SECTION 2

Electric Force

SECTION OBJECTIVES

- **Calculate electric force using Coulomb's law.**
- **Compare electric force with gravitational force.**
- **Apply the superposition principle to find the resultant force on a charge and to find the position at which the net force on a charge is zero.**

COULOMB'S LAW

Two charged objects near one another may experience acceleration either toward or away from each other because each object exerts a force on the other object. This force is called the *electric force.* The two balloon experiments described in the first section demonstrate that the electric force is attractive between opposite charges and repulsive between like charges. What determines how small or large the electric force will be?

The closer two charges are, the greater is the force on them

It seems obvious that the distance between two objects affects the magnitude of the electric force between them. Further, it is reasonable that the amount of charge on the objects will also affect the magnitude of the electric force. What is the precise relationship between distance, charge, and the electric force?

In the 1780s, Charles Coulomb conducted a variety of experiments in an attempt to determine the magnitude of the electric force between two charged objects. Coulomb found that the electric force between two charges is proportional to the product of the two charges. Hence, if one charge is doubled, the electric force likewise doubles, and if both charges are doubled, the electric force increases by a factor of four. Coulomb also found that the electric force is inversely proportional to the square of the distance between the charges. Thus, when the distance between two charges is halved, the force between them increases by a factor of four. The following equation, known as Coulomb's law, expresses these conclusions mathematically for two charges separated by a distance, *r*.

COULOMB'S LAW

$$F_{electric} = k_C\left(\frac{q_1q_2}{r^2}\right)$$

$$\textbf{electric force} = \textbf{Coulomb constant} \times \frac{\textbf{(charge 1)(charge 2)}}{\textbf{(distance)}^2}$$

When dealing with Coulomb's law, remember that force is a vector quantity and must be treated accordingly. The electric force between two objects always acts along the line that connects their centers of charge. Also, note that Coulomb's law applies exactly only to point charges or particles and to spherical distributions of charge. When applying Coulomb's law to spherical distributions of charge, use the distance between the centers of the spheres as *r*.

Did you know?

The symbol k_C, called the *Coulomb constant,* has SI units of $N\bullet m^2/C^2$ because this gives N as the unit of electric force. The value of k_C depends on the choice of units. Experiments have determined that in SI units, k_C has the value $8.9875 \times 10^9\ N\bullet m^2/C^2$.