PRACTICE E

Torque

1. Find the magnitude of the torque produced by a 3.0 N force applied to a door at a perpendicular distance of 0.25 m from the hinge.
2. A simple pendulum consists of a 3.0 kg point mass hanging at the end of a 2.0 m long light string that is connected to a pivot point.
   a. Calculate the magnitude of the torque (due to gravitational force) around this pivot point when the string makes a 5.0° angle with the vertical.
   b. Repeat this calculation for an angle of 15.0°.
3. If the torque required to loosen a nut on the wheel of a car has a magnitude of 40.0 N•m, what *minimum* force must be exerted by a mechanic at the end of a 30.0 cm wrench to loosen the nut?

TYPES OF SIMPLE MACHINES

What do you do when you need to pry a cap off a bottle of soda? You probably use a bottle opener, as shown in **Figure 19.** Similarly, you would probably use scissors to cut paper or a hammer to drive a nail into a board. All of these devices make your task easier. These devices are all examples of *machines.*

The term *machine* may bring to mind intricate systems with multicolored wires and complex gear-and-pulley systems. Compared with internal-combustion engines or airplanes, simple devices such as hammers, scissors, and bottle openers may not seem like machines, but they are.

A machine is any device that transmits or modifies force, usually by changing the force applied to an object. All machines are combinations or modifications of six fundamental types of machines, called *simple machines.* These six simple machines are the lever, pulley, inclined plane, wheel and axle, wedge, and screw, as shown in **Table 2** on the next page.

Figure 19
Because this bottle opener makes work easier, it is an example of a machine.

Using simple machines

Because the purpose of a simple machine is to change the direction or magnitude of an input force, a useful way of characterizing a simple machine is to compare how large the output force is relative to the input force. This ratio, called the machine's *mechanical advantage,* is written as follows:

$$MA = \frac{\text{output force}}{\text{input force}} = \frac{F_{out}}{F_{in}}$$