Scientists read to **understand how** facts, assumptions, principles, & proofs are **interrelated**.

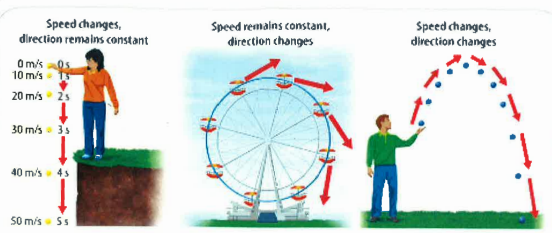


Figure 5 The velocity of an object changes if the speed changes, the direction changes, or both the speed and the direction change.

Math Skills — Solve a One-Step Equation

Solve for Accerleration A skateboarder moving at 2 m/s starts skating down a ramp. As the skateboarder heads down the ramp, she accelerates to a speed of 6 m/s in 4 seconds. What is the skateboarder's acceleration?

1. **This is what you know:** final speed: $v_f = 6$ m/s; initial speed: $v_i = 2$ m/s; time: $t = 4$ s
2. **This is what you need to find out:** acceleration: a
3. **Use this formula:** $a = \frac{v_f - v_i}{t}$
4. **Substitute:** the values for v_f, v_i, and t: $\frac{6\text{ m/s} - 2\text{ m/s}}{4\text{ s}}$; subtract: $\frac{4\text{ m/s}}{4\text{ s}}$; and divide: $= 1\text{ m/s}^2$

Answer: The acceleration is 1 m/s^2.

Practice As the skateboarder starts moving up the other side of the ramp, her velocity changes from 6 m/s to 0 m/s in 3 seconds. What was her acceleration?

Figure 3-14

When the forces on the girl are balanced, she does not move. *What happens if the forces on her become unbalanced?*

Remember that velocity involves both speed and direction. A net force acting on an object will change its speed, direction, or both. In the tug-of-war, the net force on you causes both your speed and direction to change.

Inertia and Mass

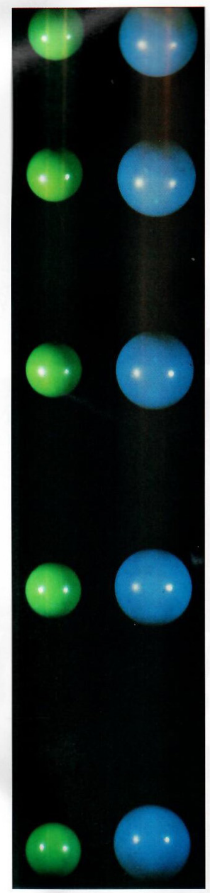
Picture a hockey puck sliding across the ice as in **Figure 3-15.** Its velocity hardly changes until it hits something, such as the wall, the net, or a player's stick. The velocity of the puck is constant, and its acceleration is zero until it hits something that alters its speed or direction.

The sliding puck demonstrates the property of inertia. **Inertia** is the tendency of an object to resist any change in its motion. If an object is moving, it will keep moving at the same speed and in the same direction unless an unbalanced force acts on it. In other words, the velocity of the object remains constant unless a force changes it. If an object is at rest, it tends to remain at rest. Its velocity is zero unless a force makes it move.

Would you expect that a bowling ball would have the same inertia as a table-tennis ball? Why would there be a difference? The more mass an object has, the greater its inertia is. Recall that mass is the

Figure 3-15

The velocity and acceleration of a hockey puck are constantly changing during a game.



Falling Objects

It is hard to believe, but, if you dropped a bowling ball and a marble from a bridge at the same time, they'd both splash into the water at almost the same instant. (As you read further, you'll find out why they don't hit the water at exactly the same instant.) This means their accelerations would be just about the same. Would you have expected the bowling ball to hit the water sooner because it has more mass? It's true that the force of gravity would be greater on the bowling ball because of its larger mass. But the larger mass also gives the bowling ball more inertia, so more force is needed to change its velocity. The marble has a much smaller mass than the bowling ball, but its inertia also is much less. **Figure 4-2** shows the falling motion of two balls revealed by high-speed photography. The blue ball is more massive than the green one, but you can see that they fall at the same rate.

Acceleration Caused by Gravity

Near Earth's surface, gravity causes all falling objects to accelerate at 9.8 m/s^2. Does the number 9.8 seem familiar? When you studied the relationship between mass and weight, you learned that any object with a mass of 1 kg weighs 9.8 N on Earth. Now, you'll find out why.

Any force can be calculated using the equation:

$$F = m \times a.$$

The weight of an object, W, is the force of gravity acting on its mass. So, we can substitute and write:

$$W = m \times a.$$

Acceleration due to gravity is 9.8 m/s^2, therefore:

$$W = m \times 9.8\text{ m/s}^2.$$

This means that a mass of 1 kg weighs 9.8 kg · m/s^2, or 9.8 N. You could calculate your weight in newtons if you knew your mass. For example, a person with a mass of 50 kg would have a weight of 490 N.

Remember that this discussion is concerned only with *falling* objects. This refers to an object that is dropped from some height and allowed to fall freely. As the object is released, the only downward force acting on it is gravity. The situation changes for an object that is *thrown* downward. In this case, the object is affected by gravity *and* the downward force of the throwing hand. Therefore, the object's downward acceleration would be greater than 9.8 m/s^2.

Figure 4-2

As the photograph shows, the rate of acceleration of a falling body is not affected by the mass of the body. *What effect does inertia have on the falling bodies?*