Section 1: Electric Charge and Force

Preview

Key Ideas

- What are the different kinds of electric charge?
- How do materials become charged when rubbed together?
- What force is responsible for most everyday forces?

Bellringer

1. Name at least five examples of static electricity that occur in everyday life.
2. Fabric softeners are commonly used because they eliminate static cling. Explain why clothes in the dryer get static cling.
3. Why can walking across a carpeted room be a shocking experience.
4. Magnets have both north and south poles. While like poles repel each other, opposite poles attract each other. Explain the parallelism between magnetism and electric charge.

Electric Charge

〉 What are the different kinds of electric charge?

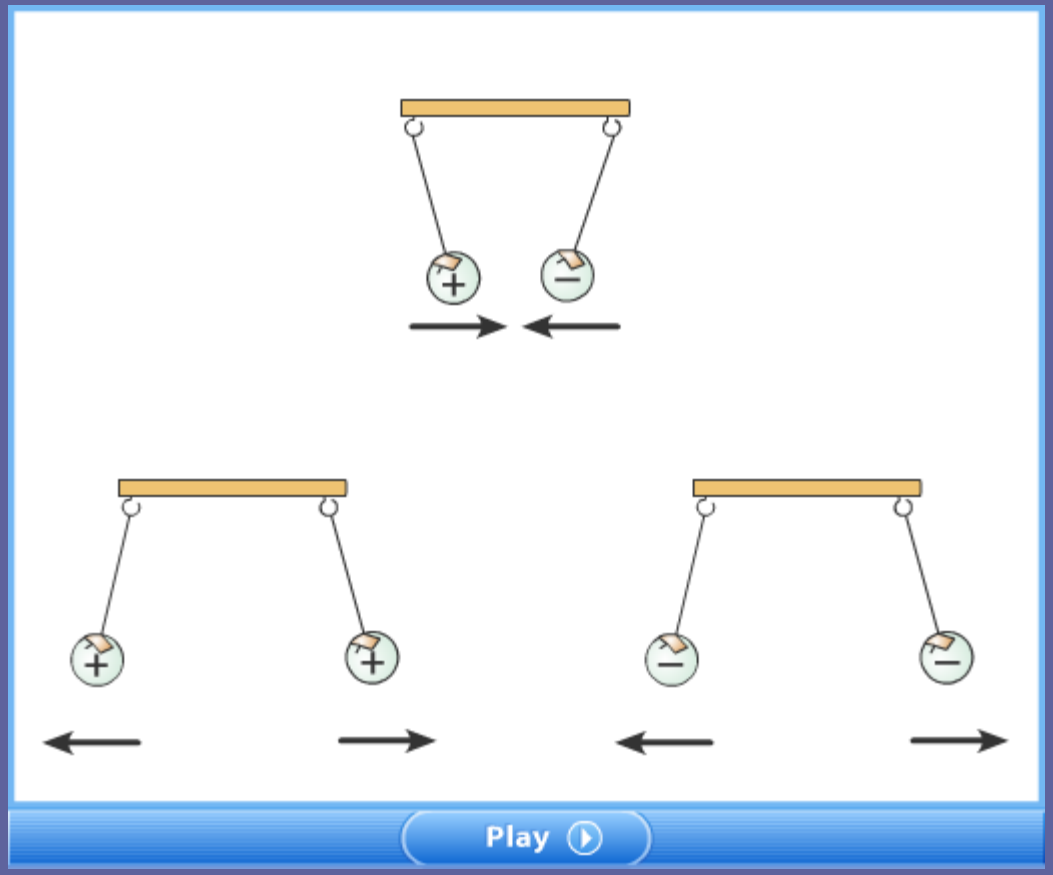
〉 An object can have a negative charge, a positive charge, or no charge at all.

- **Electric charge:** an electrical property of matter that creates electric and magnetic forces and interactions

Electric Charge, *continued*

- Like energy, electric charge is never created or destroyed.
- Like charges repel, and opposite charges attract.
- Electric charge depends on the imbalance of protons and electrons.
  - Electrons are negatively charged.
  - Protons are positively charged.
  - Neutrons are neutral (no charge).
  - Negatively charged objects have more electrons than protons.
  - Positively charged objects have fewer electrons than protons.

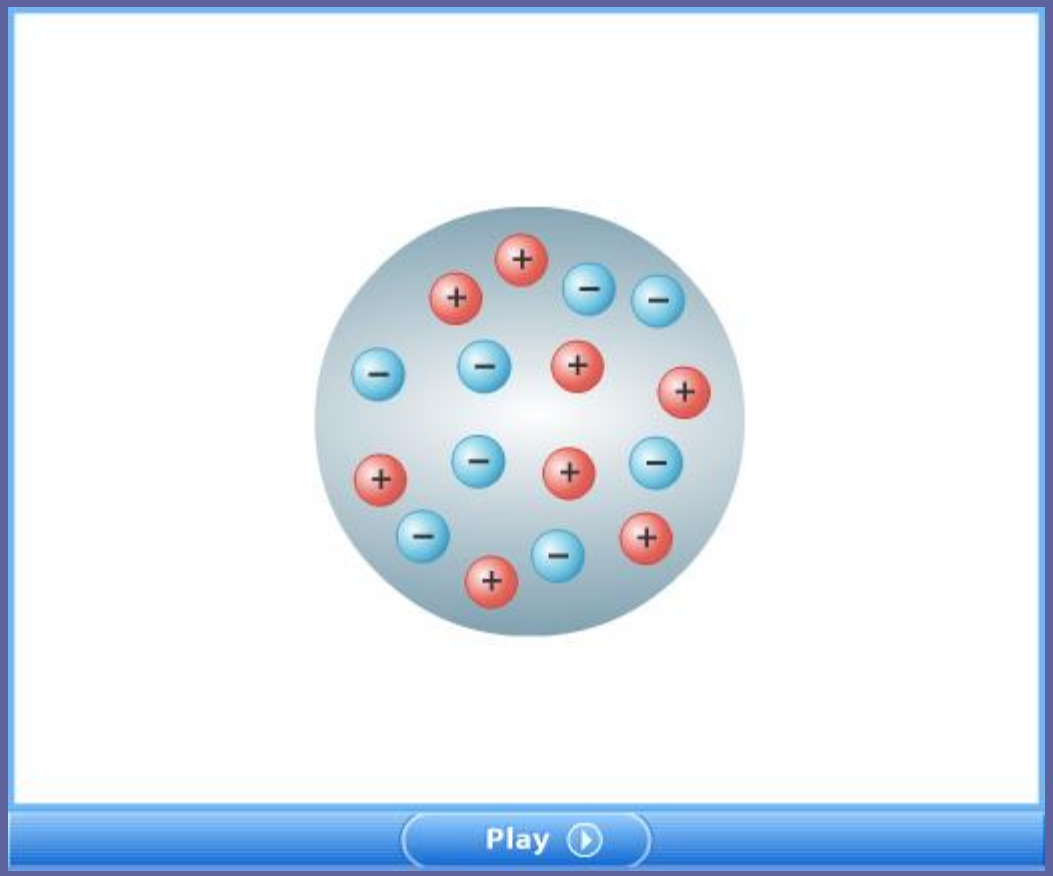
Visual Concept: Electric Charge



Electric Charge, *continued*

- The SI unit of electric charge is the *coulomb,* C.
  - A proton has a charge of $+1.6 \times 10^{-19}$ C.
  - An electron has a charge of -1.6×10^{-19} C.
  - The amount of electric charge on an object depends on the number of protons and electrons.
    - The net electric charge of a charged object is always a multiple of 1.6×10^{-19} C.

Visual Concept: Characteristics of Electric Charge



Transfer of Electric Charge

〉 How do materials become charged when rubbed together?

〉 When different materials are rubbed together, electrons can be transferred from one material to the other.

- The direction in which the electrons are transferred depends on the materials.

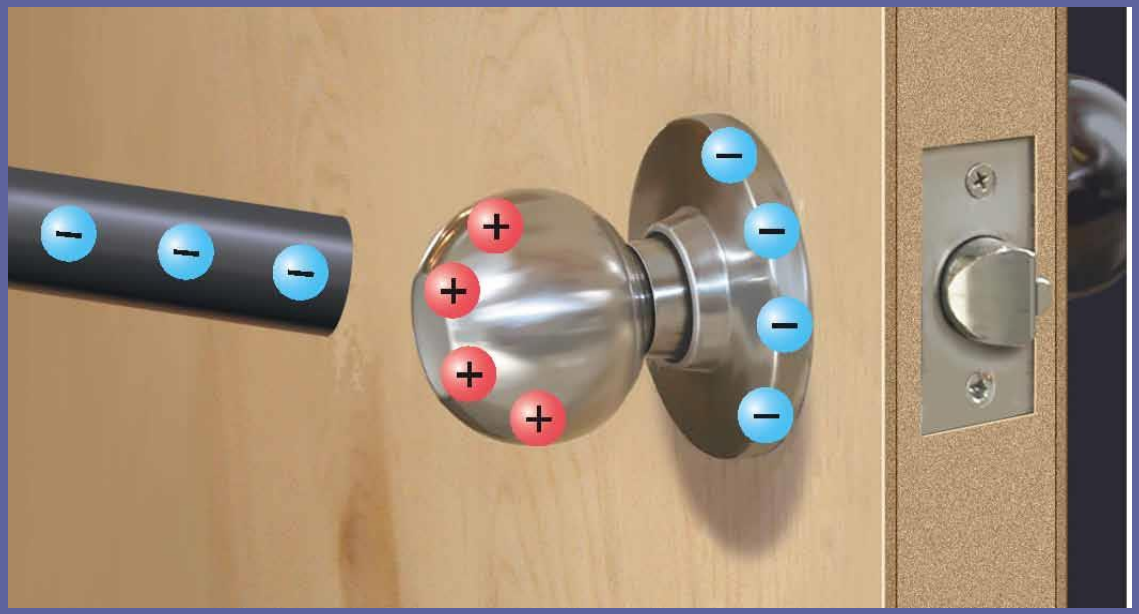
Transfer of Electric Charge, *continued*

- Conductors allow charges to flow; insulators do not.
  - **electrical conductor:** a material in which charges can move freely
  - **electrical insulator:** a material in which charges cannot move freely

- Charges can move within uncharged objects.
  - The charges in a neutral conductor can be redistributed without changing the overall charge of the object.
  - Although the total charge on the conductor will be zero, the opposite sides can have an *induced* charge.

Visual Concept: Electrical Conductors and Insulators

Induced Charges



A negatively charged rod brought near a metal doorknob induces a positive charge on the side of the doorknob closest to the rod and a negative charge on the side farthest from the rod.

Transfer of Electric Charge, *continued*

- Objects can be charged by contact.
  - The transfer of electrons from one object to another can charge objects.
  - Objects charged by touching a charged object to a neutral object are said to be charged by *contact*.

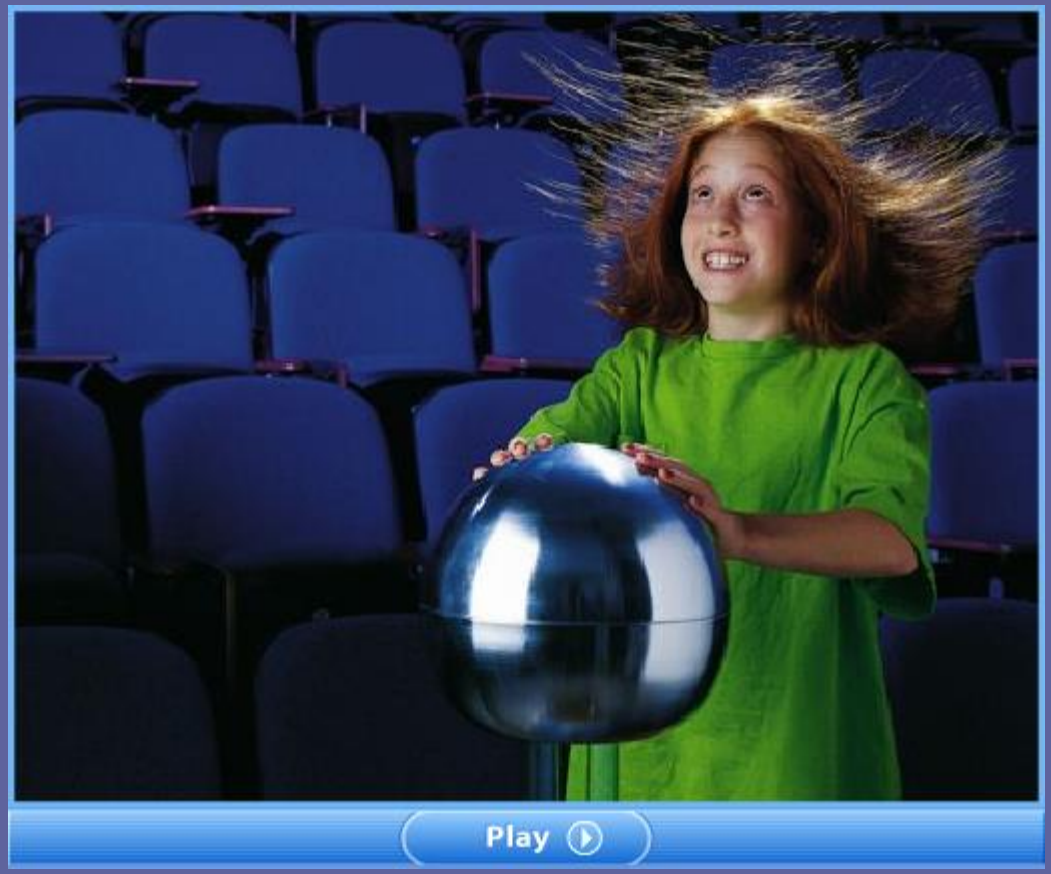
- Objects can be charged by friction.
  - *Charging by friction* occurs when one material gains electrons and becomes negatively charged, and the other loses electrons and becomes positively charged.
  - Your clothes are charged by friction as they rub against each other inside the dryer, and stick together because of static electricity.

Charging by Contact

When a negative rod touches a neutral doorknob, electrons move from the rod to the doorknob.

The transfer of electrons to the metal doorknob gives the doorknob a net negative charge.

Visual Concept: Charging by Contact



Transfer of Electric Charge, *continued*

- A surface charge can be induced on insulators.
  - When a charged object is brought near an insulator, the positions of the electrons within the individual molecules of the insulator change slightly.
  - One side of a molecule will be slightly more positive or negative than the other side.
    - The molecules are *polarized.*

Electric Force

〉 What force is responsible for most everyday forces?

〉 The electric force at the atomic and molecular levels is responsible for most of the everyday forces that we observe, such as the force of a spring and the force of friction.

- **electric force:** the force of attraction or repulsion on a charged particle that is due to an electric field

Electric Force, *continued*

- The electric force is also responsible for effects that we cannot see.
  - Bonding of atoms to form molecules is also due to the electric force.

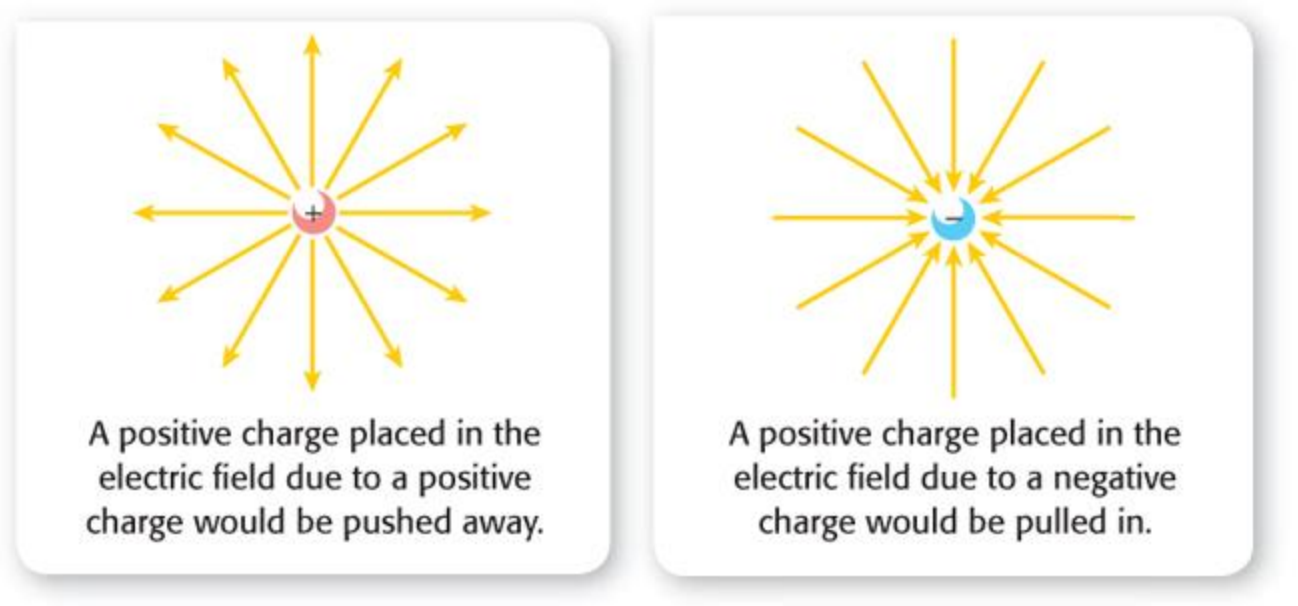
- Electric force depends on charge and distance.
  - The electric force between two objects is proportional to the product of the charges on the objects.

  - The electric force is inversely proportional to the square of the distance between two objects.

Electric Force, *continued*

- Electric force acts through a field.
  - **electric field:** the space around a charged object in which another charged object experiences an electric force
  - One way to show an electric field is by drawing electric field lines.
  - *Electric field lines* point in the direction of the electric force on a positive charge.

Electric Field Lines



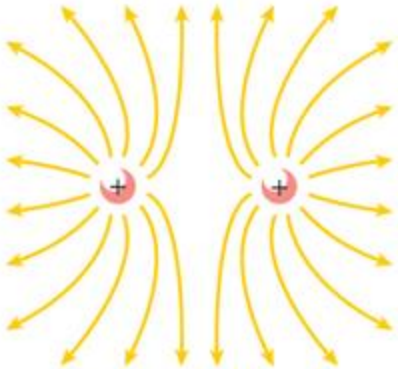
The electric field lines around a positive charge point outward.

The electric field lines around a negative charge point inward.

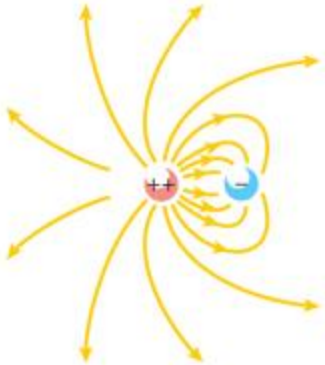
Electric Force, *continued*

- Electric field lines never cross one another.
- The field lines near two like charges point away from each other, and show that the charges repel each other.
- Field lines show both the direction of an electric field and the relative strength due to a given charge.
  - More lines are drawn for greater charges to indicate greater force.

Electric Field Lines



The electric field lines for two positive charges located near each other show the repulsion between the charges.



Half of the field lines starting on the positive charge end on the negative charge because the positive charge is twice as large as the negative charge.

Two positive charges repel each other.

The positive charge is twice as large as the negative charge.

Visual Concept: Electric Fields and Test Charges