Everyday Forces

SECTION 4

SECTION OBJECTIVES

- **Explain the difference between mass and weight.**
- **Find the direction and magnitude of normal forces.**
- **Describe air resistance as a form of friction.**
- **Use coefficients of friction to calculate frictional force.**

WEIGHT

How do you know that a bowling ball weighs more than a tennis ball? If you imagine holding one ball in each hand, you can imagine the downward forces acting on your hands. Because the bowling ball has more mass than the tennis ball does, gravitational force pulls more strongly on the bowling ball. Thus, the bowling ball pushes your hand down with more force than the tennis ball does.

The gravitational force exerted on the ball by Earth, $\mathbf{F_g}$, is a vector quantity, directed toward the center of Earth. The magnitude of this force, F_g, is a scalar quantity called **weight.** The weight of an object can be calculated using the equation $F_g = ma_g$, where a_g is the magnitude of the acceleration due to gravity, or free-fall acceleration. On the surface of Earth, $a_g = g$, and $F_g = mg$. In this book, $g = 9.81\ \text{m/s}^2$ unless otherwise specified.

weight

a measure of the gravitational force exerted on an object; its value can change with the location of the object in the universe

Weight, unlike mass, is not an inherent property of an object. Because it is equal to the magnitude of the force due to gravity, weight depends on location. For example, if the astronaut in **Figure 10** weighs 800 N (180 lb) on Earth, he would weigh only about 130 N (30 lb) on the moon. As you will see in the chapter "Circular Motion and Gravitation," the value of a_g on the surface of a planet depends on the planet's mass and radius. On the moon, a_g is about $1.6\ \text{m/s}^2$—much smaller than $9.81\ \text{m/s}^2$.

Even on Earth, an object's weight may vary with location. Objects weigh less at higher altitudes than they do at sea level because the value of a_g decreases as distance from the surface of Earth increases. The value of a_g also varies slightly with changes in latitude.

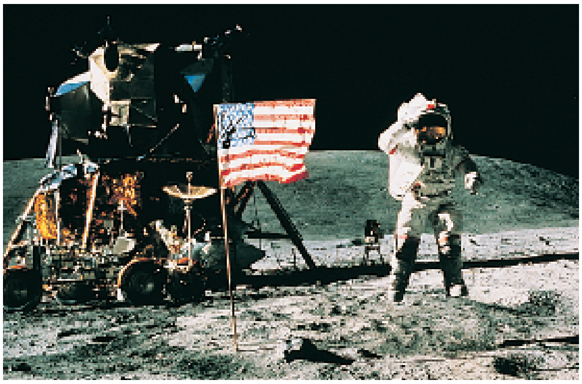

Figure 10
On the moon, astronauts weigh much less than they do on Earth.

THE NORMAL FORCE

Imagine a television set at rest on a table. We know that the gravitational force is acting on the television. How can we use Newton's laws to explain why the television does not continue to fall toward the center of Earth?

An analysis of the forces acting on the television will reveal the forces that are in equilibrium. First, we know that the gravitational force of Earth, $\mathbf{F_g}$, is acting downward. Because the television is in equilibrium, we know that another force, equal in magnitude to $\mathbf{F_g}$ but in the opposite direction, must be acting on it. This force is the force exerted on the television by the table. This force is called the **normal force, $\mathbf{F_n}$.**

normal force

a force that acts on a surface in a direction perpendicular to the surface