General Relativity

In the appendix features on Einstein's theory of special relativity, you studied situations involving observers in different reference frames, such as one observer on a moving train and another on the ground. These examples all assumed that the two reference frames were moving uniformly with respect to each other. In other words, neither reference frame was accelerating relative to the other. Special relativity applies only to nonaccelerating reference frames. Einstein expanded his special theory of relativity into the general theory to cover all cases, including accelerating reference frames.

Gravitational attraction and accelerating reference frames

Einstein began with a simple question: "If we pick up a stone and then let it go, why does it fall to the ground?" You might answer that it falls because it is attracted by gravitational force. As usual, Einstein was not satisfied with this typical answer. He was also intrigued by the fact that in a vacuum, all objects in free fall have the same acceleration, regardless of their mass. As you learned in the chapter on gravity, the reason is that gravitational mass is equal to inertial mass. Because the two masses are equivalent, the extra gravitational force from a larger gravitational mass is exactly canceled out by its larger inertial mass, thus producing the same acceleration. Einstein considered this equivalence to be a great puzzle.

To explore these questions, Einstein used a thought experiment similar to the one shown in **Figure 1.** In **Figure 1(a),** a person in an elevator at rest on Earth's surface drops a ball. The ball is in free fall and accelerates downward, as you would expect. In **Figure 1(b),** a similar elevator in space is moving upward with a constant acceleration. If an astronaut in this elevator releases a ball, the floor acceler-

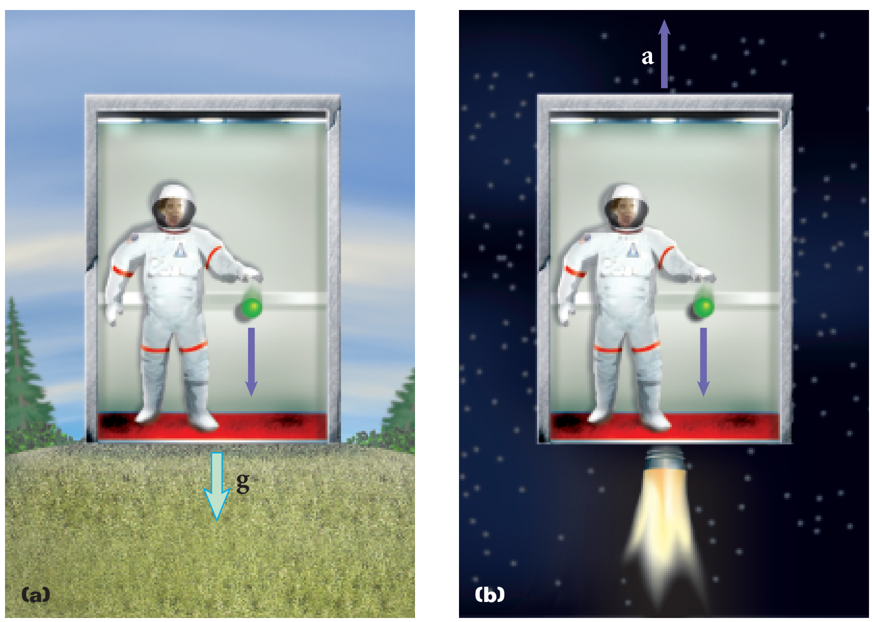

Figure 1
Einstein discovered that there is no way to distinguish between **(a)** a gravitational field and **(b)** an accelerating reference frame.