Although we generally use SI units in this book, we need to know another system, the U.S. customary system, still used in the United States, which is based on the foot, the second, and the pound. The U.S. customary system differs from SI in that it uses a unit of force, the pound, as a fundamental unit rather than using a unit of mass. The **pound** was originally defined as the weight of a particular standard object at a particular location. It is now defined as 4.448222 N. Rounding to three places, we have 1 lb ≈ 4.45 N. Since 1 kg weighs 9.81 N, its weight in pounds is

$$9.81\text{ N} \times \frac{1\text{ lb}}{4.45\text{ N}} = 2.20\text{ lb} \qquad \text{4-6}$$

Weight of 1 kg

The unit of mass in the U.S. customary system is the rarely encountered slug, defined as the mass of an object that weighs 32.2 lb. When working problems in the U.S. customary system, we substitute w/g for mass m, where w is the weight in pounds and g is the acceleration due to gravity in feet per second per second:

$$g = 32.2\text{ ft/s}^2 \qquad \text{4-7}$$

Example 4-4

The net force acting on a 130-lb student is 25 lb. What is her acceleration?

According to Newton's second law, her acceleration is the force divided by her mass:

$$a = \frac{F}{m} = \frac{F}{w/g} = \frac{25\text{ lb}}{(130\text{ lb})/(32.2\text{ ft/s}^2)}$$
$$= 6.19\text{ ft/s}^2$$

Exercise What force is needed to give an acceleration of 3 ft/s^2 to a 5-lb block? (*Answer* 0.466 lb)

4-4 Newton's Third Law

The word *force* is used to describe the interaction between two objects. When two objects interact, they exert forces on each other. Newton's third law states that these forces are equal in magnitude and opposite in direction. If object A exerts a force on object B, object B exerts a force on A that is equal in magnitude and opposite in direction. Thus, forces always occur in pairs. It is common to refer to one force in the pair as an action and the other as a reaction. This terminology is unfortunate because it sounds like one force "reacts" to the other, which is not true. Both forces occur simultaneously. Either can be called the action and the other the reaction. Action and reaction forces can never balance *each other* because they act on *different objects.* In Figure 4-2, a block rests on a table. The force acting downward on the block is the weight $\vec{w}$ due to the attraction of the earth. An equal and opposite force $\vec{w}' = -\vec{w}$ is exerted by the block on the earth. These forces are an action–reaction pair. If they were the only forces present, the block would accelerate downward,

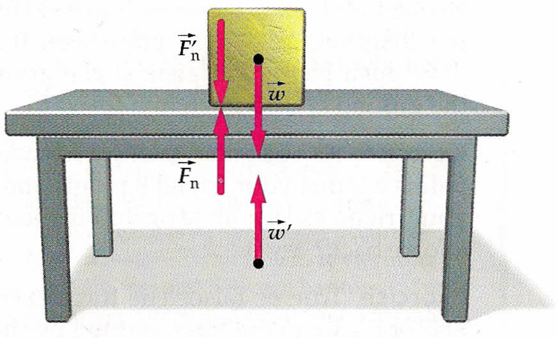

Figure 4-2