

fied forces. If the object is either stationary or moving with constant velocity, then the forces must vectorially cancel each other.

The **force of gravity** exerted on an object is equal to the product of its mass (a scalar quantity) and the free-fall acceleration:  $\mathbf{F}_g = m\mathbf{g}$ . The **weight** of an object is the magnitude of the force of gravity acting on the object.

**Newton's third law** states that if two objects interact, then the force exerted by object 1 on object 2 is equal in magnitude and opposite in direction to the force exerted by object 2 on object 1. Thus, an isolated force cannot exist in nature. Make sure you can identify third-law pairs and the two objects upon which they act.

The **maximum force of static friction**  $f_{s,\max}$  between an object and a surface is proportional to the normal force acting on the object. In general,  $f_s \leq \mu_s n$ , where  $\mu_s$  is the **coefficient of static friction** and  $n$  is the magnitude of the normal force. When an object slides over a surface, the direction of the **force of kinetic friction**  $\mathbf{f}_k$  is opposite the direction of sliding motion and is also proportional to the magnitude of the normal force. The magnitude of this force is given by  $f_k = \mu_k n$ , where  $\mu_k$  is the **coefficient of kinetic friction**.

### More on Free-Body Diagrams

To be successful in applying Newton's second law to a system, you must be able to recognize all the forces acting on the system. That is, you must be able to construct the correct free-body diagram. The importance of constructing the free-body diagram cannot be overemphasized. In Figure 5.23 a number of systems are presented together with their free-body diagrams. You should examine these carefully and then construct free-body diagrams for other systems described in the end-of-chapter problems. When a system contains more than one element, it is important that you construct a separate free-body diagram for *each* element.

As usual,  $\mathbf{F}$  denotes some applied force,  $\mathbf{F}_g = m\mathbf{g}$  is the force of gravity,  $\mathbf{n}$  denotes a normal force,  $\mathbf{f}$  is the force of friction, and  $\mathbf{T}$  is the force whose magnitude is the tension exerted on an object.

## QUESTIONS

1. A passenger sitting in the rear of a bus claims that he was injured when the driver slammed on the brakes, causing a suitcase to come flying toward the passenger from the front of the bus. If you were the judge in this case, what disposition would you make? Why?
2. A space explorer is in a spaceship moving through space far from any planet or star. She notices a large rock, taken as a specimen from an alien planet, floating around the cabin of the spaceship. Should she push it gently toward a storage compartment or kick it toward the compartment? Why?
3. A massive metal object on a rough metal surface may undergo contact welding to that surface. Discuss how this affects the frictional force between object and surface.
4. The observer in the elevator of Example 5.8 would claim that the weight of the fish is  $T$ , the scale reading. This claim is obviously wrong. Why does this observation differ from that of a person in an inertial frame outside the elevator?
5. Identify the action–reaction pairs in the following situations: a man takes a step; a snowball hits a woman in the back; a baseball player catches a ball; a gust of wind strikes a window.
6. A ball is held in a person's hand. (a) Identify all the external forces acting on the ball and the reaction to each. (b) If the ball is dropped, what force is exerted on it while it is falling? Identify the reaction force in this case. (Neglect air resistance.)
7. If a car is traveling westward with a constant speed of 20 m/s, what is the resultant force acting on it?
8. "When the locomotive in Figure 5.3 broke through the wall of the train station, the force exerted by the locomotive on the wall was greater than the force the wall could exert on the locomotive." Is this statement true or in need of correction? Explain your answer.
9. A rubber ball is dropped onto the floor. What force causes the ball to bounce?
10. What is wrong with the statement, "Because the car is at rest, no forces are acting on it"? How would you correct this statement?