Making Science Fun.

Teacher/Parent Notes.

Caution.

The yellow fan.

With fresh batteries, the fan may fly into the air with some force so it is advisable to keep faces well away from it!

Fuses.

Your kit has a fused battery holder and the fuse will blow if the battery terminals are directly connected to each other without an active component like a motor, bulb or LED wired in series. A blown fuse is indicated by the little LED close to the fuse shining red.
This is a safety measure to protect the user as batteries which are shorted out can get very hot indeed.
To carry on using the batteries, replace the fuse with a new one. Be careful not to repeat the mistake that caused to fuse to blow in the first place.
Replacement fuses can be purchased from most retail electrical outlets. Take the old fuse with you or ask for a 20mm. 250volt fuse rated at 2amps.

Electricity, What is it?

Electricity is a flow of electrons. An electron is the smallest part of an atom and rotates around the nucleus binding the atoms together.

It is very important to point out to children the dangers of using mains electricity. None of the ideas as shown in any of these kits should ever be attempted using mains voltage.

The Battery.

A battery is a store of electrons produced by the reaction between the metal of the case and a chemical inside the case. When the positive and negative terminals are connected as in an electric circuit, electrons flow around the circuit. The voltage is a measure of the pressure with which the electrons flows. The Amperage is a measure of the amount of electrons that flow.

In materials that conduct electricity, like metals, there is an electron that is easily pushed out of orbit from the first atom and into the orbit of the next atom. This in turn knocks an electron from the second atom into the third atom and so on. This is the way electricity flows around the circuit and because of this, there is no measurable time delay in the movement of electrons between one end of the circuit and the other.

Direction of the flow of electricity.

Electricity flows from positive to negative, however electrons flow from negative to positive. This contradictory state of affairs exists because the direction of flow of electricity was decided long before scientists discovered the electron. To-day, the standard flow of electricity is accepted as being from positive to negative. It is however important for students to know the facts, it is up to individuals to decide when to introduce the concept of electron flow.

Electricity as a producer of light and heat.

When electrons are forced through a thin wire as in the filament of a bulb or the element of an electric fire, so much heat is generated by friction created when the electrons brush past each other, that the filament glows red or white hot.

Electricity as a producer of movement.

When electricity flows through a wire, it produces the effect of a magnet. If the wire is coiled around a nail, it produces a powerful magnetic effect. This electro magnetic force is the basis on which the electro magnet and electric motor works.

Bulbs in Series and Parallel.

When bulbs are connected together in series, the electricity has to flow through the filaments of both bulbs before it can get back to the battery. Be careful not to use too much force when screwing the bulb into the bulb holder as the glass may break.
The filaments in series act as a high resistance to the flow and this slows down the speed at which the electrons travel. The brightness of both bulbs will be only half as bright as one bulb on its own.
If the bulbs are connected in parallel, the electrons have to still flow through the filaments of both bulbs but, wired in parallel, they offer a low resistance to the flow and so the bulbs glow with the same brightness as one bulb on its own.

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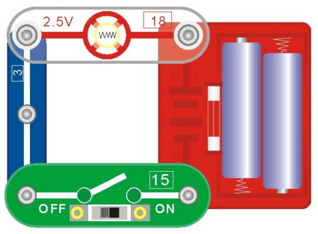
Circuits

Experiment 1. A complete circuit?

Start by making this circuit.



Clip the battery holder and the blue 3 connector to the base-board then clip the lamp holder and switch as shown.
Be careful not to clip anything directly across the battery terminals.

Slide the switch 15 to the ON position, the bulb should light. If it does not, check that the bulb is screwed fully into the bulb holder. If this does not work, check the fuse. If the red LED is on then the fuse has blown and must be replaced.

With the bulb still alight, remove the top blue connector 3. Note what happens to the bulb. Replace the connector and now unscrew the bulb from its holder, again note what happens to the bulb. Screw the bulb back into its holder and switch off.

You have just proved that if electricity is to flow around a circuit, the circuit must be complete. If there is a break in the circuit, like removing the blue connector or unscrewing the bulb, the electricity is unable to flow and the bulb will not light.

Just in case you wondered, look on the under side of the blue connector and you will see the wire connecting the two press-studs together.

The next question is, can we use just anything to connect up a circuit?

Experiment 2. Will just anything do to make a circuit?

In this section, we need to find out if materials other than metal can be used to make a electric circuit.

You will need something made of wood, plastic and metal. Rulers are often made of wood or plastic and so are pencils and pens. A piece of baking foil will do for the metal or perhaps a hair slide, scissors, a paper clip or a piece of silver paper.
Using the same circuit, switch on to check that the bulb lights up and then remove the blue connector 3.

Now, in place of the blue connector, try the wood, plastic and metal. Make certain that the wood, plastic or metal touches the pres-studs on the bulb holder and the battery at the same time. If the bulb lights up, put a Yes in the second column of the table below.

Material	Did the bulb light?	Conductor	Insulator
Wood			
String			
Plastic			
Metal			

You may like to try some other things like paper or, if you can find it, a length of pencil led.
Materials like string, do not allow electricity to flow, they are called ‘Insulators’. If it did allow electricity to flow, then it would be called a ‘conductor’.

When is a Battery not a Battery?

In this circuit, you are using a battery made up of two 1.5 Volt cells so the voltage of the battery is 3 Volts. The cells are connected together in series, so the voltage is the sum of the voltages of both cells.
As scientists, we must get used to using the correct names for the parts we use.

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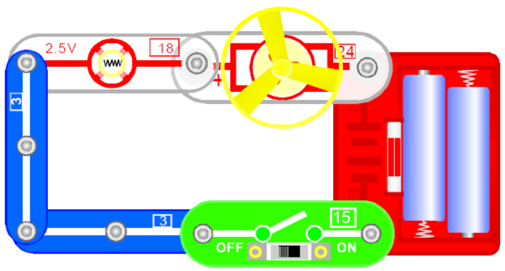
Experiment 3. Series or Parallel?

In this experiment you are going to use the same bulb and motor in each circuit. In the first circuit, they will be connected in series and in the second circuit they will be connected in parallel. We need to find out the advantages and disadvantages of each circuit.



Do not connect anything directly across the battery terminals. If this happens the fuse will blow and will have to be replaced.
A blown fuse is shown by a red LED on the battery holder.

It is called a series circuit because the electricity has to go through each of the components before it can get back into the battery so in this circuit, the motor and the lamp share the 3 Volts.
Switch on; does the bulb light up and the motor run? If they do, switch off. If not, check the bulb is screwed in to the holder and all the connections are ok.
What about the brightness of the bulb and the speed of the motor?
To help answer this question, take another blue connector 3 out of the box.

Switch on again and remove the motor, clip the blue connector 3 in its place. Does the bulb get brighter? Brightness is quite easy to judge, but what about the speed of the motor?

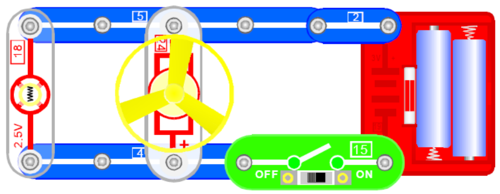
The best way to judge the speed of the motor is to listen to the noise it makes. The higher the pitch of the sound, the faster it is rotating

To test the speed of the motor, swap over the positions of the bulb and the motor in the circuit and then repeat the test as you did for the bulb. Did you find that the motor turned faster without the bulb in the circuit?

One more experiment to try. Put the bulb back into the circuit and switch on. Now unscrew the bulb and note what happens to the speed of the motor then screw the bulb up again and switch off.

From our experiments, this is what we found out.
When connected in *series*, bulbs light up less brightly and motors rotate more slowly, this is because the electricity has to flow through one component and then the other so they share the voltage.
If one component breaks, the other components will not work because the electricity can not flow back to the battery.

Now its time to experiment with Parallel circuits.
Make up this circuit.



Switch on, look at the brightness of the bulb and listen to the speed of the motor, how do they compare with the series circuit? About the same brightness and speed or brighter and faster?
Remove the motor, what happens to the bulb? Replace the motor and remove the bulb, does the motor still run?
If you need to check anything, make up the series circuit again and check it out.

So we can say this about a parallel circuit.
When connected in *parallel*, bulbs light up brightly and motors run faster than when connected in series.
If one component breaks, the others will continue to work as the electricity is still able to flow back into the battery. All components in a parallel circuit get the full battery voltage.

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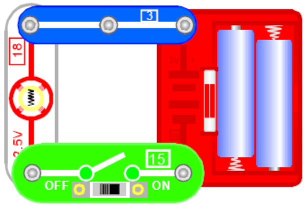
Experiment 4. Switches

Switches are used to control an electric circuit. When a circuit is not being used, the switch should always be in the off position. Make up the circuit shown below.



The switch simply controls the flow of electricity and turns the bulb on and off. Removing the blue connector would do the same but it is not so convenient!

This switch is called a slide switch but there are many other types. At home or in your classroom the lights are turned on and off with a rocker switch. Your torch may have a press switch to make it flash.

In your kit there is a new type of switch, called a reed switch, it is part number 13, take it out and have a look at it. In side the glass or plastic envelope, there are two thin pieces of metal that do not touch each oth-er, however when a magnet is brought close to them they are forced together and electricity can flow through it.

Remove the slide switch and replace it with the reed switch. Use the circular magnet from the kit and slide it past the reed switch, the bulb should flash on and off as the magnet passes the reed switch. If you listen carefully, you should be able to hear the switch working.

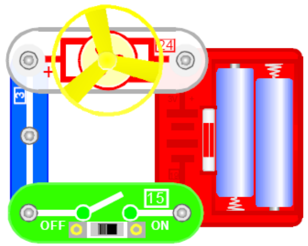
This type of switch could be used to switch a light on when a door is opened, very much like a refrigerator light comes on when the door is opened and goes off when the door is closed.

Experiment 5. LED's (Light emitting diodes)

An LED is a polarised device. That means that it is sensitive to the direction of the flow of electricity. To see what this means, use the LED 17 in place of the bulb in the last circuit. The positive end (the end with the + sign) should be connected to the blue connector. Switch on to check your LED lights up. If it does not, swap the LED around and try again. The LED will only give out light when the electricity is flowing from positive to negative (+ to -). Because it uses very little electricity, it is often used as an indicator light to show that something is working.

Experiment 6. Electric Motors, forwards and reverse.

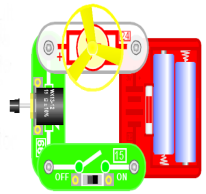
You have already used an electric motor but we did not take any notice of which way it rotated. Electric motors can rotate both ways depending on which way the electricity flows through it. This is very useful if we want to make something go backwards as well as forwards!
Make up this circuit. Clip the positive terminal of the motor to the positive terminal on the battery.

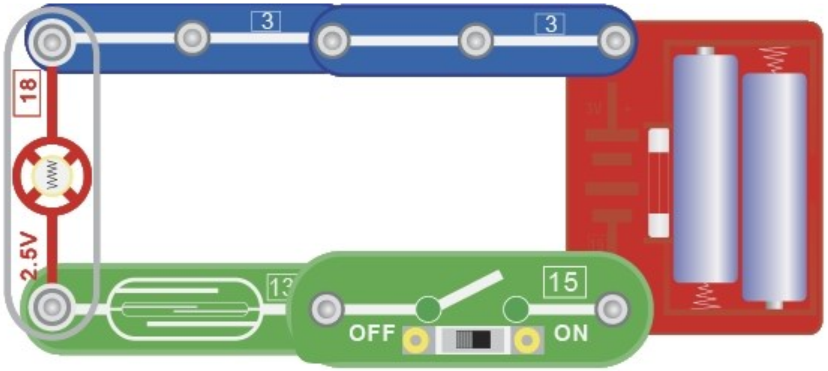


Switch on, note down which way it rotates. Turn the motor around, and again note the direction of rotation.
As you will have seen, when the + terminal on the motor is connected to the + terminal on the battery, the motor runs clockwise and when the - terminal on the motor is connected to the + terminal on the battery, the motor runs anti-clockwise.

Experiment 7. Controlling the speed of a motor.

To make the motor go faster or slower, you can use a variable resistor, it is part number 66 in your kit. The variable resistor slows down the flow of electricity around the circuit and is connected in series with the motor as in the picture.
The motor runs fastest when the knob is turned fully clockwise. Switch on and then turn the knob slowly anti -clockwise. You could also use the variable resistor to control the brightness of a bulb.





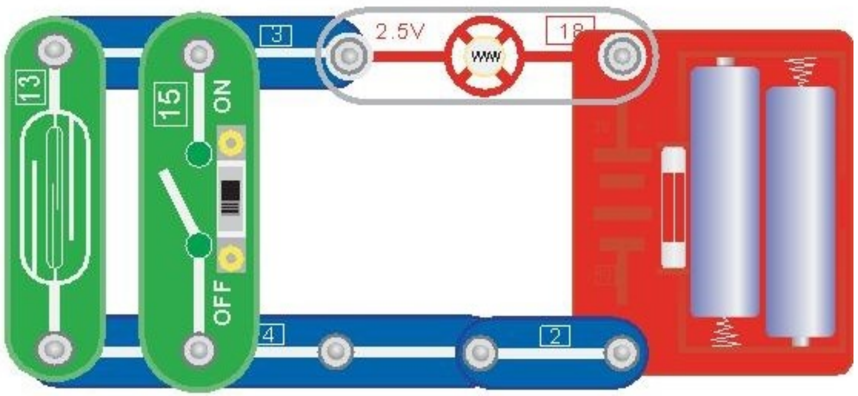
8. The AND Gate.
Switch the slide switch on and then bring a magnet up to the dry reed switch. The bulb will light. Removing the magnet will make the bulb go out.
This is called an AND gate because switch 1 AND switch 2 must be on to make the bulb light.

This type of circuit is used for security reasons, two people have to be present to switch the circuit on.

Imaging that the two switches are operated by keys. If you don't have the correct key, you can not turn on the switch. If this was a missile launcher, the missile can not be fired unless both switches can be turned on. In this case, two different people have a key each, one person on their own can not fire the missile.

9. The OR Gate.
In this circuit, the bulb will light up if either of the switches or on. It is called an OR gate because the bulb will light if switch 1 OR switch 2 is on.

This type of circuit is used when either one of two different people have permission to operate the circuit.



All these experiments use the integrated sound module 23. Inside module 23 is an integrated circuit into which have been programmed many space war sounds.

10. Testing the circuit.
Leave switch 15 in the off position. Bring a magnet up to the reed switch 13 and the loudspeaker will make a space war sound. Take the magnet away and bring it back again and a different sound will be made.

11. Selecting the space war sound.
Using switch 15, switch on and off repeatedly and select a sound. Now bring a magnet up to the reed switch. The original sound will have a new sound played on top of the original.

12. Using the Light Dependent Resistor (LDR).
Replace the switch 15 with the LDR 16. Place your finger over the LDR to stop the sound. The LDR responds to light. When light shines on the LDR its resistance falls and allows electric current to flow which produces the sound. When you cover up the LDR the resistance is greater and so the flow of electricity stops and also the sound.

13. Using the Touch Plate.
Replace the reed switch 13 with the touch plate 12. Touch a finger on the touch plate and a sound will be made. The dampness on you skin allows contact between both of the metal strips on the touch plate.

14. Musical motor.
Replace the loudspeaker with the motor. Switch on and the motor will play the sounds softly.

15. Effect of using an LED.
In this circuit, the LED 17 slows down the flow of electricity so making the sounds softer and slower. This is because of the resistor on the underside of the LED.
Try doing the above experiments again and notice the difference.

16. Changing the polarity of the LED.
Try reversing the direction of the LED and notice that the circuit will not work. This is because the LED allows electricity to flow from positive to negative and not the other way round.

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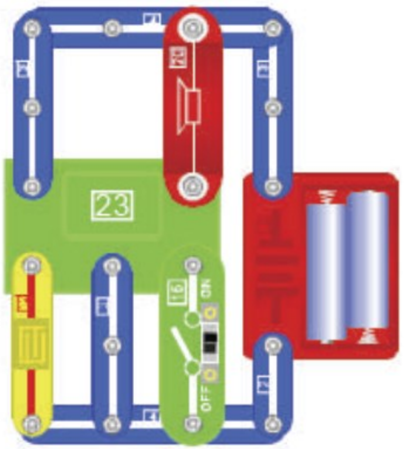
Sensors and Alarms 1

This section supports the National Curriculum Design and

Technology at Key Stage 3 and provides an easy introduction to the use of sensors.

This part introduces the idea of things being controlled by sensors. Street lights switch on when it gets dark and switch off again when it gets light. Some cars have windscreen wipers that switch on when it starts raining and switch off when it stops. Washing machine doors will not open while the machine is switched on.
These are all examples where sensors are used to control what happens.



Experiment 1.

Experiments 1, 2, 3 and 4 all use this circuit and are based on the space war sound module, part number 23. This module contains a pre-programmed chip having many different space war sounds. You can listen to these sounds by switching switch 15 on and off a few times.

To keep noise levels down, the loudspeaker could be replaced with the red light emitting diode (LED) (17). The LED will only work when the positive end (+) is connected to the positive end of the battery, in this case, via the top blue 4 connector.

Experiment 2. *Using the touch sensor.*

Remove the switch 15. Replace the loudspeaker with the LED.
Place your finger on the touch sensor 12, the LED will light up, remove your finger and the LED will go out. The touch sensor works when both parts of the sensor are connected together.
Your finger makes contact with both parts of the touch plate.
Try using other things like a paper clip, a drop of water, a piece of wood or plastic or a piece of tinfoil.
If you wish to make a noise again, replace the LED with the speak-er.

Experiment 3. *Using the reed relay 13*.

The reed relay is a sensor controlled by a magnet. Connect the reed relay 13 in place of the switch 15, bring the magnet close to the reed relay and the LED will light up. Remove the magnet and the LED will go out. Inside the switch are two strips of steel that do not touch each other. The magnet causes the two steel strips to touch so that electricity will flow.

Experiment 4. *Using the light sensor 16*.

Replace the reed relay 13 with the light sensor 16 and the LED with the speaker. Point the light sensor at a bright light and the speaker will sound.
Put you finger over the sensor, the sound will stop.
The light sensor contains a light sensitive resistor which has a low resistance in bright light and a high resistance in the dark. When the resistance is low, electricity can flow through the sensor. When the resistance is high, electricity will not be able to flow.

This circuit could be use to monitor light levels. If a room is in darkness, the alarm will not sound but if someone should enter the room and switch the light on, then the alarm would sound.

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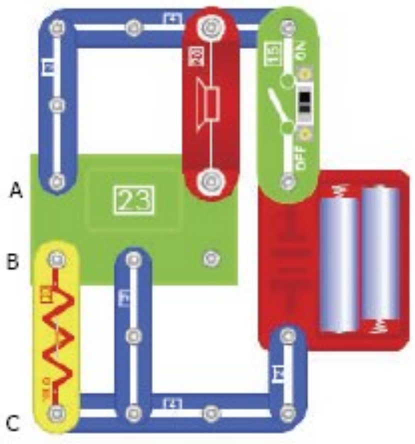
Sensors and Alarms 2

Having found out how sensors work, this next section shows you how to use the circuits to alert you to any change detected by the circuit.



Experiments 5, 6 and 7 all use this circuit.

Experiment 5. *Protecting your bicycle*.
Connect a long thin wire to terminal A, pass the wire through your bicycle wheel and connect the other end to terminal B. Switch on using switch 15. The alarm will not sound unless the wire is broken or removed.
If your bicycle is removed, the wire will be broken and the alarm will sound.
The best way to connect the wire to the terminals is to make a small loop in the end of the wire, put the loop on the terminal and clip the connector 3 on top of it.

Experiment 6. *Protecting doors or windows*.

Fix the reed relay on the door or window frame, (the fixed part), using double-sided adhesive tape or other means. Connect the terminals of the reed relay with thin wire to terminals A and B.

Fix the magnet on the door or window close enough to the reed relay to make the contacts touch. Switch on switch 15.
If the door or window is opened, the reed relay contacts will open and the will alarm sound.

Experiment 7. *An automatic rain detector*.

Using the touch sensor 12, connect the terminals to B and C using thin wire. Switch on and hang the touch sensor out of a window. If it starts to rain, the touch sensor will get wet so making contact with both parts of it and the alarm will sound.

This experiment could also be used as a bath water level monitor. Hang the touch sensor over the side of the bath to the height you would like the water. Turn on the taps and when the alarm sounds its time to turn the taps off.

Use terminals A and B when contact has to be broken to make the alarm sound.

Use terminals B and C when contact has to be made to make the alarm sound.