Section 2: Current

Preview

Key Ideas

- How are electrical potential energy and gravitational potential energy similar?
- What causes electrical resistance?

Bellringer

1. Dry cell batteries are a source of mobile electrical power. Name five devices that use dry cell batteries.
2. Give reasons why copper is normally used to wire a home for electricity.
3. Why do you think it is important to unplug a device by pulling the plug instead of by yanking the plug out of the socket by pulling on the electrical cord?
4. Why are electrical appliances, such as razors, hair dryers, and curling irons, not to be used in the bathtub or shower?

Voltage and Current

〉 How are electrical potential energy and gravitational potential energy similar?

〉 Just as a ball will roll downhill, a negative charge will move away from another negative charge.

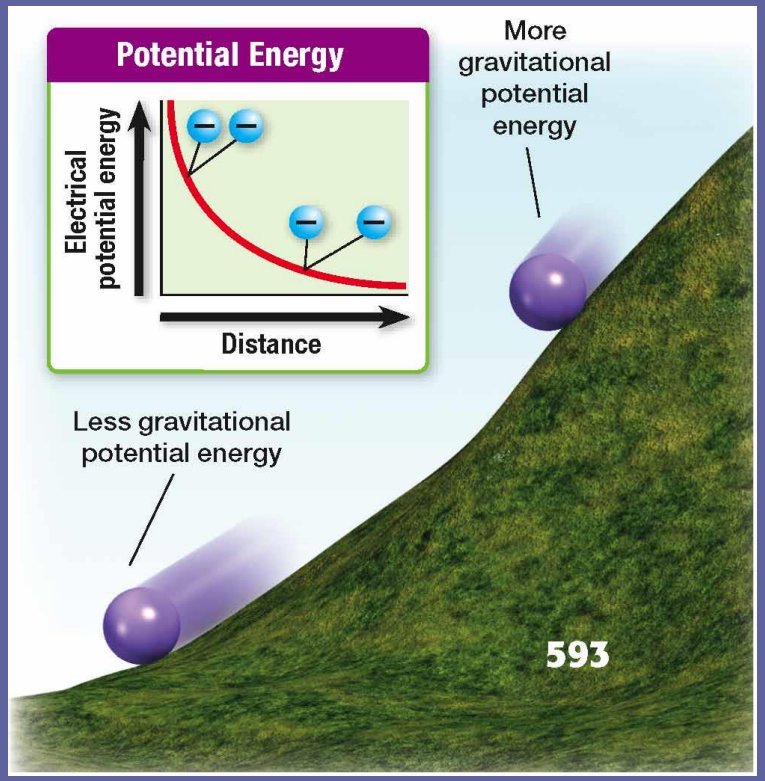
- **electrical potential energy:** the ability to move an electric charge from one point to another

Voltage and Current, *continued*

- The potential energy of an electric charge depends on its position in an electric field.

- The electrical potential energy of a moving charge decreases because the electric field does work on the charge.

Electrical Potential Energy

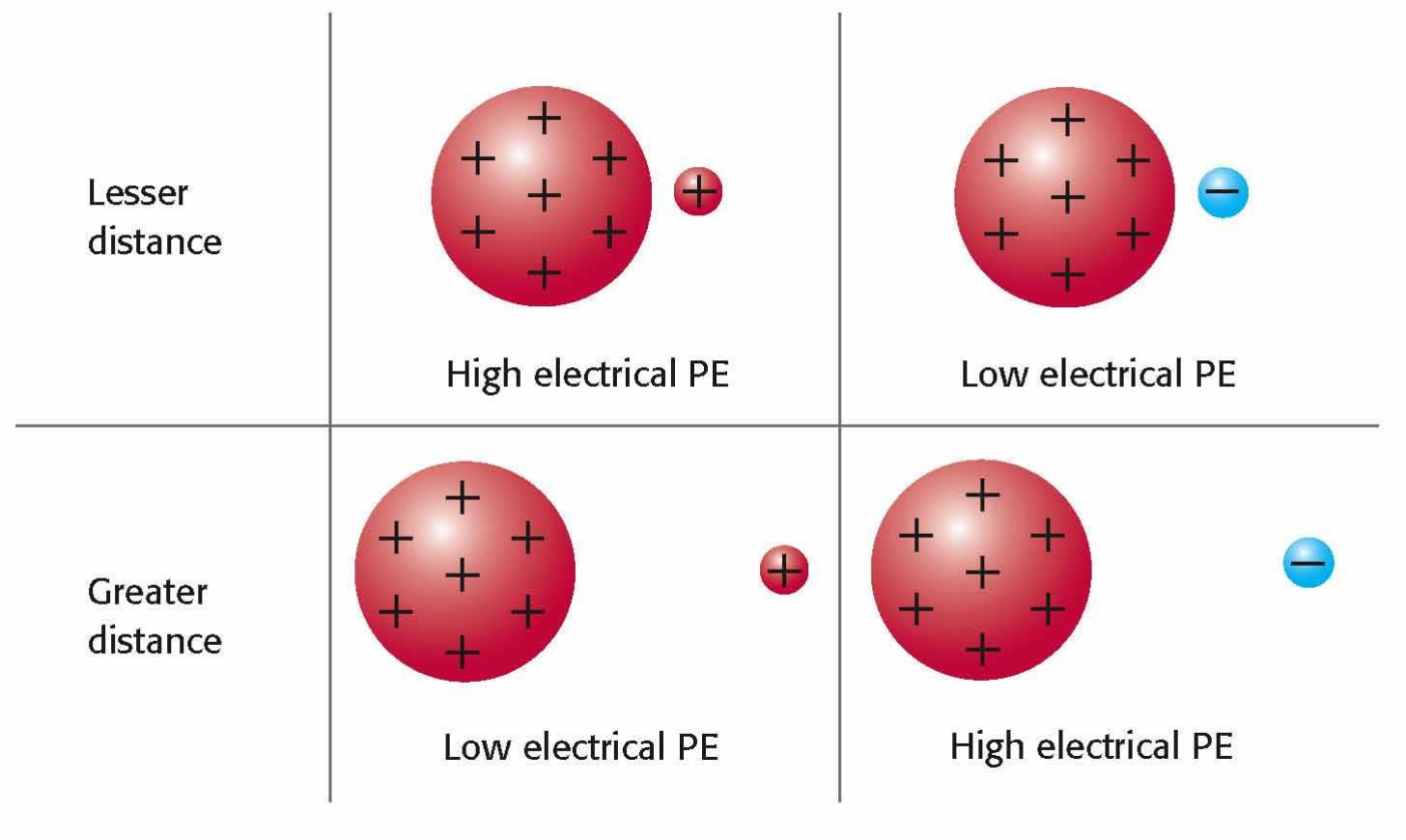


The electrical potential energy between two negative charges decreases as the distance between them increases.

Voltage and Current, *continued*

- Potential difference is measured in volts.
  - **potential difference:** the voltage difference in potential between two points in a circuit
  - For a repulsive force electrical potential energy increases as the charges move closer to each other.
  - The *volt,* V, is equivalent to one joule per coulomb (1 J/C).
  - Potential difference is often called *voltage.*

Electrical Potential Energy and Relative Position



Visual Concept: Electrical Potential Energy

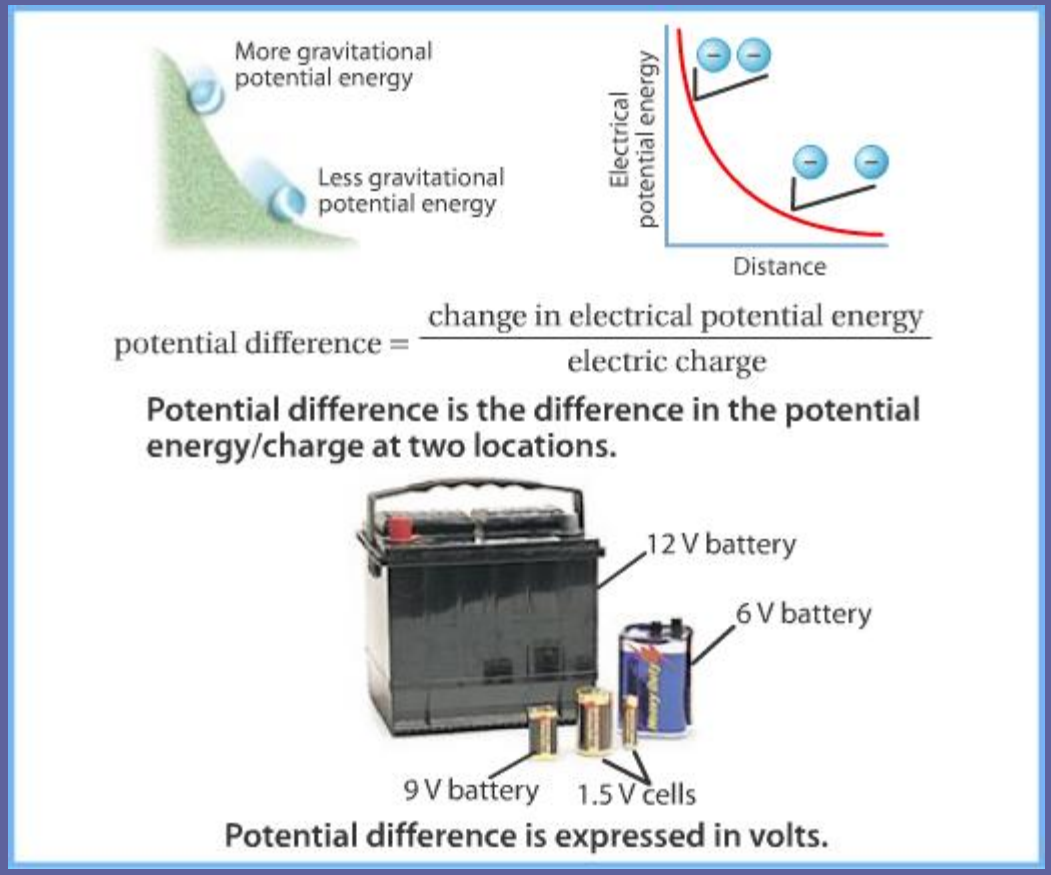
Electrical potential energy for a pair of charges

$$PE_{electric} = k_C \frac{q_1 q_2}{r}$$

$$electrical\ potential\ energy = Coulomb\ constant \times \frac{charge\ 1 \times charge\ 2}{distance}$$

Play

Visual Concept: Potential Difference

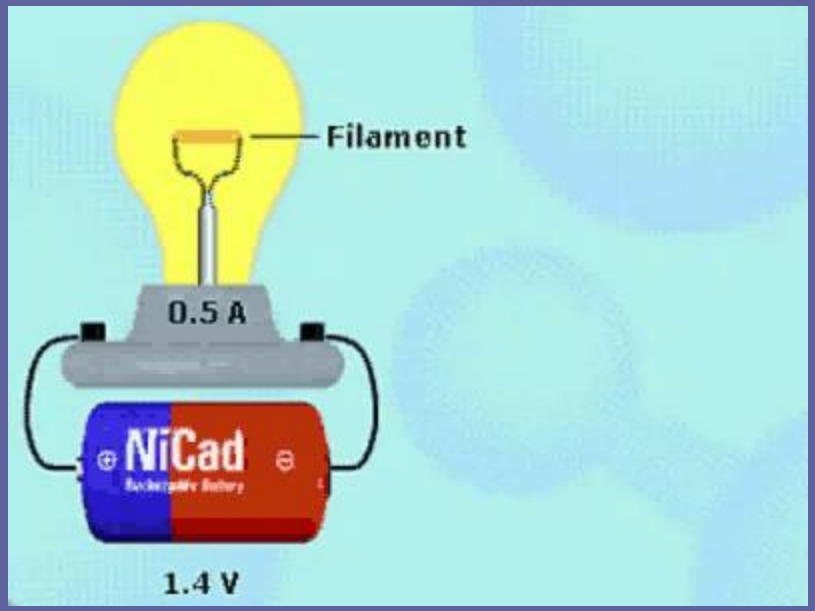


Visual Concept: Voltage

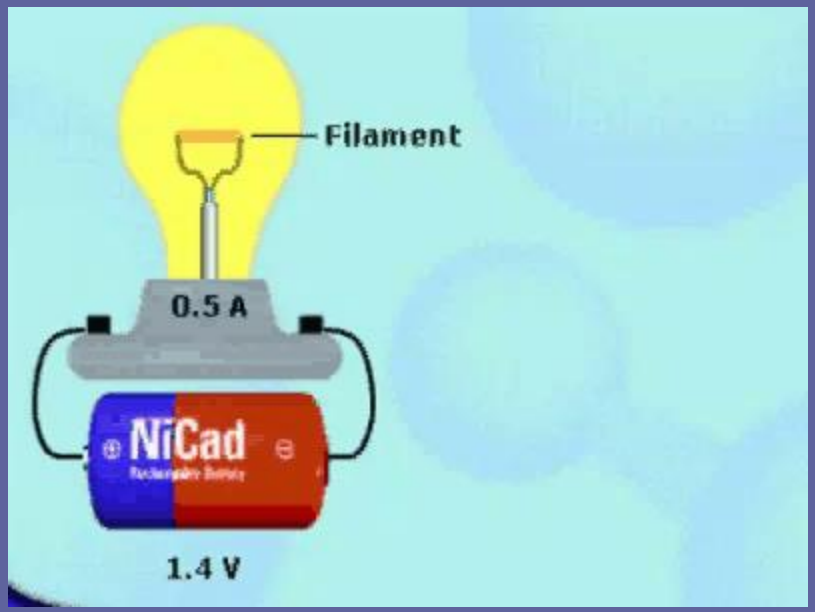
Voltage and Current, *continued*

- There is a voltage across the terminals of a battery.
  - **cell:** a device that produces an electric current by converting chemical or radiant energy into electrical energy
  - One terminal, or end, is positive, and the other is negative.
  - Batteries convert chemical energy into electrical energy.

Battery



Electric Cell



Voltage and Current, *continued*

- A voltage sets charges in motion.

- Current is the rate of charge movement.
  - **electric current:** the rate at which charges pass through a given point

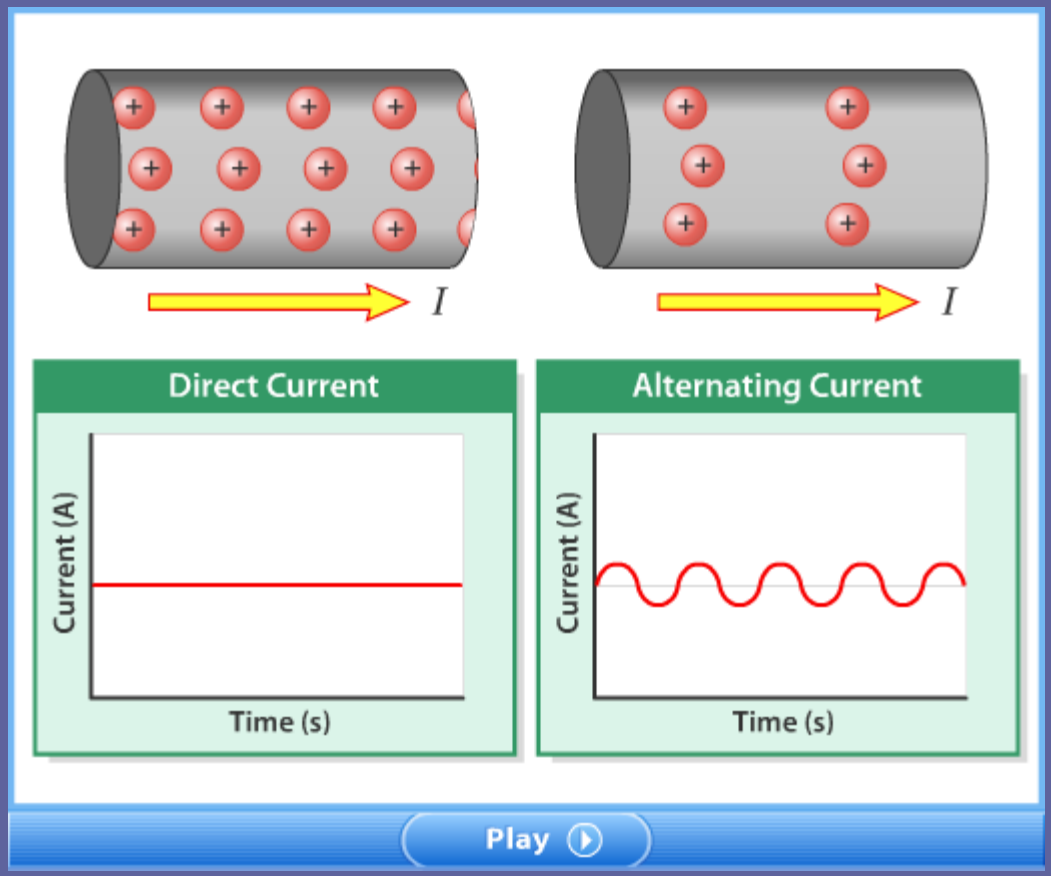
  - The SI unit of current is the *ampere,* A.

    - 1 amp = 1 C/s

Voltage and Current, *continued*

- In a *direct current* source the charges always move from one terminal to the other in the same direction.
  - example: battery
- *Conventional current* is the current made of positive charge that would have the same effect as the actual motion of charge in the material.
  - The direction of current is *opposite* to the direction that electrons move.

Visual Concept: Comparing Direct and Alternating Current



Visual Concept: Conventional Current

Electrical Resistance

〉 What causes electrical resistance?

〉 Resistance is caused by internal friction, which slows the movement of charges through a conducting material.

- **resistance:** the opposition presented to the current by a material or device

Electrical Resistance, *continued*

- Resistance can be calculated if current and voltage are known.
  - A conductor's resistance indicates how much the motion of charges within it is resisted because of collisions of electrons with atoms.
  - *Ohms' law:*

$$resistance = \frac{voltage}{current} \qquad R = \frac{V}{I}$$

  - The SI unit of resistance is the *ohm* (Ω).
    - 1 Ω = 1 V/A
- A *resistor* is a special type of conductor used to control current.

Math Skills

Resistance

The headlights of a typical car are powered by a 12 V battery. What is the resistance of the headlights if they draw 3.0 A of current when turned on?

1. List the given and unknown values.

Given: *current*, I = 3.0 A

voltage, V = 12 V

Unknown: *resistance*, R = ? Ω

Math Skills, *continued*

2. Write the equation for resistance.

$$resistance = \frac{voltage}{current} \qquad R = \frac{V}{I}$$

3. Insert the known values into the equation, and solve.

$$R = \frac{V}{I} = \frac{12\ \text{V}}{3.0\ \text{A}}$$

$$R = 4.0\ \Omega$$

Electrical Resistance, *continued*

- Conductors have low resistances.
- Insulators have high resistances.
- Semiconductors conduct under certain conditions.
  - *semiconductors:* materials that have electrical properties between those of insulators and conductors
- Some materials can become superconductors.
  - Some metals and compounds have zero resistance when their temperature falls below the *critical temperature.*
  - Once a current is established in a superconductor, the current continues even if the applied voltage is removed.