BATTERIES

Batteries are a simple and safe way to provide electricity for our experiments.

Batteries come in a huge variety of sizes and types.

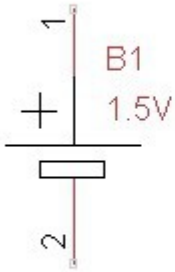
The power of batteries is measured in 2 ways:

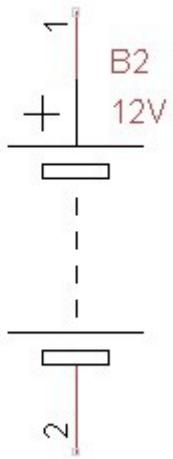
1) The VOLTAGE. Measured in Volts.

2) The CAPACITY. Measured in Amp-hours, or milliamp-hours for small batteries.

In a Circuit Diagram the symbol for a battery is:

Single Cell battery. Typically 1.2V to 3V depending on chemistry.



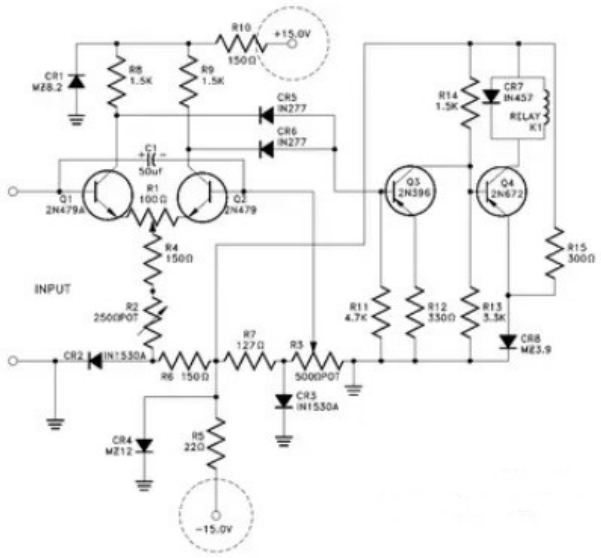


Multi-Cell battery made of a stack of single Cells. A 12V battery is 8 1.5V Cells.

One end or connector of a battery is marked "+", called the 'Positive' terminal, and often coloured red or brown. The other end or connector is marked "-", called the negative terminal, and often coloured black or blue.

CIRCUIT DIAGRAMS

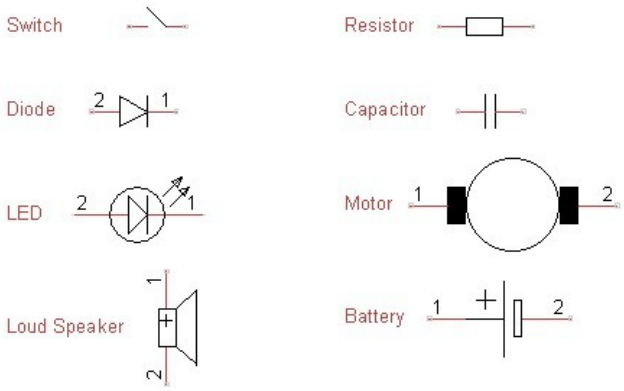
A Circuit Diagram is standardised way of describing the components of an electrical system and the connections between them.



Circuit Diagrams are often called 'schematics' because they don't show the physical size, shape or layout of the actual components.

Using standard symbols enables anyone, anywhere, to build the circuit.

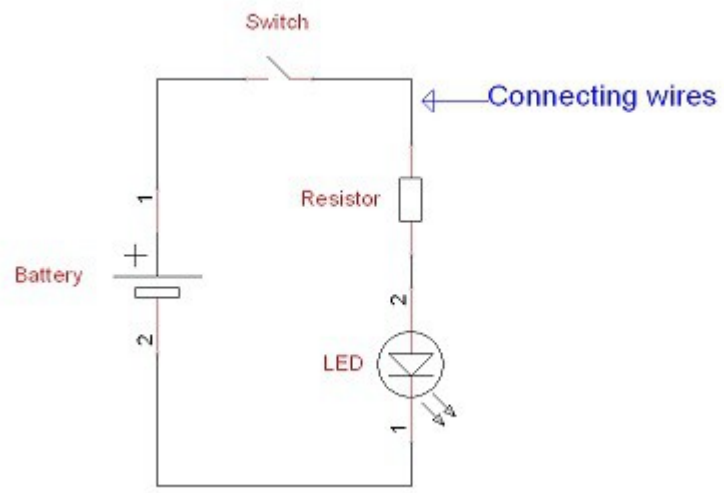
The term 'Circuit' has a specific meaning, as we shall learn later, but is also used less formally to mean any arrangement of electrical components.



Here is a small selection of common symbols. We will be learning more about these components later.

In the circuit diagram, lines indicate the wires that connect the various components.

Laying out the diagram carefully can help the reader to understand how the circuit works.



MULTIPLES AND SUB-MULTIPLES

Symbol	Name	Multiplier	Power of 10
G	Giga	1000000000	9
M	Mega	1000000	6
K	Kilo	1000	3
		1	0
m	milli	0.001	-3
μ	micro	0.000001	-6
n	nano	0.000000001	-9
p	pico	0.000000000001	-12

The symbols for multiples are capital letter and for sub-multiples are lower-case letters, e.g. mV – millivolts, MV – Megavolts..

The Greek letter μ is often changed to u for convenience.

Values can often be expressed in more than one way,

e.g. 100 microvolts = 0.1 millivolts.

Giga	Mega	Kilo	(unit)	milli	micro	nano	pico
1.0	1000						
0.1	100						
	10	10000					
	1	1000					
	0.1	100					
	0.01	10	10000				
	0..001	1	1000				
		0.1	100				
		0.01	10	10000			
		0..001	1	1000			
			0.1	100			
			0.01	10	10000		
			0..001	1	1000		
				0.1	100		
				0.01	10	10000	
				0..001	1	1000	
					0.1	100	
					0.01	10	10000
					0..001	1	1000
						0.1	100
						0.01	10
						0..001	1

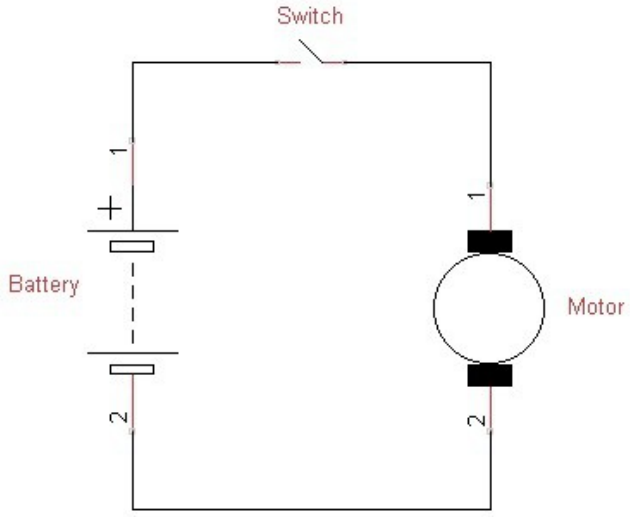
CIRCUITS

A circuit is a complete circular path that electricity flows through.

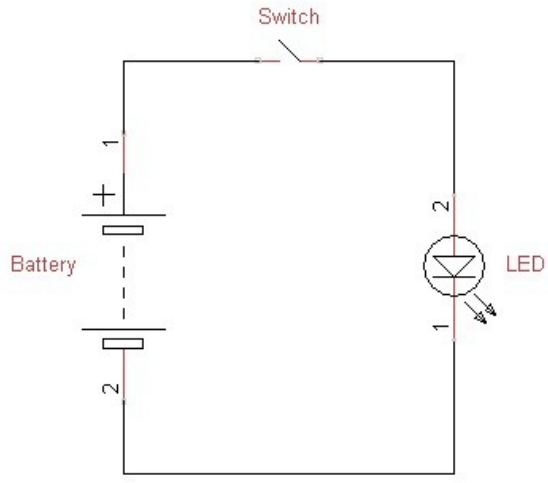
A simple circuit consists of a current source, conductors and some component(s) that use the electricity. These components are often called the 'load'.

The term circuit can be used in a general sense to refer to any fixed path that electricity, data or a signal can travel through.

EXERCISE: Use a battery, switch and motor to make this circuit:



Reverse the connections to the motor. What happens?



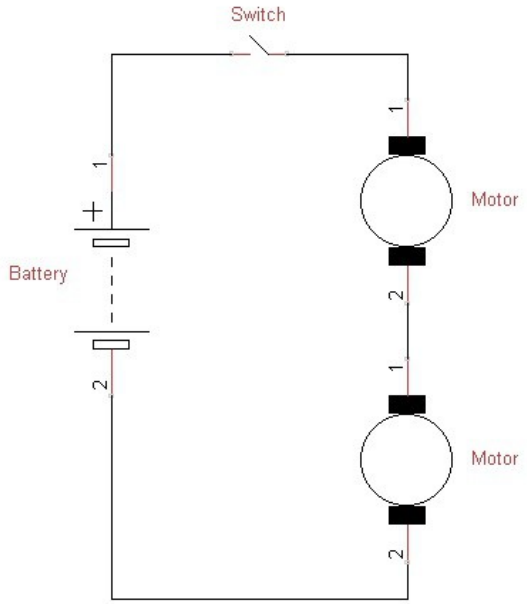
Replace the motor with the LED.

Again, try reversing the connections.

Note: You would not normally connect an LED straight across a battery. The LED you are using in this session have been specially prepared so that they can be used in this way. Also, they have been made so that the power they use is different in each one.

We will be looking at LEDs in detail later.

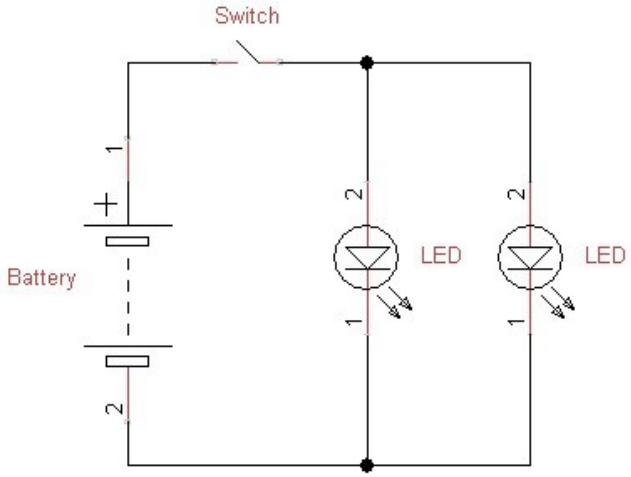
SERIES AND PARALLEL



If electricity frows through one component, then through another we say they are in series.

In this circuit the two motors are in series.

The current flowing through each motor must be the same, but the voltage across each motor may be different.



If components share the total current we say they are in parallel.

In this circuit the two LEDs are in parallel.

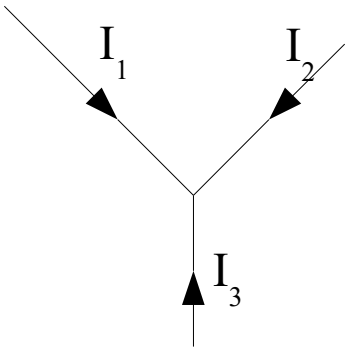
They both have the same voltage applied to them, but the current through each may be different.

Try different combinations of motor and LED in series and parallel. What do you discover?

KIRCHHOFF'S LAWS

Kirchhoff's laws are statements of the obvious, but, as with all sciences, it is important to establish the fundamentals in a formal way.

Kirchhoff's 1st law: The sum of currents at a junction is zero. (current flowing in is positive, current flowing out is negative).

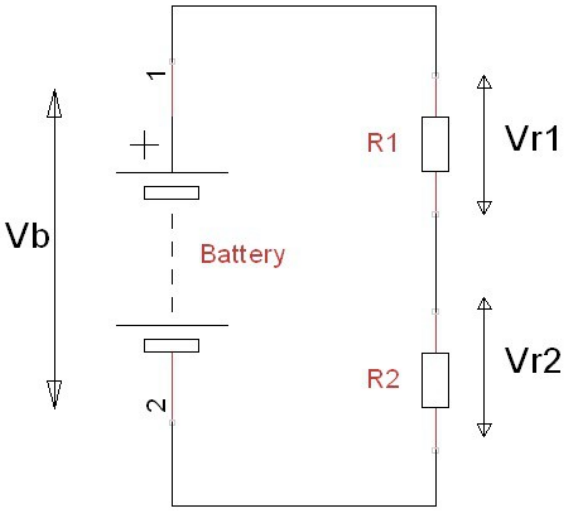


$$I_1 + I_2 + I_3 = 0$$

(at least one of these currents must be negative)

$$\sum_{x=1}^{x=n} Ix = 0$$

Kirchhoff's 2nd Law: The sum of voltages round a closed loop is zero. (batteries etc. are positive, other component are negative)



Vb + Vr1 + Vr2 = 0

(Vb is positive, Vr1 and Vr2 are negative)

$$\sum_{x=1}^{x=n} Vx = 0$$

These laws are a way of saying that electricity is never 'lost'. We can account for all the current flowing round a circuit, and all the voltage that is generated appears across the other components somewhere.

USING THE TEST METER

IMPORTANT

When using the meter, always check that...

1) The correct range of measurements is selected. If unsure, start high and gradually reduce.

2) The test leads are inserted into the appropriate sockets.

DO NOT ATTEMPT TO MEASURE VOLTAGES OVER 50V OR CURRENTS OVER 10A WITHOUT PROPER TRAINING.

(This section introduce terms that we have not discussed yet; they will be described fully later.)

A typical test meter can measure:

- DC Volts
- AC RMS Volts
- DC Amps
- AC RMS Amps
- Resistance Ohms

Each of these can be measured over several ranges of scale.

DC = Direct Current

AC = Alternating Current

RMS = Root-Mean-Square (a way of measuring the 'average' of AC.)

Volts, Amps and Ohms are written with capital letters because they are named after people (Alessandro Volta, André-Marie Ampère and Georg Simon Ohm.

Units that are not named after people, like hours and metres are written with lower-case letters.

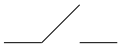
SWITCHES

Switches came in a huge variety of types. But we can classify them by two key characteristics “Pole” and “Throw”.

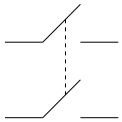
The number of poles is the number of separate circuits the switch controls.

The number of throws is the number of possible output connections that can be made.

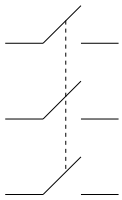
SPST



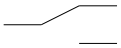
DPST



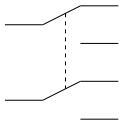
3PST



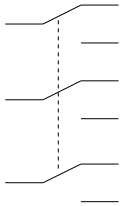
SPDT



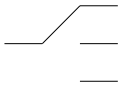
DPDT



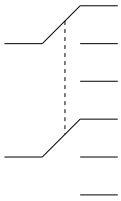
3PDT



SP3T

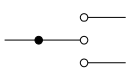


DP3T

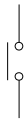


There are also many configurations of switch for specific purposes

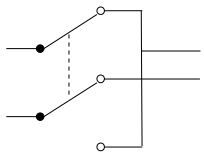
SPDT Centre Off

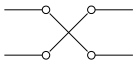


Momentary



Changeover



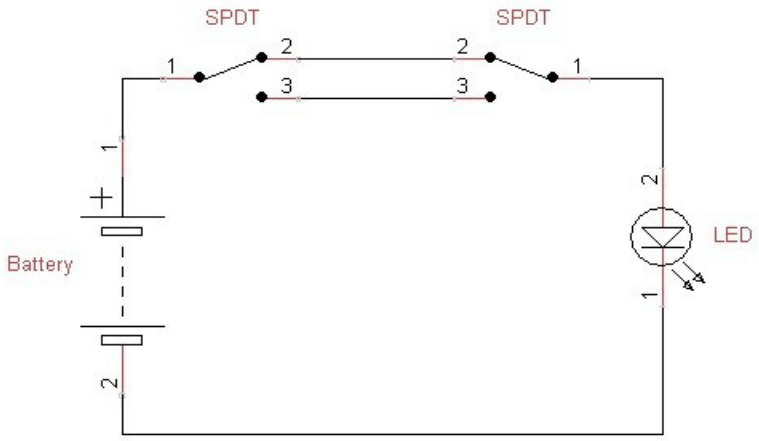


LANDING LIGHTS

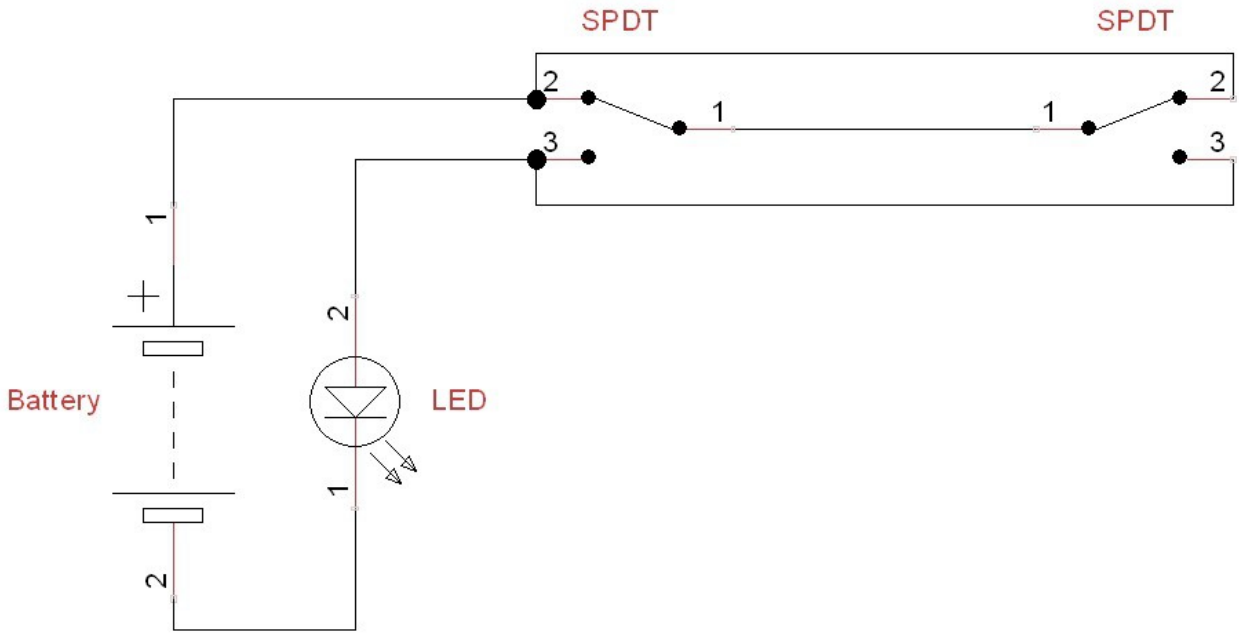
2-Way light switches, such as is commonly used on landing lights, allows one light bulb to be controlled from two separate locations. The circuit uses SPDT switches.

EXERCISE:

Build this circuit and explain how it works.



Now try this variation...



What's the advantage of the 2nd method?