CONDUCTORS IN ELECTROSTATIC EQUILIBRIUM

A good electric conductor, such as copper, contains charges (electrons) that are only weakly bound to the atoms in the material and are free to move about within the material. When no net motion of charge is occurring within a conductor, the conductor is said to be in *electrostatic equilibrium.* As we shall see, such a conductor that is isolated has the four properties summarized in **Table 5.**

The first property, which states that the electric field is zero inside a conductor in electrostatic equilibrium, can be understood by examining what would happen if this were not true. If there were an electric field inside a conductor, the free charges would move and a flow of charge, or current, would be created. However, if there were a net movement of charge, the conductor would no longer be in electrostatic equilibrium.

Table 5 Conductors in Electrostatic Equilibrium

The electric field is zero everywhere inside the conductor.
Any excess charge on an isolated conductor resides entirely on the conductor's outer surface.
The electric field just outside a charged conductor is perpendicular to the conductor's surface.
On an irregularly shaped conductor, charge tends to accumulate where the radius of curvature of the surface is smallest, that is, at sharp points.

The fact that any excess charge resides on the outer surface of the conductor is a direct result of the repulsion between like charges described by Coulomb's law. If an excess of charge is placed inside a conductor, the repulsive forces arising between the charges force them as far apart as possible, causing them to quickly migrate to the surface.

We can understand why the electric field just outside a conductor must be perpendicular to the conductor's surface by considering what would happen if this were not true. If the electric field were *not* perpendicular to the surface, the field would have a component along the surface. This would cause the free negative charges within the conductor to move on the surface of the conductor. But if the charges moved, a current would be created, and there would no longer be electrostatic equilibrium. Hence, **E** must be perpendicular to the surface.

To see why charge tends to accumulate at sharp points, consider a conductor that is fairly flat at one end and relatively pointed at the other. Any excess charge placed on the object moves to its surface. **Figure 13** shows the forces between two charges at each end of such an object. At the flatter end, these forces are predominantly directed parallel to the surface. Thus, the charges move apart until repulsive forces from other nearby charges create a state of equilibrium.

At the sharp end, however, the forces of repulsion between two charges are directed predominantly perpendicular to the surface. As a result, there is less tendency for the charges to move apart along the surface and the amount of charge per unit area is greater than at the flat end. The cumulative effect of many such outward forces from nearby charges at the sharp end produces a large electric field directed away from the surface.

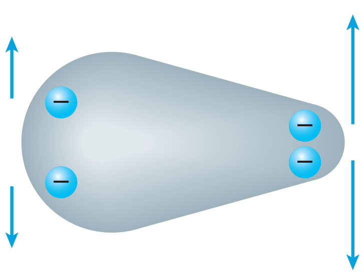

Figure 13
When one end of a conductor is more pointed than the other, excess charge tends to accumulate at the sharper end, resulting in a larger charge per unit area and therefore a larger repulsive electric force between charges at this end.