The Institution of Engineering and Technology

SCOUT ELECTRONICS BADGE
SCOUT PACK

By earning this badge, you will learn about how electronics has shaped our world and get to make some fun gadgets that will help you to understand how electronics works.

"The five essential skills for success are concentration, discrimination, organisation, innovation and communication".
Michael Faraday.

ENJOYING WORKING ON THIS BADGE?

We live in a world full of engineering! Everything we do and use has had professional engineers involved in designing it or finding solutions to problems surrounding it and technicians making the engineers' ideas a reality. If you enjoy undertaking the projects and activities in the Scout Electronics Badge activity pack, you may want to find out more about electronic engineering, other areas of engineering, the stories of people who work as engineers and how to become an engineer or technican yourself.

For all this and more, visit **www.tomorrowsengineers.org.uk**

The Scout Electronics Badge is sponsored by the Institution of Engineering and Technology (IET)

The IET is a world-class members' organisation for the engineering and technology community. It provides a wide-range of professional support services for engineers and technicians and represents the sector to opinion formers and the public.

In the UK there is a significant need for more people with the right qualifications, skills and experience to become engineers and technicians. As part of its charitable remit the IET has an education programme that seeks to encourage young people's interest in science and engineering, encourage them to study science, maths, design and technology and computing at school and then help them make informed choices about courses and careers.

The IET's Education for Schools and Colleges programme offers:

IET Faraday – www.ietfaraday.org

- A library of free video case-studies of innovative engineering and product designs and the engineers behind them with accompanying activities.
- Free posters.
- Guidance on how to deliver your own engineering activity days.

***FIRST*® LEGO® League – www.firstlegoleague.co.uk**

The UK and Ireland arm of this international robotics competition where teams undertake a project and build and programme robots using LEGO® Mindstorms® to overcome series of challenges based around real-world problems.

Flipside magazine – flipside.theiet.org

The teen-magazine where fact is stranger than fiction.

The IET also offers funding for engineering-based educational projects and supports some of the UK's best engineering-themed competitions. Many IET members are also STEM (Science, Technology, Engineering and Maths) Ambassadors - professional engineers who have been checked and trained to work with educational groups. **www.theiet.org/education**

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The Institution of Engineering and Technology

INTRODUCTION
What's in this pack?

This pack contains all the information, activities and projects you need to earn your badge and make some brilliant electronic games and gadgets along the way.

Your pack includes:

- Some information about electronics and electronic components.
- Instructions on how to solder and use a multimeter.
- Instructions for some fun electronics projects.

What you have to do to earn your badge:

1. Show an understanding of components by completing the following three tasks:

a. Be able to recognise common electronic components that are shown to you. Explain, in simple terms, the functions they perform in electronic circuits.

b. Understand the systems used for marking components with their values and be able to identify the values of resistors and capacitors so marked. Understand the importance of the rating of a component.

c. Know the symbols that are used to represent common components in circuit diagrams. Show how to identify the polarity of a diode and a specific pin number on an integrated circuit.

2. Demonstrate knowledge of safe working practices to be followed when handling electronic components, and circuit boards and when undertaking soldering.

3. Use a multimeter to measure voltage, current and resistance in a simple circuit. Discuss the relationship between these values.

4. Discuss the main differences in operation of digital and analogue circuits.

5. Construct three simple circuits, one of which should be based mainly on digital electronics. These may be from a book or magazine, or circuits that you have designed yourself. At least one of the circuits should be soldered using either strip-board or a custom made printed circuit board. Explain the principles behind the operation of each circuit and the typical values of voltage and current found in each.

HOW DOES ELECTRONICS WORK?

Here are some brief descriptions of the things you are going to come across as you work through your projects. You can keep referring back to the information here as you complete your projects so that you get a good understanding of how electrical circuits work and the terminology involved.

Electricity

Electricity is a type of **energy** produced by the movement of tiny particles called **electrons**.

Conductors

In some types of materials, **electrons can move around freely.** These materials are known as conductors and the flow of electrons through them produces an electric current. The metal copper is the most widely used electrical conductor.

Insulators

In other types of materials, the **electrons cannot flow around**. These materials are known as insulators.

Semiconductors

Semiconductors are in **between insulators and conductors**. They are vital in electronics because they can be controlled to switch between behaving as a conductor and behaving as an insulator. Two important semiconductors are **silicon**, which is used in computer chips and **germanium**, which is used in fibre-optics.

Voltage, current and resistance

Some important terms used when talking about electricity are voltage, current and resistance.

Voltage

Voltage is a measure of the **difference in electrical energy** between two points. Electrons will flow from high to low energy points. If you imagine electrons being pushed round a circuit, the voltage is how hard they are being pushed. Voltage is sometimes called potential difference. It is measured in **volts** (V).

Current

Current is a measure of the **rate** at which electrons flow through the circuit. Current is measured in **Amps** (A).

Resistance

Resistance is a measure of **how difficult it is for electrons to flow** around a circuit. It is measured in **Ohms** (Ω).

Voltage, current and resistance are connected through Ohm's Law. If you want to design your own circuits, you will need to use Ohm's Law to help you decide what components you need to use.

Ohm's Law states: voltage (V) = current (I) x resistance (R)

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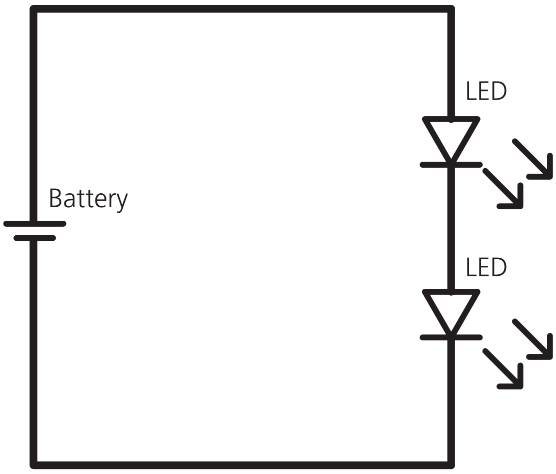
CIRCUIT BASICS – SERIES AND PARALLEL CIRCUITS

For electricity to flow around a circuit, it needs a continuous connection between the point of high voltage and low voltage. Current is always shown flowing from positive to negative. In wiring red is positive and black is negative.

Series and parallel circuits

A **series circuit**



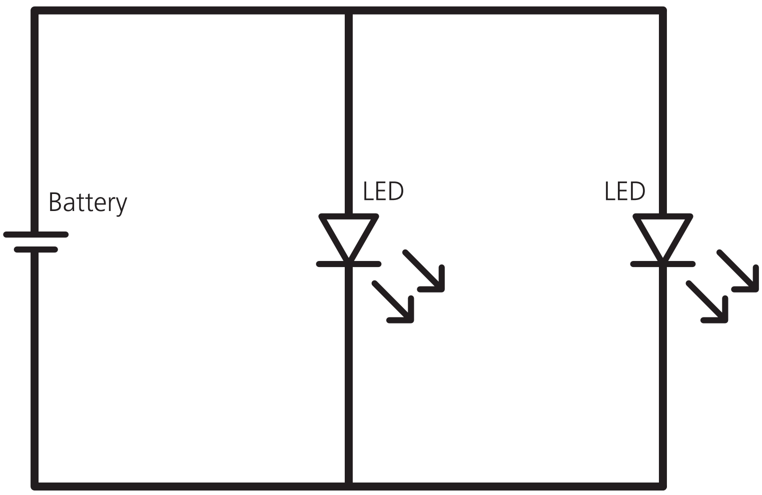
Components wired side by side like these two LEDs are described as being **in series**.

Damage to any one component in a series circuit will break the circuit.

When items are wired in series, the total voltage available is shared between them.

An LED is a type of electronic component. LED stands for light emitting diode.

The alternative to a series circuit is a **parallel circuit** like this**.**

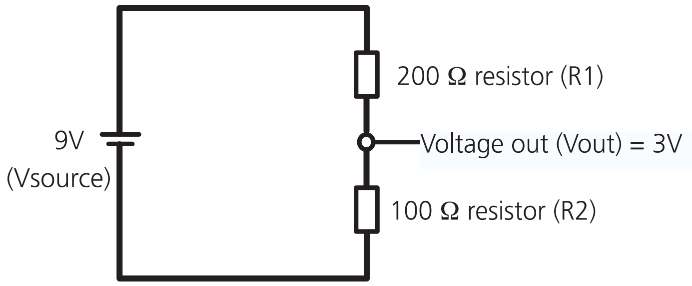


In a parallel circuit, the failure of one component does not break the whole circuit.

The two components receive the same voltage, but the available **current** is shared between them.

CIRCUIT BASICS – VOLTAGE DIVIDERS

A resistor is a type of component that limits the flow of electricity round a circuit (see activity 3 for more about different types of components). When two resistors are connected series, the voltage at the point in between the two resistors can be controlled. This set-up is called a voltage divider (or a potential divider).



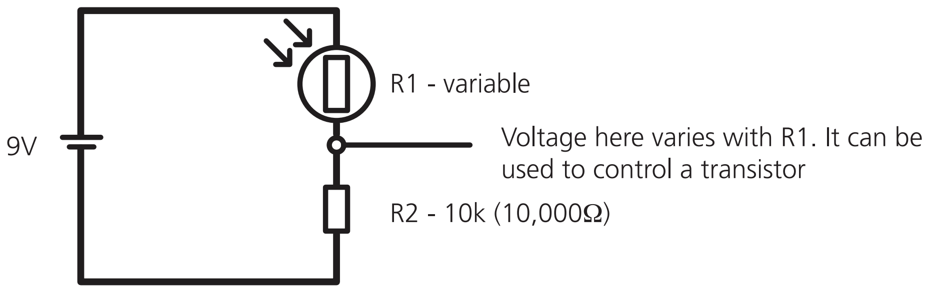
Voltage out (Vout) changes in proportion to the size of the resistors.

$$\frac{R2}{R1 + R2} \times \text{Vsource} = \text{Vout}$$

$$\frac{100}{200 + 100} \times 9 = 3V$$

You can try this for yourself in activity 5.

By making one of these resistors a variable resistor (for example a light dependent resistor) the voltage at the point between the two resistors can be varied. This can be used to control a transistor. A transistor is an important type of electronic component that can be used as a switch. It uses a semiconductor which changes from being an insulator to being a conductor at a threshold voltage.



This means that when the resistance of the variable resistor reaches a certain value, the voltage reaching the transistor will hit the threshold that switches the transistor on. This can be used to control another part of the circuit.

DIGITAL AND ANALOGUE

Electronics can be roughly divided into two types – analogue and digital. Analogue electronics uses components such as capacitors and resistors to control the voltage and current (you can find out more about these components in activity 3). Voltage and current could be any value. Digital circuits work in a different way. In a digital circuit, the voltage can only be one of two fixed values. It can either be on or off.

In digital electronics these on/off values are used to build switches called logic gates. The simplest types of logic gates are the AND gate, the OR gate and the NOT gate.

- **AND** gates accept two inputs - both of these (input 1 AND input 2) have to be on to create an output.
- **OR** gates also accept two inputs - one of these (input 1 OR input 2) needs to be on to create an output.
- **NOT** gates accept one input. They invert the signal - the input is NOT the output. If the signal in is on, they do not produce an output; if they receive no signal, they do produce an output.

These and other logic gates, built on microchips from combinations of transistors, resistors and diodes, are the basis of all computing.

SOLDERING – IMPORTANT INFORMATION

Safety first:

- Make sure your working area is clean and tidy before you start.
- Check the mains cable of your soldering iron before you plug it in. If it is damaged, don't use it!
- **Never touch the tip of the soldering iron!** It gets extremely hot (300^{o}C) and will melt your fingers as well as the solder. And do not let it touch the mains flex or anything it could damage.
- **Always** put the soldering iron back in its stand **whenever** you are not using it.
- Wear safety glasses when soldering and finishing your circuits - solder can spit and sometimes the ends of leads can fly off when you trim them.
- Work in a well-ventilated area to avoid inhaling too many nasty fumes from the flux that burns off from the solder.
- **Always wash your hands** after you have handled solder.

Listen carefully to any instructions from your leaders and any other supervising adults and make sure you have understood what you are supposed to do before you start.

Instructions:

1) Dampen the sponge from the soldering iron stand (it should be damp, not dripping wet!).
2) Put the iron in the stand, turn it on and let it heat up.
3) Test the iron on the dampened sponge to see if it is hot enough. The sponge should steam where the iron touches it.
4) Once the iron is hot, clean the tip by wiping it on the sponge.
5) Take the solder and melt a little over the tip of the iron until the tip is coated – this is called tinning and helps make soldering quicker and easier. **Now you are ready to solder!**
6) Touch the tip of the soldering iron on the joint you want to solder and keep it there for a couple of seconds. Make sure it is in contact with both parts of the joint you want to solder.
7) Touch the solder onto the **joint** (**not** onto the iron), it should flow down and make a volcano shaped peak.
8) Take the solder away from the joint, and then remove the iron. Keep the joint still until the solder has cooled.

Soldering delicate components

Some electronic components such as IC chips are easily damaged by too much heat.

To avoid damaging components while you solder them, you can attach a crocodile clip to the component lead between the component body and the joint you are soldering. The crocodile clip will act as a heat sink and stop the component from overheating.

Getting everything in the right place

Make sure you know what all your components are and where they need to go before you start. You could print out the circuit diagram for your project and tape the components to it so that you can find them easily when you start building your circuit.

If you find you want to remove some solder then you may need to use a solder removal tool. This sucks up melted solder so that you can remove the component and start again.

ACTIVITIES 01 – ELECTRONIC DIARY

Look back on your day, and write a list of everything you have used from the time you woke up until now that used electronics.

Did a digital clock wake you up? Or an alarm on a mobile phone? Did you have nice cold milk on your cereal, or maybe you had toast? How did you get to school? What did you do when the bell rang for break or lunch? How did the bell work? You will probably come up with quite a long list. It is possible that even your pets used some electronics today…

How can you identify things that use electronics? It is not always easy to be sure, but you can make an informed guess. If it has an LED light, it uses electronics; if your kettle switches off automatically, it uses electronics; if something has a printed circuit board, it uses electronics.

What can you think of that you did today that didn't involve any electronics at all?

ACTIVITIES 02 – SMART PHONE EXPLODED

Smart phones have a huge range of functions – this one tiny gadget can do so many things that could only be done by many more, much bigger items in the past. Work in a team to think about all the different things that could be replaced by a smart phone.

You will need:

- A picture of a smart phone
- String
- Sticky tape
- Paper and marker pens

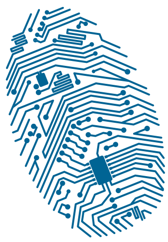
Instructions:

Write or draw each of these things on a piece of paper and join them to the picture of the smart phone with a length of string to make a big spider diagram.

When you have done this, think about the history of each of the things you have drawn. For example, when was it first possible to send an email or take a photograph using a digital camera? What did people do before these things were invented?

Can you think of any words or other things that have stuck around even though they refer to the way things used to work before the technology changed - things like dialling a phone number or hearing a camera click?

As you think of these things, add them to your exploded diagram. Ask any adults around to help you with some of the details. Can they think of any technology they once used that is no-longer common?



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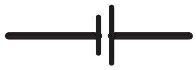
ACTIVITIES 03 – COMPONENT RECOGNITION AND MATCHING GAME

Everything in electronics from burglar alarms to computers is made from a combination of resistors, transistors, capacitors and diodes. These are called components.

The component recognition game, which is in the Leaders' Pack, will help you learn more about different components.

Here are some common component symbols to get you started. You will learn more about these and other components as you play the game.

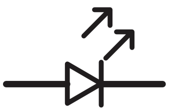


Cell
Electrical power source that produces electricity through a chemical reaction.

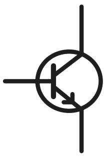
Battery
A series of cells joined together.

Switch
Used to turn circuits on and off.

Capacitor
Used to store charge. The amount of charge they can store is measured in Farads (F).

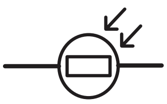


Light Emitting Diode (LED)
A diode is a component that lets electricity pass in one direction only. An LED is a diode that produces light.

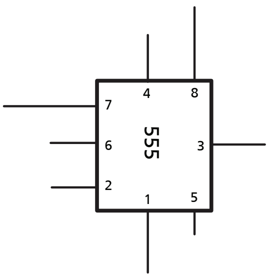


Transistor
Electronic component used as a switch or an amplifier.

Resistor
Used to restrict the flow of electricity. Their value is measured in Ohms (Ω).



Light Dependent Resistor
The resistance of this component decreases in response to light.



555 timer (e.g. of integrated circuit chip)
A common type of integrated circuit chip (IC).

ACTIVITIES 04 – BRING IT OHM!

The Bring it Ohm! game will help you to get to know how resistors are labelled. Your leader will explain how to play the game – instructions are in the Leaders' Pack.

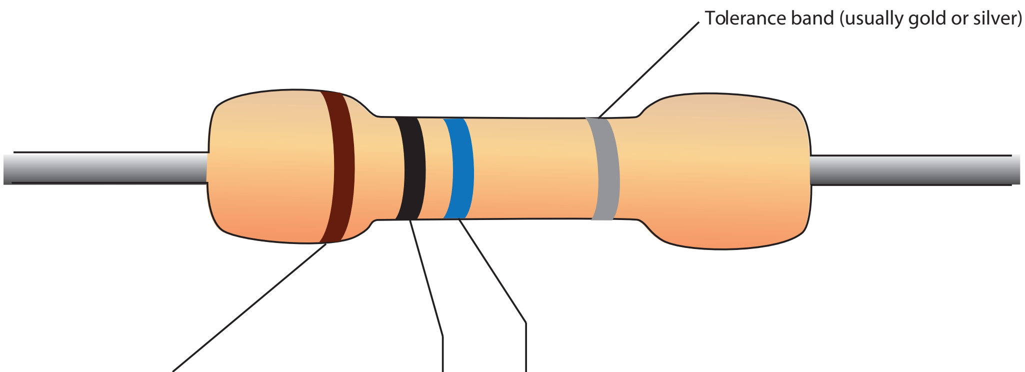
Here is some background information to help you.
Resistors are essential components in most electronics circuits. They are tiny and it would be impossible to print much information on them, so instead a labelling system has been developed using coloured bands.

Most resistors are labelled with four coloured bands. On one end will be a gold or silver band – this represents the tolerance of the resistor (gold = 5% and silver = 10%).
Looking at the resistor with the tolerance band on the right, the other three bands represent the resistance value of the resistor.

- The first band (left-most) represents the first digit of the resistor value.
- The second band represents the second digit of the resistor value.
- The third band is the multiplier of this value.

For example for a 47 Ω resistor, the first band will be yellow (4), the second band will be violet (7) and the third band will be black (x1). A 470 Ω resistor would be represented by yellow(4), violet(7), brown (x10). A 4.7 Ω resistor by yellow (4), violet(7), gold (x0.1) and so on…

When resistors have values of more than 1000 Ω, their values are usually written as kilo-ohms, or k for short. So a 1k resistor is the same as a 1000 Ω and a 470k resistor is the same as a 470,000 Ω resistor. The word kilo comes from the Greek word for 1000. It is the standard scientific way to describe 1000 of something. For example 1kg (kilogram) = 1000g (grams) and 1km (kilometer) = 1000m (meters).



Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Grey	8
White	9

Silver	multipy by 0.01
Gold	multipy by 0.1
Black	multipy by 1
Brown	multipy by 10
Red	multipy by 100
Orange	multipy by 1,000
Yellow	multipy by 10,000
Green	multipy by 100,000
Blue	multipy by 1,000,000

ACTIVITIES 05 –
HOW TO USE A MULTIMETER 1/4

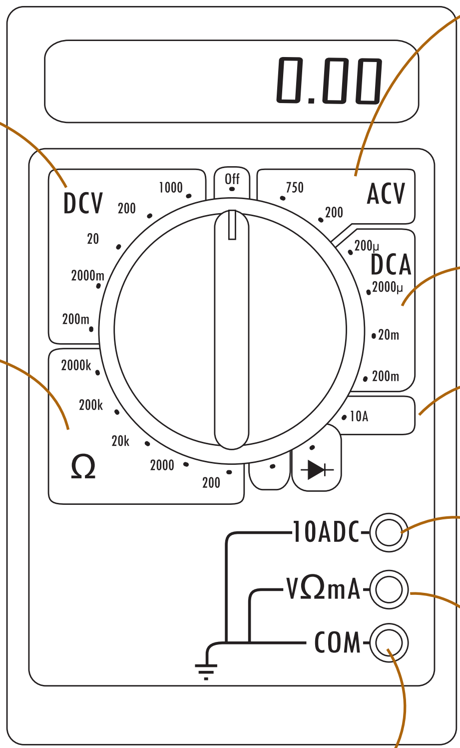
A multimeter is an important tool for measuring current, voltage and resistance in circuits and components. This section gives general information on how to use a multimeter. You should check the instructions for the multimeter you are using for more detail.

Have a good look at your multimeter. It will probably look something like the illustration below. Make sure you know which bit is which on the multimeter you will be using.

A typical digital multimeter has three connection jacks and a dial with a range of settings.

Settings for measuring voltage up to 20V (Volts).

Settings for measuring resistance (Ohms).



Settings for measuring voltage ranges over 20V.
IMPORTANT: You should never be handling voltages high enough to need this setting.

Settings for measuring current ranges up to 200mA*.

Setting for measuring current ranges between 200mA and 10A (you are unlikely to use this setting).

"10A" jack - connector for positive (red) lead when measuring 10A.

"VΩmA" jack - connector for positive (red) lead when measuring voltage, resistance and current (except 10A) measurements.

"COM" jack – connector for negative (black) test lead.

- The black lead goes in the jack labelled "COM".
- The red lead goes in a different jack depending on what you are measuring. You will be using the VΩmA jack.
- They also have a special diode test setting.

* Currents of less than 1A are measured in milliamps (mA). 1mA = 0.001A.

Look after your multimeter – they can get damaged easily

- Always disconnect the multimeter before changing any settings.
- Always check the settings before you connect to a circuit.
- Never leave a multimeter set to a current range.

ACTIVITIES 05 – HOW TO USE A MULTIMETER 2/4

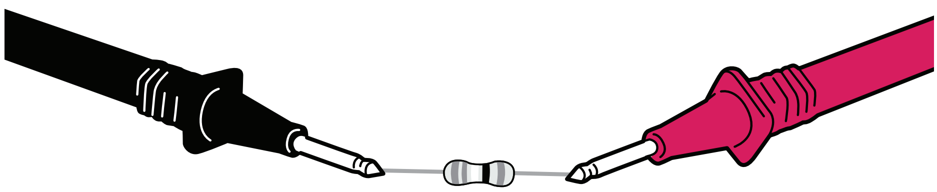
For this activity, you will need:

- A multimeter
- Terminal block
- A battery clip
- A 9V battery
- A 330Ω (or 470Ω) resistor
- Resistors of different values - these should all be above 100Ω
- LEDs
- Light Dependent Resistors or other variable resistors (optional)
- Wire
- A screwdriver
- Wire cutters
- Wire strippers

Measuring resistance

Resistance can only be measured for components that are not in a circuit. If they are in a circuit, you will get an incorrect reading and could damage the multimeter.

1) Choose a resistance setting (from the Ω section of the dial) that is higher than the maximum resistance you are expecting. The meter will read off the scale when the probes are not connected to anything because air has a very high resistance.
2) Touch the probes together – the meter should read zero.
3) Take a resistor and put one probe on each of the terminals. Make sure you are not touching the ends of both probes at once yourself. If you do, your own resistance will change the reading.



What resistance reading do you get? Does it match the code on the resistor? Try it with resistors of different values.

Remember, when you use the multimeter on one of the higher settings (the ones with a "k" after them - 20k, 200k, 2000k) the readout will be in kilo-Ohms, not Ohms. For example the readout for a 470k resistor will be 470, not 470,000.

ACTIVITIES 05 –
HOW TO USE A MULTIMETER 3/4

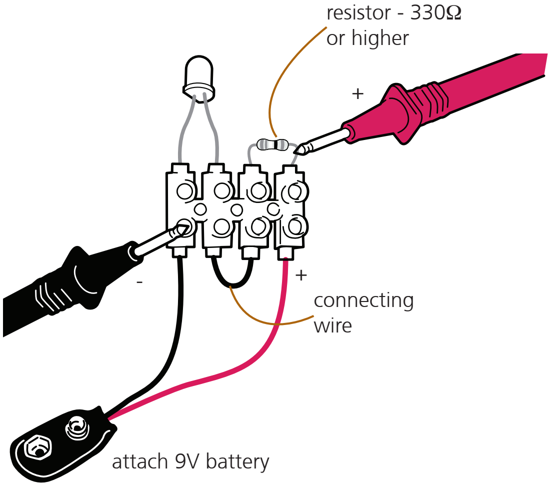
Measuring voltage

1) Choose a dial setting that is higher than the maximum value you are expecting (this should be one of the settings in the DCV part of the dial). If you are not sure, pick a higher range than you are expecting. If you the range you pick is too low, you could damage the meter.
2) Connect the **black lead** at the **negative** terminal of your battery and use the red lead as a probe to test the voltage and current at different points in the circuit. If you connect the leads the wrong way round, you will get a negative reading.

Here are a couple of circuits you can make and test (build the circuits first, but the battery needs to be attached before you try to test the voltage).

IMPORTANT: Ask your Leader to check each circuit before you attach the battery.

Testing voltage circuit 1:

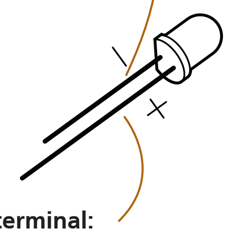


Make sure you have used the right value of resistor and that the LED is the right way round.

When you attach the battery the LED should light.

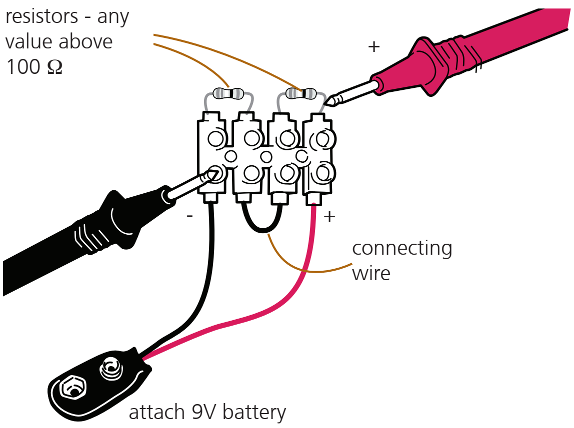
Make sure the multimeter is on an appropriate setting for a 9V battery (start with the 20V range). Take a reading. What value is it? What happens to the reading if you move the red probe to a different place in the circuit?

Negative terminal:
The negative terminal has a flattened area on the case and a shorter wire.



Positive terminal:
The positive wire is longer, and the case is round.

Testing voltage – circuit 2:



This circuit uses two resistors of any value **above 100** Ω. The resistors make a voltage divider. You can find out more about voltage dividers in the introduction.

Make sure the multimeter is on an appropriate setting for a 9V battery. Take a reading. Move the red probe to a different place in the circuit. How does the reading change?

Experiment with different values of resistor. What happens to the voltage reading?

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ACTIVITIES 05 –
HOW TO USE A MULTIMETER 4/4

Measuring current

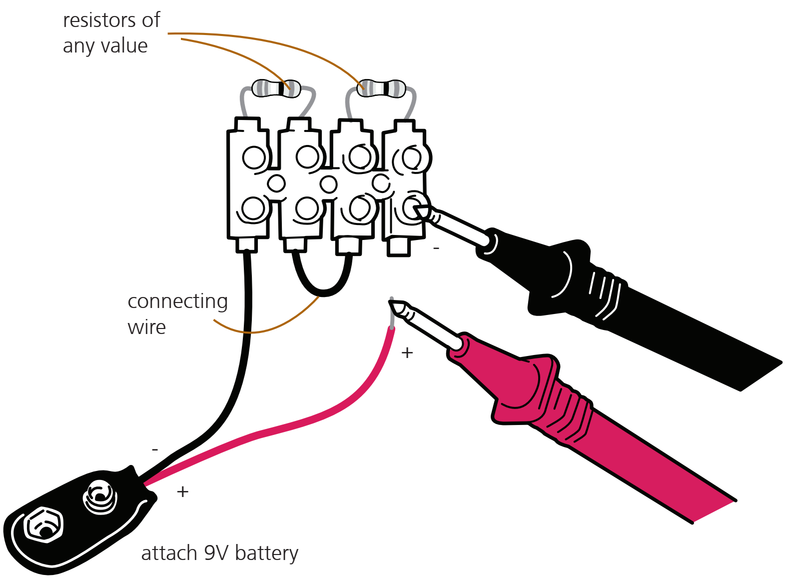
To measure current, the multimeter has to become part of the circuit. The current flowing through the circuit has to flow through the meter too so that it can be measured.

1) Choose a current setting (from the DCA section of the dial) that is higher than the maximum current you are expecting.
2) Break the circuit and connect the multimeter into it – **make sure it is the right way round.**

Measuring current – test circuit

This circuit is the same as the one you used in the second voltage test, but the red (positive) wire of the battery is disconnected so that you can link in the multimeter to measure the current (a tool that measures current is called an ammeter).

Make sure you choose an appropriate setting on the multimeter dial before you link it to the circuit.



Testing diodes

1) Select the diode setting (usually marked with the diode symbol —▷|—).
2) Test the diode by connecting the red lead to the positive terminal and the black lead to the negative terminal. If the diode is working, the meter will display the voltage across the diode.
3) Reverse the leads. The diode should not conduct and the meter should read off the scale.

PROJECTS 01 – LIGHT-UP GREETINGS CARDS 1/3

In this project you will make a light-up greeting card using a circuit made from an LED and a battery. You will be making the circuit using tin foil. You can make your card using the template from this pack, or simply experiment and find out what works for yourself.

You will need:

Electronic components

- A selection of LEDs
- A 3V coin battery (with PCB pins if possible)

Other items

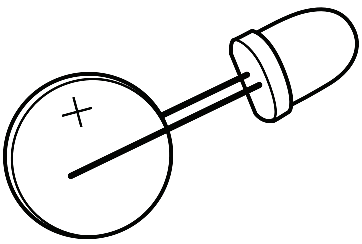
- Tin foil and double-sided tape
- Card template printed on thin card OR blank card*
- Glue
- Scissors
- Hole punch

Here is the circuit diagram for the circuit you will be making.

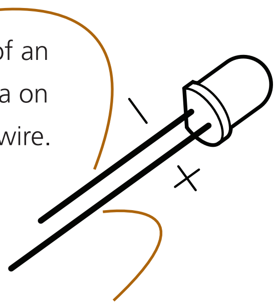
Instructions:

1) Test the battery and the LED - a 3V battery will light an LED, try it for yourself.

LEDs have a positive (+) and a negative (-) side.
Electricity can only flow through them in one direction so they have to be connected the right way round to work.



Negative terminal:
The negative terminal of an LED has a flattened area on the case and a shorter wire.



Positive terminal:
The positive wire is longer, and the case is round.

Connect the LED to the battery like this.

If the LED does not light, make sure its negative terminal is connected to the negative side of the battery and its positive terminal is connected to the positive side of the battery.

"The five essential skills for success are concentration, discrimination, organisation, innovation and communication".
Michael Faraday.

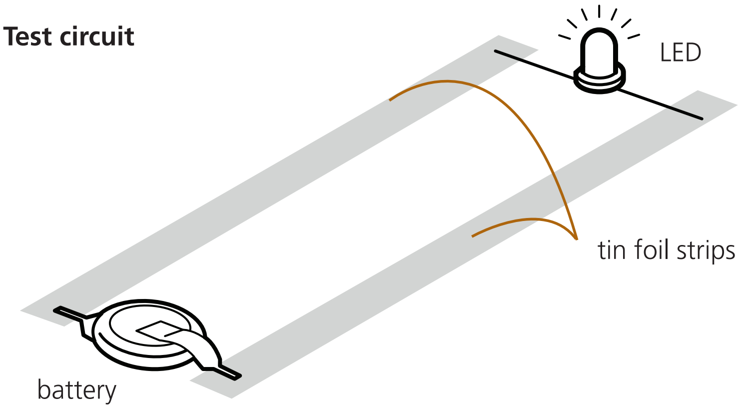
* the template is available from the Electronics Activity Badge page of the Scout Association website - scouts.org.uk/iet

PROJECTS 01 – LIGHT-UP GREETINGS CARDS 2/3

2) Now see what happens when you make a bigger circuit by adding tin foil.
Bend out the legs of the LED and the battery connectors so that both components will lie flat on a sheet of paper.

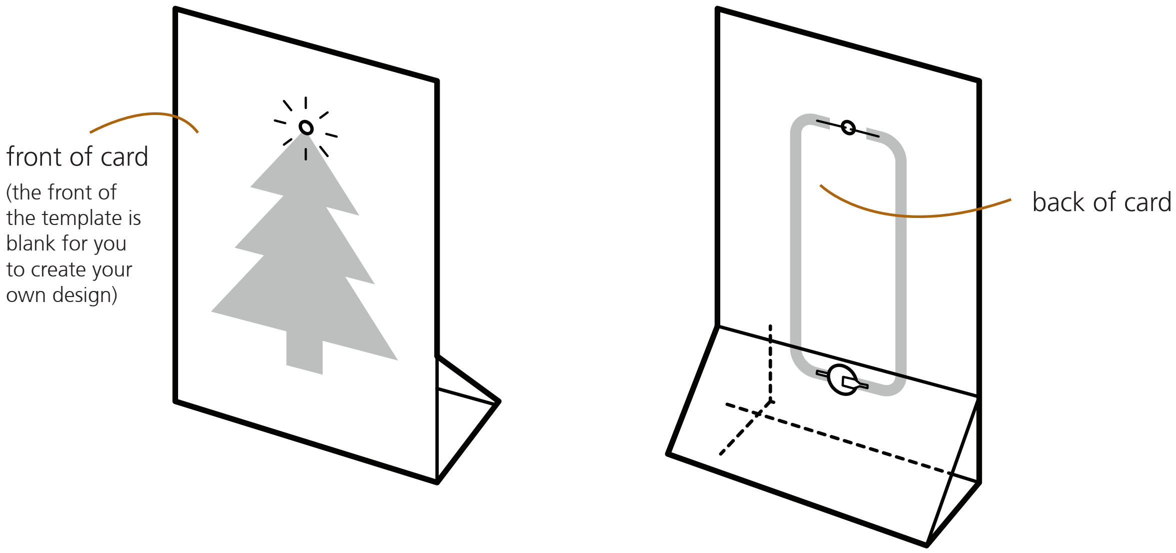
Next, take two strips of tin foil and lay them parallel with each other. Join them at one end with the battery and at the other end with the LED. The LED should light up.

Test circuit



3) Use what you have just found out to put a circuit in a greetings card and make it light up.
You can use the printed template in this pack as a starting point, or design your own from scratch.

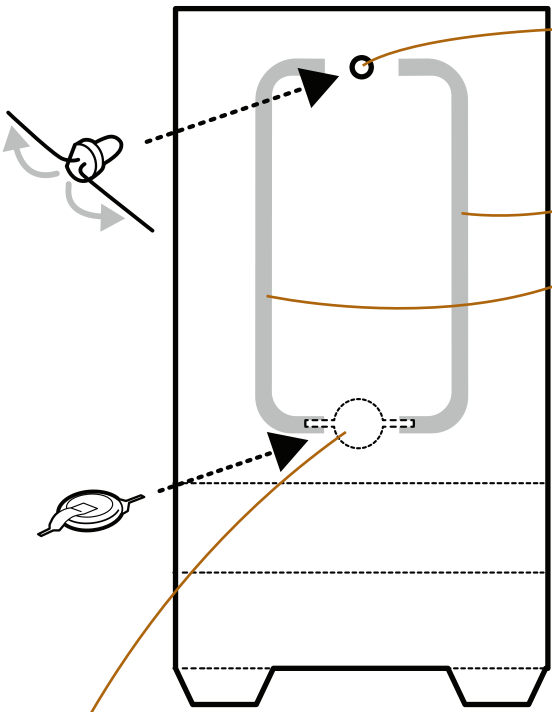
If you are using the template, the finished card will look something like this:



If you are designing your own card, you need to decide where the LED will go on the front of the card and work out how the circuit should fit on the back of the card before you go to the next step.

PROJECTS 01 – LIGHT-UP GREETINGS CARDS 3/3

Making your card



1) Punch a hole through the card where the LED will go.

2) Take a piece of tin foil that is big enough to make your circuit and cover the back with double sided tape.
Cut out the tracks for your circuit from the foil.
Carefully peel off the tape backing and stick the foil tracks to the back of your card – make sure you leave gaps for the LED and the battery.

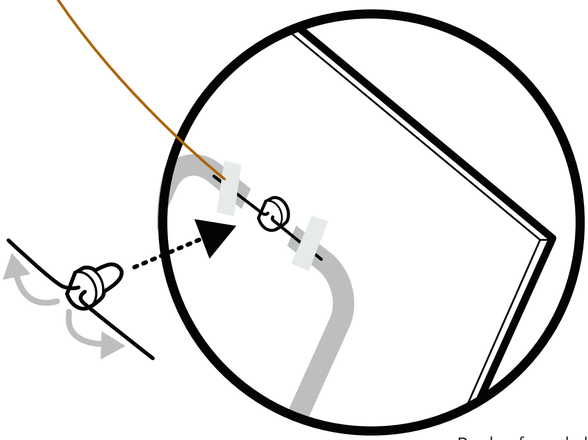
3) Tape the LED terminals to the foil with the main body of the LED poking through the hole to the front of the card. Press the tape down firmly to make sure there is a good connection between the LED and the foil.

4) Attach the battery in the same way – make sure it is the right way round with the positive terminal of the battery is linked to the positive terminal of the LED and the negative terminal of the battery to the negative terminal of the LED. If the LED does not light, try putting the battery the other way round.

5) Remove the battery and finish decorating your card.

6) Replace the battery and stick the card together.

Your card is finished.



Back of card showing LED pins taped to tinfoil

Other things you could try:

- Make a circuit that lights more than one LED. Can a 3V battery light two LEDs in series or do they need to be in parallel?
- Find a way to switch your card on and off – (try using a paperclip and/or a split pin).
- Make a popup card where the LEDs light by pulling a tab or lever.
- You could use conductive tape or Bare Conductive Paint as alternatives to tin foil.

PROJECTS 02 – BRUSH BUG 1/2

In this project you will make a skittering, skating bug using the head of a toothbrush and a vibration motor similar to the sort that makes a mobile phone vibrate.

A vibration motor is an ordinary motor with an off-set weight attached to the axle. As the axle rotates the weight rises and drops making anything attached to the motor vibrate.

You will use a paperclip to make a very basic switch. Removing it breaks the circuit.

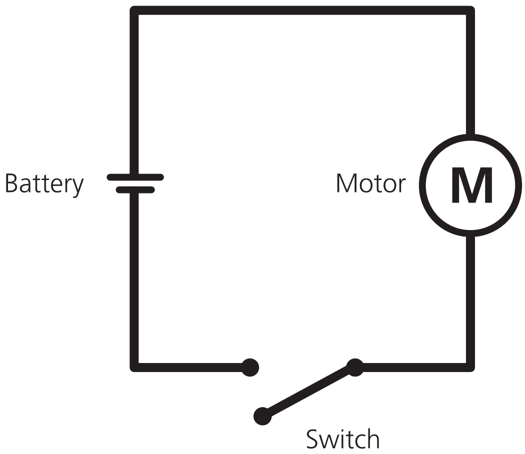
You will need:

Electronic components

- A mini vibration motor
- A 3V coin battery

Other items

- A toothbrush head
- Double-sided foam tape
- Sticky tape
- Two paperclips
- A small piece of card
- Wire stripper
- Scissors
- Googly eyes (optional)
- Pipe cleaners (optional)

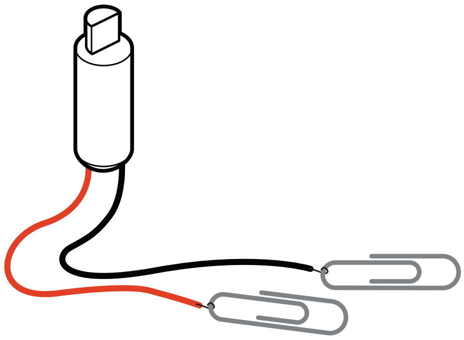


Here is a diagram of the circuit you will be making.

Instructions:

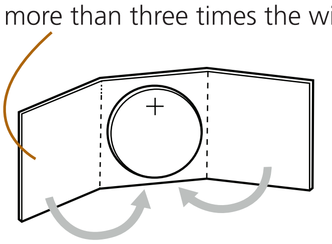
a) Prepare your motor

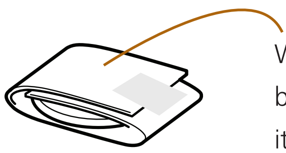
1) Cut down the wires from the motor so that they are about 4cm long.
2) Very carefully strip 1-2cm of insulation from the end of each terminal of your motor.
3) Attach a paperclip to each wire by looping the wire through and twisting it around on itself. The paperclips will be used as battery contacts.



b) Make a battery holder

Cut a rectangle of card that is the same height, and slightly more than three times the width of your 3V coin battery.





Wrap it round into a pocket that the battery can slide in and out of and stick it together – it should have two layers of card on one side and one of the other.

PROJECTS 02 – BRUSH BUG 2/2

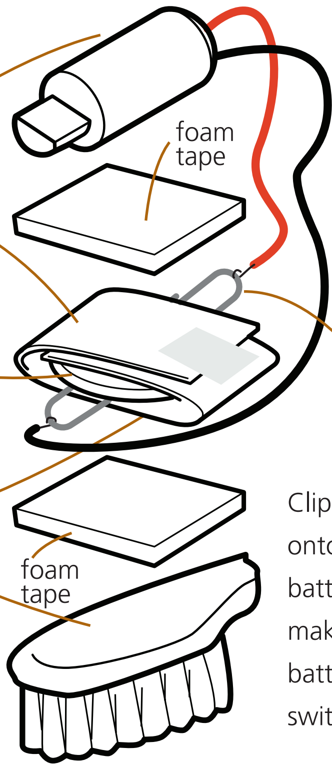
c. Assemble your bug

Stick the motor to the top of the pocket – make sure the motor can rotate freely.

Insert the battery into the pocket so that it is in contact with the paperclip.

Clip one of the paperclips attached to the motor onto the single layered side of the pocket.

Stick the side with the paperclip attached to the back of the toothbrush head.

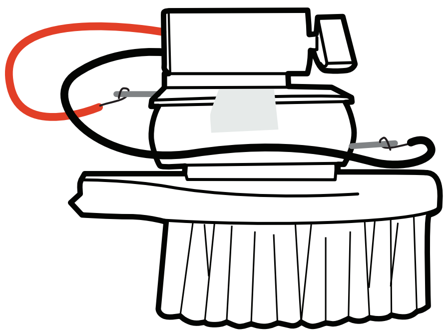


Clip the second paper clip onto the inside fold of the battery pocket so that it makes contact with the battery. The motor should switch on.

Finish your bug by adding eyes and other features - unclip the top paperclip to switch the motor off first.

Replace the paperclip to switch on your completed brush bug.

If you have problems with your bug toppling over, you could add some pipe-cleaner stabilisers.



Other things you could try:

- Use bigger brushes and motors to make brush bugs of different sizes. You can turn an ordinary motor into a vibration motor by attaching a weight to the axle (see explanation above). You will also need to use batteries of the appropriate voltage to power the motors.
- Can you invent some games for your brush bugs? Do they behave differently on different surfaces?
- What about attaching a felt tip to them and creating some brush bug art?

PROJECTS 03 - USB POWERED COLOUR-CHANGING LED 1/2

In this project you will create an colour-changing LED light that is powered by a USB cable. The USB connection on a computer gives out 5V of electricity and a colour-changing LED also needs 5V of electricity.

You could use this project to practice your soldering skills, but it will work perfectly well with no soldering.

You will need:

Electronic components

- A 5V colour-changing LED
- A USB power lead

Other items

- Insulating tape
- Computer or USB power adapter for testing
- Soldering equipment (optional)
- Wire cutters
- Wire strippers

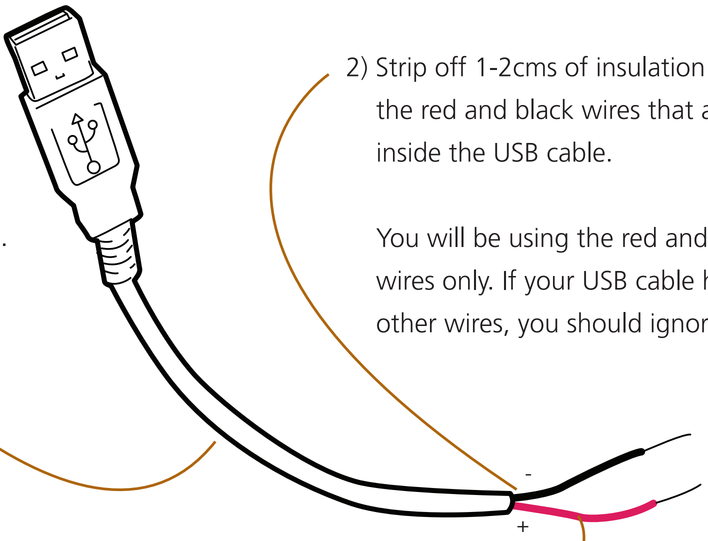
Here is a circuit diagram for the USB light.

Instructions:

Prepare the USB cable

1) Decide how long you want the cable of your light to be.

If the cable is too long, trim it to the length you want to use.



2) Strip off 1-2cms of insulation from the red and black wires that are inside the USB cable.

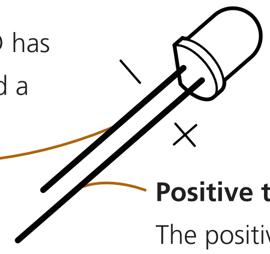
You will be using the red and black wires only. If your USB cable has other wires, you should ignore them.

3) Strip the outer casing from the last 5cms of the cable to expose the wires inside.

PROJECTS 03 – USB-POWERED COLOUR-CHANGING LED 2/2

Identify the negative and positive terminals of your LED.

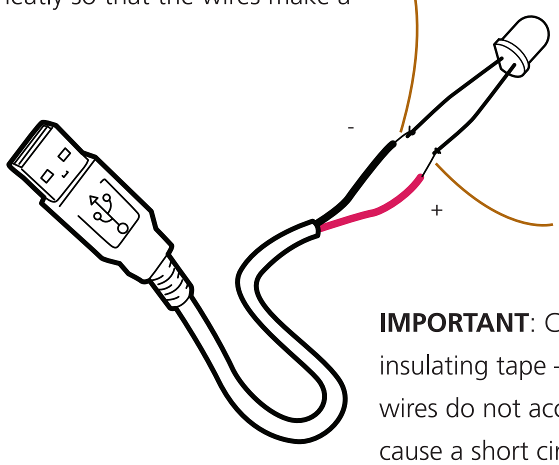
Negative terminal:
The negative terminal of an LED has a flattened area on the case and a shorter wire.



Electricity can only flow one way through LEDs, they need to be wired the right way round.

Positive terminal:
The positive wire is longer, and the case is round.

Line up the negative terminal of your LED side by side with the negative (black) terminal of the USB cable. Tape them together neatly so that the wires make a good contact.



Do the same with the negative wire and the negative terminal of the LED

IMPORTANT: Cover any exposed wire with insulating tape – this is to make sure the bare wires do not accidentally make contact and cause a short circuit.

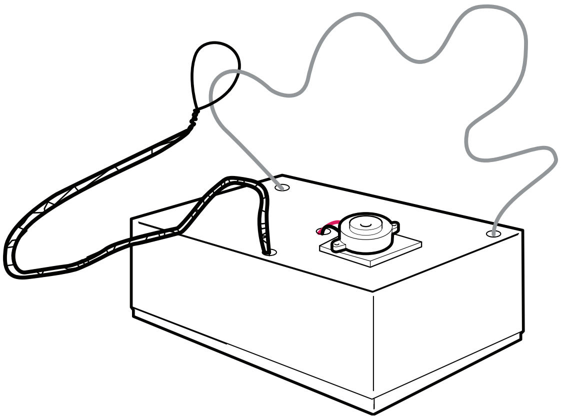
Your light is ready to test.
To make a stronger, longer-lasting version of this light and practice your soldering skills, you could solder the joints instead of taping them together. You should still cover any bare wire in insulating tape once you have finished to avoid any short circuits.

Other things you could try:

- How could you add more than one colour-changing LED to the USB power cable? Is there enough power to light them both in series, or would you need to put them in parallel?
- Could you connect other types of LED to the USB cable? How much resistance would you need to add to make sure the LEDs do not burn out?
- What other useful circuits could you build that could be powered from a USB cable?
- You could insert the LED into a ping pong ball with a hole cut in it. Draw on some eyes and whiskers and stick on some ears to create a computer mouse! What else could you use to diffuse the light?

PROJECTS 04 – STEADY HAND GAME 1/3

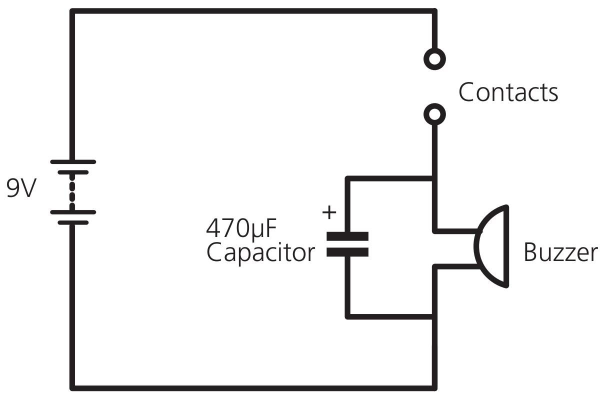
In this project, you will make a steady hand game where players have to guide a loop round a bendy wire without the loop touching the wire. As soon as contact between the wire and the loop is made a buzzer sounds.



A capacitor has been added into the circuit to make the sound from the buzzer last for slightly longer. A capacitor is a little bit like a battery – it can store a small amount of charge.

When the circuit is completed, the capacitor gets charged up. When the contact between the loop and the wire is broken, the capacitor releases the stored charge through the buzzer. This makes the buzzer sound continue for a moment after the circuit has been broken.

Here is the circuit diagram for the game.



You will need:

Electronic components

- A 9V piezo buzzer
- A 470µF, 16V electrolytic capacitor
- 4-pole terminal block connector
- 50cm bare copper wire or other bare wire (e.g. florists wire)
- 70cm stranded insulated wire
- A 9V battery
- A battery snap

Other items

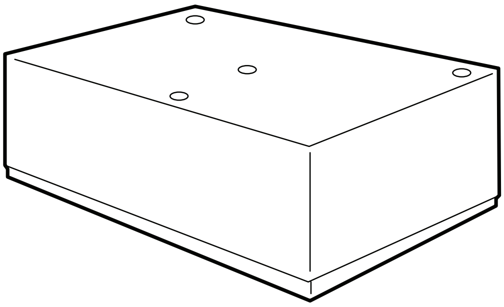
- A shoebox or similar sized box to make the base
- Insulating tape
- Foam tape
- Wire strippers
- Wire cutters
- Screwdriver
- Play dough or modelling clay to press on when you make holes in the box

PROJECTS 04 – STEADY HAND GAME 2/3

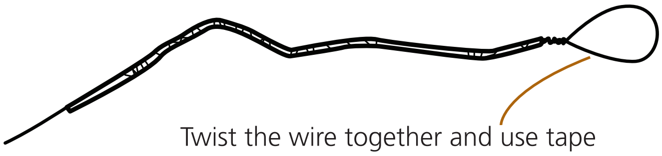
Instructions:

1) Identify the components - check the list to make sure you have all the components you need and know what they are. Make sure you can recognise their circuit symbol too.

2) Prepare your box: use a screwdriver to poke four small holes in the lid of the shoebox as shown.



3) Make the loop for the game - cut off about 5cm of your insulated wire and put it to one side. You will be using this later to wire up your circuit. Use the rest to make the loop.

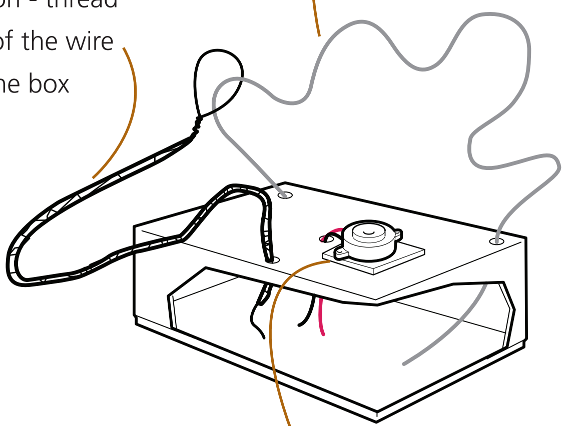


Strip the insulation from around 5cm of one end of the wire. Make it into a loop.

Twist the wire together and use tape to fix the ends in place.

4) Put the loop in position - thread the non-looped end of the wire through the hole in the box as shown.

5) Make the wire puzzle for the game - take the bare wire and bend it into the shape you want to use for the game.

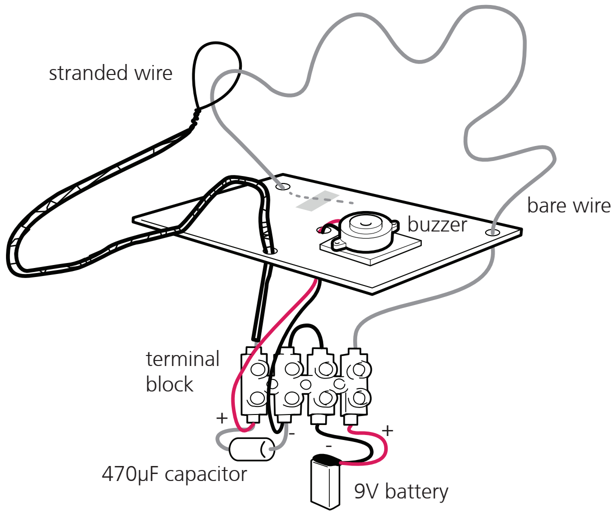


More bends will make the game harder.

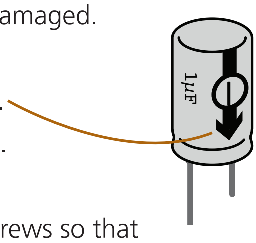
No two parts of the bare wire should be in contact with each other.

6) Put the buzzer in position
Secure it in place using foam tape.

7) Build the circuit using the terminal block.



First you need to identify the negative and positive terminals of the buzzer and the capacitor. They will not work if they are the wrong way round and could be damaged.



- The capacitor should have painted arrows pointing to the negative terminal.
- The buzzer should have a red wire for positive and a black wire for negative.

Wire the components into the terminal blocks as shown above. Loosen the screws so that you can push the wires in, then tighten them to hold the wires in place.

8) Attach the terminal block to the inside of the box using foam tape.

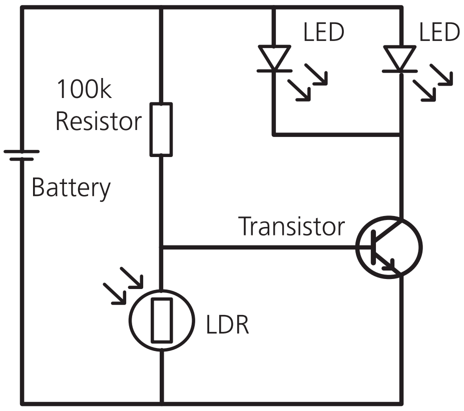
9) Finally, connect the battery - **MAKE SURE IT IS THE RIGHT WAY ROUND**

Your steady hand game is ready to play.

PROJECTS 05 – NIGHT LIGHT 1/4

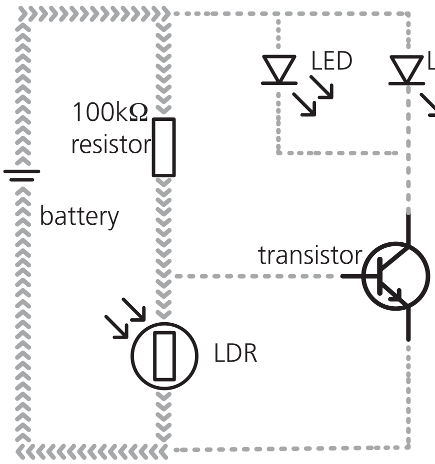
In this project you will use a light dependent resistor (LDR) to build an LED light that switches on when it gets dark. The circuit will fit into a plastic 1 pint milk bottle which can be sealed with tape to make it waterproof and hung outside your tent. The circuit is made using Bare Conductive Paint instead of wires. This is a special type of paint that can conduct electricity.

Here is a circuit diagram for the night light. It is an example of a type of circuit called a voltage divider.

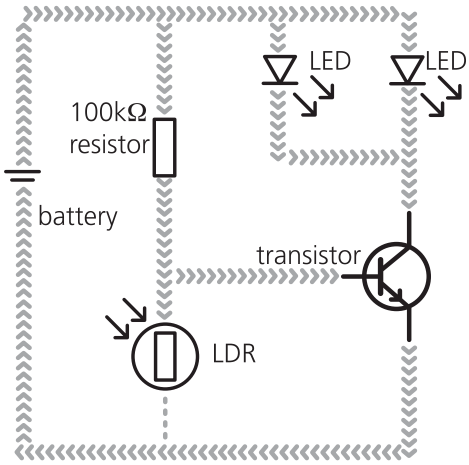


When it is light, the LDR's resistance is low, so electricity flows through it easily. There is no electricity reaching the base terminal of the transistor, so it is switched off. This means the circuit to the LEDs is broken, so they do not light.

When it is dark, the LDR resistance is high so electricity does not flow through it. Instead, electricity takes the easier route and flows to the base terminal of the transistor. This switches the transistor on which means that electricity can flow round the circuit through the LEDs, so they light up.



Flow of electricity in the light.



Flow of electricity in the dark.

You can find out more about how each component works in the glossary which is available from the Electronics Activity Badge page of the Scout Association website - scouts.org.uk/iet

PROJECTS 05 – NIGHT LIGHT 2/4

You will need:

Electronic components

- 1 light dependent resistor (LDR)
- 2 ultra-bright LEDs
- A transistor (number BC547)
- 100kΩ resistor
- PP3 battery clip
- 9V battery

Other items

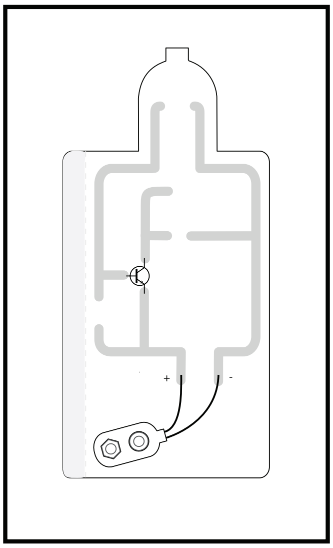
- Circuit layout printed onto thin card*
- Bare Conductive Paint
- A clean, dry 1 pint PET milk bottle with lid
- A single hole hole-punch or a craft knife
- Masking tape (or other removable sticky tape)
- Duct tape (for waterproofing - optional)
- Scissors
- Wire strippers
- Wire trimmers
- Modelling clay or play dough to rest on when making holes

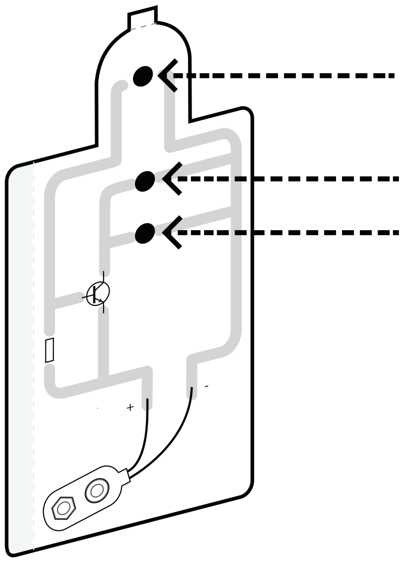
Instructions

1) **Identify the components** – check the list above to make sure you have all the components you need and know what they are. Make sure you can recognise the circuit symbol too.

2) **Prepare the circuit**

Cut out your card circuit board.





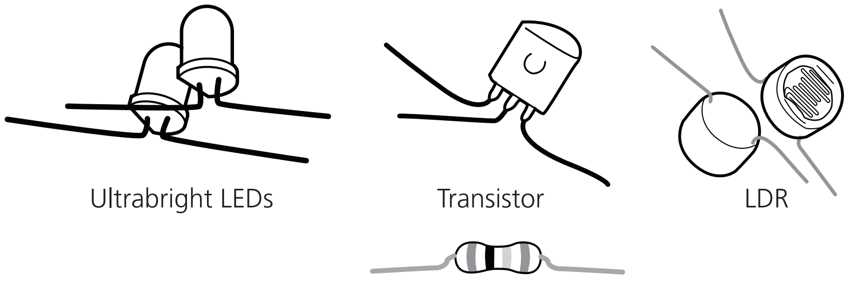
Punch holes in the circuit where the two LEDs and the LDR will go.

* the template is available from the Electronics Activity Badge page of the Scout Association website - scouts.org.uk/iet

PROJECTS 05 – NIGHT LIGHT 3/4

3) **Prepare the components**

- Strip off around 1cm of the insulation from each of the battery clip wires.
- Bend out the wires on each of the components to make them sit flat on the circuit. Trim each wire so that it is about 1cm long.



4) **Build the circuit**

Start by fixing the components in place using Bare Conductive Paint. Use small blobs of paint to stick each of the component wires in place on the ends of the grey lines. The wires need to be covered in paint, so add a little more paint on top if you need to.

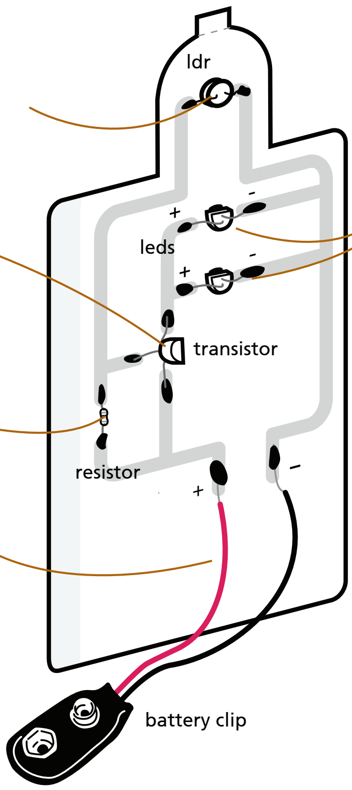
IMPORTANT: Try not to get paint outside the grey lines.

Stick the LDR in position with the LDR **sensor down facing** through the hole.

Fix the transitor in place with three blobs of paint.

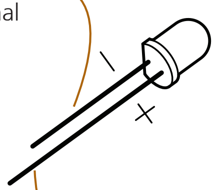
Fix the resistor in place using a blob of paint on each wire.

Use tape to hold the battery clip in place, then use paint to stick the exposed wire to the circuit. Make sure you put the battery clip the right way round.



Stick the **LEDs** in position. They must be **connected with negative to negative and positive to positive**.

The LED lights should **poke through the holes** so that the part that lights up is on the reverse side to the circuit.



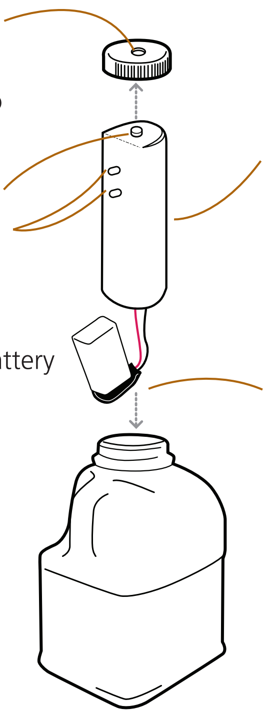
Once all the components are in place, complete the circuit by painting over the grey lines and leave to dry. The paint needs to be completely dry before the circuit will work properly.

PROJECTS 05 – NIGHT LIGHT 4/4

5) When the paint is dry, connect the battery and test your circuit. When you cover the LDR and block out the light, the LEDs should come on.

6) Finish the light by fitting the circuit into a plastic pint bottle.

Ask an adult to help you to make a hole in the middle of the lid of the bottle – this is for your LDR to fit through.

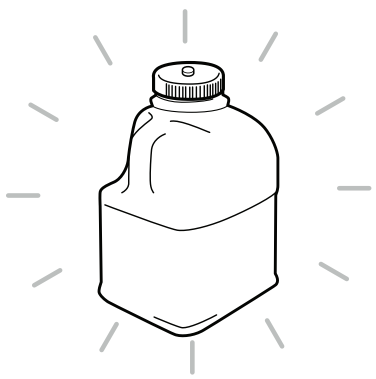


Roll the card into a tube with the **painted circuit** on the **inside** and fix it in shape with tape. Do this carefully - if you crack the paint, you will break the circuit.

Take the circuit with the battery attached and gently lower it into the bottle, battery first. Be careful not to knock the LEDs out of place.

- If you want to make your light waterproof, seal the top of the bottle using duct tape before you put the lid on the bottle. Make sure there is a hole in the tape for the LDR sensor to show through.

- Hang up your light and wait for dark (or cover the LDR with your finger to test that it is working).



Other things you could try:

- Replace the resistor with resistors of different values and see how this affects the sensitivity of the light.

PROJECTS 06 – LIGHT-UP MAP 1/3

Help your patrol to find their way around with a light-up map. In this project, you will make a map which has LEDs that light up when you press a button to show you the location on the map.

There are many ways you could do this depending on your skills, equipment and how much time you have. You could build your circuit using a combination of soldering and terminal block, or using terminal block and a little tape.

The quality of your final map will depend on the materials you use. A soldered version will be much sturdier and last longer. It is also quite a good way of getting some practice at soldering.

Here are some instructions to get you started.

You will need:

Electronic components

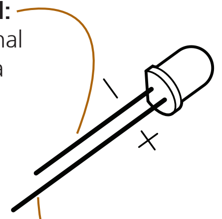
- Five or more LEDs – you will need one for each location on your map
- 330Ω resistors – as many as you have LEDs
- A 9v battery
- Terminal block
- Wire
- Paperclips and split pins to use as switches

Other items

- A printed map OR pens and paper to make your own
- Cereal box and glue
- Wire stripper
- Insulating tape
- Screwdriver
- Soldering iron and solder (optional)
- Cardboard to make a box (optional)

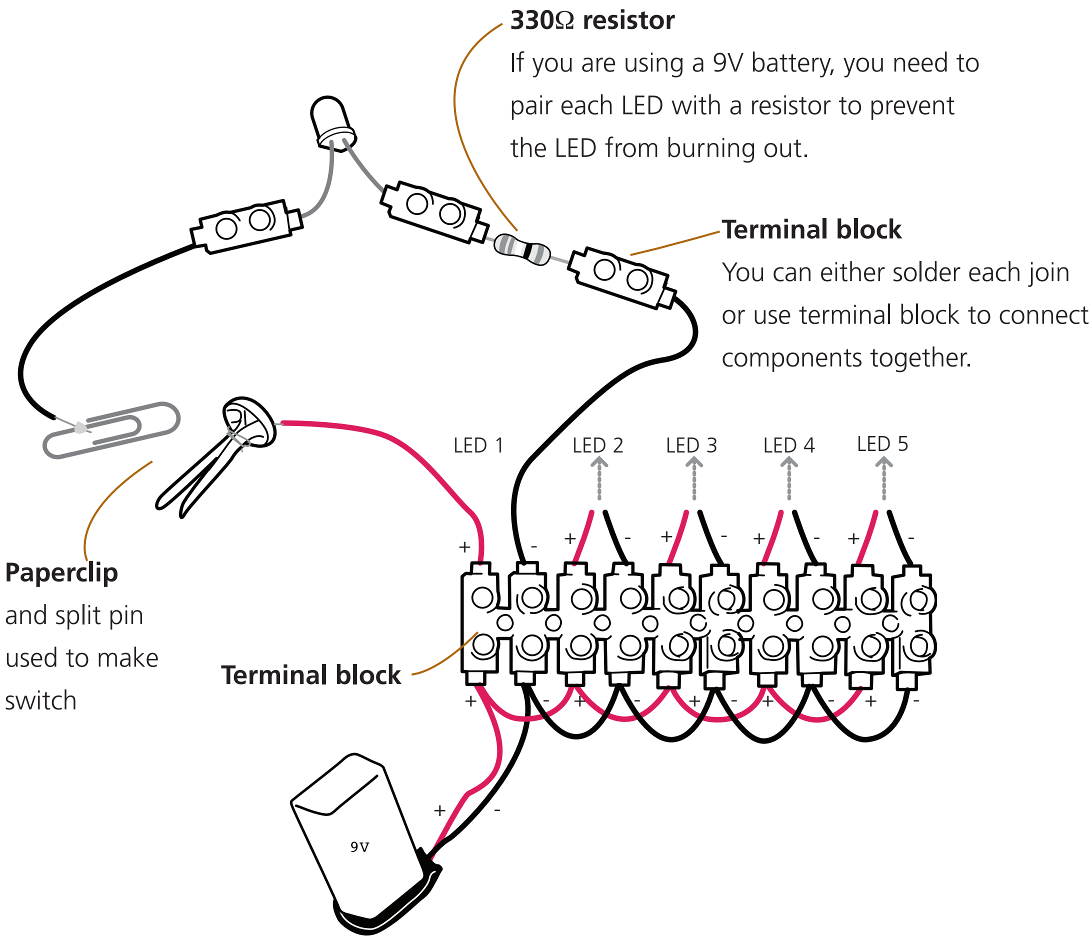
You will need to light a number of LEDs using just one battery. The LEDs need to be connected in parallel so that they can be switched on and off independently. Each of the parallel circuits will contain an LED, a switch and a resistor.

DON'T FORGET: LEDs need to be connected the right way round.



PROJECTS 06 – LIGHT-UP MAP 2/3

First, you will need to split the power from one battery into a parallel circuit for each LED. Here is one way you could do that using terminal block.



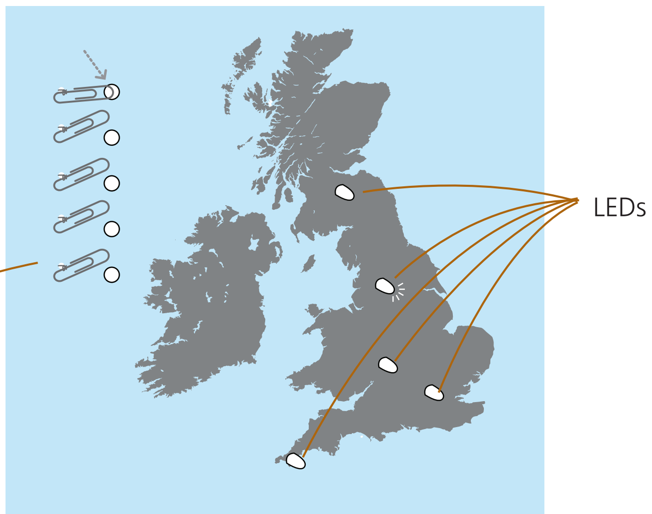
You should also connect the same circuit that is shown in the diagram above for LED 1 to the positions marked LED 2, LED 3, LED 4 and LED 5 on the diagram.

Instructions

1) Make a map if you don't already have one and back it onto card.

2) Neatly mark the positions of the LEDs on the map.

3) On the same paper, mark the area where you will put the "key" of switches that will turn the lights on and off.



Map key made from paperclip and split pin switches.

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4) Work out the circuit you need to use. Think about how you are going to connect the switches and LEDs through the map and into the circuit.

5) Build your circuit. Be careful and make sure you test each step as you build it. This is much easier than getting to the end and finding that nothing works.

6) You may need to build a small box or frame to hold all the circuitry behind the map.

7) Once you have assembled your map, it is ready to use.

How to calculate the value of resistors to use

Resistance is calculated using Ohm's law.

Ohm's Law: $\text{resistance (R)} = \dfrac{\text{voltage (V)}}{\text{current in amps (I)}}$

LEDs need a voltage of around 2.4V at a current of 20mA. The exact value for the LEDs you are using should have been supplied with the LEDs. The circuit needs enough resistance to reduce the supply voltage to the LED's operating voltage (you are not trying to reduce the voltage reaching the LED to zero). This means that the resistance required can be calculated as:

$$R = \frac{Vsupply - VLED}{I}$$

Ohm's law uses the current in amps (A), not milliamps (mA). LEDs typically draw 20mA or 0.02A
So for a 9V battery, the resistance would be calculated as below:

Voltage of battery

Voltage LED needs

$$\frac{9 - 2.4}{0.02} = 330\ \Omega$$

Current LED needs

Resistors are only commonly available at standard values. If the value you calculate is not a standard value, you should choose a resistor that is the closest value greater than the calculated value.

Other things you could try:

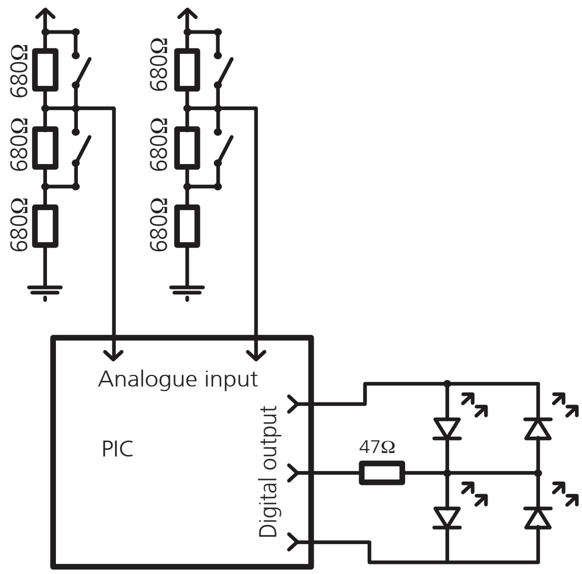
- Make a treasure map with lots of dummy lights and only one real light.
- Make a map that lights from behind to reveal hidden information.
- Make a light up diagram to show parts of the body or the planets in the solar system.
- Try using LDRs or thermistors so that the lights turn on or off in response to light or heat instead of through a contact switch.

PROJECTS 07 – MEMORY REACTION AND TIME GAME 1/2

Test your friends' reaction times and memory with this electronic game. The game has two modes. The first is a memory game where you copy a sequence of flashing lights. If you copy it correctly, another light is added to the sequence making it increasingly difficult to remember. The second is a reaction time game where you need to respond to one of four lights by quickly pressing a switch. Get it right and the game speeds up, get it wrong and it's game over.

This digital circuit uses a printed circuit board and pre-programmed microcontroller on an integrated circuit (IC).

The game uses resistors to make up a voltage divider. Depending on which buttons are pressed, the voltage changes across the resistors. This voltage is fed into the microcontroller which can then work out which button is pressed. The microcontroller then produces a digital output, either 1 or 0 - on or off - to light up one of the four LEDs.



You will need:

Electronic components

- Electronic Memory and Reactions Game kit
- Two AA batteries

Other items

- Soldering iron and solder
- Wire cutters
- Card or thin foam board (optional)
- Coloured pens, pencils or crayons (optional)
- Tape or glue (optional)
- Scissors or a craft knife (optional)

Before you start, have a look at the circuit board. On one side you will see a number of labelled spaces where the components need to go. You will need to solder the components on the back of the board.

PROJECTS 07 – MEMORY REACTION AND TIME GAME 2/2

If you look carefully at the back of the board you will also be able to see the printed circuit that will connect each of the individual components. When soldering the components in place you will find it easier to start with the small components and work up to the larger ones. The kit comes with instructions on how to solder the components in place, but you must remember to trim back the terminals of the resistors and LEDs with wire cutters after you've soldered them in place so that they don't connect with any of the other components causing a short circuit.

You will need to solder the circuit to ensure that the connections are secure. If any of the components come loose then the circuit will be broken and the game will not work.

Instructions:

1) Identify the components – check the kit list to make sure you have all the components you need and know what they are. Make sure you can recognise their circuit symbol too.

2) Ensure you have all the soldering equipment you will need before you start. If you haven't done so already then read the guide to soldering in this pack and test out your soldering skills before you start to build the game.

3) Once you are comfortable using the soldering iron, follow the instructions that come with the kit to solder the components in place. The instructions include information on what you will need to check before you insert the batteries, and how to test your circuit.

If your circuit doesn't work then have a look at the finding fault flow chart that comes with the kit. You may need to remove some of the solder if it is causing a short circuit or if you have a dry joint where it isn't making a good connection. **Check everything carefully.**

Other things you could try:

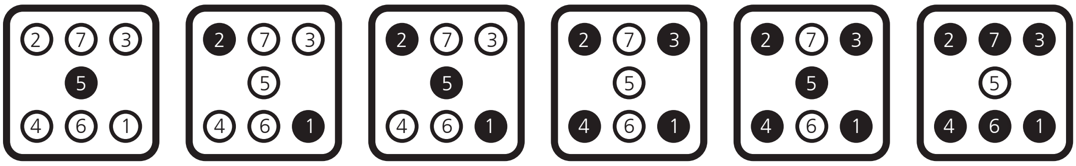
- Design a cover for your game with holes for the switches and LEDs, but enclosing all of the other components. You can design the cover any way you like, you may want to draw large coloured squares for each of the coloured LEDs, or you may want to keep it very simple and just include some basic information about which button to press to start the reaction game and which to start the memory game.

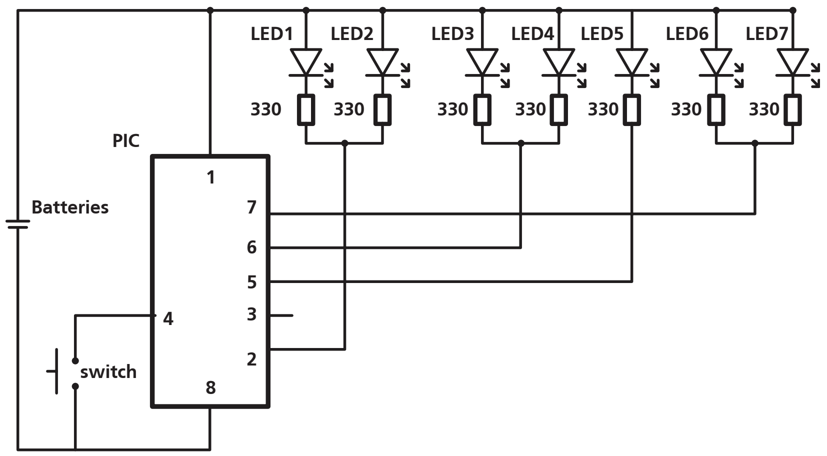
PROJECTS 08 – ELECTRONIC DICE 1/2

This project uses a kit to create an electronic dice. A 'roll' of the dice randomly generates a number between 1 and 6 which is displayed like the face of a dice with lit LEDs for the spots.

This digital circuit uses a printed circuit board, a push switch, resistors, LEDs and a microcontroller on an integrated circuit (IC). When the switch is pressed, the microcontroller, which is like a small computer, rapidly cycles through numbers 1 to 6.

When the button is released a final number is displayed and the microcontroller determines which of the LEDs should be lit up.





Number on dice	LEDs that are on	IC pins
1	5	5
2	1+2	2
3	1+2+5	2+5
4	1+2+3+4	2+6
5	1+2+3+4+5	2+5+6
6	1+2+3+4+6+7	2+6+7

You will need:

Electronic components

- Electronic dice kit
- Three AA batteries

Other items

- Soldering iron and solder
- Wire cutters
- Card or thin foam board (optional)
- Coloured pens, pencils or crayons (optional)
- Tape or glue (optional)
- Scissors or a craft knife (optional)

Before you start, have a look at the circuit board. On one side you will see a number of labelled spaces where the components need to go. You will need to solder the components on the back of the board.

If you look carefully at the back of the board you will also be able to see the printed circuit that will connect each of the individual components.

When soldering the components in place you will find it easier to start with the small components and work up to the larger ones. The kit comes with instructions on how to solder the components in place, but you must remember to trim back the terminals of the resistors and LEDs with wire cutters after you've soldered them in place so that they don't connect with any of the other components causing a short circuit.

You will need to solder the circuit to ensure that the connections are secure. If any of the components come loose then the circuit will be broken and the game will not work.

Instructions:

1) Identify the components – check the kit list to make sure you have all the components you need and know what they are. Make sure you can recognise their circuit symbol too.

2) Ensure you have all the soldering equipment you will need before you start. If you haven't done so already then read the guide to soldering in this pack and test out your soldering skills before you start to build the dice.

3) Once you are comfortable using the soldering iron, follow the instructions that come with the kit to solder the components in place. The instructions include information on what you will need to check before you insert the batteries, and how to test your circuit.

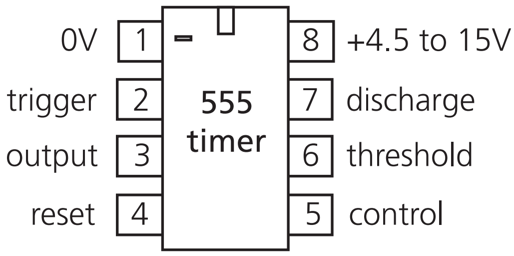
If your circuit does not work, check everything carefully. You may need to remove some solder if it is causing a short circuit or if you have a dry joint that isn't making a good connection.

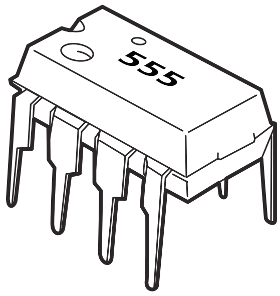
Other things you could try:

- Design a cover for your dice. This will need holes for the button and LEDs, but enclosing all of the other components.

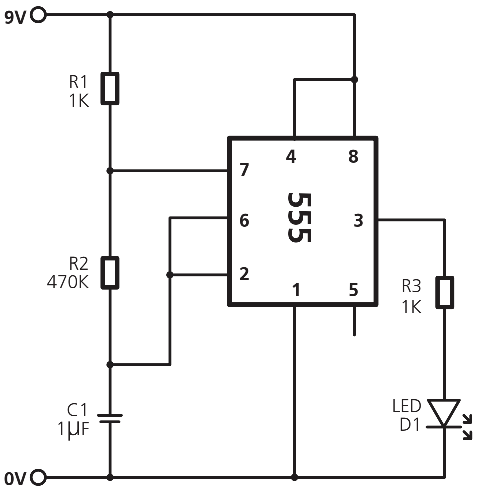
PROJECTS 09 – GUY ROPE GUIDES 1/3

Make some flashing LEDs to attach to guy ropes so that your fellow Scouts don't trip over them in the dark. This project uses a 555 integrated circuit (IC) timer chip which converts analogue input, in this case variable voltage, into digital outputs - 1 or 0 - to switch an LED on and off.





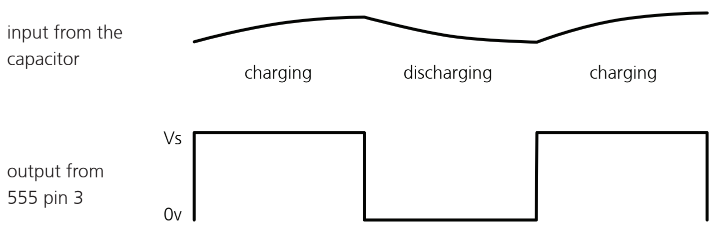
Each of the 555 chip's pins is numbered and performs a different function. In this circuit the 555 IC chip is used with a capacitor and resistors to switch a single LED on and off.



If you look at the circuit diagram and the numbers on the 555 chip you will notice that they are not in the same order. The diagram is schematic and gives the clearest way to display the information needed to build the circuit. You will need to use wires to connect some of the pins and complete the circuit.

The circuit also contains three resistors, a capacitor and an LED. The resistors R1 and R2 create a voltage divider which charges the capacitor (C1). When the capacitor reaches a threshold voltage it discharges with current flowing to one of the pins of the 555 chip.

The capacitor then begins to charge again and repeats the charge/discharge cycle at a regular frequency. The 555 chip converts this change in voltage into a square wave and produces an output that switches the LED on and off.



The circuit is built on strip-board and you will need to solder the circuit to ensure that the connections are secure. If any of the components come loose then the circuit will be broken and the light will not work.

The components will need to be placed on the side of the board without the tracks with their leads pushed through to the back of the board and soldered in to place on the metal tracks.

You will need:

Electronic components

- A 470K resistor
- Two 1K resistors
- A 1µF capacitor
- An LED
- A NE555N chip
- An IC holder
- Strip board
- 9V battery
- A battery snap
- Wires

Other items

- Soldering iron and solder
- Wire cutters
- Spot tool or drill bit

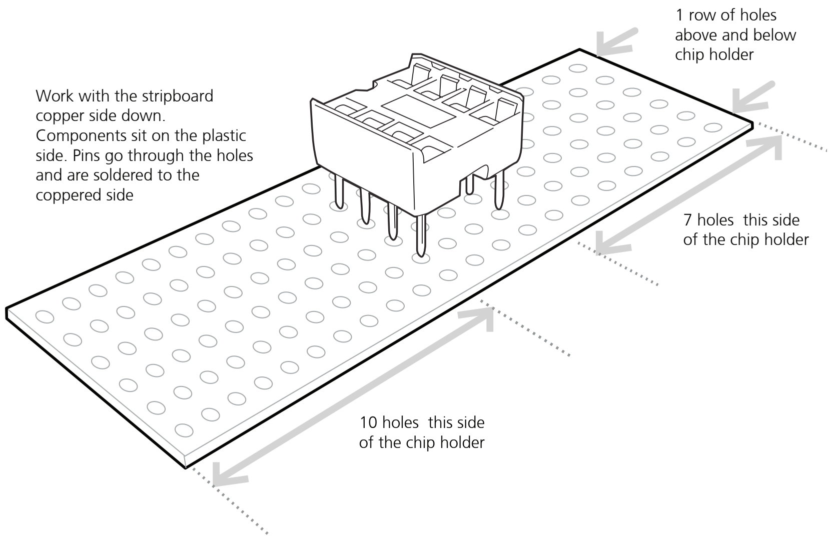
Instructions:

1) Identify the components – make sure you have all the components you need and know what they are. Make sure you can recognise their circuit symbol too.

2) Ensure you have all the soldering equipment you will need before you start. If you haven't done so already then read the guide to soldering in this pack and test out your soldering skills before you start to build the circuit.

3) Make sure the tracks of the strip board are running horizontally (left to right) rather than vertically and place on the table with the track side down.

4) Place the IC holder on the board pushing through the pins to the back and soldering into place. The IC holder will have a notch in one end, make sure this is facing the right way.



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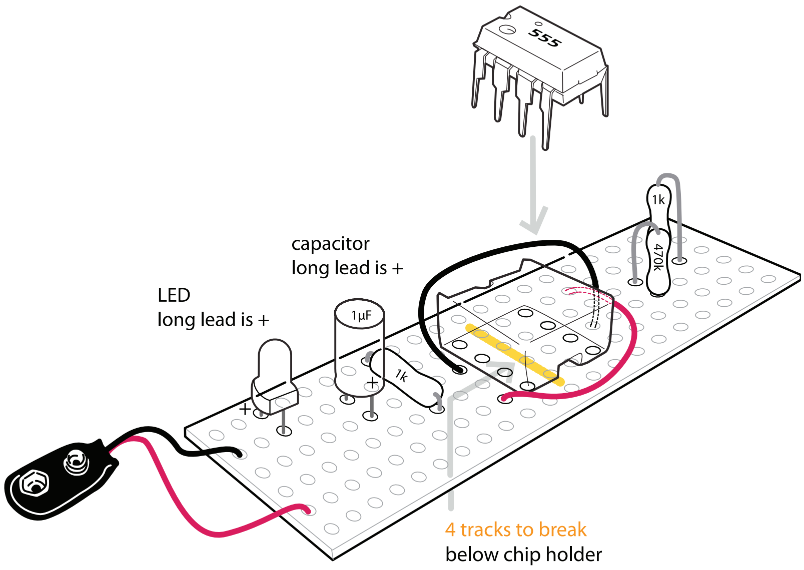
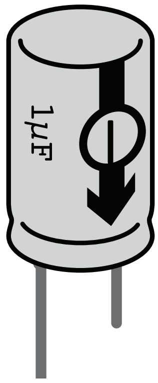
5) Use a spot tool or drill bit to break the tracks under the IC holder as marked on the diagram. You can do this by placing the spot tool or drill bit into one of the holes on the back of the board and twisting until it breaks the metal track.

6) Next insert the resistors. They can be placed either way round, but they must line up correctly with the IC.





7) Next solder into place the LED and capacitor. These both need to be the right way round for the circuit to work. You can identify which is the anode (positive terminal) as that is the long lead.

8) Solder in place the wires that connect up the pins of the IC. You may need to strip some of the insulation from the ends of the wires before you do this. Make sure you leave enough exposed wire to solder securely into place. Too short and it may come loose.

9) Finally solder the battery snap in place ensuring that you have the positive and negative terminal the right way round.

10) Place the IC in to the holder ensuring the notch on the chip lines up with the notch on the holder.

Insert a 9V battery and the LED should start to flash. If it does not, check all your connections and make sure the solder is not bridging any of the tracks on the back of the board. Check that the LED and capacitor are the correct way around and make sure the notch of the 555 chip is lined up with the notch on the IC holder.

Other things you could try:

- Once you have successfully mastered the flashing LED circuit you could make more using different coloured LEDs and attach these to guy ropes when camping. You will have to think of a way to make your circuits weather proof, such as placing them in clear plastic sandwich bags.

CHALLENGES

Below are some open-ended challenges for you to have a go at. The challenges give some of the kit needed, but doesn't cover everything so you will have to apply your knowledge of electronics and your problem solving skills to come up with a solution.

CHALLENGES 01 – MAKE A CREDIT CARD TORCH

The situation:

You find yourself stranded in the middle of a wood with some members of your patrol. You realise that it is starting to get dark and the batteries in the only torch you have are starting to go. In order to find your way home you are going to need some light, so everyone digs into their pockets to see if they have anything that would be useful. You have got:

- A couple of ultra bright LEDs
- Some string
- A few pieces of card
- Some electrical tape
- A couple of 3V coin batteries
- A paperclip
- A small piece of foam

Can you make a torch from this equipment? You have some basic material too such as a penknife and a pair of scissors.

Things to consider:

- You will need to work out what voltage you need to power a bright LED.
- How will you switch the torch on and off?

"The five essential skills for success are concentration, discrimination, organisation, innovation and communication".
Michael Faraday.

CHALLENGES 02 – MAKE A MARSHMALLOW TOASTING ALARM

The situation:

You are sitting round the campfire with your friends toasting some marshmallows. Unfortunately you aren't getting to eat many marshmallows as every time you get near to the fire to hold your toasting fork up you suddenly become very sleepy and let your fork slip into the fire ruining your marshmallow treat.

Just as you are about to give up, your friend points out that some kit has been left over from the Electronics Badge and maybe you could make something to help you stay awake long enough to toast a marshmallow.

In the kit there is:

- Some electrical tape
- Some AA batteries with holders
- A piezo buzzer
- A tilt switch
- Some card
- Elastic bands
- Wires

Can you make something that will prevent you from falling asleep whilst toasting marshmallows? You have some basic material too, such as a penknife and a pair of scissors.

Things to consider:

- You may need to experiment to find out what angle this circuit needs to be held at.

CHALLENGES 03 – MAKE A FLASHING BADGE

The situation:
You have just been awarded your electronics badge but when you get it home your little brother likes the look of it so much that he wants one too. He is a bit too young for Scouts, so you decide to make him a replica, but he wants his badge to be different - he wants his badge to flash!

Using your new found skills and knowledge in electronics you buy:

- Some electrical tape
- A 9V battery with snap
- A capacitor
- Some resistors
- Some strip board
- Some LEDs
- Wires
- A 555 timer IC chip and holder

You also have some basic materials and the soldering equipment you used to complete your badge.

Things to consider:

- The 9V battery is quite large so you have to think about how you can attach this to the badge.
- How will you light up the badge itself? Are you going to copy the design on to card and cut sections out? Or are you going to make it out of something semi-transparent?