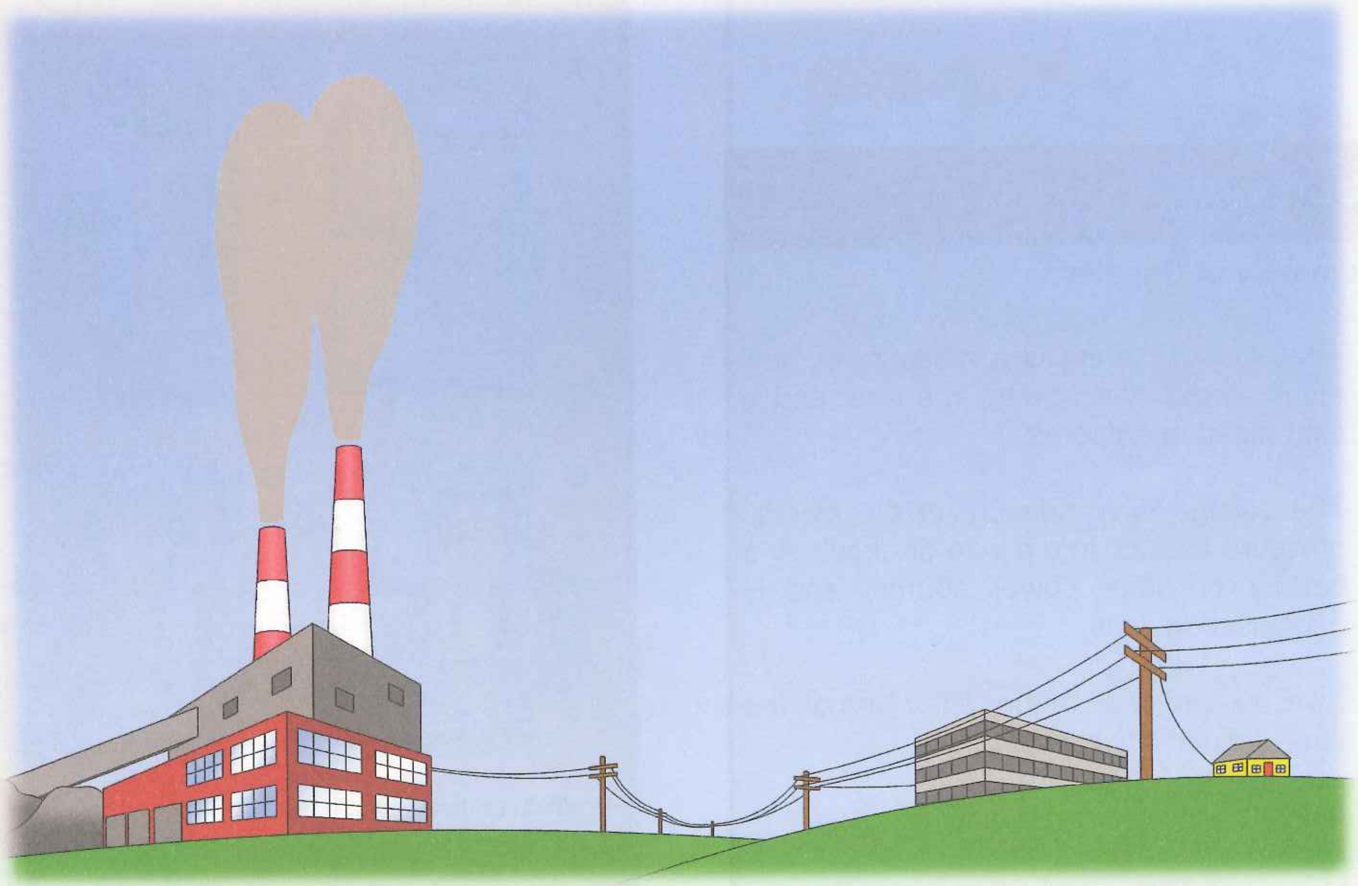
# CHAPTER 2: MOTORS & ELECTRICITY

Learn By Doing®

In this chapter you will learn about generators and motors. A generator uses mechanical motion to create electricity and a motor uses electricity to create mechanical motion. This statement may not seem important to you but it is actually the foundation of our present society. Nearly all of the electricity used in our world is produced at enormous generators driven by steam or water pressure. Wires are used to efficiently transport this energy to homes and businesses where it is used. Motors convert the electricity back into mechanical form to drive machinery and appliances. **The most important aspect of electricity in our society** - more important than the benefits of the Internet - **is that it allows energy to be easily transported over distances**.



Note that "distances" includes not just large distances but also tiny distances. Try to imagine a plumbing structure of the same complexity as the circuitry inside a portable radio - it would have to be large because we can't make water pipes so small. Electricity allows complex designs to be made very small.



## 2-1 Motors

Water flowing under pressure in a pipe or a fast-moving stream can be used to turn a paddlewheel. If the paddlewheel was linked to a fan blade then you could use the water pressure to turn the fan, perhaps to cool yourself on a hot day. If the water was flowing very fast due to high pressure, then you could get the fan moving fast enough it might create a strong airflow like a propeller on a plane.

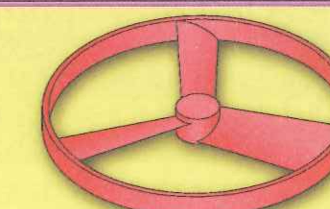
A similar thing happens in a motor, with electricity instead of water. A motor converts electricity into mechanical motion.

## Introducing New Parts

Snap Circuits includes one motor, shown here with its symbol. Snap Circuits also includes a fan, which is used with the motor. An electric current in the motor will turn the shaft and the motor blades, and the fan blade if it is on the motor.

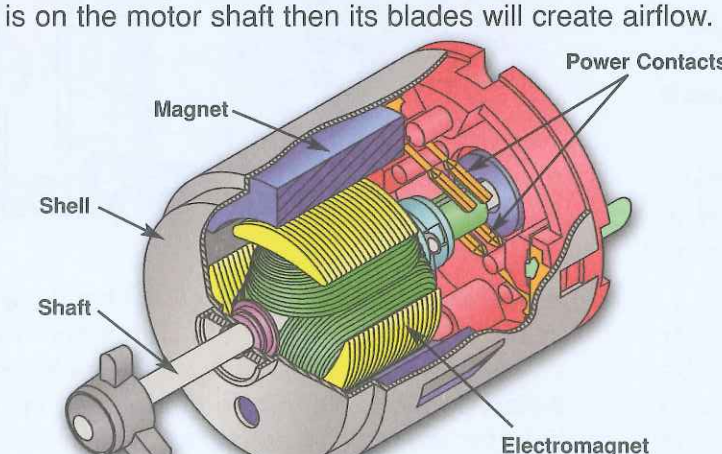
Motor Symbol

Motor (M1)



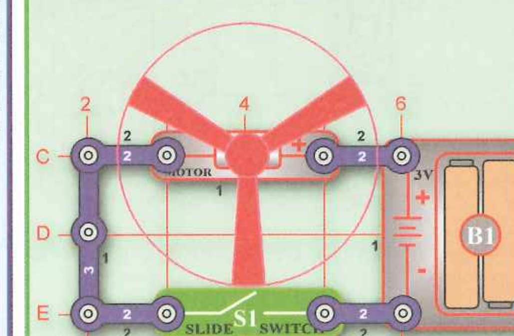
Fan Blade

How does electricity turn the shaft in the motor? The answer is magnetism. Electricity is closely related to magnetism, and an electric current flowing in a wire has a magnetic field similar to that of a very, very tiny magnet. Inside the motor is a coil of wire with many loops wrapped around metal plates. This is called an electromagnet. If a large electric current flows through the loops, it will turn ordinary metal into a magnet. The motor shell also has a magnet on it. When electricity flows through the electromagnet, it repells from the magnet on the motor shell and the shaft spins. If the fan is on the motor shaft then its blades will create airflow.




## Experiments

Consider this circuit (which is project 2):



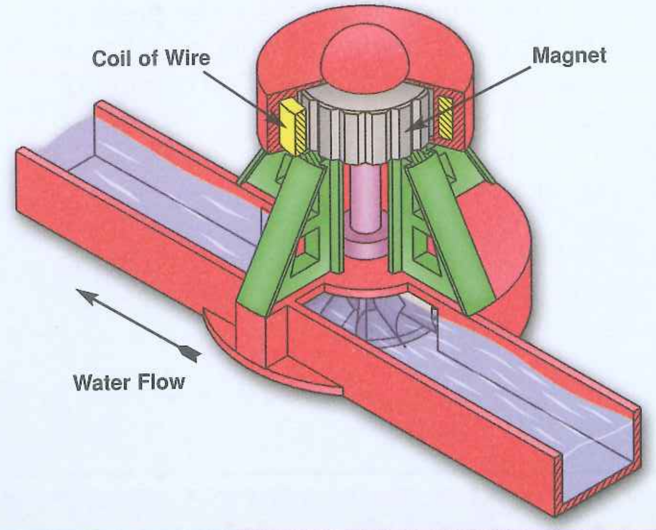

When the switch is on, current flows from the batteries through the motor making it spin. The fan blades will force air to move past the motor. Be careful not to touch the motor or fan when it is spinning at high speed.

Motors are used in all electric powered equipment requiring rotary motion, such as a cordless drill, electric toothbrush, and toy trains. An electric motor is much easier to control than gas or diesel engines.

The electromagnetic effect described above also works in reverse - spinning a magnet next to a coil of wire will produce an electric current in that wire. This is what happens in a **generator**, which uses mechanical motion to create electricity. In an electric power plant, high-pressure water (from a dam) or steam (heated by burning oil or coal) is used to spin a paddlewheel linked to magnets. The magnets create an electric current in a coil of wire, which is used to power our cities.

In theory, you could connect your Snap Circuits motor directly to the 2.5V lamp and spin the fan blade with your fingers to light the lamp. In reality, it would be impossible for you to spin the motor fast enough to produce enough current to get even a glimmer of light from the lamp.

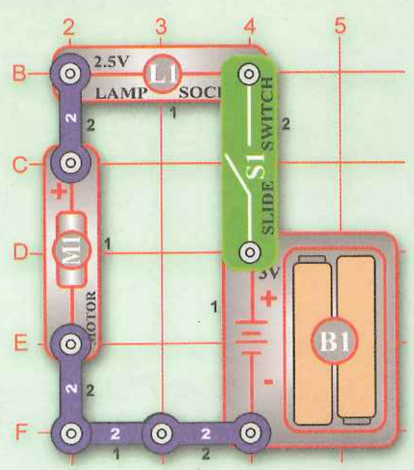
To summarize, **a generator uses mechanical motion to create electricity and a motor uses electricity to create mechanical motion.**




# 2-2 Motor Circuits

## Experiments

Consider this circuit (which is project 5):

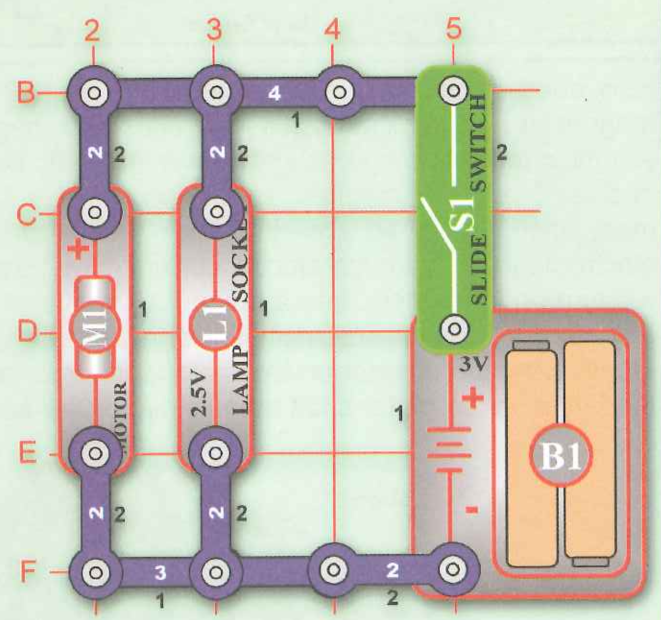


If the switch is on, the lamp will light and the fan will spin.

The lamp and motor are in series, so the voltage from the batteries will get divided between them. In this circuit more of the voltage will be used at the lamp than at the motor.

If the fan was not on the motor then the motor would spin much faster but the lamp would not be as bright. The motor needs more voltage to spin faster, so there is less voltage available to light the lamp.

Consider this circuit (which is project 6):

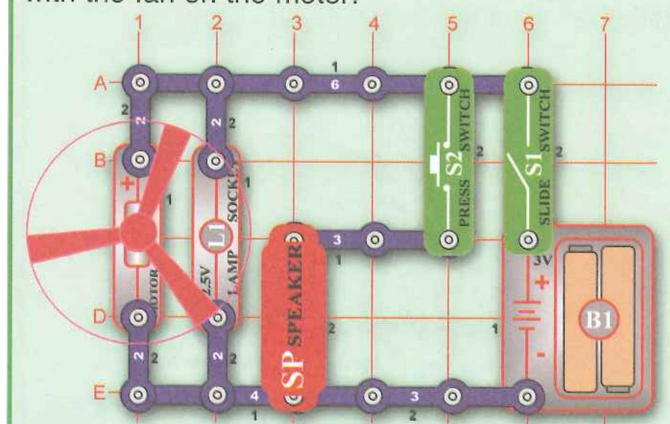


If the switch is on, the lamp will light and the fan will spin. This circuit has the lamp and motor in parallel, so the full voltage from the batteries would be applied to both. So the fan would spin faster than for the circuit in project 5, which divided the battery voltage between the lamp and motor.



## Experiments

Now consider this circuit (which is project 80), with the fan on the motor:



In this circuit the lamp will not be at full brightness, even though the full battery voltage is applied to it. Do you know why?

Remember that as the circuit current increases, the voltage produced by a battery is reduced. The motor draws a high current, very high when it first starts up with the fan on. The chemical reaction in the batteries can't supply such a high current, so the battery voltage (electrical pressure) drops.

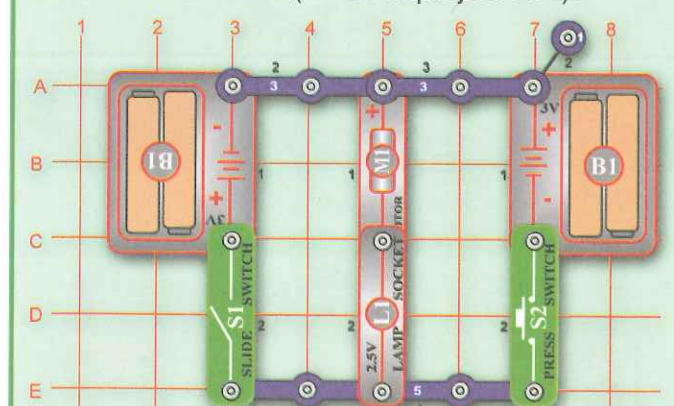
If your instructor has a meter to measure voltage, ask him to measure the battery voltage with the slide switch on and off. You would see the voltage drop to under 2.5V when the switch is on.

Push the press switch to add the speaker to the circuit and increase the circuit current even more. This will make the lamp less bright. Take the fan off the motor and turn on the switch again. The lamp will be brighter now.It doesn't take as much current to spin the motor without the fan, so the battery voltage doesn't drop much.

You know that the AA batteries used to power your snap circuits have + and – markings on them, called **polarity** markings. The chemical reaction in the batteries only makes the electric current flow in one direction. To make the current flow in the other direction you just reverse the batteries (all batteries in the same circuit must be reversed). The motor also has + and – markings, because if the direction of current flow through is reversed than the motor will spin in the opposite direction (reversing the electric current reverses the magnetic field generated, which reverses the direction the shaft spins). The lamp, switch, and wires have no such + and – markings on them because they work the same regardless of which way the current is flowing.

## Experiments

Consider this circuit (which is project 262):



If the slide switch is on, the fan will spin to the left. If the press switch is on, the fan will spin to the right. The slide and press switches apply opposite voltages to the circuit. The lamp lights in either case, since it is not affected by the direction of current flow.

What happens if both switches are on? Nothing happens, just as if both were off. The opposite voltages from the batteries cancel each other out. Think of this as two pumps trying to pump water through a pipe in opposite directions.