

# Circuits Exploration

## Lesson #1

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### Background Information

Electricity powers our world but is a secondary energy source. This means that we must first use a primary source of energy such as coal or wind to make electricity. At coal, natural gas or petroleum power plants, the fuel is burned and used to superheat water in a boiler to make steam. At nuclear power plants, the process of fission is used to superheat the water to make steam. Regardless of the energy source, the superheated steam is directed under high pressure towards the blades of a turbine, causing it to spin. The turbine blades are connected to a generator, which contains a large magnet surrounded by coils of copper wire. The turbine blades spin the magnet inside the coil, which produces electricity. Since there are two poles to the magnet, the flow of electric charge within the copper wire reverses direction with each turn of the magnet. The electricity produced is called an alternating current (AC). One advantage with alternating current is that it can travel long distances with minimal loss of energy. Additionally, transformers can be used to increase or decrease the voltage. High voltage current can be sent through transmission lines with transformers decreasing the voltage before it enters homes and businesses.

Electricity can also be produced using chemical energy in a battery, which uses two different metals in a chemical solution. The reaction in the anode (positive end) gives up electrons, and the reaction in the cathode (negative end) absorbs them. When a load is connected to the anode and cathode, electricity flows creating a current. However, it can only flow in one direction, from the terminal with excess electrons to the terminal with fewer electrons. Since this electricity only flows in one direction, it is known as direct current (DC). The battery will continue to produce electricity until either the anode or cathode run out of the material necessary for the reactions to occur. An advantage to a battery is that it is small and portable.

Why do charges flow in an electric current? It is because of electric potential energy. Potential energy is stored energy of an object due to its position or shape. An electric charge has potential energy because of its position in an electric field. For example, when two negative charges are close together, they have potential energy because they repel each other and have the potential to push apart. If the charges move apart, their potential energy decreases. Electric charges always move spontaneously from a position where they have higher potential energy to a position where their potential energy is lower. This is like water falling over a dam from an area of higher to lower gravitational potential energy.

#### Terms:

1. Electric current is the measure of how fast electricity is flowing through a conductor. It can be compared to water flowing in a pipe or a river. Just as a molecule of water moves from Point A to Point B in a river, an electron in a wire can move from Point A to Point B. The unit to measure electricity flow is an **ampere or amp**.  
One *ampere* of current represents one coulomb of electrical charge ( $6.24 \times 10^{18}$  charge carriers) moving past a specific point in one second.  $1 \text{ ampere} = 1\text{C/sec}$ .

- To make water move in a pipe, you need a push created by a pump. To make electricity move through wires, we use a battery or other power source to create the electrical push or pressure. **Voltage** measures the pressure that pushes electrons in a circuit. It can be compared to water pressure. It is expressed in volts. Batteries are selected based on the amount of voltage your circuit needs. A small load may need an AA battery which is rated at 1.5 volts. If the load is larger, it may need more voltage and the batteries can be wired in series. Two AA batteries would be 3 volts (1.5 v + 1.5v).
- An electrical **load** is an electrical component or portion of a circuit that consumes electric power. Appliances and lights are examples of loads in electric power circuits.
- Resistance** refers to the electrical friction between the electric current and the material it is flowing through. Resistors limit and control the flow of electricity. Resistance is measured in ohms ( $\Omega$ , named after George Ohm).
- In a basic **series** circuit, each element has the same current (but not necessarily the same voltage; that will only happen if their resistances are all the same). In a basic **parallel** circuit, each element has the same voltage (but not necessarily the same current; that will only happen if their resistances are all the same).
- Every circuit will include a power source (battery), resistor and wire connectors. If wires from a different part of the circuit touch or connect, a **short circuit** will occur. This creates a no-resistance path across the batteries and will damage your components and/or quickly drain the battery.

