

Describing and Measuring Motion

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Guide for Reading

- ◆ When is an object in motion?
- ◆ How can you find the speed and velocity of an object?

An object is in **motion** when its distance from another object is changing. Whether an object is moving or not depends on your point of view. For example, a woman riding on a bus is not moving in relation to the seat she is sitting on, but she is moving in relation to the buildings the bus passes. A **reference point** is a place or object used for comparison to determine if something is in motion. **An object is in motion if it changes position relative to a reference point.** You assume that the reference point is stationary, or not moving.

Units of measurement are used to describe an object's motion. The system of measurement used by scientists all over the world is called the **International System of Units**, or in French, *Système International (SI)*. The SI system is based on the number 10.

The basic SI unit of length is the **meter (m)**. A meter is a little longer than a yard. To measure the length of an object smaller than a meter, scientists use the metric unit called the centimeter (cm). There are 100 centimeters in a meter. Meters and centimeters can be used to describe the distance an object travels.

Rate is the amount of something that occurs or changes in one unit of time. Speed is a type of rate. The **speed** of an object is the distance the object travels in one unit of time. To calculate the speed of an object, divide the distance the object travels by the amount of time it takes to travel that distance. Speed measurements consist of a unit of distance divided by a unit of time, such as meters per second.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

When an object travels at a constant speed, its speed at any point during its motion is the same as it is at every other point. Most objects do not move at constant speeds. To find the average speed of an object, divide the total distance traveled by the total time. An object's speed tells how fast it is moving, but not the direction of the motion. **When you know both the speed and direction of an object's motion, you know the velocity of the object.** Speed in a given direction is called **velocity**.

A line graph in which distance is plotted against time can show the motion of an object. A straight line represents motion at a constant speed. The steepness of the line's slope depends on the speed of the object. A horizontal line represents an object that is not moving at all.

SECTION 1 - 1

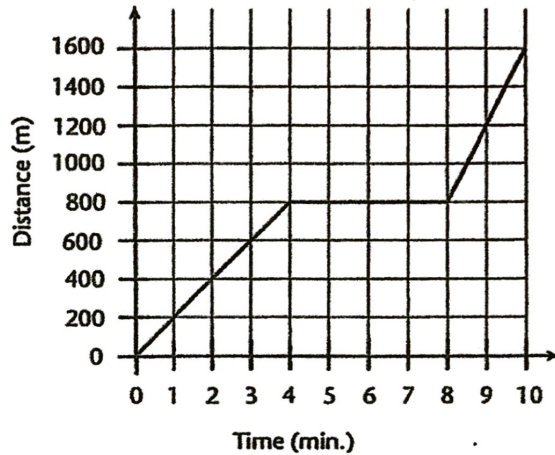
REVIEW AND REINFORCE

Describing and Measuring Motion

◆ Understanding Main Ideas

Use the following paragraph and graph to answer questions 1 through 5. Write your answers on a separate sheet of paper. Remember to include units in your answers.

On Saturday, Ashley rode her bicycle to visit Maria. Maria's house is directly east of Ashley's. The graph shows how far Ashley was from her house after each minute of her trip.



1. Ashley rode at a constant speed for the first 4 minutes of her trip. What was her constant speed?
2. What was her average speed for the entire trip?
3. What was her average velocity for the entire trip?
4. Ashley stopped to talk with another friend during her trip. How far was she from her house when she stopped?
5. Ashley's brother rode beside her for several minutes. During this time, was he moving relative to Ashley?

◆ Building Vocabulary

From the list below, choose the term that best completes each sentence. Write your answers on the line provided.

- | | | |
|-----------------|-------------------------------|-------|
| motion | International System of Units | foot |
| reference point | yard | meter |
| average | velocity | speed |

6. Scientists around the world use the _____, a system of measurement based on the number ten.
7. An object is in _____ when its distance from a(n) _____ is changing.
8. Speed in a given direction is _____.
9. _____ can be calculated if you know the distance that an object travels in one unit of time.
10. The basic SI unit of length is the _____.

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SECTION 1-3

SECTION SUMMARY

Acceleration

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Guide for Reading

- ◆ What happens to the motion of an object as it accelerates?
- ◆ How is acceleration calculated?

Acceleration is the rate at which velocity changes. Recall that velocity has two components—direction and speed. Acceleration involves a change in either of these components. **In science, acceleration refers to increasing speed, decreasing speed, or changing direction.**

Any time the speed of an object changes, the object experiences acceleration. That change can be an increase or decrease. A decrease in speed is sometimes called deceleration, or negative acceleration.

An object that is changing direction is also accelerating, even if it is moving at a constant speed. A car moving around a curve or changing lanes at a constant speed is accelerating because it is changing direction.

Many objects continuously change direction without changing speed. The simplest example of this type of motion is circular motion, or motion along a circular path. The moon accelerates because it is continuously changing direction as it revolves around Earth.

Acceleration describes the rate at which velocity changes. **To determine the acceleration of an object, you must calculate the change in velocity during each unit of time.** This is summarized by the following formula.

$$\text{Acceleration} = \frac{\text{Final velocity} - \text{Initial velocity}}{\text{Time}}$$

If velocity is measured in meters/second and time is measured in seconds, the unit of acceleration is meters per second per second, which is written as m/s^2 .

If an object is accelerating by the same amount during each unit of time, the acceleration at every point in its motion is the same. If the acceleration varies, however, only the average acceleration can be calculated. For an object moving without changing direction, the acceleration is the change in its speed during one unit of time.

A line graph can be used to analyze acceleration by showing speed versus time. When a graph shows speed versus time as a straight line, the acceleration is constant. If an object accelerates by a different amount each time period, a graph of its acceleration will not be a straight line. A graph of distance versus time for an accelerating object is curved.

SECTION 1-3

REVIEW AND REINFORCE

Acceleration

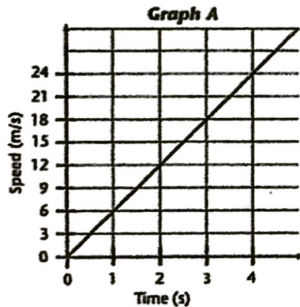
◆ Understanding Main Ideas

If the statement is true, write true. If it is false, change the underlined word or words to make the statement true.

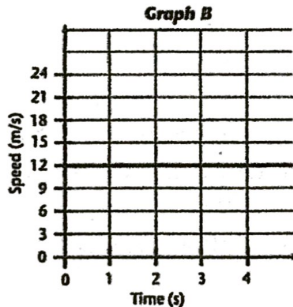
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- _____ 1. If a train is slowing down, it is accelerating.
- _____ 2. To find the acceleration, you must calculate the change in distance during each unit of time.
- _____ 3. A Ferris wheel turning at a constant speed of 5 m/s is not accelerating.
- _____ 4. An airplane is flying west at 200 km/h. Two hours later, it is flying west at 300 km/h. Its average acceleration is 100 km/h².
- _____ 5. Graph A plots a race car's speed for 5 seconds. The car's rate of acceleration is 6 m/s².
- _____ 6. Graph B plots the same car's speed for a different 5-second interval. The car's acceleration during this interval is 12 m/s².

Graph A



Graph B



◆ Building Vocabulary

From the list below, choose the term that best completes each sentence. Write your answers on the line provided.

- acceleration velocity speed distance

7. _____ occurs when the velocity of an object changes.
8. When you say that a race car travels northward at 100 km/h, you are talking about its _____.

Forces • Section Summary

Friction and Gravity

Key Concepts

- What factors determine the strength of the friction force between two surfaces?
- What factors affect the gravitational force between two objects?
- Why do objects accelerate during free fall?

The force that two surfaces exert on each other when they rub against each other is called **friction**. It acts in a direction opposite to the direction of the moving object. Friction will eventually cause an object to come to a stop.

The strength of the friction force depends on two factors: how hard the surfaces push together and the types of surfaces involved. Rough surfaces produce greater friction than smooth surfaces. Friction also increases if the surfaces push hard against each other.

Static friction acts on objects that aren't moving. **Sliding friction** occurs when solid surfaces slide over each other. **Rolling friction** occurs when an object rolls over a surface. **Fluid friction** results when an object moves through a fluid—a liquid or a gas. The force needed to overcome rolling friction or fluid friction is usually less than that needed to overcome sliding friction.

Gravity is a force that pulls objects toward each other. The law of universal gravitation states that the force of gravity acts between all objects in the universe. Any two objects in the universe, without exception, attract each other. **Two factors affect the gravitational attraction between objects: mass and distance.** Mass is a measure of the amount of matter in an object. The more mass an object has, the greater its gravitational force. The farther apart two objects are, the less the gravitational force between them.

Weight is the force of gravity on a person or object at the surface of a planet. Weight is a measure of the force of gravity on an object, and mass is a measure of the amount of matter in that object.

When the only force acting on an object is gravity, the object is in **free fall**. **In free fall, the force of gravity is an unbalanced force that causes an object to accelerate.** Near Earth's surface, acceleration due to gravity is 9.8 m/s^2 .

Objects falling through air experience a type of fluid friction called **air resistance**. Air resistance is not the same for all objects. The greater the surface area of an object, the greater the air resistance. Air resistance also increases with velocity. So, as the velocity of a falling object increases, air resistance increases until it is equal to the force of gravity. When forces are balanced, the velocity stops increasing. The greatest velocity that can be obtained by an object in free fall is called **terminal velocity**.

An object that is thrown is called a **projectile**. While a projectile moves horizontally, the force of gravity pulls it toward Earth.

Forces ■ *Review and Reinforce*

Friction and Gravity

Understanding Main Ideas

Answer the following questions on another sheet of paper.

1. What are the two factors that affect the friction force between two surfaces?
2. What is one way you could reduce the friction between two surfaces?
3. The acceleration due to gravity of all objects in free fall is the same. Why, then, do some objects fall through the air at a different rate than others?
4. How does mass differ from weight?
5. What two factors affect the gravitational force between two objects?

Building Vocabulary Skills

Match each term with its definition by writing the letter of the correct definition in the right column on the line beside the term in the left column.

- | | |
|-----------------------------|---|
| _____ 6. friction | a. the force that accelerates objects towards Earth |
| _____ 7. rolling friction | b. the kind of friction that exists between oil and a door hinge |
| _____ 8. sliding friction | c. the general term for the force that one surface exerts on another when they rub against each other |
| _____ 9. fluid friction | d. the kind of friction that slows a falling object |
| _____ 10. weight | e. the state that exists when the only force acting on an object is gravity |
| _____ 11. free fall | f. the kind of friction that results when you rub sandpaper against wood |
| _____ 12. gravity | g. the kind of friction that results when a wheel turns on a surface |
| _____ 13. terminal velocity | h. a measure of the force of gravity on an object |
| _____ 14. air resistance | i. a falling object reaches this when forces of gravity and air resistance are balanced |

