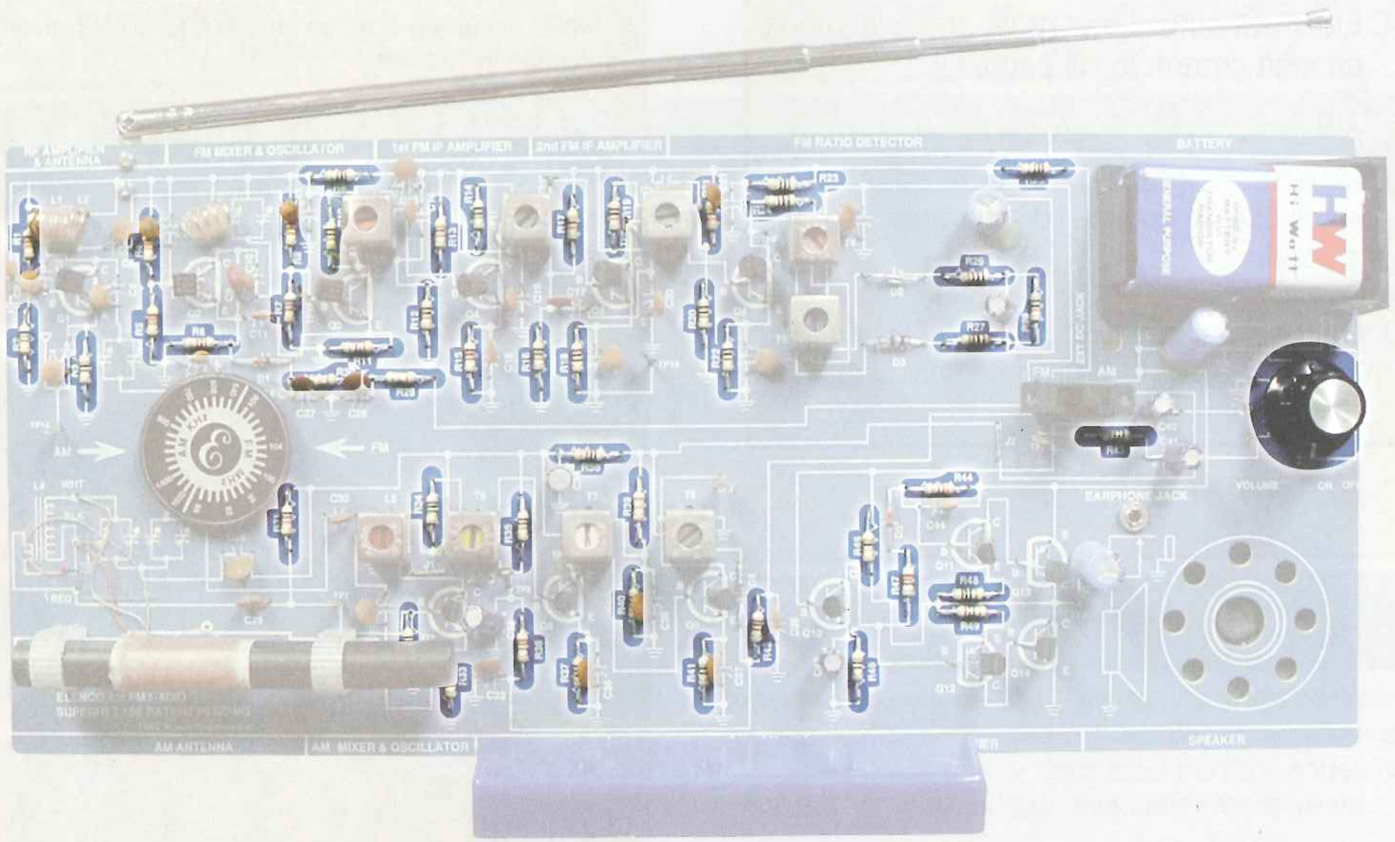
CHAPTER 3: RESISTANCE

Learn By Doing®

All of the circuits and components studied in chapters 1 and 2 are commonly used by electricians, though the actual parts used will be for much higher voltages and currents than the snap circuit parts representing them. Electricians are concerned with getting the electricity to where it will be used as efficiently as possible, without wasting energy.

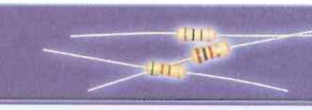
In consumer products like toys, radios, and computers, electronics engineers and technicians want to control how it is used.

In this chapter you will learn about resistors, which are used to limit and control the flow of electricity. As an example of how important resistors are in electronics, consider a typical AM/FM radio:



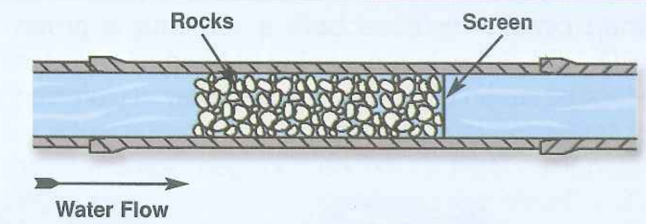
This radio contains 50 resistors, which are highlighted. The radio needs every one to operate properly. Televisions contain hundreds of resistors, and computers contain even more.

3-1 Resistors



Why is the water pipe that goes to your kitchen faucet smaller than the one that comes into your house from the water company? And why is it much smaller than the main water line that supplies water to your entire town? The reason is that you don't need so much water. The pipe size limits the water flow to what you actually need.

Electricity works in a similar manner, except that wires have so little resistance that they would have to be very, very thin to limit the flow of electricity. They would be hard to handle and break easily. But the water flow through a large pipe could also be limited by filling a section of the pipe with rocks (a thin screen would keep the rocks from falling over), which would slow the flow of water but not stop it.

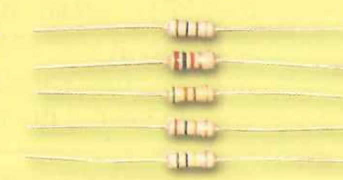


Resistors are like rocks for electricity, they control or limit how much electric current flows. The resistance, expressed in **ohms** (Ω, named after George Ohm) or kilohms (KΩ, 1000 ohms) is a measure of how much a resistor resists the flow of electricity.

To increase the water flow through a pipe you can increase the water pressure or use less rocks. To increase the electric current in a circuit you can increase the voltage or use a lower value resistor.

Introducing New Parts

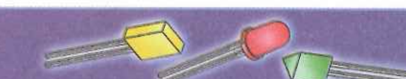
Snap circuits includes five resistors: 100Ω (R1), 1KΩ (R2), 5.1KΩ (R3), 10KΩ (R4), and 100KΩ (R5). If you have the parts with you, take them out and look at them.



The symbol for the resistor is this squiggly line:

Resistors R1 - R5

3-2 LEDs

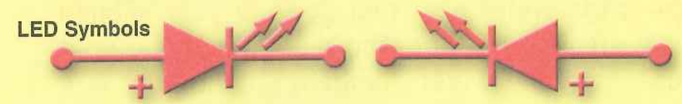


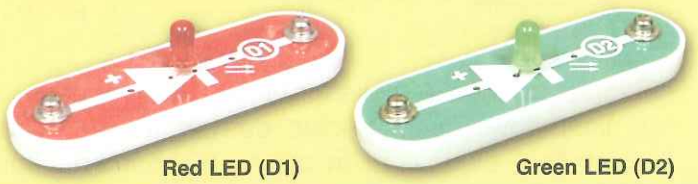
The snap circuits lamps you have (parts L1 and L2) need a high current to be bright, and can be thought of as high current meters since their brightness is an indication of how much current is flowing in a circuit. Even the smallest resistor included in Snap Circuits will limit the current such that the lamps would not light at all. So you need a low current meter.

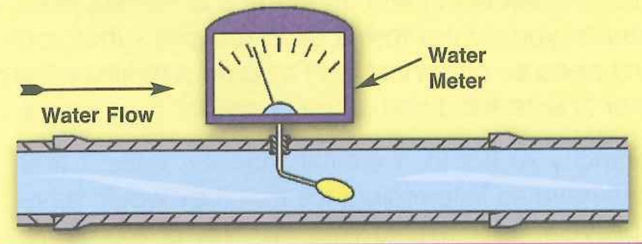
Light Emitting Diodes (**LEDs**) may be thought of as one-way, low-current meters. Like light bulbs, their brightness increases as the current through them is increased. But they are made from different materials and so have other characteristics. They are more sensitive than light bulbs and become bright at much smaller currents, but will be damaged by high currents (which is why they should always be used with resistors or other parts to limit the current). They can be made to produce specific colors of light, usually red, green, or yellow. They also completely block current flow in one direction.

Introducing New Parts

Snap circuits includes both a red and a green LED. The arrow in the symbol of the part includes which direction it allows current to flow in (referred to as the forward direction):

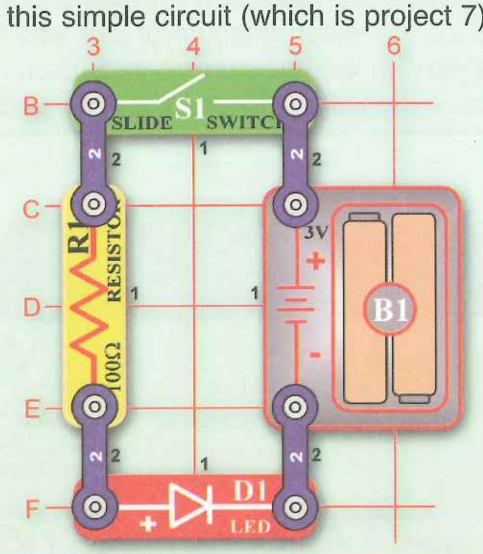






Experiments

Consider this simple circuit (which is project 7):

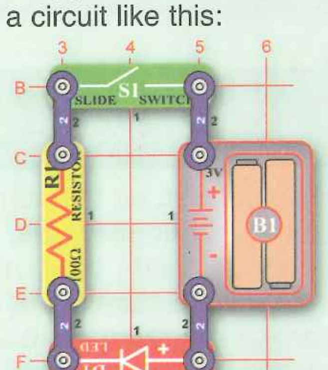


If the switch is on, the LED (D1) will light. The resistor limits the current so that the LED is not damaged (never place an LED directly across the battery). The LED is just like a lamp here, except that it would not be as bright and would use less battery power. Also, an LED appears much brighter when viewed from above than from the side. LEDs concentrate most of their light in one direction, unlike a light bulb which emits light nearly equally in all directions.

If the resistor value in the circuit were increased, the LED would become much dimmer. For example, if the 100Ω resistor (R1) was replaced with the 10KΩ resistor (R4), the LED light could only be seen if the room was very dark.

Experiments

What would happen if the LED position were reversed, in a circuit like this:

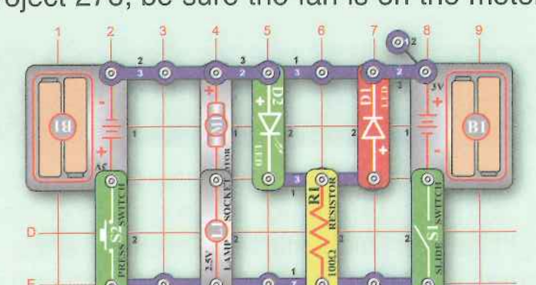


Nothing will happen. The LED prevents any current from flowing, and the LED will be off.

Other snap circuits projects related to this subject: 175

Experiments

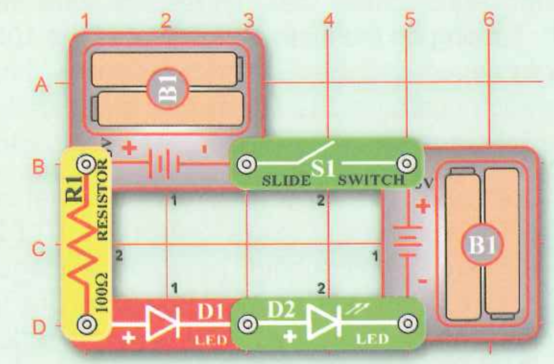
For another example, consider this circuit (which is project 276; be sure the fan is on the motor):



The two sets of batteries will drive the fan in opposite directions, depending on which switch is turned on. Only one LED will light, indicating direction. Unlike the LEDs, the lamp has no polarity and will light in either case. Note that if both switches are on, a short circuit is created and nothing will happen (but the batteries get weaker).

Experiments

Now consider this circuit (which is project 102, redrawn):



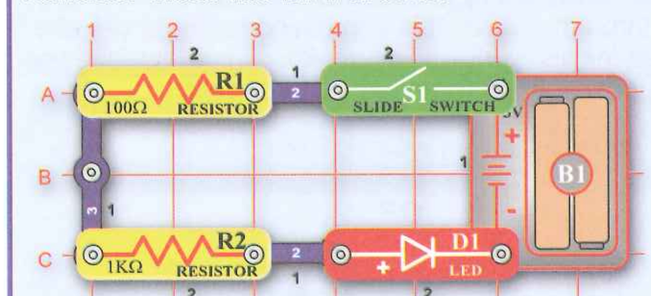
The LEDs would have the same brightness. The same current will flow through both, since they are in series.

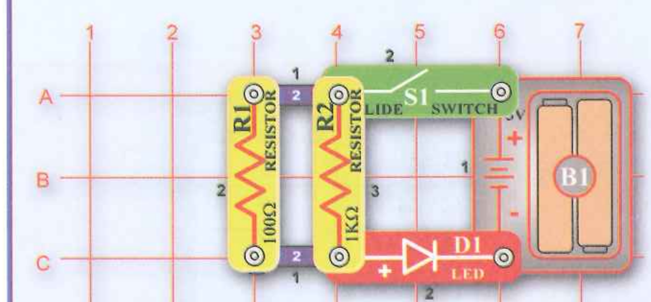
Can you guess why this circuit uses two sets of batteries instead of just one? Each LED has a "turn-on" threshold of about 1.5V that must be exceeded before current will start to flow, after that the brightness depends on the current. When two LEDs are in series the combined threshold is 3V, so one set of batteries will not exceed the threshold by any noticeable degree. This threshold is due to the semiconductor material used in its construction.

LEDs are used as indicator lights in a wide range of electronic products. They are more efficient than ordinary light bulbs and so use less electricity to be seen. But they cannot handle high currents, and so cannot be used to light up a room like light bulbs do.

3-3 Resistors in Series & Parallel

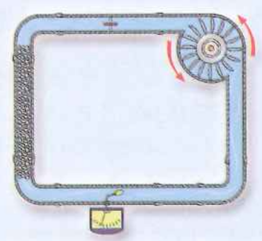
Consider these two mini-circuits:

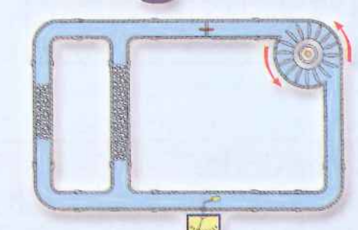




The first circuit has the 100Ω and 1KΩ resistors in series, the second circuit has them in parallel. Which circuit will make the LED brighter?

Just think of the resistors as rock piles slowing down the flow of water in a pipe:





From the water diagrams, it should be easy to see that the circuit with the resistors in parallel will have the brighter LED. You can build these mini-circuits with your snap circuits parts to prove this.

Placing resistors in series increases the total resistance, and so decreases the current to the LED. Resistors in series add together. **Placing resistors in parallel decreases the total resistance**, and so increases the current to the LED.

Advanced students can compute the total resistance as follows:

$$R_{series} = R1 + R2 + R3 + \ldots$$

$$\frac{1}{R_{parallel}} = \frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \ldots$$

The total series resistance is greater than the biggest resistor, and the total parallel resistance is smaller than the smallest resistor.