Coulomb quantified electric force with a torsion balance

Earlier in this chapter, you learned that Charles Coulomb was the first person to quantify the electric force and establish the inverse square law for electric charges. Coulomb measured electric forces between charged objects with a torsion balance, as shown in **Figure 6.** A torsion balance consists of two small spheres fixed to the ends of a light horizontal rod. The rod is made of an insulating material and is suspended by a silk thread.

In this experiment, one of the spheres is given a charge and another charged object is brought near the charged sphere. The attractive or repulsive force between the two causes the rod to rotate and to twist the suspension. The angle through which the rod rotates is measured by the deflection of a light beam reflected from a mirror attached to the suspension. The rod rotates through some angle against the restoring force of the twisted thread before reaching equilibrium. The value of the angle of rotation increases as the charge increases, thereby providing a quantitative measure of the electric force. With this experiment, Coulomb established the equation for electric force introduced at the beginning of this section. More recent experiments have verified these results to within a very small uncertainty.

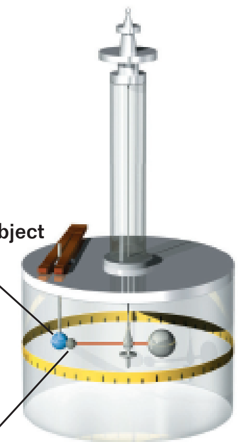

Figure 6
Coulomb's torsion balance was used to establish the inverse square law for the electric force between two charges.

SECTION REVIEW

1. A small glass ball rubbed with silk gains a charge of +2.0 μC. The glass ball is placed 12 cm from a small charged rubber ball that carries a charge of −3.5 μC.

a. What is the magnitude of the electric force between the two balls?

b. Is this force attractive or repulsive?

c. How many electrons has the glass ball lost in the rubbing process?

2. The electric force between a negatively charged paint droplet and a positively charged automobile body is increased by a factor of two, but the charges on each remain constant. How has the distance between the two changed? (Assume that the charge on the automobile is located at a single point.)

3. A $+2.2 \times 10^{-9}$ C charge is on the x-axis at $x = 1.5$ m, a $+5.4 \times 10^{-9}$ C charge is on the x-axis at $x = 2.0$ m, and a $+3.5 \times 10^{-9}$ C charge is at the origin. Find the net force on the charge at the origin.

4. A charge q_1 of -6.00×10^{-9} C and a charge q_2 of -3.00×10^{-9} C are separated by a distance of 60.0 cm. Where could a third charge be placed so that the net electric force on it is zero?

5. Critical Thinking What are some similarities between the electric force and the gravitational force? What are some differences between the two forces?