KnowAtom™
Focus on what matters.

Matter and Electricity

UNIT 7

Student Reader

Front Cover:

The front cover shows a photograph of light bulbs hanging from the ceiling. Light bulbs work when they are part of a closed circuit.

Unit 7: Matter and Electricity

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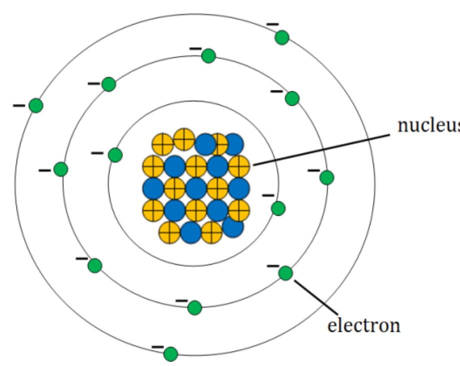
1 How Electricity Moves

Holiday Lights

Adam Atkinson has a bright hobby. Every December, he puts on a holiday display. It lights up his entire neighborhood. Adam's display is a favorite of many neighbors. His display even has its own Facebook page. It takes Adam all year to plan for it.

Holiday lights are powered by electricity.

All of the lights are powered by electricity. **Electricity** is the flow of electrons through a conductor.

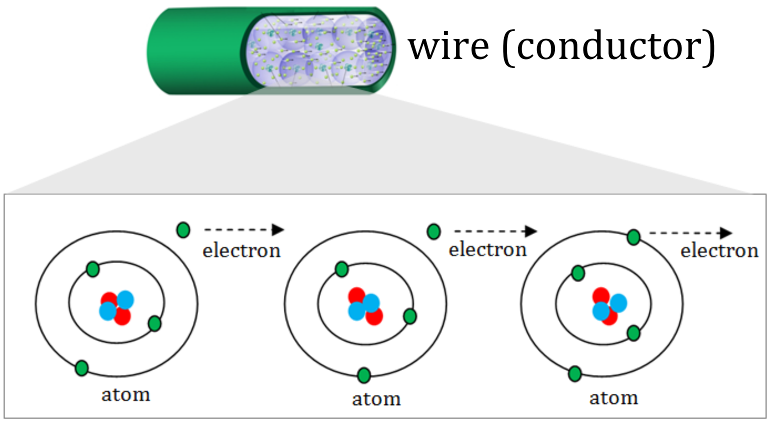


This is a model of an atom.

Remember that all matter is made of atoms. Atoms are tiny particles too small to be seen. Atoms are made up of even smaller particles. Electrons are one kind of these smaller particles. Electrons have a negative charge (-). They are in constant motion around the nucleus.

Conducting Electricity

In some kinds of matter, electrons can move from one atom to another. Materials that allow electrons to pass through are **electrical conductors**. In conductors, the electrons all move in the same direction as one another.



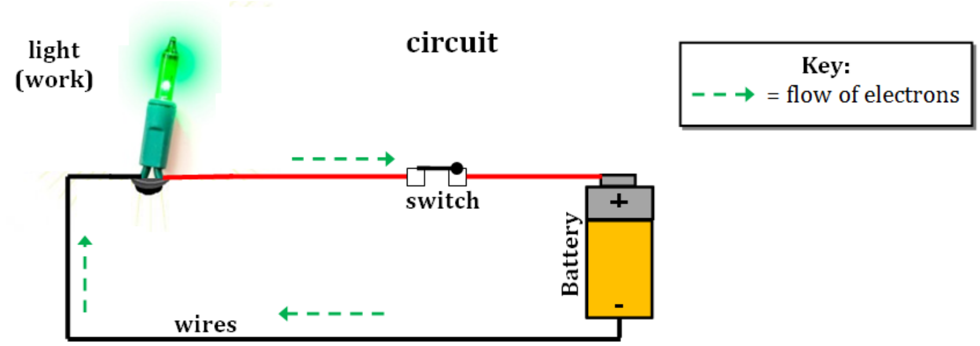
This diagram shows electricity moving through a conductor. The green outer covering of the wire is an insulator.

Metals are common conductors. Silver, copper, bronze, and aluminum are all metals. They are good electrical conductors. Scientists can control electricity by passing electrons through these materials.

Some materials don't allow electrons to pass through. These materials are **electrical insulators**. Glass, rubber, plastic, and ceramic are all good insulators.

Think about the cord that you plug in to turn on holiday lights. The wire inside the cord is metal. The outer part of the cord is plastic or rubber. This keeps the electricity moving through the wires. It also protects you from an electric shock.

When electricity reaches a light, the light turns on. This is because the moving electrons transfer electrical energy through a circuit. A **circuit** is the circular path that electrons travel in a negative to positive direction.



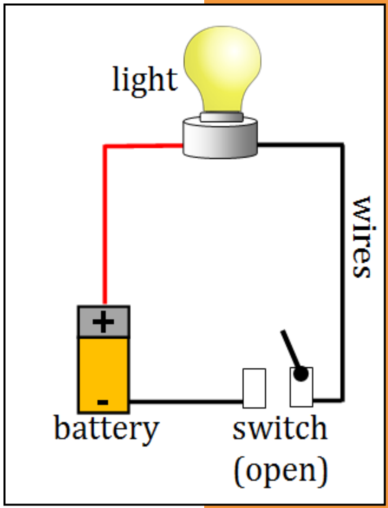
Energy is moved in electric currents through a circuit.

All circuits have the same basic parts. All circuits have an energy source such as a battery. The battery has stored chemical energy that converts to electrical energy. This energy provides the force that pushes the electrons in the conductive material through the circuit.

All batteries have a negative end and a positive end. Electrons travel from the negative end through the circuit to the positive end. They move because the negatively charged electrons are attracted to the positive side of the battery. This attraction pulls the electrons toward the positive side of the battery.

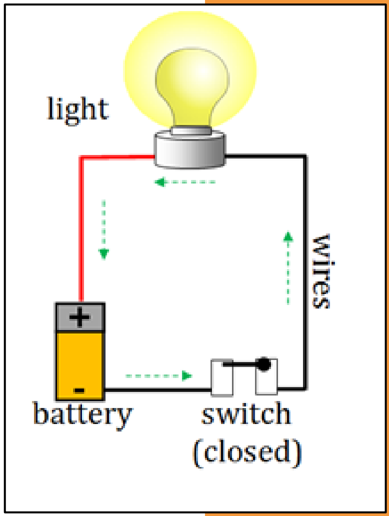
Circuits also have wires. Wires are the paths that electrons travel in the circuit. Energy moves from the battery through the conductors inside the wires.

The wires in a circuit are attached to an object that can convert electrical energy to do <u>work</u>. Work is any change in position, speed, or state of matter due to force. For example, a light bulb is an object that does work. When electrons reach the light bulb in a circuit, they transfer electrical energy. The light bulb changes the electrical energy into light energy and heat. The same amount of energy that was transferred through the circuit is available to light up the bulb. This is because of the conservation of energy. The electrons then continue on their path. They return to the opposite side of the battery.



All circuits must include something that can do work. Without this part, the electricity will cause danger by overheating the circuit. This is called a "short circuit."

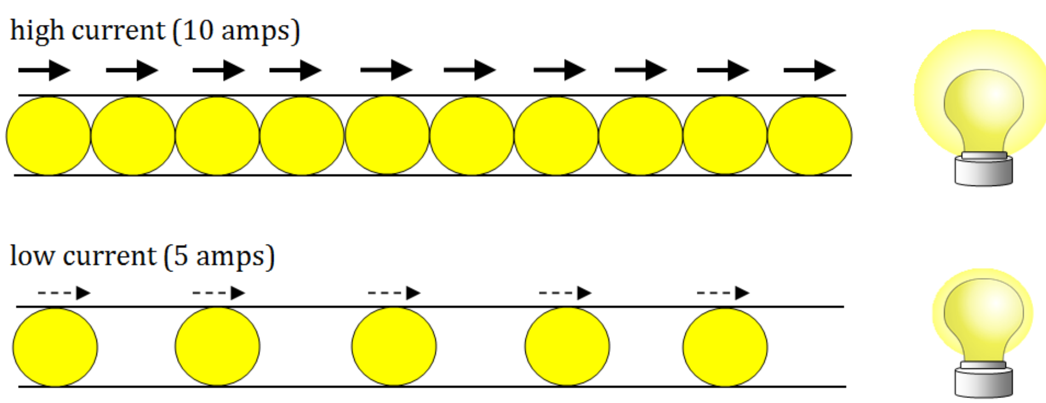
Finally, most circuits have <u>switches</u>. The <u>switch</u> opens and closes the circuit. Electrons flow when a circuit is closed. This is "on." A closed circuit will cause the light bulb to light up.



Electrons cannot flow when a circuit is open. This is "off." No work can be done in an open circuit.

The way a circuit is put together affects the amount of electric current that can do work. **Current** is a measure of the rate that electric charge passes through a point in an electric circuit over time. In other words, it is the amount of electrons flowing through a circuit over time. The amount of work that can be done increases as current increases.

For example, a fast current will cause a light bulb to be brighter than a slow current. This is because more electrons reach the bulb in the same amount of time. Current is measured in amps (A). An electric current with higher amps has more power.

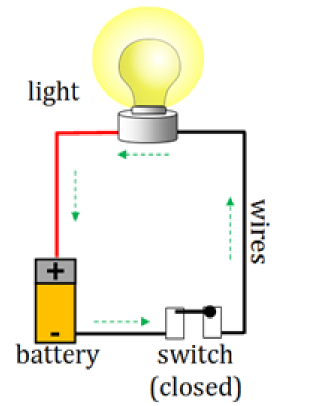


Current is a measure of the rate that electric charge passes through a point in an electric circuit over time.

Designing a Circuit

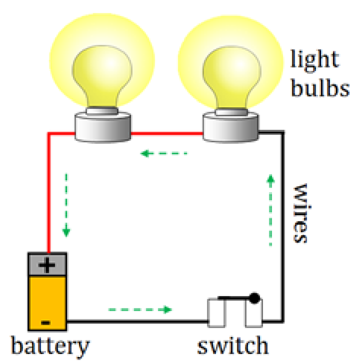
There are many different ways to design a circuit. We'll use the example of a circuit with a light bulb.

A simple circuit has one path and one light bulb. To connect multiple lights, you need either a series circuit or a parallel circuit.



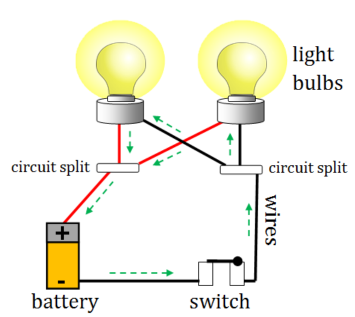
simple circuit

A series circuit has one path for electrons to travel but multiple light bulbs. This means the electricity moves from one light bulb to the next before it returns to the energy source. If one bulb stops working, it breaks the circuit. The electricity cannot continue on its path.



series circuit

In a parallel circuit, there are multiple paths for energy to travel. Each light is connected to the energy source by a separate path.



parallel circuit

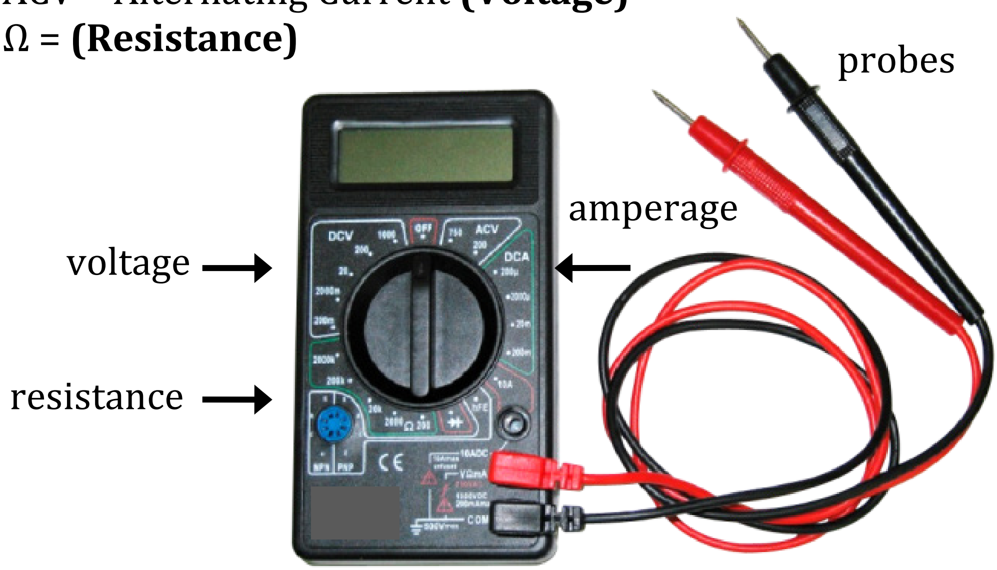
How to Use a Multimeter

How to Use a Multimeter

- This instrument will allow you to measure the amount of current (amperage) moving through a circuit. It can be used to measure voltage and resistance, but only amperage will be measured in your circuits.
- The dial on the multimeter turns the instrument on and is used to select what you want to measure.
- **DO NOT** use this instrument to test wall outlets or other electrical devices.
- Use this instrument to test the ends of batteries supplied in the kit and the circuits built in this unit.
- To extend the life of the battery, the switch should be in the “OFF” position when the instrument is not in use and the dial should be turned slowly.

Symbols

- A multimeter dial is divided by the type of measurement being taken. The options are:
  - DCV = Direct Current **(Voltage)**
  - DCA = Direct Current **(Amperage)**
  - ACV = Alternating Current **(Voltage)**
  - Ω = **(Resistance)**



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Circuits Investigation

Focus Question: How does the amount of current in a circuit change when more light bulbs are added to a series circuit compared to a parallel circuit?

Part 1: Series Circuits

1. Use the following materials to assemble a series circuit on the cardboard base that powers two light bulbs and has one switch:

- 2 red alligator clip wires
- 2 black alligator clip wires
- 2 small light bulbs
- 2 small light bulb holders
- 2 binder clips
- 1 battery
- 1 cardboard base
- 1 roll of invisible tape

2. Diagram and label the parts of your series circuit in the space below:

Series Circuit Diagram

3. Measure Series Circuit Current: Use a multimeter and the steps below to measure and record the current in your series circuit with 1 and 2 light bulbs.

1. Plug the red multimeter probe into the 10ADC port.
2. Turn the multimeter dial slowly to (DCA) 20m.
3. Touch the metal probes of the multimeter to each side of the switch so the electricity flows through the multimeter and closes the circuit. The light bulb(s) will turn on.
4. Record the current in the circuit in Table 1.
5. Remove 1 light bulb and 1 red alligator clip wire from the series circuit. Reassemble the circuit with one light bulb. Repeat Steps 3-4.

Table 1: Comparing Current in Series and Parallel Circuits with 1-2 Light Bulbs			
Light Bulbs in the Circuit	**Current (milliamps)**		
	Series Circuit	**Parallel Circuit**	**Difference**
1			
2			

Part 2: Parallel Circuits

1. Set up the parallel circuit board with two paper clips, two light bulbs, a switch, and a battery as instructed by your teacher. Use the following wires to assemble a parallel circuit on the cardboard base that powers two light bulbs and has one switch:

- 4 black alligator clip wires
- 3 red alligator clip wires

2. Diagram and label the parts of your parallel circuit in the space below:

Parallel Circuit Diagram

3. Measure Parallel Circuit Current: Use a multimeter and the steps below to measure and record the current in your parallel circuit with 1 and 2 light bulbs.

1. Plug the red multimeter probe into the 10ADC port.
2. Turn the multimeter dial slowly to (DCA) 20m.
3. Touch the metal probes of the multimeter to each side of the switch so the electricity flows through the multimeter and closes the circuit. The light bulb(s) will turn on.
4. Record the current in the circuit in Table 1.
5. Choose one of the two light bulbs on the cardboard base and carefully unscrew it from the light bulb holder so it turns off. Repeat Steps 3-4.

Section 1 Review

<u>Reading Comprehension Questions</u>:

1. How is electricity related to the structure of matter?

2. What makes a material an electrical conductor?

3. Why does a circuit have to be closed to do work?

4. What is the main idea of Section 1?

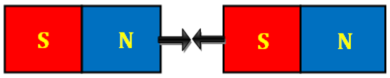
5. What key details does the text provide to support the main idea of the text?

Ringing the Doorbell

This button is connected to an electromagnet and a bell.

When you go to someone else's house, the first thing you often do is ring the doorbell. A simple push on a small button sends electricity that powers a sound to the inside of the house. This lets people inside know someone is at the door.

Doorbells work because they use a special kind of magnet. Magnets are useful because they can attract or repel (push apart) other objects without touching.



magnets attracting

magnets repelling

All magnets have a north pole and a south pole. The north pole of one magnet always attracts the south pole of another. However, two north poles will always repel each other, as will two south poles. This is why magnets attract some magnetic objects and repel others.

Kinds of Magnets

There are different kinds of magnets. **Permanent magnets** stay magnetized without electricity.

These are permanent magnets on the fridge. They stay magnetized without electricity.

Natural magnets are magnetized rocks.

Temporary magnets act like a permanent magnet when they are within a strong magnetic field. They lose their magnetism when the magnetic field goes away. Paperclips and iron nails are temporary magnets.

This is an electromagnetic crane. It temporarily picks up metals and other magnetic materials.

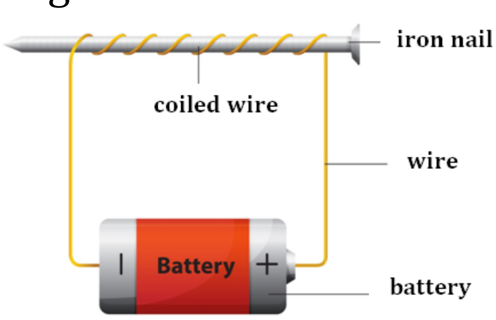
Finally, **electromagnets** are tightly wound coils of wire that produce a magnetic field when electricity passes through the wire.

Electromagnets

Electromagnets become magnetized when electricity moves through the wire. This is because electric current produces a magnetic field. Remember that all of the electrons in a conductor move in the same direction as one another. This produces a magnetic field around the wire. A magnetic field is the area around a magnet that attracts or repels other magnets or objects that contain iron or steel.

The magnetic field around a straight wire isn't very strong. However, if the wire is wrapped in a coil, each turn of the coil produces a magnetic field. The magnetic field of each coil combines to create a strong magnetic field when electricity passes through the coil.

Electromagnets are useful because the magnet can be turned off by switching the circuit off. It can be turned on by switching the circuit on.



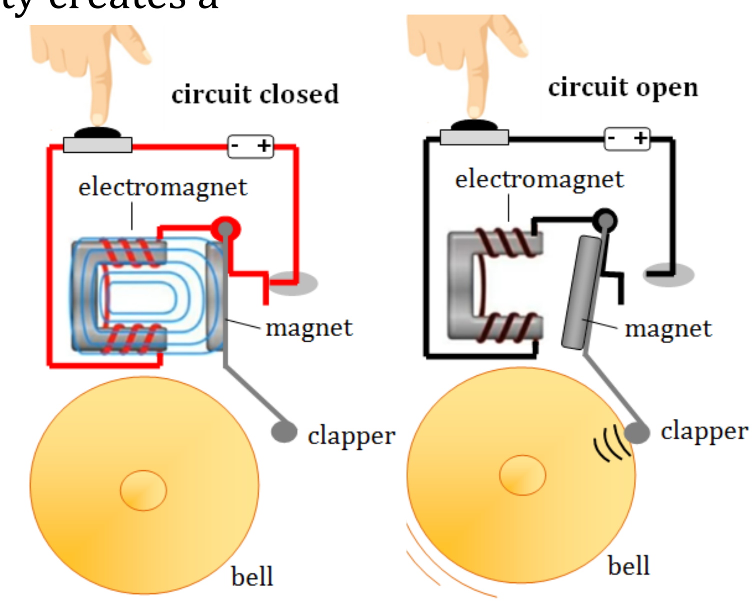
an electromagnet

Doorbell Electromagnets

Electromagnets are the key to how doorbells work. A simple doorbell is part of a circuit. It has a battery and wires. It also has an electromagnet connected to a magnetic clapper. Finally, it has something that makes noise, such as a bell.

When you push the doorbell, you close the circuit. This causes electricity to flow through the doorbell system.

The flow of electricity creates a magnetic field around the electromagnet. This magnetic field pulls on the magnetic clapper. When the clapper strikes the bell, it makes noise.



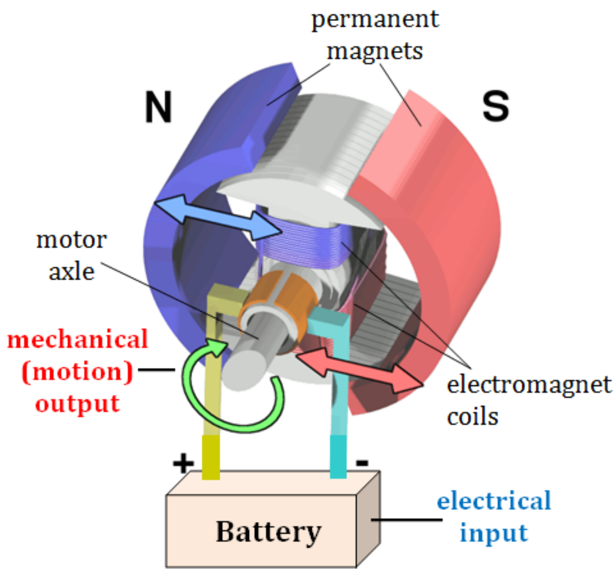
how a doorbell uses an electromagnet in a circuit

The movement of the clapper striking the bell also opens the circuit. This stops the flow of electricity. As a result, the electromagnet is no longer magnetized.

Motors

Magnets are part of many electronic devices because they are used to drive small motors. A **motor** is a machine that transfers an input of energy into an output of mechanical energy.

In an electromagnetic motor, electrical energy is converted into mechanical energy. The electromagnetic motor has two parts: an outside permanent magnet and an inside electromagnet. The electromagnet becomes magnetized when it is connected to an electrical current. It then spins rapidly because it is surrounded by the permanent magnet. If a gear is attached to the spinning electromagnet, the gear can be made to do work.



an electromagnetic motor

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Electromagnetic Motor Investigation

1. Diagram your electromagnetic motor system. Label each part of your model and use arrows and labels to show how energy is converted from one form to another in the system.

Section 2 Review

<u>Reading Comprehension Questions</u>:

1. According to the text, why are magnets useful?

2. How are magnetic forces similar to electric forces?

3. What makes an electromagnet different from a permanent magnet? How are they similar?

4. Why do electromagnets need to be part of a circuit?

5. What is the main idea of Section 2? What details support this main idea?

Science Words to Know

circuit – the circular path electrons travel in a negative to positive direction

current – a measure of the rate that electric charge passes through a point in an electric circuit over time; measured in amps

electric conductor – a material that electrons can easily pass through

electric insulator – a material that electrons cannot pass through easily

electricity – the flow of electrons through a conductor

electromagnet – a tightly wound coil of wire that produces a magnetic field when electricity passes through the wire

motor – a machine that converts an input of energy into an output of mechanical energy

permanent magnet – an object that stays magnetized without electricity

