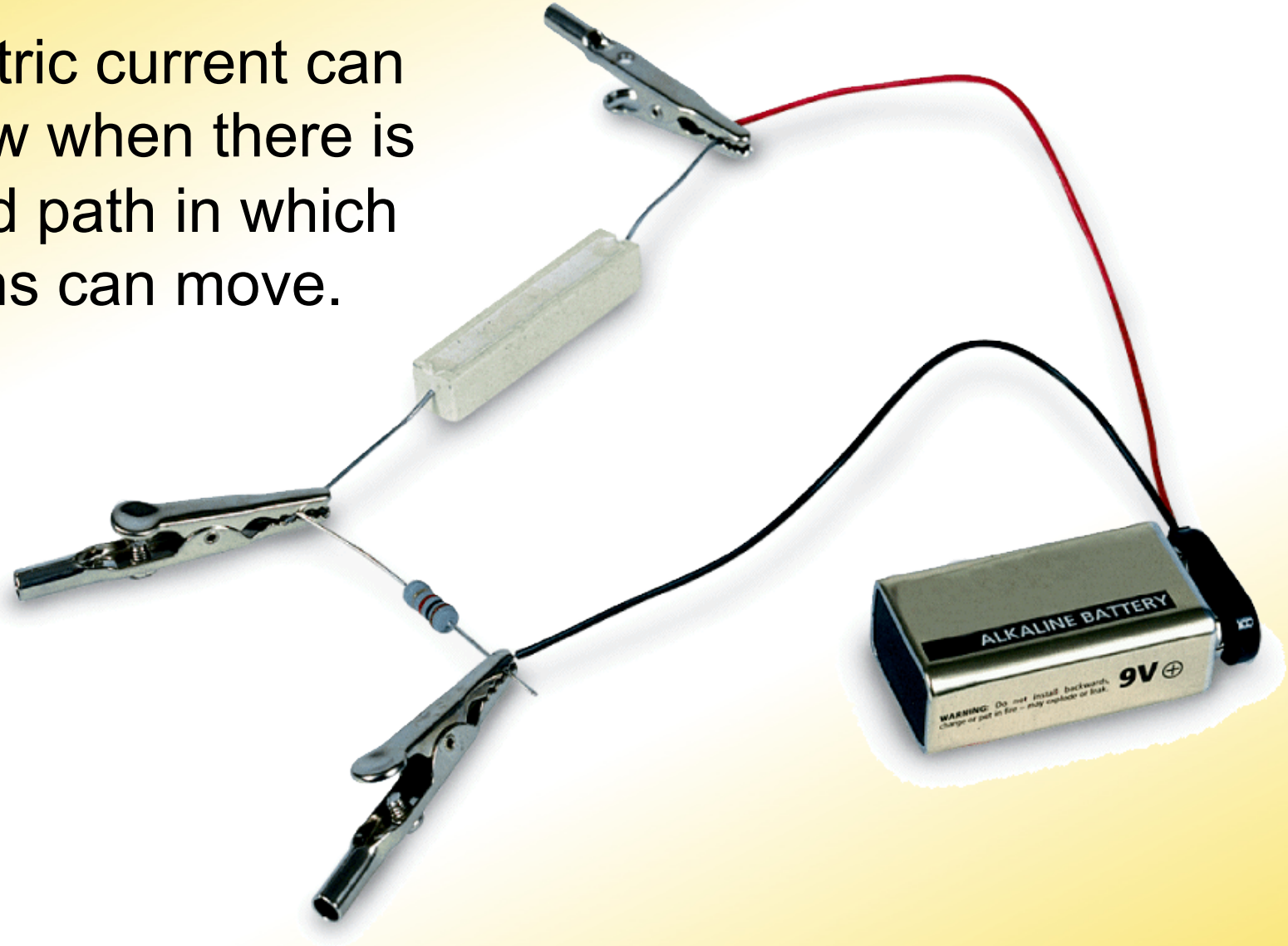
An electric current can only flow when there is a closed path in which electrons can move.



Electric Current

What are the two types of current?

The two types of current are direct current and alternating current.

Electric Current

The continuous flow of electric charge is an **electric current.**

- Charge flows only in one direction in **direct current** (DC). A flashlight and most other battery-operated devices use direct current.
- **Alternating current** (AC) is a flow of electric charge that regularly reverses its direction. Electric current in your home and school is mostly alternating current.

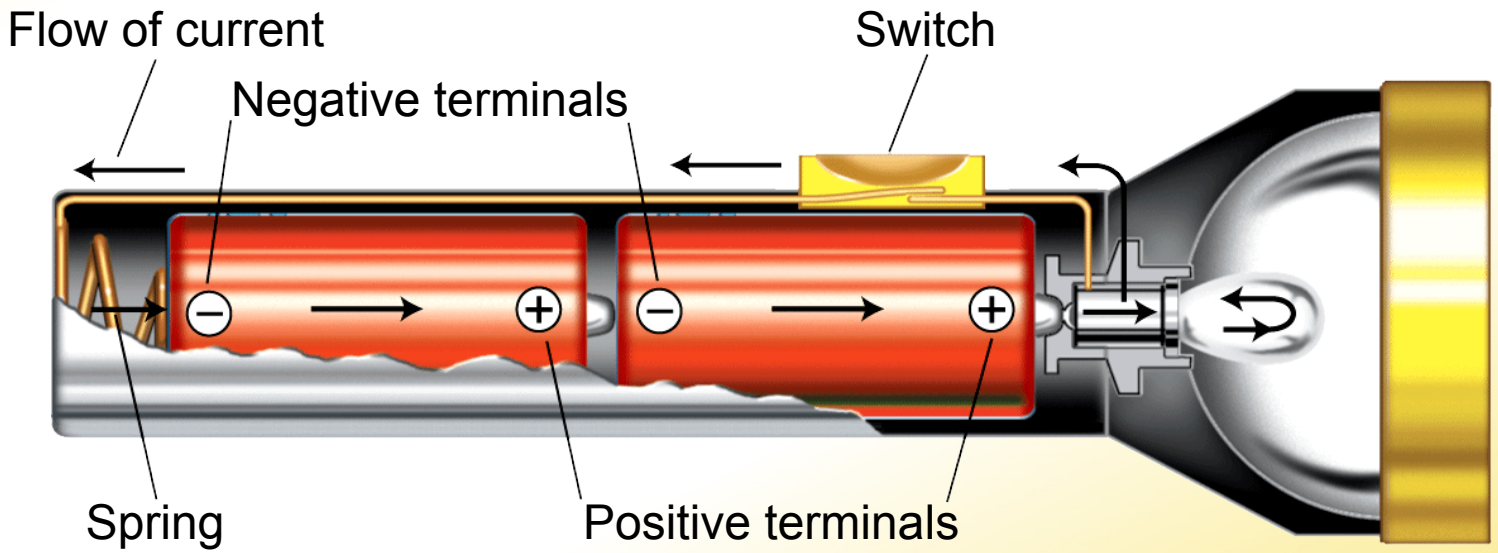
Electric Current

The SI unit of electric current is the ampere (A), or amp, which equals 1 coulomb per second.

Even though electrons flow in an electric current, scientists define current as the direction in which positive charges would flow.

Electric Current

A complete path is required for charge to flow in a flashlight. Batteries must be placed so that charge can flow from negative to positive, passing through the bulb.



Conductors and Insulators

- What are some examples of conductors and insulators?
- Metals such as copper and silver are good electrical conductors. Wood, plastic, rubber, and air are good electrical insulators.

Conductors and Insulators

An **electrical conductor** is a material through which charge can flow easily.

An **electrical insulator** is a material through which charge cannot flow easily.

Conductors and Insulators

A metal wire is usually coated with plastic or rubber.

The metal wire is an electrical conductor.

The rubber and plastic are electrical insulators.

The coating around a wire helps to control the current and keep it where it is needed.

Conductors and Insulators

A metal is made up of ions in a lattice. The ions are not free to move.

- Each ion has one or more electrons that are not tightly bound to it.
- These free electrons can conduct charge.
- Most materials do not easily conduct charge because they don't have free electrons.

Resistance

- What factors affect electrical resistance?
- A material's thickness, length, and temperature affect its resistance.

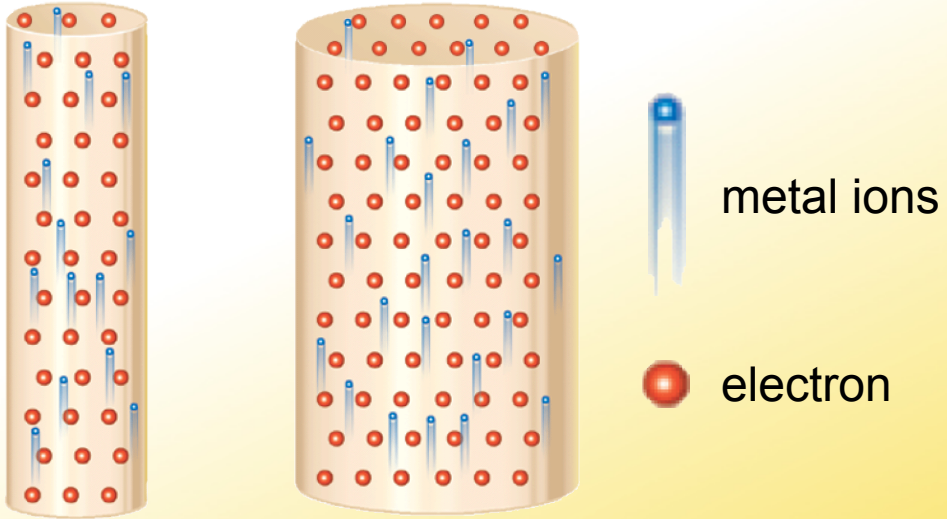
Resistance

Resistance is opposition to the flow of charges in a material.

- As electrons move through a conducting wire, they collide with electrons and ions. These collisions convert some kinetic energy into thermal energy, and the current is reduced.
- The SI unit of resistance is the ohm.

Resistance

Using a thick straw to drink a milkshake is easier than using a thin straw. Similarly, electrons flow more easily through a thick wire than they flow through a thin wire of the same material.



Resistance

Resistance is greater in a longer wire because the charges travel farther. As temperature increases, a metal's resistance increases because electrons collide more often.

A **superconductor** is a material that has almost zero resistance when it is cooled to low temperatures.

Voltage

- What causes an electric current?
- In order for charge to flow in a conducting wire, the wire must be connected in a complete loop that includes a source of electrical energy.

Voltage

Potential Difference

Water falls spontaneously from a higher to a lower height. Likewise, electric charges flow from a higher to a lower potential energy.

- **Potential difference** is the difference in electrical potential energy between two places in an electric field.
- Potential difference is measured in joules per coulomb, or volts. Because it is measured in volts, potential difference is also called **voltage.**

Voltage

A pump lifts water to the top of the fountain, increasing the gravitational potential energy of the water. A voltage source increases the electrical potential energy of electric charges.

Voltage

Voltage Sources

A source of voltage does work to increase the potential energy of electric charges. Three common voltage sources are batteries, solar cells, and generators.

A battery is a device that converts chemical energy to electrical energy.

Ohm's Law

- How are voltage, current, and resistance related?
- Increasing the voltage increases the current. Keeping the same voltage and increasing the resistance decreases the current.

Ohm's Law

According to **Ohm's law,** the voltage (*V*) in a circuit equals the product of the current (*I*) and the resistance (*R*).

Ohm's Law

$$V = I \times R \text{ or } I = \frac{V}{R}$$

When the current is in amperes, and the resistance is in ohms, the voltage is in volts.

Ohm's Law

What is the voltage if the resistance is 3 ohms and the current is 3 amps?

$V = I \times R$ = 3 amps × 3 ohms = 9 volts

Ohm's Law

A multimeter can be used to measure current, voltage, or resistance. Here the voltage of a 9-volt battery is measured.

Assessment Questions

1. Which of the following materials is a good conductor of electric current?
   a. wood
   b. glass
   c. air
   d. iron

Assessment Questions

1. Which of the following materials is a good conductor of electric current?

   a. wood
   b. glass
   c. air
   d. iron

   ANS: D

Assessment Questions

2. If a piece of wire has a certain resistance, which wire made of the same material will have a lower resistance?
   a. a hotter wire
   b. a thicker wire
   c. a longer wire
   d. a thinner wire

Assessment Questions

2. If a piece of wire has a certain resistance, which wire made of the same material will have a lower resistance?

   a. a hotter wire
   b. a thicker wire
   c. a longer wire
   d. a thinner wire

   ANS: B

Assessment Questions

3. What does the voltage between two points in an electric field represent?
   a. the total kinetic energy
   b. the difference in mechanical energy
   c. the difference in potential energy
   d. the electrical energy

Assessment Questions

3. What does the voltage between two points in an electric field represent?
   a. the total kinetic energy
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   c. the difference in potential energy
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   ANS: C

Assessment Questions

4. A 9-volt battery drives an electric current through a circuit with 4-ohm resistance. What is the electric current running through the circuit?
   a. 0.44 A
   b. 2.25 A
   c. 5 A
   d. 36 A

Assessment Questions

4. A 9-volt battery drives an electric current through a circuit with 4-ohm resistance. What is the electric current running through the circuit?

   a. 0.44 A

   b. 2.25 A

   c. 5 A

   d. 36 A

   ANS: B

Assessment Questions

1. The two types of electric current are direct current and indirect current.

   True
   False

Assessment Questions

1. The two types of electric current are direct current and indirect current.

   True
   False

   ANS: F, alternating