16.2 Current and Voltage

Current is what carries energy in a circuit. Like water current, electric current only flows when there is a difference in energy between two locations that are connected. Water flows downhill from higher gravitational potential energy to lower energy. Electric current flows "downhill" from higher electrical potential energy to lower electrical potential energy.

Current

Measuring electric current

Electric current is measured in units called **amperes** (A), or amps for short. The unit is named in honor of Andre-Marie Ampere (1775–1836), a French physicist who studied electricity and magnetism. A small battery-powered flashlight bulb uses about 1/2 amp of electric current.

Conventional current flows from positive to negative

Examine a battery and you will find a positive and a negative end. The positive end on an AA, C, or D battery has a raised bump, and the negative end is flat. In a circuit diagram, a battery's electrical symbol uses a long line to show the positive end and a short line to show the negative end.

Current in equals current out

Electric current from a battery flows out of the positive end and returns back in at the negative end. An arrow can be used to show the direction of current on a circuit diagram (Figure 16.5). In most electric circuits, negative charge flows, so you would think the correct direction would be negative to positive. It is practical and conventional, however, to describe current as flowing from positive to negative, or from high voltage to low voltage. The amount of electric current coming out of the positive end of the battery must always be the same as the amount of current flowing into the negative end. You can picture this by imagining steel balls flowing through a tube. When you push one ball into the tube, one ball comes out the other end. The rate at which the balls flow in equals the rate at which they flow out.

VOCABULARY

ampere - the unit of electric current.

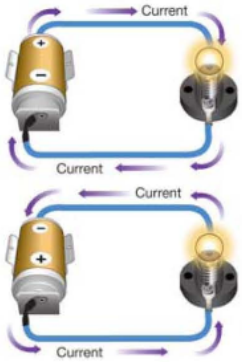


Figure 16.5: *Direction of electric current (Conventional diagrams show flow from positive to negative.)*

SCIENCE FACT

Either positive or negative charges can create an electric current, depending on the circuit materials. In the human body, current is the movement of both positive and negative charges. In ordinary electric circuits, current is the movement of negative charge in metal conductors.

Voltage

Energy and voltage

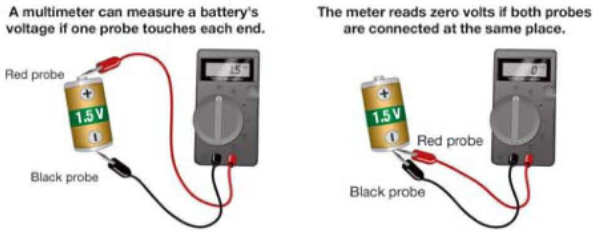
Voltage is a measure of electric potential energy, just like height is an indicator of gravitational potential energy. Voltage is measured in **volts** (V). Like other forms of potential energy, a voltage difference means there is energy that can be used to do work. Current is what actually flows and does work. A difference in voltage provides the energy that causes current to flow (Figure 16.6).

What *voltage* means

A voltage difference of 1 volt means 1 amp of current does 1 joule of work in 1 second. Since 1 joule per second is a watt (power), *voltage is the power per amp of current that flows*. Every amp of current flowing out of a 1.5-volt battery carries 1.5 watts of power. The voltage in your home's electrical system is 120 volts, which means each amp of current carries 120 watts of power.

Using a meter to measure voltage

A *voltmeter* measures voltage. A more useful meter is a **multimeter**, which can measure voltage or current, and sometimes also resistance. To measure voltage, the meter's probes are touched to two places in a circuit or across a battery. The meter shows the difference in voltage between the two places.



Batteries

A **battery** uses chemical energy to create a voltage difference between its two terminals. When current leaves a battery, it carries energy. The current gives up its energy as it passes through an electrical device such as a light bulb. When a bulb is lit, the electrical energy is taken from the current and is transformed into light and heat energy. The current returns to the battery, where it gets more energy.

VOCABULARY

voltage - a measure of electric potential energy.

volt - the unit for voltage.

multimeter - a measuring instrument for current, voltage, and resistance.

battery - a device that transforms chemical energy to electrical energy, and provides electrical force in a circuit.

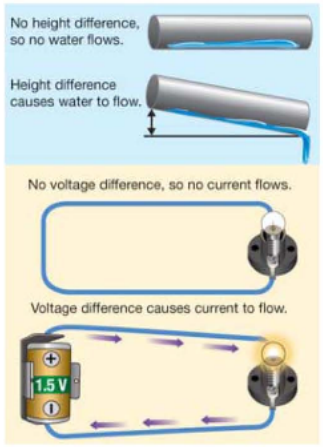


Figure 16.6: *A change in height causes water to flow through a pipe. Current flows in this circuit because a battery creates a voltage difference.*

Measuring current in a circuit

Measuring current with a meter

Electric current can be measured with a multimeter. However, if you want to measure current you must force the current to pass *through* the meter. That usually means you must break the circuit somewhere and rearrange wires so that the current flows through the meter. For example, Figure 16.7 shows a circuit with a battery and bulb. The meter has been inserted into the circuit to measure current. If you trace the wires, the current comes out of the positive end of the battery, through the light bulb, *through the meter*, and back to the battery. The meter in the diagram measures 0.37 amps of current. Some electrical meters, called *ammeters*, are designed specifically to measure only current.

Setting up the meter

If you use a multimeter, you must remember to set its dial to measure the type of current in your circuit. Multimeters can measure two types of electric current, called alternating current (AC) and direct current (DC). You will learn about the difference between alternating and direct current in the next chapter. For circuits with light bulbs and batteries, you must set your meter to read direct current, or DC. The symbols for AC and DC are shown in Figure 16.8.

Protecting the meter

A meter can be damaged if too much current passes through it. Always be sure there is a light bulb or some other resistor in the circuit when you use the meter. Without a bulb or other resistor to use some of the current, the circuit's current might become too high for the meter and can cause an overload.

To protect its delicate electronics, most meters contain a *circuit breaker* or *fuse*. Circuit breakers and fuses are fast-acting, automatic switches that open a circuit if they sense too much current.

A circuit breaker can be reset the way a switch can be flipped. A broken fuse, however, is similar to a burned out light bulb and must be replaced for the meter to work again. The meter you use in your electric circuit investigations has a fuse inside. To replace the fuse, you will need a replacement fuse and a small screwdriver to open up the back of the meter. Your teacher can show you how this is done. To make your investigations easier, be careful when measuring current and you won't have to replace the fuse!

Figure 16.7: *Current must pass through the meter when it is being measured.*

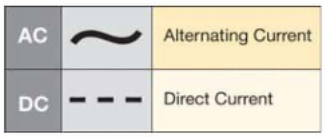
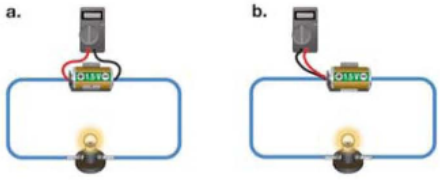


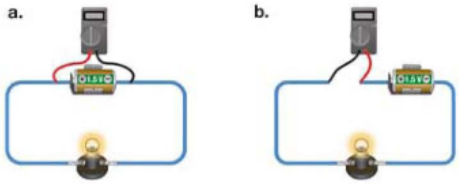
Figure 16.8: *A multimeter often uses these symbols for AC and DC settings.*

Section 16.2 Review

1. List the units for measuring current and voltage.
2. What is the difference between current and voltage, besides their units of measurement?
3. Why does a multimeter display a reading of zero when both of its probes are touched to the same end of a battery?
4. The direction of electric current is away from the _____ end of the battery and toward the _____end.
5. What voltage would the electrical meter show in each of the diagrams below?



6. Which of the following diagrams shows the correct way to measure current in a circuit?



7. A flashlight needs three C batteries. How many volts of electricity does it need (Figure 16.9)?

Figure 16.9: *Question 7.*