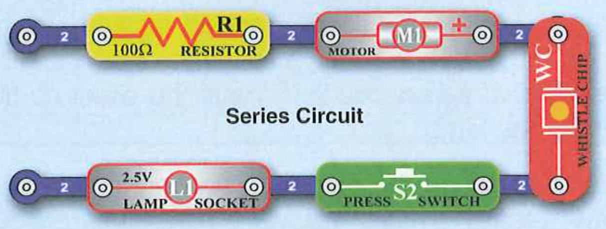
In case you haven't noticed, the batteries produce 3V and the lamp is made for voltages up to 2.5V. Don't worry, you will not damage your bulb. The voltage rating of the batteries (1.5V from each battery) is actually the voltage they produce when the electric current flowing from them is low, as the circuit current increases the voltage produced by the batteries is reduced. Think again of the lamp as a water meter - the lamp is bright so there must be lots of current flowing, hence the voltage is lower and the lamp is safe. You can see from the water diagram that with only a pump, an open valve, and a meter there is nothing to slow down the water flow and the pump will move the water as fast as it can.

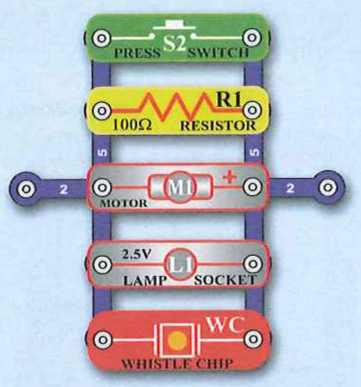
Why does the battery voltage drop as current increases? Remember that a battery produces electricity from a chemical reaction. Not only is there a limited amount of the chemicals in a small battery (batteries slowly get weaker as you use them), but also not all of the material can react together at the same time.

1-7 Series vs. Parallel Circuits

There are two ways of arranging parts in a circuit, in series or in parallel. Here are examples:

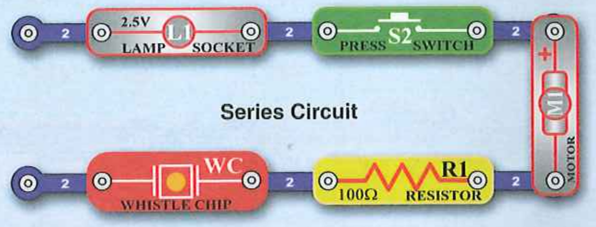


Series Circuit

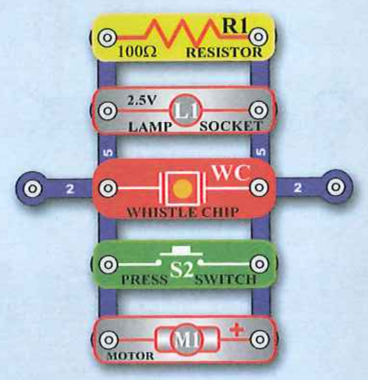


Parallel Circuit

The parts within these series and parallel sub-circuits may be arranged in different ways without changing what the circuit does. So these sub-circuits are the same as the ones on the left:

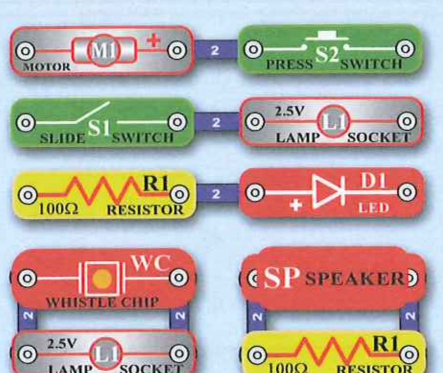


Series Circuit

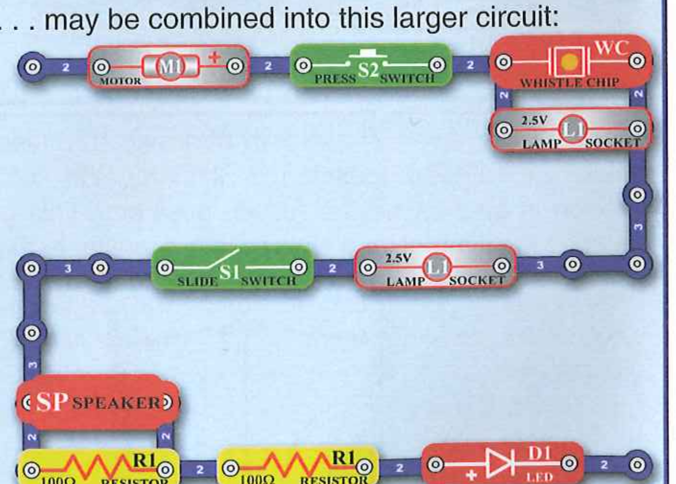


Parallel Circuit

Large circuits are made of combinations of smaller series and parallel circuits. For example, these small sub-circuits:

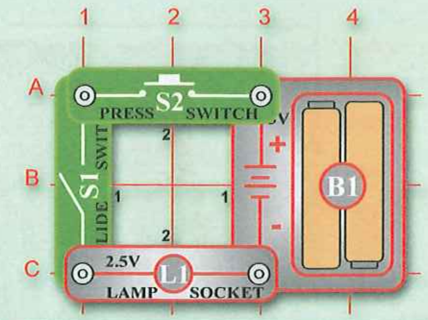


. . . may be combined into this larger circuit:



Experiments

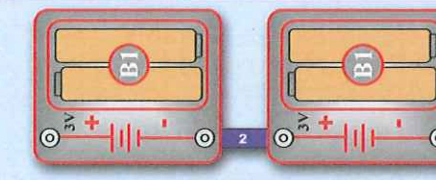
Consider this mini-circuit:



If both switches are on, the lamp will light. If one switch is off then the lamp will be off, because the switches are in series.

If you connected several lamps in series then one switch would turn them all on or off. But if one of the bulbs was broken then none would light. Strings of inexpensive Christmas lights are wired in series; if one bulb is damaged then the entire string does not work.

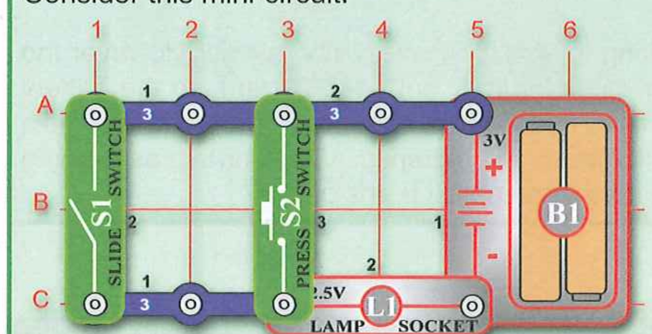
Note that battery holder B1 has two 1.5V batteries connected in series, these add together to produce 3V. If you had several battery holders, you could connect them in series to get higher voltages:



3V + 3V = 6V

Experiments

Consider this mini-circuit:



If either switch is on, the lamp will light. If one switch is off then the lamp will still be on, because the switches are in parallel.

In this circuit you could swap the locations of the switches with each other (because they are both in parallel) or, the batteries with the lamp (they are both in series), but if you swap the lamp with one of the switches then the circuit will be different. All electric circuits are made up of combinations of series and parallel circuits, from simple ones like these to the most complex computers.

If you connected two lamps in parallel then if one is broken, the other would still work. Most of the lamps in your house are wired like this; if a bulb is broken on one lamps then the other lamps are not affected.

Batteries can also be placed in parallel. Placing two batteries in parallel allows them to last longer, or to supply more current at the same time.

Think of each battery as a storage tank that supplies water. If you put two in parallel, you can get more water (current), but the pressure (voltage) stays the same.

For all of the Snap Circuits® projects, the parts may be arranged in different ways without changing the circuit. The order of parts connected in series or in parallel does not matter - what matters is how combinations of these sub-circuits are arranged together. For example, in project 1 you may swap the locations of the switch and lamp without affecting the circuit operation in any way because they are connected in series.

The choice of whether to use a series or parallel configuration in a circuit depends on the application, but will usually be obvious. For example the overhead lights in the rooms of your home are all connected in parallel so that you can have light on in some rooms and off in others, but within each room the light and switch are connected in series so the switch can control the light.

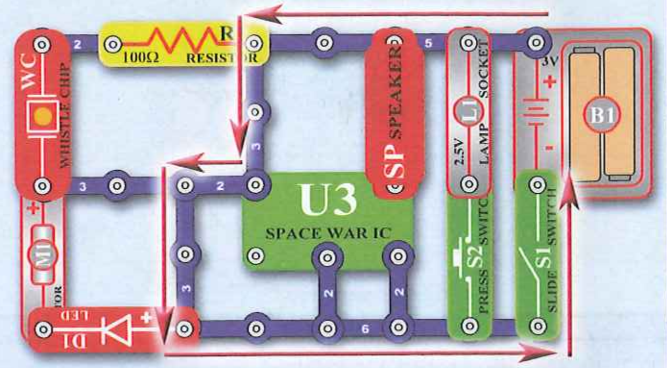
1-8 Short Circuits

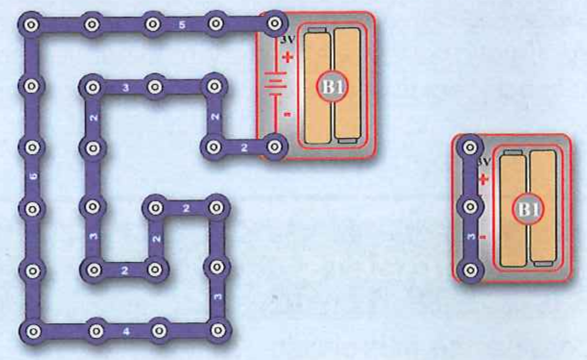
Every circuit will include a power source (the batteries), a resistance (which might be a resistor, lamp, motor, integrated circuit, etc.), and wiring paths between them and back. When wires from different parts of a circuit connect accidentally then we have a "**short circuit**". You've probably heard this term in the movies; it usually means trouble.

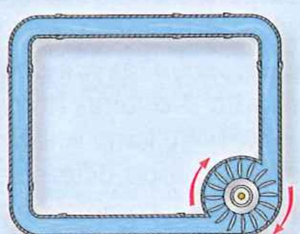
A short circuit is a wiring path that bypasses the circuit resistance, creating a **no-resistance path across the batteries. This will damage components and/or quickly drain your batteries.** Be careful not to make short circuits when building your circuits. Always check your wiring before turning on a circuit.

The name "short circuit" refers to how the current through the circuit bypasses (jumps around) other components in the circuit. It is the "easiest" path through the circuit, it is not always the "shortest".

Here are some examples:





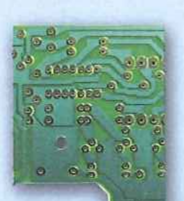


In a short circuit, there is nothing to limit the current in a circuit. However the chemical reaction in a battery cannot supply unlimited current, so the battery voltage drops to zero volts. This is called "overloading" the batteries. This overload produces heat and damages the batteries. Think of this as a pump pumping water in a loop as fast as it can until it burns out.

1-9 Solder

Solder is used to make electrical connections to components on a printed circuit board. It is a special metal made of tin and lead that melts at relatively low temperature (about 500ºF). Solder is applied and melted around a joint where a connection is being made; it creates a solid bond between the metals.

The placement of parts onto circuit boards and the application of solder to connect and hold them in place are usually done automatically with special machines. In fact, the microprocessors used in modern computers are so finely designed that they are almost impossible to solder by hand.



Before Soldering

After Soldering

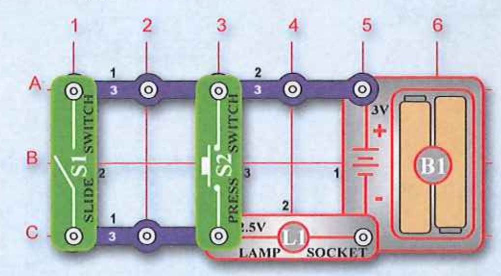
Soldering Machine

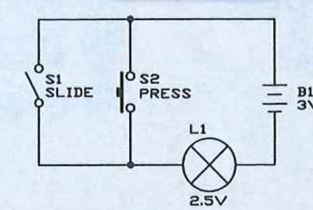
1-10 Schematics

The circuit diagrams in the Snap Circuits® manuals are easy to understand and build your circuits from. But what if you wanted to write down your own circuit? These diagrams are not very easy to draw. There are also many ways of building the same circuit. For example, you could use a jumper wire instead of a 2-snap wire.

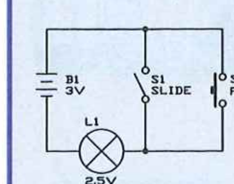
The Snap Circuit® diagrams give you more information than you really need. They tell you how to build it, when all you really need to know is how it will work. You can find your own way to build it.

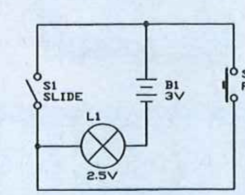
Notice the symbols marked on the parts. Those symbols are used in engineering circuit diagrams, which are called **schematics**. For example, Snap Circuits® project 153 is shown here with an engineering schematic for it:

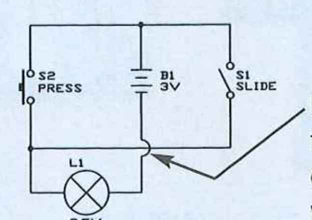




Schematics are easy to draw, and the part symbols used are international standards. Note that wires in a schematic are just lines, and can be as long as you like. Schematics are a flexible way of drawing circuits, and can be re-drawn in many different ways. For example, the above schematic could also be drawn as:

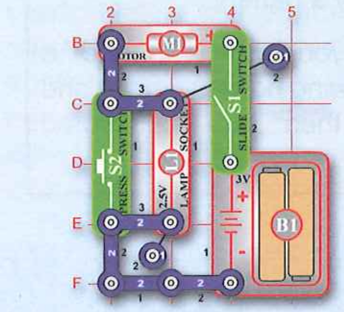


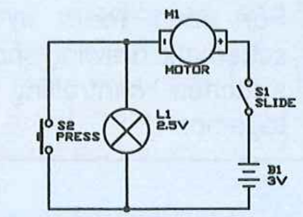


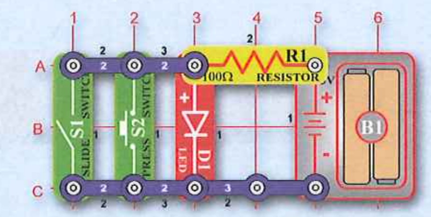


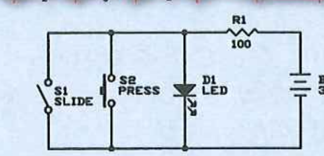
Note that ∩ represents two wires crossing over each other without connecting.

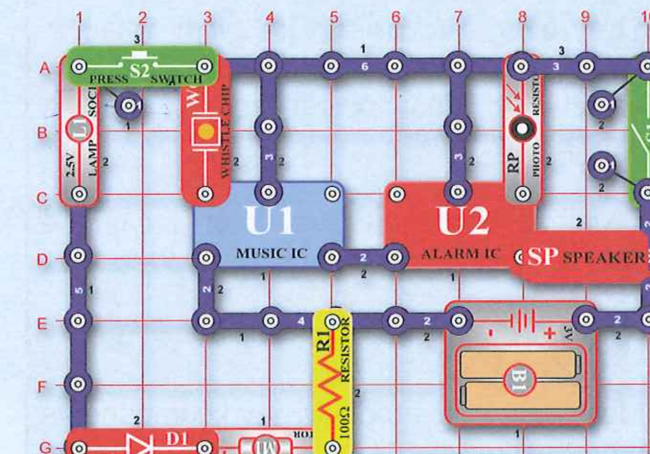
Here are some more schematic examples:

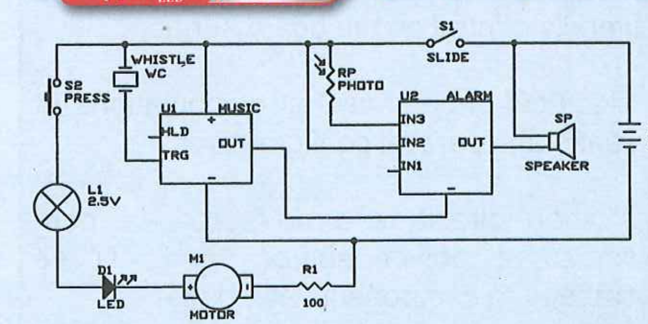












It is important to understand schematics, since many circuit designs are common and can be found in books. Almost all new circuits designed are similar to some circuit that already exists. Many products sold today come with schematics of their designs to assist in troubleshooting problems.