SECTION 3

Falling Objects

SECTION OBJECTIVES

- **Relate the motion of a freely falling body to motion with constant acceleration.**
- **Calculate displacement, velocity, and time at various points in the motion of a freely falling object.**
- **Compare the motions of different objects in free fall.**

FREE FALL

On August 2, 1971, a demonstration was conducted on the moon by astronaut David Scott. He simultaneously released a hammer and a feather from the same height above the moon's surface. The hammer and the feather both fell straight down and landed on the lunar surface at exactly the same moment. Although the hammer is more massive than the feather, both objects fell at the same rate. That is, they traveled the same displacement in the same amount of time.

Freely falling bodies undergo constant acceleration

In **Figure 14,** a feather and an apple are released from rest in a vacuum chamber. The two objects fell at exactly the same rate, as indicated by the horizontal alignment of the multiple images.

The amount of time that passed between the first and second images is equal to the amount of time that passed between the fifth and sixth images. The picture, however, shows that the displacement in each time interval did not remain constant. Therefore, the velocity was not constant. The apple and the feather were accelerating.

free fall

the motion of a body when only the force due to gravity is acting on the body

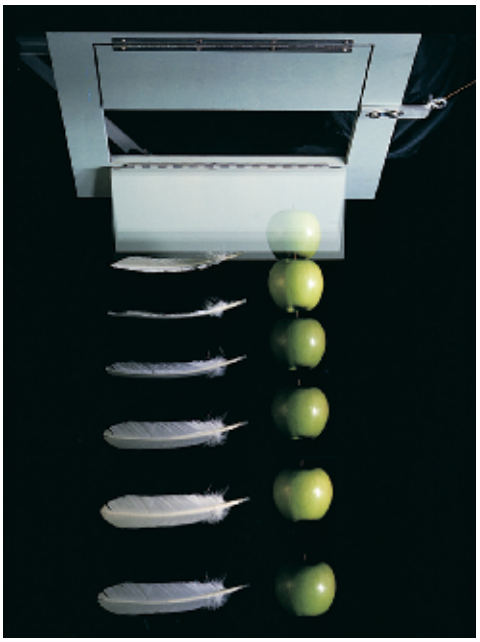

Figure 14
When there is no air resistance, all objects fall with the same acceleration regardless of their masses.

Compare the displacement between the first and second images to the displacement between the second and third images. As you can see, within each time interval the displacement of the feather increased by the same amount as the displacement of the apple. Because the time intervals are the same, we know that the velocity of each object is increasing by the same amount in each time interval. In other words, the apple and the feather are falling with the same constant acceleration.

If air resistance is disregarded, all objects dropped near the surface of a planet fall with the same constant acceleration. This acceleration is due to gravitational force, and the motion is referred to as **free fall.** The acceleration due to gravity is denoted with the symbols a_g (generally) or g (on Earth's surface). The magnitude of g is about 9.81 m/s^2, or 32 ft/s^2. Unless stated otherwise, this book will use the value 9.81 m/s^2 for calculations. This acceleration is directed downward, toward the center of the Earth. In our usual choice of coordinates, the downward direction is negative. Thus, the acceleration of objects in free fall near the surface of the Earth is $a_g = -g = -9.81$ m/s^2. Because an object in free fall is acted on only by gravity, a_g is also known as free-fall acceleration.