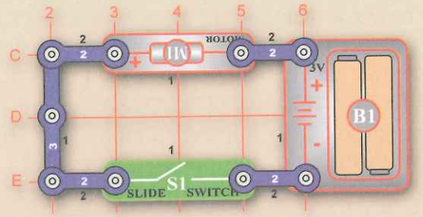
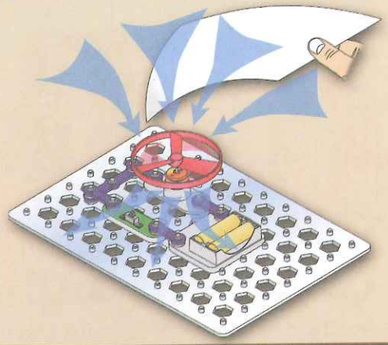
Experiments

Consider this circuit (which is project 11):



If the switch is turned off when the motor is spinning at full speed, the fan will rise into the air. Be careful not to touch the motor or fan while it is spinning at high speed. In this circuit the fan blades suck in air and push it down to the table.

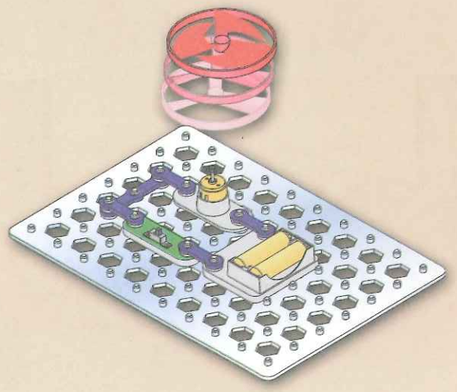
If you hold a sheet of paper above the fan, you will see it get sucked toward the fan.



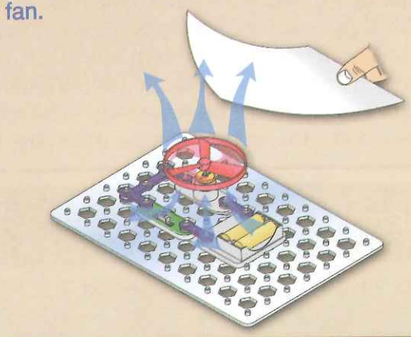
How does the fan rise? Think first about how you swim. When your arms or legs push water behind you, your body moves ahead. A similar effect occurs in a helicopter - the spinning blades push air down, and create an upward force on the blades. If the blades are spinning fast enough, the upward force will be strong enough to lift the helicopter off the ground.

While the switch is on, the motor rotation locks the fan on the motor shaft. The fan does not spin fast enough to lift the entire circuit off the ground. Sometimes there may be enough lift to make the base grid hover around the table like a puck on an air hockey table.

When the motor is turned off, the fan unlocks from the shaft. The fan rises into the air like a helicopter, since it is no longer held down by the weight of the full circuit.

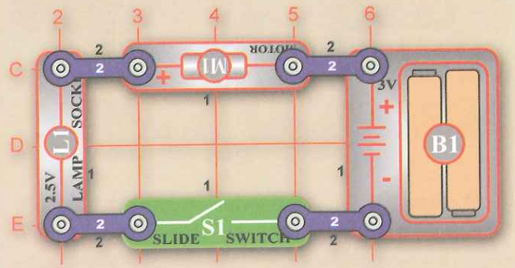


If the motor polarity were reversed (+ on the right), the fan would never fly. The fan blades are sucking in air around the motor and pushing it straight up. If you hold a sheet of paper above the fan, you will see it get pushed up and away from the fan.



Experiments

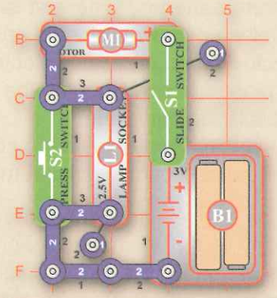
Consider this circuit (which is project 12):



By placing the lamp in series with the motor, the voltage at the motor is reduced. The motor speed will be reduced, so the fan will probably not fly off.

Experiments

Consider this circuit (which is project 13):



If the slide switch (S1) is on, the fan spins and the lamp lights. If the press switch (S2) is also on, then the fan will spin faster but the lamp will be off. In this case, the full battery voltage is applied to the motor, instead of being divided between the motor and lamp.

This is one way of controlling the speed of a fan. Commercial fans do not use this method because the lamp produces heat and wastes energy. Commercial fans change the amount of voltage applied to the motor using other methods.

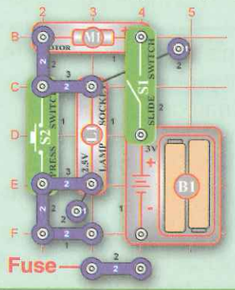
2-3 Fuses

Occasionally electronic products/components break due to people using them incorrectly, accidents, natural storms, bad design, or component failures. Often the problem is a short circuit, which results in an excessively high current flow. This high current can overheat components in the product enough to damage them, make them explode, or start a fire.

A **fuse** is usually a special wire that breaks ("blows") when too much current flows through it. A "blown fuse" shuts down the product before anything can overheat or cause a fire. Although a "**blown fuse**" prevents the product from working, fuses are easy to replace.

Experiments

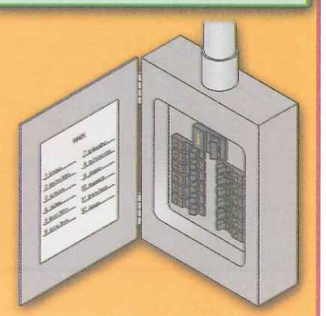
Imagine that one of the 2-snap wires in the previous circuit is a fuse (as in project 14):



If the circuit is operating properly then the "fuse" acts as a 2-snap wire. However if the motor breaks and suddenly becomes a short circuit while both switches are on, then there will be nothing to limit the current in the circuit. A very high current will flow from the batteries, and would damage them if it continues. This excessively high current will "blow" the fuse, creating an open circuit just like turning off the slide switch would do. This will protect the batteries from damage. The motor can then be repaired and the fuse replaced.

Fuses are very important and most electronic products have one. Products using electricity supplied by the electric company are usually required to have them because the high voltages and currents available here can cause severe damage and fires. Small battery-powered products usually do not have fuses because the batteries in them are not powerful enough to cause harm.

While many fuses must be replaced when blown, flipping a switch can reset some types. Every home has an electrical box of such fuses, to isolate any problems in one room from the rest of the house and your neighbors. But these fuses protecting your home take a much higher current to "blow" them than a fuse used in a radio.



2-4 Your Electric Company

Batteries are widely used because they are easy-to-use, safe, and portable. For example, snap circuits can be used on a camping trip in a remote wilderness as long as you have batteries. You can even take along spare batteries because they are small and easy to carry.

What if you wanted to take a microwave oven on the camping trip? A microwave oven uses a lot of electricity, so the batteries for it would be large, heavy, expensive, and wouldn't last long. Heavy, high-power products like microwave ovens are not moved often.

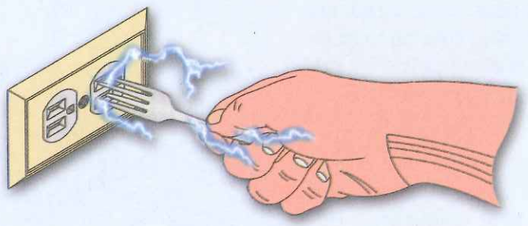
Only a tiny portion of the electricity used in our world comes from batteries. The rest is produced at enormous electric power plants, operated by your local electric company. The electricity from these power plants is available at the electrical outlets in the walls of your home.
The cost of electricity from the electric company is much less than the cost of electricity from batteries.

The voltage of the electricity supplied by the electric company is 120V, much higher than the voltage of the batteries in snap circuits. This is available at each of the electrical outlets in your home. The current available is very large, since it must power products like dishwashers and TVs.

A "**blackout**" occurs when part of a city is cut off from the power plants supplying it with electricity. The city will appear "black" from the air at night, since there are no electric lights on. This is usually due to accidents or storms, but is also done to confuse attacking bombers in war.

A "**brownout**" occurs when power plants cannot supply enough current to a city during high demand, and must reduce the voltage below 120V. This sometimes occurs on hot days in summer when everyone is using their air conditioners.

Our lives are much easier and more fun by having such power available by simply plugging into an electrical outlet. This amount of electricity is also very dangerous, and it will kill anyone who abuses it. While accidents involving electricity are rare, they kill people every year. **Never put anything into an electrical outlet except an electrical plug**. Battery-powered products are safe, since small batteries are too weak to hurt people.



The protective plastic around the wires to plug in a lamp are all that protects you from the full power of electricity. Damaged electrical cords should always be unplugged and repaired. Remember that electricity travels through water, so don't use electric products while taking a bath (battery-powered products are fine).

Your home has fuses that automatically turn off the electricity in your home if there is an electrical problem, such as a short circuit. These fuses prevent electrical problems in your home from affecting your neighbors, but they do not protect you.

2-5 Static Electricity

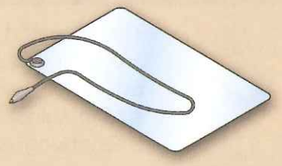
You may have noticed that sometimes you can get an electric "zap" in your home or school, how clothes stick together when you take them out of the dryer, or when taking off a wool sweater on a dry day. Occasionally differences in electrical charge build up between things, called static electricity. The things, which might include your body, are storing electrical charge. They might store a very small amount of electrical charge at high voltage. This is just like a cloud storing electrical charge before a thunderstorm.

The name "static" is used to describe the electrical charge build-up because the charge is not moving around to disperse. "Static cling" refers to how clothes sometimes cling to each other in the dryer, due to static electricity. Static electricity in the atmosphere causes the "static" (erratic noises) you hear on your AM radio when reception is poor.

Static "zaps" occur when an electrical current flows to equalize the charge difference. Though the voltage might be high, the current is small and the duration is short. The actual "zap" occurs because the voltage is high enough to "jump" across a high-resistance material (usually air), making a small spark as it happens.

Though the "zap" might sting you briefly, these effects do not harm people. However, these static zaps can damage some types of sensitive electronic components and electronics manufacturers have to protect against it. Such protection includes static wrist straps, conductive floor matting, and humidity control. The parts in snap circuits will not be damaged by static.

Anti-Static Wrist Strap



Anti-Static Floor Mat

Anti-Static Ankle Strap

In the same way, clouds can build up a static electrical charge. This charge might become very large, and it is spread out over the enormous volume of the clouds. Lightning occurs when this electrical charge discharges into the ground, and can be very destructive. Lightning is looking for the lowest-resistance path from the clouds to the ground.

Do you know why you often "see" lightning before you "hear" it? It is because light travels faster than sound.

Since people have less resistance than air, standing in an open field during a thunderstorm is very dangerous. Houses and other buildings have "**lightning rods**" to protect them, which are metal bars from the roof into the ground. Their purpose is to encourage lightning to go through the rods to the ground, instead of going through the house to the ground.

Large aircraft can build up a large electrical charge during a long flight. A wire similar to a lightning rod is usually connected to an aircraft shortly after landing, as a precaution against static zap.

Static Electricity Example:

Comb your hair vigorously with a plastic comb and hold the comb near some little (1cm x 1cm) scraps of paper to pick them up OR tilt the comb near a slow, steady stream of water from a faucet and see how the water bends towards it.

Quick Quiz

1. List all the products in your home that use an electric motor.
2. Name some examples of static electricity.