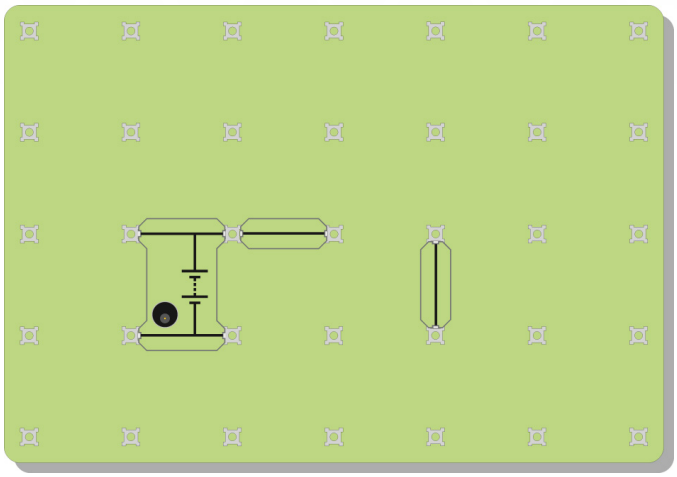
Carefully clamp them across the gap of the sampler, as shown in the photograph.

Worksheet 3 - Electric Current

Modify your circuit, as shown opposite, by swapping one of the connecting links for the sampler.

Switch on by closing the switch.

What happens?

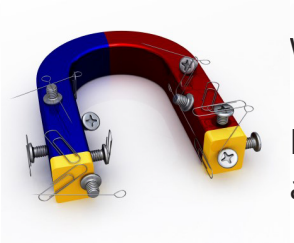


So What?

- An electric current can heat things up.
- Some kinds of wire heat up more than others.
- Some wires get so hot that they glow. This is what is happening inside some kinds of light bulb. In fact this kind of light bulb gives out more heat than light!
- Find out as much as you can about low-energy light bulbs. Explain to your partner why it is a good idea to use these instead of 'normal' light bulbs (the ones that get very hot!)

For your records:

- When an electric ..... flows through wires, it warms them up.
- Some kinds of wire get so hot that they .....
- One kind of light bulb, called a filament lamp, uses this effect to produce light.
- They are expensive to run because they give off more ..... than .....



We use electricity in many ways, not just for lighting bulbs.

It heats our homes, drives our washers, driers and vacuum cleaners, and powers our computers, games and phones.

Electric currents can make wires behave like magnets!

Over to you

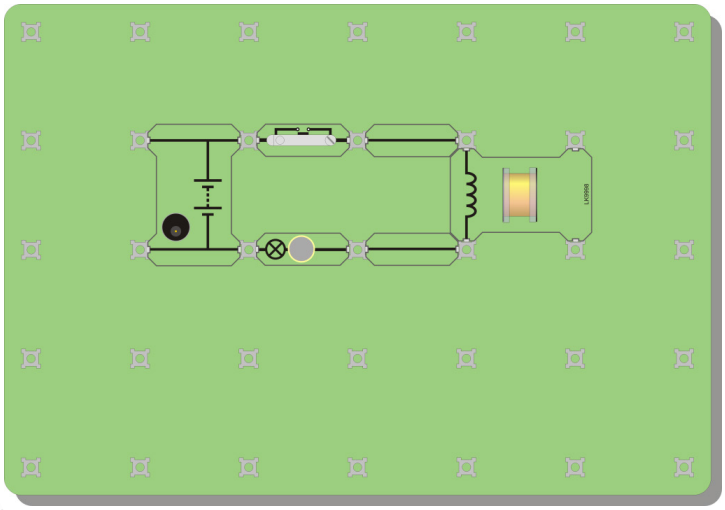
Set up the arrangement shown in the diagram, using a 12V 0.1A bulb, and the mounted coil.

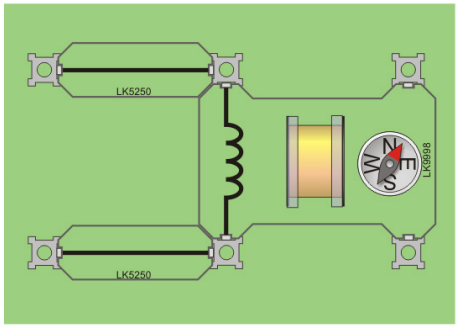
Make sure that the power supply is set to 12V.

Place a magnetic compass next to the coil.

Turn the board so that the compass needle points across the opening of the coil.

Press the switch. What happens?
Now switch off and repeat this again.





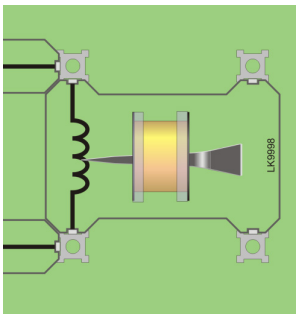
Wave a magnet near the compass.

What happens?

What does this show about the coil when it was carrying a current?

So What?

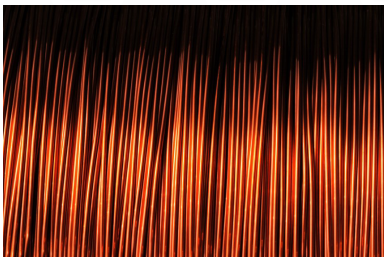
- An electric current can make the coil behave the same as a magnet.
- Slide a steel nail inside the coil. Switch on the power supply and watch the magnetic compass. Is the effect stronger than before?



- See if you can make paper clips stick to the nail.
- Try the same experiment using an iron nail instead of a steel nail. Can you see any difference? (Look carefully at what happens after you have switched off the electricity, in both cases.)
- How do you think you could make the magnetic effect stronger? Explain your ideas to your teacher. You may be able to try your ideas out!

For your records:

- When an electric current flows through a wire, it produces a ..... effect.
- The effect is stronger if you form the wire into a coil and push a nail, made of ..... or ....., down the centre.
- The nail then behaves like a ..... It affects a compass needle, and can even pick up paper clips.
- Two ways to make the magnetic effect stronger are:
- Add more .....;
- Increase the .....



Electric currents cause a number of effects.
They can:

- Heat up the cables they pass through.
- Produce magnetic effects.
- Cause chemical reactions to take place.

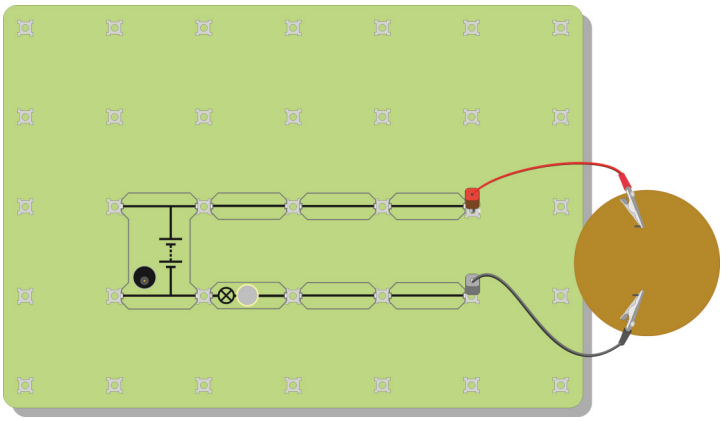
In industry, processes such as electrolysis and electro-plating rely on these chemical reactions.

Electric currents can cause chemical reactions!

Over to you

Set up the arrangement shown in the diagram as follows:

- Carefully push the two graphite pencil leads through the hardboard disc, as shown. Take care not to snap them!
- Wear your goggles to protect your eyes.
- Pour about 200ml of copper sulphate solution into a 250ml beaker. The concentration of copper sulphate used here is not hazardous, but make sure that you wash your hands at the end of the investigation.
- Lower the graphite rods into the beaker, so that the hard-board disc sits on top of the beaker.



- Connect two electrical leads to the rods using crocodile clips. Again, take care not to snap the rods!
- Connect the circuit shown in the diagram, using a 12V 0.1A bulb. The lamp is included so that you can see when a current is flowing.

Watch carefully to see if anything is happening in the beaker.

You should see two events taking place.
Notice which electrode (graphite rod) is involved.

Here is another example of a chemical reaction produced by an electric current.

This time, the electrodes are both strips of copper.

Once again, connect the electrodes to the circuit shown earlier.

Watch carefully to see what happens!

So What?

An electric current can cause a chemical reaction.

What did you see to make you think that a reaction was taking place?

How could you check that an electric current was flowing?

How can you make sure that the reaction was caused by the electric current?

Discuss your ideas with your partner, and then explain what you think to your teacher.

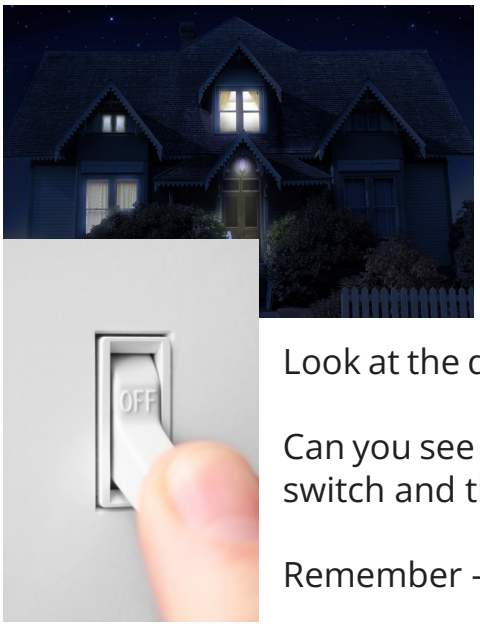
Come up with a plan to test your ideas. The teacher may be happy for you to go ahead and try out your plan.

For your records:
An electric current can cause a chemical reaction to take place.

This effect is very useful in the chemical industry.

It is used to purify chemical substances, and produce new ones.

The applications of this effect include **electrolysis and electroplating.**

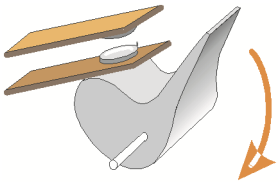


Have you ever been told not to leave lights on?

Leaving them on wastes energy, and money! We need something to control the flow of electricity.

A switch does just that!

Look at the drawing! It shows how a switch works.



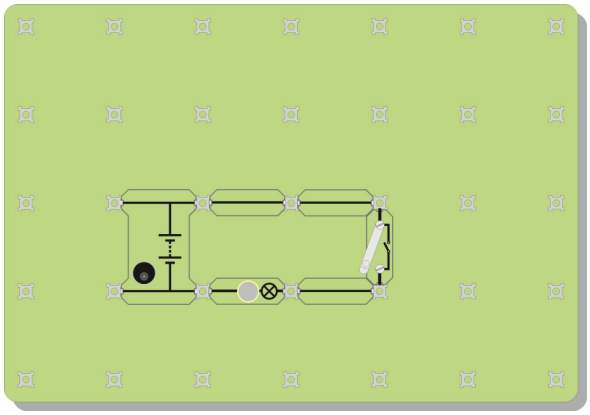
Can you see what will happen when you press the switch and the lever moves down?

Remember – air is an insulator!

A switch starts and stops the flow of electricity.

Over to you

Set up the arrangement shown in the diagram, using a 12 V power supply and a12V 0.1A bulb.



Close the switch, and see what happens.

Change the circuit so that there are two bulbs in it, and the switch controls both bulbs.

Now change the circuit again so that the switch controls only one bulb.

The other bulb should be lit all the time.

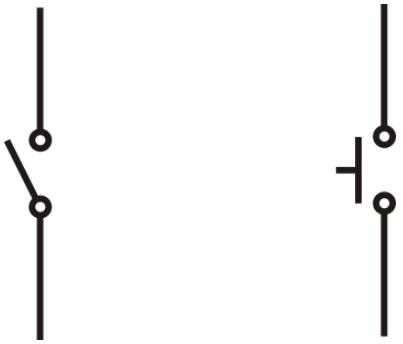
WORKSHEETS

Worksheet 6 - Switches

The diagram on the right shows the symbols used for two kinds of switch.

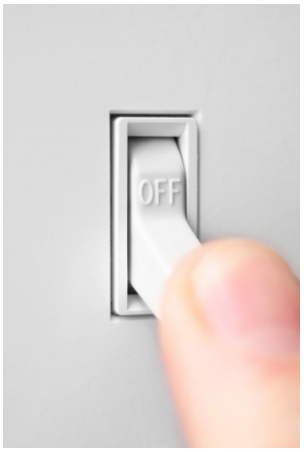
A push switch is 'on' only as long as you are pressing it. When you turn on a toggle switch, it stays on, until you turn it off.

Here are two pictures of switches—a doorbell switch, and a light switch. Decide whether each is a toggle switch or a push switch.



Toggle Switch

Push Switch

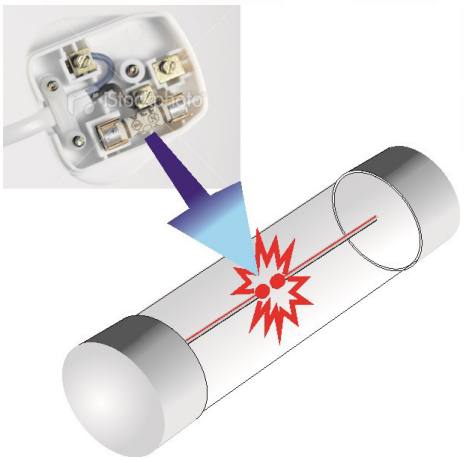


So What?

- A switch starts and stops the flow of electricity. What stops the electricity from flowing when the switch is open?
- Does it matter where the switch is placed in the circuit shown in step 1? Explain the answer to your partner, and then do an investigation to see if you were right.

For your records:

- A switch starts and stops the flow of .....
- When the switch is open, the ..... gap stops the flow of electricity.
- When the switch is ....., the air gap disappears, and electricity flows around the circuit.
- A toggle switch stays on or stays off all the time. A push switch is on only as long as you press it.
- A doorbell is one type of ..... switch.
- A light switch is one type of ..... switch.



Electricity can be dangerous.

The low voltage you are using in your experiments is safe, but the high voltage used in the mains electricity supply can kill.

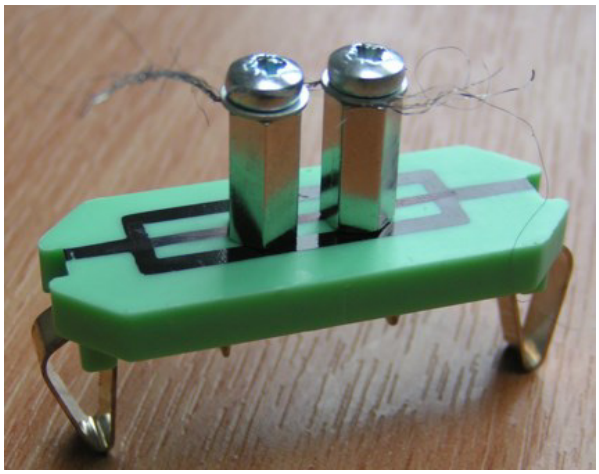
If there is a problem in a mains circuit, the wires can get so hot that they set the house on fire.

We need a safety device!

Fuses protect us when electrical gadgets are faulty.
They prevent fires when electrical faults occur.

Over to you

Clamp one or two fibres of steel wool between the terminal pillars of the sampler.



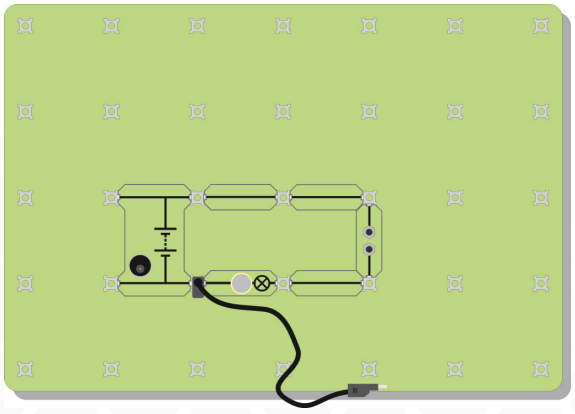
Build the circuit shown in the next diagram, using a 12V power supply and a 12V 0.1A bulb.

Leave one end of the black lead loose. Make sure that it does not touch any part of your circuit.

Close the switch and make sure that the bulb lights.

Now create a fault in the circuit.

Touch the loose end of the wire lead onto the right hand side of
the bulb, for a moment.



You just short-circuited the bulb. What happens?

This diagram shows the symbol used for a fuse.

Fuse

So What?

- The fine fibre of steel wool gets hotter than the other wires. In fact, it gets so hot that it melts. Try to find out from the internet what temperature steel melts at.

- Once the fibre melts, there is an air gap in the circuit, rather like when a switch is open. No electric current can flow.

For your records:

- A fuse contains a fine metal wire.

- When the flow of electricity gets too big, this metal gets so hot that it ....., and breaks.

- This creates an air ..... in the circuit, which stops the flow of electricity.

- This stops the other ..... in the circuit from getting too hot, and causing a fire.

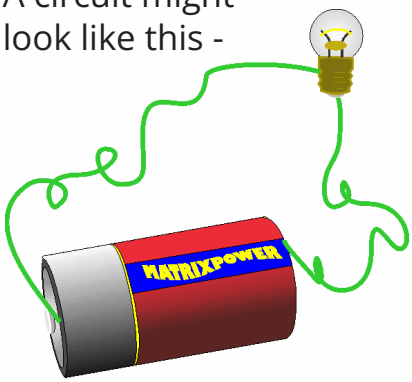
Everyday you come across **symbols**, used at home or when you are out and about.

They are quicker to read than long messages using words!

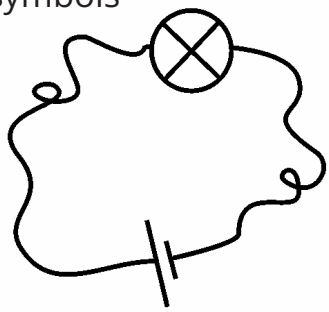
In this sign the language may be difficult to understand, but the symbols are not!

Circuit symbols are used to describe which components are used in a circuit, and how they are connected.

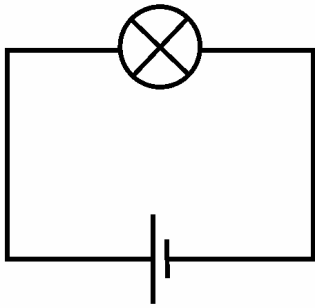
A circuit might look like this -



It is simpler to use symbols -

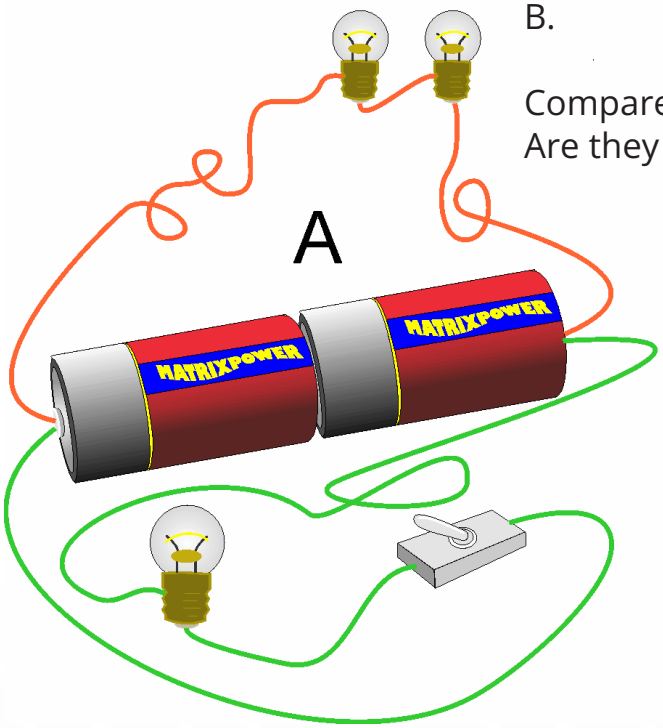


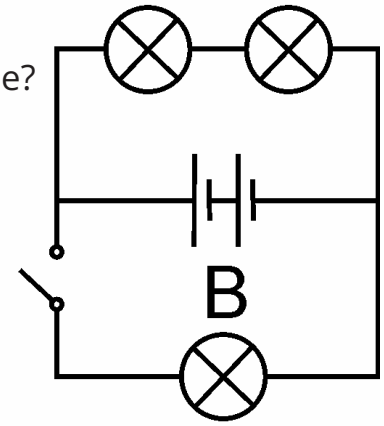
Or better still -



Look at the two circuits, A and B.

Compare them.
Are they the same?



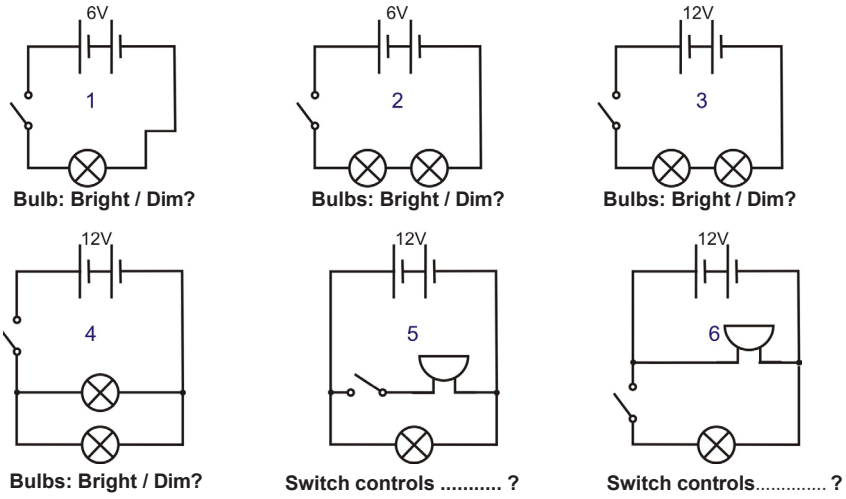


Over to you

Build the circuits shown in the next diagram, using 12V 0.1A bulbs.

The power supply voltage is given in each circuit diagram.

Work out the answers to the questions.



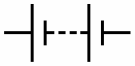
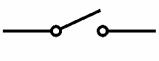
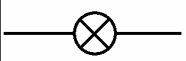
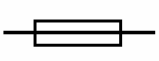
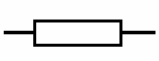
So What?

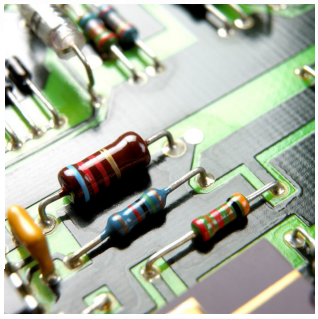
It is much quicker and easier to describe what is in a circuit by drawing a diagram using symbols. However, you must use the symbols that everyone understands.

For your records:
Copy the following table.

You have seen the buzzer, or sounder, in the circuits above.

You will learn about the resistor soon.

					
Battery	**Toggle switch**	**Lamp**	**Fuse**	**Resistor**	**Sounder**
Supplies electrical energy	**Allows a circuit to work**	**Turns electricity into light**	**A safety device**	**Controls the size of the current**	**Turns electricity into sound**



Using a tap, we can change the flow of water from fast to slow.

With electricity, we change the flow using a resistor.

The second picture shows resistors connected in a printed circuit board.

Electric currents can cause a variety of effects – heating, lighting, magnetism and chemical.

Although we cannot see them, tiny particles called electrons make up electric currents. The flow of these electrons can be reduced by adding more resistance to the circuit.

The effect of resistance is like you trying to run in mud.

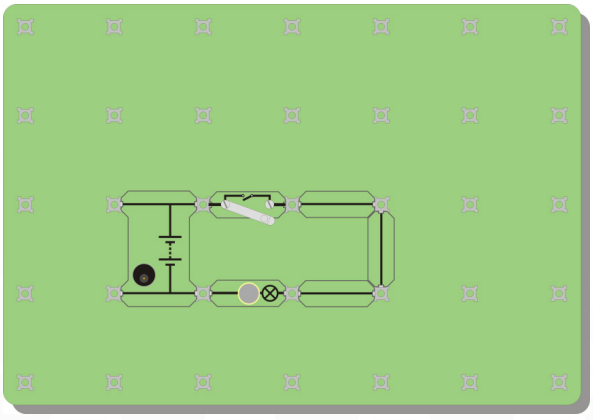
Over to you

Make your own resistor by clamping a rod of graphite (a mixture of carbon and clay, used in pencil lead,) using crocodile clips onto the ends of two connecting leads . The rod should be as long as possible, and at least 15cm long.

Set up the circuit shown on the right, using a 12V 0.1A bulb.

Close the switch and notice how bright the bulb looks.

Remember – the brighter the bulb, the greater the current flowing.

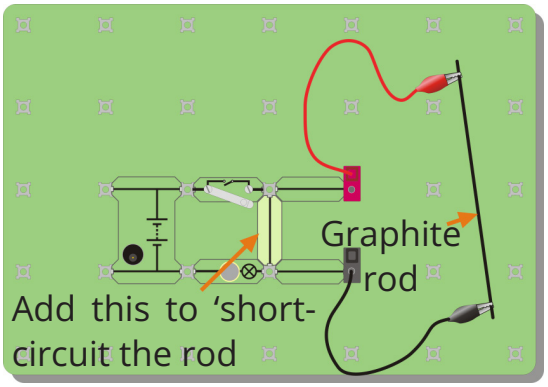


Over to you

Next, swap your pencil lead resistor for one of the connecting links and then close the switch again.

What do you notice about the bulb? What does this tell you about the electric current when you add the resistor?

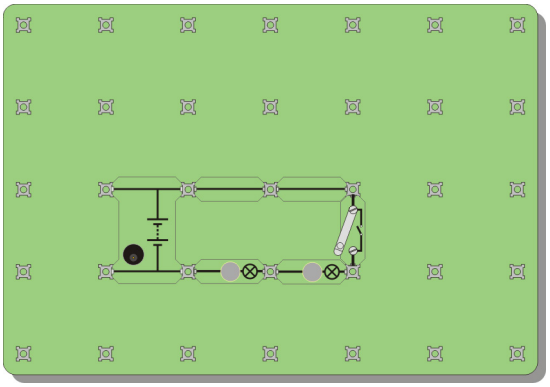
(You could make it easier to compare by 'short-circuiting' your resistor. To do this, add a connecting link as shown in the diagram.)



Now set up the circuit shown in the next diagram, using two 12V 0.1A bulbs.

Close the switch.

What do you notice about the brightness of the two bulbs compared to the brightness of the single bulb in the first circuit (before you added your resistor)?



So What?

- Adding more resistance to a circuit makes the electric current smaller.
- It is not only 'resistors' that have resistance – pencil lead, bulbs, even the wires themselves and the power supply have some resistance.
- Swap one of the bulbs for a 12 ohm resistor. Notice the brightness of the remaining bulb. What does this tell you about bulbs?
- A good question – where does the 'extra' electric current go when you add a resistor? Think about the flow of other things, like water, or traffic. When you turn a tap down a little to lower the flow of water, where has the 'missing' flow of water gone? When a car breaks down on a busy road, the flow of traffic is reduced. Where is the 'missing' flow of cars?

For your records:

- A resistor limits the flow of electricity.
- The bigger the resistance, the smaller the electric current.
- Resistance is measured in ohms. Usually, we use the Ω sign to mean 'ohms'.
- The symbol used for a resistor is shown opposite:

Resistor

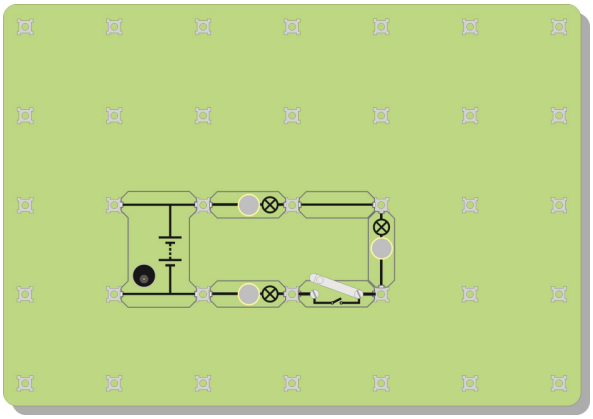
We use sat-nav (satellite navigation) systems to plan our route when travelling by car. These powerful electronic processors look at the many possible routes and choose the best.

In some electrical circuits, there is only one possible route, and all the electricity must flow around it. These are called **series** circuits.

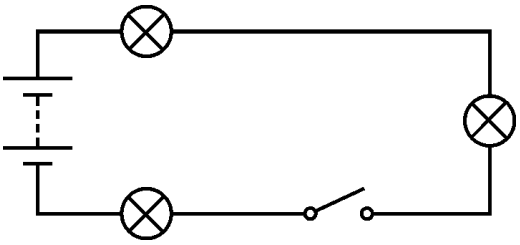
A series circuit offers only one route around the circuit, from one end of the battery back to the other! There are no junctions in a series circuit.

Over to you

Set up the arrangement shown, using a 12 V power supply and 12V 0.1A bulbs.



This is a series circuit—everything connected in a line, one after the other. There is only one way for electric current to get from one end of the battery to the other. There are no junctions, no alternative routes!



Here is the same circuit, drawn using symbols, compare the two versions of the same circuit diagram!

Close the switch and notice how bright the bulbs look.

Don't forget – the brighter the bulb, the greater the current flowing. Unscrew one of the bulbs and notice the effect.

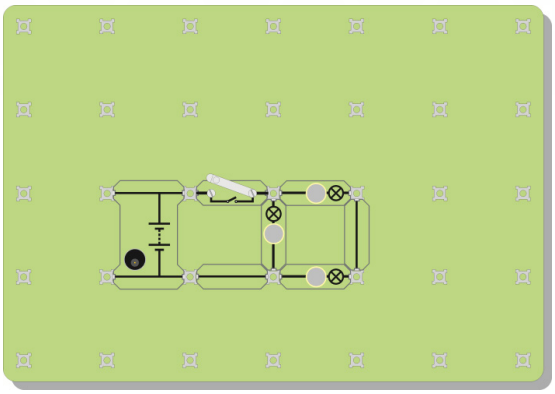
Does it look as if electric current is getting 'used up' as it goes round the circuit? (In other words, do the bulbs get dimmer as you move further from the battery?)

If the bulbs have the same brightness, then the current flowing through them must be the same. (Remember - the bulbs are mass-produced, and so are never completely identical.)

WORKSHEETS

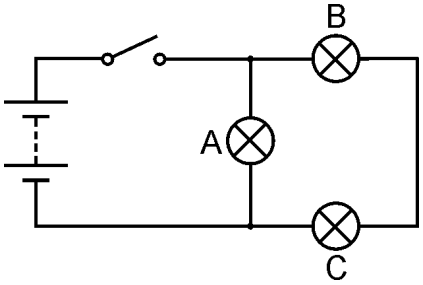
Worksheet 10 - Bulbs in Series and Parallel

Now change the circuit for the one shown, still using the 12V setting on the power supply and 12V 0.1A bulbs.



This is not a series circuit—there are two ways to get from one end of the battery to the other!

Trace these routes out for yourself.



The 'blobs' above and below bulb A mark junctions in the circuit.

Look at the brightness of the bulbs.
What does this tell us?
Unscrew bulb A. What happens?
Unscrew bulb B. What happens?

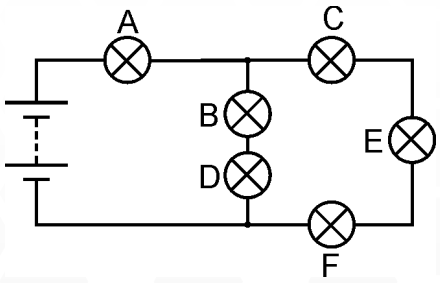
So What?

- One route goes through only one bulb. The other goes through two bulbs. That route is twice as difficult for the electrons. Most will take the easy route through just one bulb. The more electrons flow per second, the greater the electric current. Explain to your partner or your teacher how your observations support this idea.
- The second circuit is not a series circuit as there are two ways to get from one side of the battery to the other. Bulb A is connected in parallel with the other two bulbs. Bulb B is in series with bulb C because they are on the same route.
- **A challenge!** Change the circuit so that the switch controls only bulbs B and C, BUT you can only move bulb A.

For your records:

- A series circuit offers only one route for the electric current. If a break appears anywhere in the circuit, then the electric current stops everywhere. If one bulb fails in the circuit, then all the bulbs go out. The electric current is the same size throughout the circuit.
- A parallel circuit offers more than one route and so different currents can flow in different parts of the circuit.
- Copy the circuit diagram and answer these questions:

1. Bulb B is in series with bulb ..... .
2. Bulb C is in ..... with bulb E and bulb F.
3. Bulbs B and D are in ..... with bulbs C, E and F.
4. The biggest current will flow through bulb .....
5. Bulb ..... will be the brightest bulb.



Quiz

Round 1

Name three materials which pass electricity.

Which of these is an insulator? Copper, mercury, rubber, tin.

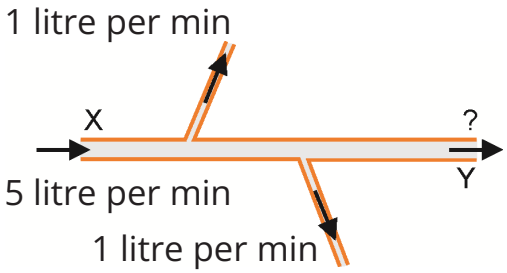
What happens to the fine wire in a fuse when it 'blows'?

When a switch is open, what substance stops electricity flowing?

An electric current can produce a magnetic effect, a heating effect and a chemical effect.

Which of these effects is used in a filament light bulb, like the one shown in the picture?

Round 2



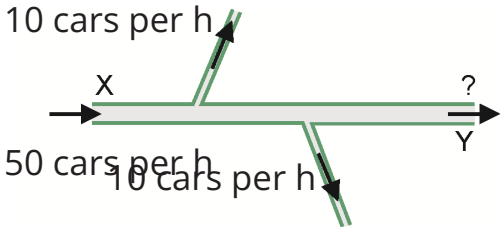
Here is a pipe, carrying water. It does not leak!

Five litres of water enter the pipe at X every minute. Some water flows down the side pipes, as shown.

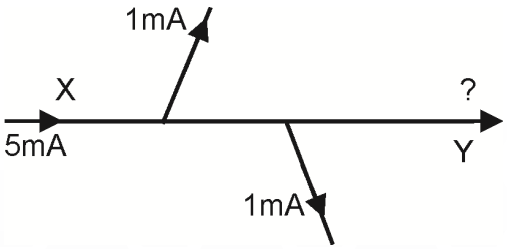
How many litres per minute leave the pipe at Y?

Here is part of a one-way system of roads, carrying only cars!

There are no crashes! No-one parks! There are no car factories or garages!



How many cars leave the system at Y each hour?



Here is part of an electric circuit.

Electric current is measured in units called milliamps, (mA).

How big is the current at Y?

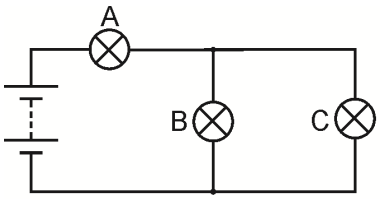
Electric currents are made up of millions of electrons flowing down the wires. These questions suggest that electric circuits do not leak, and that electrons do not crash or park, and are not made in factories, even on a Sunday!

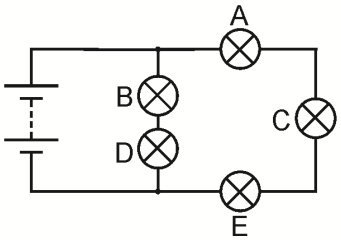
Quiz

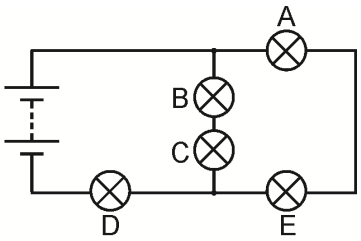
Round 3

In the next three circuit diagrams, all the bulbs are identical.

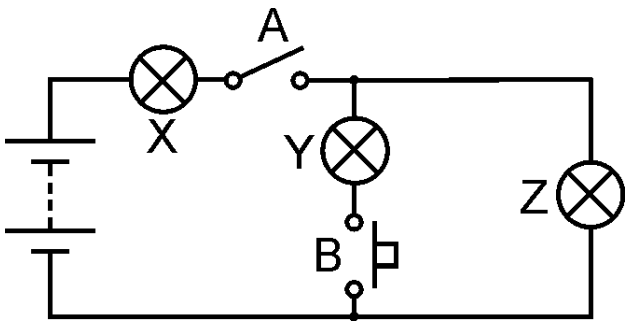
Which bulb, or bulbs, will be the brightest in each of the circuits?







Round 4

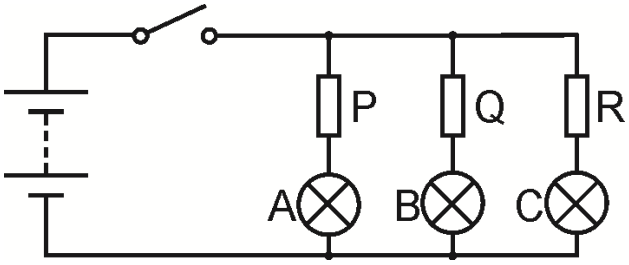


Look at the circuit opposite.

To begin with, only switch A is closed (switched on.) Which bulb, or bulbs, light(s)?

Next switch B is closed as well as switch A. Which bulb, or bulbs, light(s) now?

Round 5



When the switch is closed, bulbs A and C have the same brightness. Bulb B is dimmer than they are.

What can you say about resistors P, Q and R?

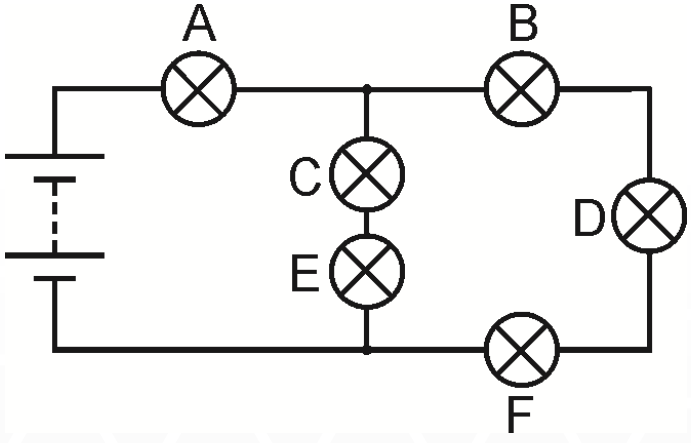
Round 6

To begin with, all the bulbs are lit.

One bulb fails, and all the bulbs go out.

Which bulb failed?
That bulb is replaced with a new one.

Then bulb C is unscrewed.
Which bulbs are still lit?



STUDENT HANDOUT

Student Handout

Worksheet 1
- Most of the conductors belong to the class of substances called .....
- I think that the hard shiny object that felt cold would ..... electricity, because it is probably made of a .....
- Pure water is an ..... However, if there are any impurities in it, such as salt, or chlorine, then the water is a .....
- Air is an ..... which explains why we do not get an electric shock when we stand near a mains electricity socket.

Worksheet 2

For a bulb to light, there must be:
- A source of ....., such as a battery or power supply;
- Wires of metal to ..... the electricity;
- Wires which are insulated by a ..... coating to stop the metal conductors touching each other;
- A complete ....., with no gaps in it.

Worksheet 3
- When an electric ..... flows through wires, it warms them up.
- Some kinds of wire get so hot that they .....
- One kind of light bulb, called a filament lamp, uses this effect to produce light.
- They are expensive to run because they give off more ..... than .....

Worksheet 4
- When an electric current flows through a wire, it produces a ..... effect.
- The effect is stronger if you form the wire into a coil and push a nail, made of ..... or ....., down the centre.
- The nail then behaves like a ..... It affects a compass needle, and can even pick up paper clips.
- Two ways to make the magnetic effect stronger are:
- Add more .....;
- Increase the .....

Worksheet 5

Fill in the gaps with either ‘positive’ or ‘negative’.
- During the experiment with copper sulphate solution, the ..... electrode gets coated with copper and gas bubbles are given off at the ..... electrode. We know that an electric current is flowing through the solution because .... Fill in the gaps with either ”electrolysis’ or ‘electroplating’.
- In ..... an electric current causes a chemical reaction that splits compounds into simpler molecules. It is used to obtain pure elements, such as copper, aluminium and chlorine from their ores or from commonly oc-curring compounds.
- ..... is one example of ..... where the aim is to coat one metal with a thin layer of another to protect the underlying metal from corrosion or wear (e.g. chrome plating on automotive parts), or to enhance its appearance (e.g. gold plating.)

Student Handout

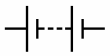
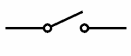
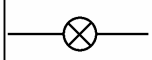
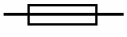
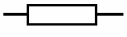
Worksheet 6

- A switch starts and stops the flow of .....
- When the switch is open, the ..... gap stops the flow of electricity.
- When the switch is ....., the air gap disappears, and electricity flows around the circuit.
- A toggle switch stays on or stays off all the time. A push switch is on only as long as you press it.
- A doorbell is one type of ..... switch.
- A light switch is one type of ..... switch.

Worksheet 7

- A fuse contains a fine metal wire. When the flow of electricity gets too big, this metal gets so hot that it ....., and breaks. This creates an air ..... in the circuit, which stops the flow of electricity.
- This stops the other ..... in the circuit from getting too hot, and causing a fire.

Worksheet 8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Supplies electrical energy	**Allows a circuit to work**	**Turns electricity into light**	**A safety device**	**Controls the size of the current**	**Turns electricity into sound**

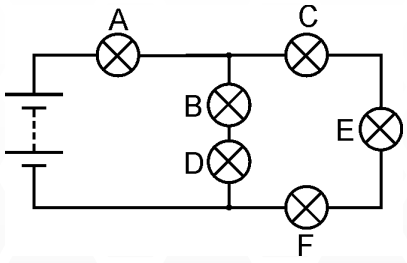
Worksheet 9

- A resistor limits the flow of electricity
- The bigger the resistance, the smaller the electric current.
- Resistance is measured in ohms. Usually, we use the Ω sign to mean 'ohms'.

Worksheet 10

- A series circuit offers only one route for the electric current.
- If a break appears anywhere in the circuit, then the electric current stops everywhere.
- If one bulb fails in the circuit, then all the bulbs go out.
- The electric current is the same size throughout the circuit.
- A parallel circuit offers more than one route and so different currents can flow in different parts **of the circuit.**

1. Bulb B is in series with bulb ..... .
2. Bulb C is in ..... with bulb E and bulb F.
3. Bulbs B and D are in ..... with bulbs C, E and F.
4. The biggest current will flow through bulb .....



Notes

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