FOCUS ON SCIENCE

Objects in Motion

Advanced Level

Physical Science
Forces and Motion on Earth

FOCUS curriculum

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Objects in Motion

Scientific Inquiry

The central purpose of scientific inquiry is to develop explanations of natural phenomena in a continuing, creative process.

Represent, present, and defend their proposed explanations of everyday observations so that they can be understood and assessed by others.

Beyond the use of reasoning and consensus, scientific inquiry involves the testing of proposed explanations involving the use of conventional techniques and procedures and usually requiring considerable ingenuity.

Use conventional techniques and those of their own design to make further observations and refine their explanations, guided by a need for more information.

Conduct an experiment designed by others.

Physical Science

Energy and matter interact through forces that result in changes in motion.

The motion of an object is always judged with respect to some other object or point. The idea of absolute motion or rest is misleading.

The motion of an object can be described by its position, direction of motion, and speed.

An object's motion is the result of the combined effect of all forces acting on the object. A moving object that is not subjected to a force will continue to move at a constant speed in a straight line. An object at rest will remain at rest.

Force is directly related to an object's mass and acceleration. The greater the force, the greater the change in motion.

For every action there is an equal and opposite reaction.

Electric currents and magnets can exert a force on each other.

English Language Arts

The following is a selective listing of the competencies and indicators addressed in this book.

Word Recognition

- Use word recognition skills and strategies quickly,accurately, and automatically when decodingunfamiliar words

Background Knowledge and Vocabulary Development

- Use self-monitoring strategies to identify specific vocabulary difficulties that disrupt comprehension,and employ an efficient course of action, such asusing a known word base or a resource such as aglossary to resolve the difficulty

Comprehension Strategies

- Use a variety of strategies (e.g., summarizing,forming questions, visualizing, and making connections) to support understanding of texts read

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How to Help Your Students Make the Best Use of This Book

Encourage students to develop nonfiction literacy skills by completing the Active Reader activities. Also encourage them to . . .

- Underline main ideas in paragraphs.
- Circle details that support the main ideas.
- Write down questions as they read.
- Circle key words as well as unfamiliar words.

Printing Instructions

Student Book: print pages 5–28

Assessments: print pages 29–32

Answer Key: print pages 33–36

FOCUS ON SCIENCE

Objects in Motion

How do we apply the laws of motion to explain the movement of objects on Earth?

Have you ever wondered what makes things move? When you kick a soccer ball with your foot, why does it sometimes travel on the ground? Why does it sometimes travel in the air? Why do some soccer balls travel so far they hit the goal and some go only a few yards before hitting the ground?

Motion is the change in the position of an object over time. An object's change in position can be seen when the object is compared to a non-moving reference point.

A force is a push or pull on an object. When forces act on an object, such as hitting a baseball, they can change the motion of the object.

Objects in Motion

Table of Contents

Starting Points

Build Background

Predict

How can you tell when something is moving? How does something start moving in the first place? Write down some of your ideas below.

Brainstorm

Sometimes things move more easily at different times. For example, objects that can slide easily on ice are much harder to move on a brick floor. A heavy box of books is easier to move when it rolls on wheels. Thin pointed objects move faster through air or water than wider, fatter ones. Why do you think this happens? What can cause motion to change. Brainstorm some ideas and write them on the lines below.

Starting Points

Key Vocabulary

Rate Your Knowledge

The words listed below have to do with motion. Each word is important, but some of them may be new. Read each word. Rate your knowledge of each by putting a check or writing a few words in the appropriate column.

	I don't know it.	I've seen it, but I'm not sure what it means.	I know it well. It means...
acceleration			
force			
friction			
gravity			
position			
speed			
velocity			
weight			

Everyday Meanings

Some of the words in this book are used in everyday language. Their everyday meanings might be the same or different than their scientific meanings. Look at the words below and read the sample everyday sentences. Then write the everyday meaning of each word. As you read through this book, come back to this page and write the scientific meanings of these words.

1. ***friction***

   Sample Everyday Sentence: *Gossip caused some friction between the two friends.*

   Everyday Meaning: ______________________________

   Scientific Meaning: ______________________________

2. ***weight***

   Sample Everyday Sentence: *The football player was trying to gain weight before the season started.*

   Everyday Meaning: ______________________________

   Scientific Meaning: ______________________________

Key Concepts

Observing Motion

Motion is the change in the position of an object over time. When you are standing still, you can see that other things are changing position around you. When you are watching a soccer game, for example, you can see that the players, the ball, and the referee are all in motion on the field.

Funny things start to happen when you are in motion, though. Have you ever been on a train? If you are not looking out the window on a moving train, you might feel as if you are not moving at all. If you look out the window, the scenery looks like it is in motion. Trees and buildings appear to rush past while you feel like you are standing still. If another train catches up to you and moves at the same speed as your train, it looks as if that train is standing still as well while the scenery flies by.

You have probably figured out that motion is a relative thing. After all, we are all moving along with Earth as Earth rotates on its axis and orbits the Sun. Yet we don't feel like we're moving at all when we are sitting, lying down, or just standing around. How we observe and detect motion depends on many things.

What Causes Motion?

Have you ever thought about what causes motion? Think about a book that is sitting on a shelf. When you pick up that book, you are causing the book to move. So what allowed you to pick up the book? Your arm exerted a force on the book. A force is simply a push or pull on an object. All motion is caused by forces.

On a moving train, objects outside look like they are moving even though they are not.

ACTIVE READER

1 Describe *Look around your classroom and out the window. Describe all of the different motions that you can see. Also describe the motions that you cannot see. For example, describe motions inside of objects.*

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Chapter 1 Describing Motion

FOCUS The underlined sentences contain important ideas about the position and motion of objects. As you read, think about how you can detect the motion of an object.

Motion and Reference Points

At a swim meet, nervous competitors position themselves along the starting line. They crouch down, ready to begin the 50-meter race. At the sound of the starter's gun, the swimmers dive in and swim to the other end of the pool. As the crowd cheers, one swimmer touches the wall to win the race.

Swimmers are in motion as they race. An object is in motion when it changes position over time. You can observe that an object is changing position when you compare it to a nonmoving object, called a reference point. The two ends of the pool are good reference points at a swim meet. One end is 50 meters away from the other end. Officials and spectators at the meet can keep track of each swimmer's motion—and see who might win—by watching where each swimmer is in relation to the ends of the pool. Spectators can cheer competitors on as they approach the reference point that serves as the finish line.

The end of a pool is a reference point that allow you to observe and describe the motion of the swimmers.

ACTIVE READER

1 Explain *How does a reference point allow you to see that an object is in motion?*

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Good to Know

Geostationary weather satellites move at the exact same rate as Earth's rotation. This allows each satellite to remain over one point on Earth's surface. These satellites serve as reference points for moving weather, because they are not moving in relation to Earth's surface.

Everyday Reference Points

Any object that is not moving can be used as a reference point. Useful natural reference points include trees, hills, mesas, mountains, lakes, and rivers. Other useful reference points might include telephone poles, communications towers, wind turbines, roads, and buildings. You can observe the motion of a car, for example, by watching to see how its position changes in relation to telephone poles on a road.

ACTIVE READER

1 Identify *What could be used as a reference point for describing the motion of the bird in the picture?*

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FOCUS QUESTIONS

1. How can you tell that an object is in motion?

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2. Would a bus make a good reference point? Why or why not?

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Think Like A Scientist

Visualize Motion Draw a scene showing how you could use reference points to observe the motion of a jet that is taking off. Then write a paragraph to describe your scene.

FOCUS In this section, you will learn how the motion of an object can be described by its speed, velocity, and acceleration. As you read, note the differences between these terms.

Describing the Motion of an Object

A champion swimmer can cover a distance of 50 meters in less than a minute. When you divide the distance of the race by the finish time, you get the swimmer's average **speed**. Speed is just one way to describe the motion of a person or object. If you combine speed with direction, you can describe **velocity**. If you keep track of how an object speeds up, slows down, or changes direction, you can describe the object's **acceleration**.

Speed

Speed is the distance that is traveled by an object over a certain period of time. The equation for average speed is:

$$\text{average speed} = \frac{\text{total distance traveled}}{\text{total time}}$$

Let's say that a train travels 300 miles in 5 hours. What was its average speed? We can use the formula to figure it out:

$$\text{average speed} = \frac{\text{300 miles}}{\text{5 hours}} = \text{60 miles per hour (mph)}$$

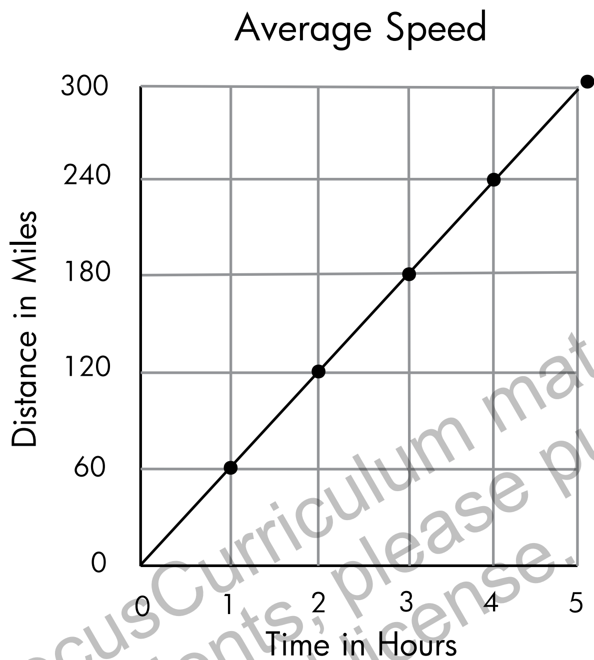
You can measure speed using a variety of measurement units. Distance can be measured using feet and inches, for example, or meters and centimeters. Time can be measured in hours, minutes, or seconds. Speed, then, can be measured in meters per second, kilometers per hour, feet per minute, or miles per hour, etc.

ACTIVE READER

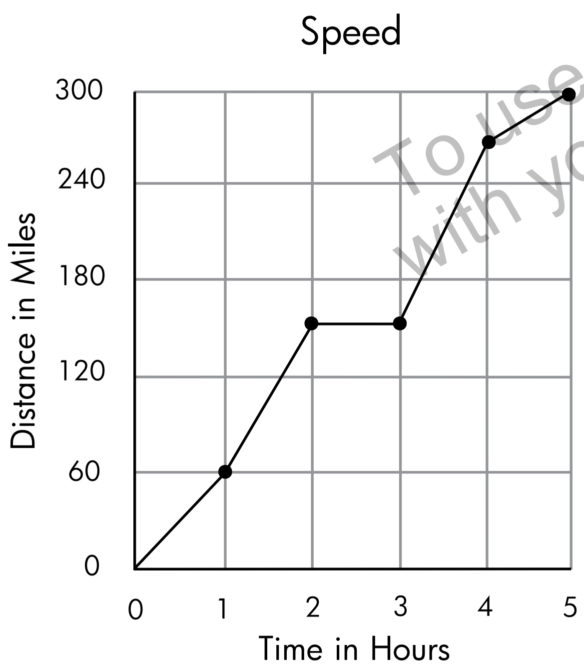
1 Calculate *What is the average speed of a cheetah that runs 9 km in 10 minutes? Give your answer in km/hr. (Hint: 10 minutes is 1/6 of an hour.)*

The graph at the right shows the average speed of a train. The train went 300 miles in 5 hours. Notice that when you divide each distance by its time, you get 60 mph. For example, after 2 hours the train went 120 miles. 120 ÷ 2 = 60 mph.

The smooth straight line suggests that the speed of the train never changed during the trip.



Speed is found by comparing distance to time.



But trains in the real world don't travel at a constant speed. They might slow down, or speed up. They might even stop at a station for a while.

The graph at the left shows how the speed of the train might change over the five hour trip. It shows that the train still covered the same 300 miles in the same 5 hours. But its speed varied along the way.

ACTIVE READER

1 Explain *How are the two graphs on this page alike? How are they different?*

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2 Analyze *According to the graph entitled "Speed," what was the speed of the train between hours two and three of the trip?*

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Velocity and Acceleration

Velocity describes both the speed of an object and its direction. If a train is traveling at a speed of 60 mph, its velocity could be 60 mph north or 60 mph west. Velocity is really a description of the rate of change in the position of an object over time.

An object moves at a constant velocity if its speed and direction stay the same. Its velocity changes if either its speed or direction changes.

The rate of change in velocity is called **acceleration**. An object is accelerating when it speeds up, slows down, or changes direction. The formula for average acceleration is:

$$\text{average acceleration} = \frac{\text{change in velocity}}{\text{change in time}} \quad \text{or} \quad \frac{\text{final speed} - \text{starting speed}}{\text{total time}}$$

Let's say you are riding your bicycle at 9 meters per second (m/s). You slow down to 4 m/s for 5 seconds as you climb a hill, but you are still traveling in the same direction. What is your average acceleration as you climb the hill? You can figure it out using the formula:

$$\text{average acceleration} = \frac{4\text{ m/s} - 9\text{ m/s}}{5\text{ s}} = \frac{-5\text{ m/s}}{5\text{ s}} = -1\text{ m/s}^2$$

As you climb the hill, your average acceleration is -1 m/s^2. That means your velocity is decreasing at a rate of 1 meter per second every second. Your acceleration is negative. What if you were speeding up by 1 m/s every second? Then your average acceleration would be $+1$ m/s^2. Your acceleration would be positive.

We most often think of acceleration in relation to our speed. Speeding up and slowing down changes our acceleration. But remember that acceleration is a change in velocity, and velocity has to do with speed and direction. Acceleration changes when you change direction—even if your speed remains constant.

Dear Ms. Understanding,

I thought that acceleration meant that something was getting faster and deceleration meant that something was slowing down. Am I wrong?

Confused in Cortland

Dear Confused,

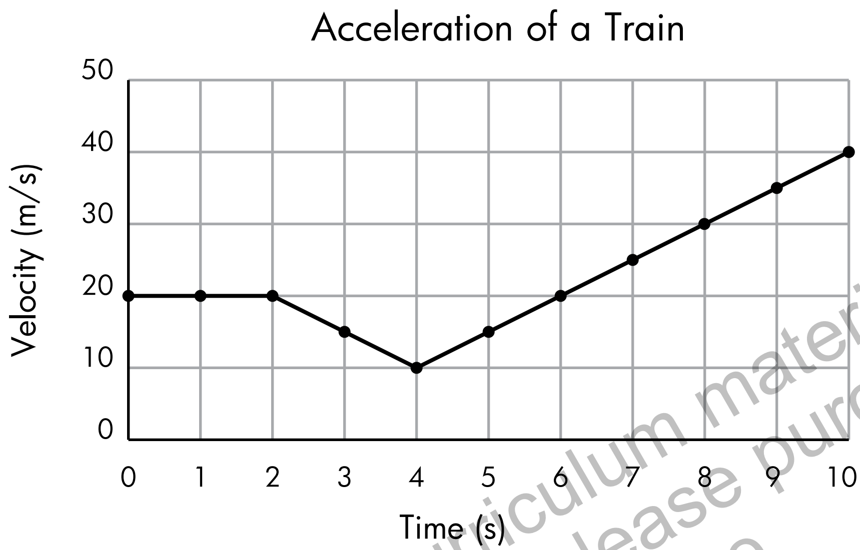
You are only partly wrong. Most people use acceleration to describe a thing that is speeding up. In science, *acceleration* describes how a thing is changing velocity (speeding up, slowing down, or changing direction). If you want to be crystal-clear to everybody, you can use the term positive acceleration to describe how a thing is speeding up, and negative acceleration to describe how a thing is slowing down. You can also use the word you already use, deceleration, to describe how a thing is slowing down.

Ms. Understanding

Graphing Acceleration

You can use a graph to show how an object accelerates. The graph on the right shows how a train accelerates as it moves forward on its tracks.

The graph shows that the train maintains a constant velocity for the first 2 seconds. The train slows down during the next 2 seconds, with an acceleration of –5 m/s^2. The train then speeds up for the remaining 6 seconds, with an acceleration of 5 m/s^2.



FOCUS QUESTIONS

1. Look back at the graph above. At what point does the train reach its highest speed?

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2. Use meters and seconds to show how the units of speed, velocity, and acceleration relate to each other.

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ACTIVE READER

1 Explain *How are velocity and acceleration related?*

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2 Calculate *What is the acceleration of a dog speeding up from 5 m/s to 14 m/s over 3 seconds to chase a squirrel? Assume that the dog is running north in a straight line.*

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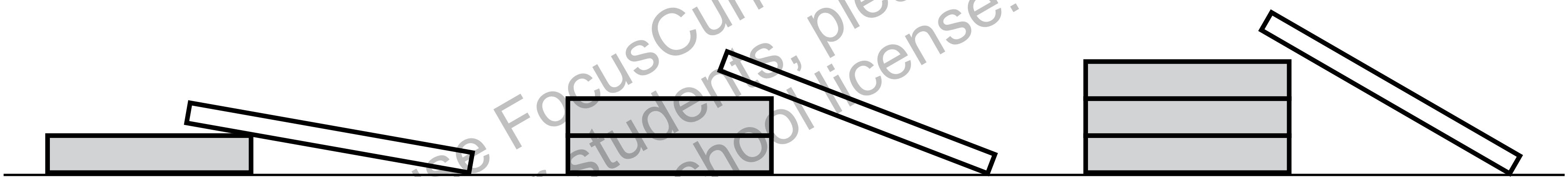
Hands On Science

Speed and Acceleration

How does the steepness of a hill affect the speed of a car? You can begin to answer this question using this investigation.

1. Obtain a meterstick, stopwatch, small toy car, three books that are the same size, and a wooden board.
2. Set up the board and one of the books so that they form a ramp. This will be Ramp 1.
3. Use the meterstick to measure the length of the ramp. Use the stopwatch to measure how much time it takes for the car to get from the top of the ramp to the bottom. Calculate the average speed of the car.
4. Repeat the experiment three times and record the speeds in the table. Find the average speed from all four trials.
5. Add another book to the ramp. Repeat the entire investigation using Ramp 2.
6. Add the third book to the ramp. Repeat the entire investigation using Ramp 3.
7. Answer the Think Like a Scientist questions on the next page.



Ramp 1 Ramp 2 Ramp 3

Trial	Speed on Ramp 1 (cm/sec)	Speed on Ramp 2 (cm/sec)	Speed on Ramp 3 (cm/sec)
1			
2			
3			
4			
Average Speed			

Think Like A Scientist

Time Trials

How does the steepness of a hill affect the speed of a car? Answer these questions based on your Hands On Science: Speed and Acceleration time trials.

1. How did changing the ramp cause a change in the motion of the car?

2. The speed of the car at the top of each ramp was 0 cm/sec. In the table on page 18, you calculated the average speed of each car at the bottom of the ramp. Calculate the average acceleration for the car on each ramp. Show Your calculations.

Ramp 1	Ramp 2	Ramp 3

3. Some students set up a pair of connected ramps to test how different inclines affect speed and acceleration. Their toy car averages 20 cm/sec on the first ramp. This increases to 45 cm/s on the second, steeper ramp. Total time down the second ramp is 20 seconds. What is the acceleration of the toy car on the steeper ramp? Show your calculations.

Stop and Think

This page will help summarize what you have read so far.

Tip: When you are asked a question about a graph, make sure you read the main title and the titles on each axis to understand what is being compared.

1. Which could be used as a reference point to determine that Earth is in motion?

(1) stars in the sky (2) cars on a highway

(3) birds in the air (4) hills in the distance

2. Which statement best describes the motion of a car traveling at a constant speed of 10 mph as it makes a left turn?

(1) It is traveling at a constant velocity. (2) Its acceleration is gradually decreasing.

(3) It is accelerating at a constant speed. (4) It has a constant velocity but changing speed.

3. In the graph at the left, the *y-axis* is labeled *Velocity.*

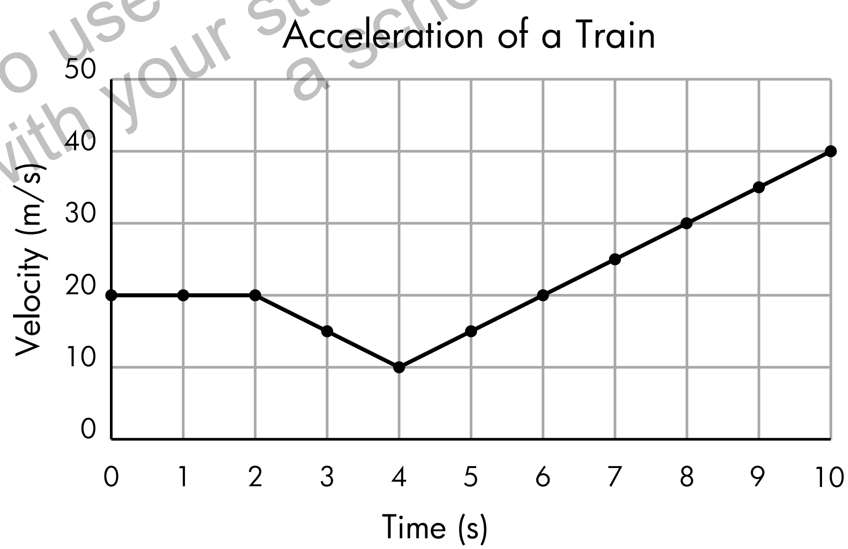
What aspect of velocity is shown on the graph?

(1) time, but not speed

(2) speed, but not time

(3) speed, but not direction

(4) direction, but not speed



Web Quest

Did you know that the male Anna's Hummingbird is the fastest animal on Earth? The tiny bird can dive at about 58 mph. This translates to about 385 body lengths per second. The fastest fighter jet can only travel at about 150 aircraft lengths per second!

What are some other fast animals? What is the slowest animal on Earth? You can use the Internet to find answers to all these questions, and any more questions that you have about animals and speed.

Chapter 2 Describing Forces

FOCUS This section explains what a force is, and describes how forces affect you in everyday life. Read on to learn about the things that push and pull you.

What Is a Force?

What is your favorite team sport? Maybe it is soccer, where players dribble a ball and try to kick it into their opponent's net. Or perhaps your favorite sport is football, where teams tackle each other as they try to move a ball down the field.

Whatever the sport is, you can be sure that a lot of forces are involved in it. A force is a push or pull on an object. A soccer player exerts a force on a ball when she kicks it. Football players exert forces on each other when they collide at the line of scrimmage. Forces often change the speed or direction of an object. A kick can change the direction of a soccer ball. A tackle can stop a football player in his tracks.

Forces act on us in everyday life as well. Think about all the things that you do each day. You might get up, take the bus to school, study at your desk, and then walk home from school. After school, you might ride your bike, do your homework, and watch television. In every one of these actions, you have forces pushing and pulling on you. In every one of these actions, you are also exerting forces.

Many forces act on objects used in sports such as soccer and football.

ACTIVE READER

1 Select *Underline the definition of a force. Circle the sentence that describes what kind of effects a force can have.*

2 Extend *What are some forces that are exerted in a game you play? List them below.*

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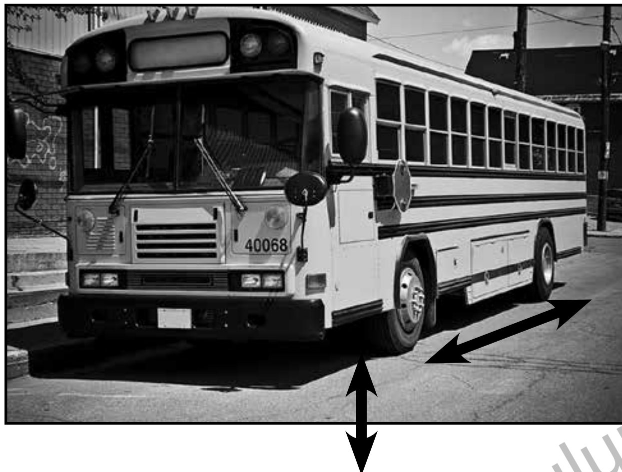
What forces are present when you ride the bus to school? **Gravity** pulls the bus down and keeps it on the ground. The ground also pushes up on the bus. Gravity pulls you down into your seat, and the seat pushes up on you.

The bus engine exerts a force on the axle, causing the wheels to turn. The bus moves forward as the tires and the ground push against each other.



Turning wheels exert a forward push. The friction of the brakes counters that force.

Gravity pulls down on the bus as the ground pushes up.

When the bus driver hits the brakes, the brakes and the ground exert a force on the wheels. This slows the bus down.

FOCUS QUESTIONS

1. What is a force?

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2. Describe some of the forces that act on a school bus.

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ACTIVE READER

1 Extend *What forces are present when you run on a park trail?*

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2 Sketch *Use the space below to draw a picture of four of the forces that are present when you ride your bike.*

FOCUS The underlined sentences describe common forces on Earth. As you read, think about how each of these forces affects objects that you see or use every day.

Forces in Nature

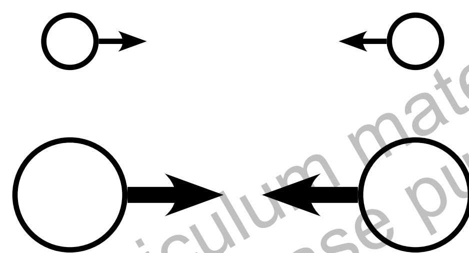
There are two important forces that affect objects on Earth: gravity and **friction**. Gravity pulls on all objects. Friction pushes on objects to slow their motion.

Gravity

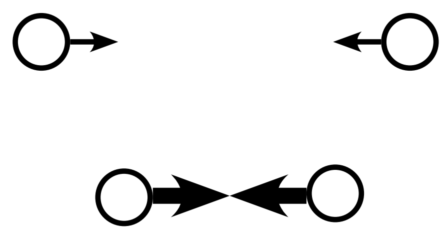
Gravity is the force of attraction that pulls on all objects. Earth's large mass creates a large gravitational force. This force pulls objects on Earth's surface down towards its center.

The **weight** of an object is a measure of the gravitational force on that object. Weight is measured in newtons (N). The amount an object weighs depends on its mass and gravity. An object with a large mass weighs more than an object with a smaller mass. Weight also depends on where you are in the solar system. If you are on Earth, you will weigh more than if you are on the moon. This is because Earth's gravitational force is stronger than the moon's gravitational force.

Gravity is a force that acts between all objects throughout the universe. The size of a gravitational force depends on the mass of objects and the distance between them. Gravitational force is largest when objects with large masses are close together. It is smallest when objects with small masses are far away from each other. For example, because we are on Earth, Earth exerts more gravitational pull on us than the sun does, even though the sun is more massive than Earth.



The force of gravity is larger between two massive objects than between two less massive objects.



The force of gravity is larger between two close objects of the same mass than between two distant objects.

ACTIVE READER

1 Infer *Why do you think the moon orbits Earth instead of just revolving around the sun?*

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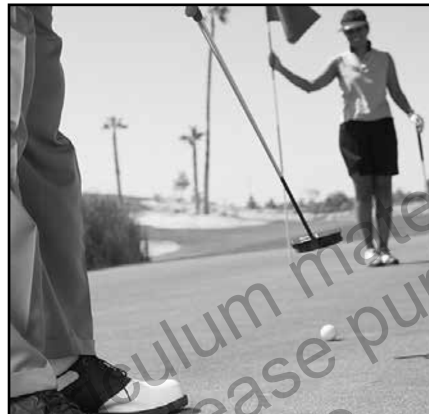
Web Quest

Imagine you were able to travel to Mercury. Do you think you would feel a gravitational force that was weaker or stronger than Earth's? What about if you traveled to other planets, like Jupiter or Saturn? Use the Internet to find the gravitational force on the surface of each of the eight planets in our solar system. Write a story about how an explorer might feel on or near the surface of each planet.

Friction

Have you ever played mini-golf? If you have, you know that you have to hit the ball just right to get it in the hole. Sometimes the ball flies past the hole and stops. Other times, it stops right in front of the hole. Why do you think the ball stops at all on a mini-golf course? Moving golf balls are affected by a force called friction. Friction is a force that opposes motion between two surfaces that are touching. The friction between the ball and the artificial turf on a mini-golf course causes the golf ball to stop. Friction acts on most things that are in motion.



Friction slows the motion of the golf ball as it comes into contact with the surface of the green.

So how does friction work? Most surfaces are not very smooth. But even smooth surfaces have microscopic bumps. As an object moves, its surface sticks to and then slips apart from the surface it is moving over. This process of sticking and slipping causes the object to slow down and eventually stop.

The force of friction is greater between rough surfaces than between smooth surfaces. The force of friction is also greater when the downward force on the moving object is greater. That means that heavy objects experience greater friction than lighter objects.

Newton's Laws of Motion

Sir Isaac Newton was a sixteenth-century scientist who thought a lot about forces such as gravity and their effect on the motion of objects. He figured out that objects at rest tend to stay at rest and objects in motion tend to stay in motion unless they are affected by a force. A space ship shot into the vacuum of space will continue traveling away from Earth forever because, once it leaves Earth's atmosphere, there is no air to cause friction and slow it down. Only if it is acted upon by another force, such as the gravity of a nearby star, will its velocity change.

In addition, he figured out that forces are related to the mass and acceleration of an object. That's why the force of gravity is greater between two massive objects than between two less massive objects. That's also why friction is greater when the downward force on an object is greater.

ACTIVE READER

1 Explain *How does the force of gravity affect friction?*

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2 Predict *How would the motion of a baseball rolling over a grassy surface be different from the motion of a baseball rolling over a concrete surface?*

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Good to Know

Smooth ice is an almost frictionless surface, so an object sliding on ice might keep sliding without slowing down or stopping.

Finally, Newton understood the idea that for every action there is an equal and opposite reaction. For example, have you ever stepped off a boat onto a dock? What happens? As you push off and one foot lands on the dock, you notice that the boat is propelled backward. You have to be careful not to lose your balance and fall into the water. Newton's three laws of motion can be summarized as follows:

Newton's First Law: **An object at rest or in uniform motion will stay that way unless acted upon by a force.**

Newton's Second Law: **The force acting on an object is related to its mass and acceleration.**

Newton's Third Law: **For every action, there is an equal and opposite reaction.**

ACTIVE READER

1 Recall *What is the difference between speed, velocity, and acceleration?*

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FOCUS QUESTIONS

1. How are the forces of gravity and friction different from each other?

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2. Gravity can pull on objects over great distances. Can friction do the same? Explain.

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Think Like A Scientist

Balanced and Unbalanced Forces

Forces act in pairs. **Balanced forces** are a pair of equal forces acting in opposite directions. When the forces on an object are balanced, the net force is zero and there is no change in the object's motion. **Unbalanced forces** are a pair of unequal forces acting in opposite directions. Only unbalanced forces can change the speed or direction of an object. In a pair of unbalanced forces, the object moves in the direction that the strongest force is pushing or pulling. Complete this chart to identify the forces and describe the motions.

Activity	Balanced or Unbalanced Forces?	Description of Forces and Motion
Sitting in a chair		
Riding a skateboard or bicycle along a sidewalk		
Using a rope to play tug-of-war with three friends		
Pushing against a wall		
Dribbling a soccer ball		
Using a jump rope		

Stop and Think

This page will help summarize what you have read so far. Use the tip to help you answer the questions.

Tip:
When you are answering multiple choice questions, be sure to read each answer choice carefully before deciding on your final answer. There may be one or more choices that seem correct until you read the choice that is actually correct.

1. **This car is moving at 60 mph.**

   Draw and label arrows to show the forces of gravity and friction that are acting on the car. Then, draw and label an arrow to show the force that the road is exerting on the car.

2. **Which statement is true about friction?**

   (1) Friction pulls on all objects.

   (2) Friction can change the speed of an object.

   (3) Friction can affect objects that are far away.

   (4) Friction is unaffected by gravitational forces.

3. **Which of these would produce the most friction?**

   (1) a truck stopping on a gravel surface

   (2) a skateboard rolling on a concrete surface

   (3) a soccer ball being kicked across a grassy surface

   (4) a bowling ball rolling down a waxed wooden surface

Dear Ms. Understanding,

I know that gravity is a force that can pull on an object, and friction is a force that can oppose the motion of an object. These forces seem a lot bigger than me. Can I exert forces, too?

Tiny in Troy

Dear Tiny,

Yes! You are an object, and every object exerts a gravitational force. You also exert a force every time you push or pull on something. When you text a friend, you are exerting a force on the keys of your cell phone. The cell phone keys are also exerting forces on you as well. When you think about it, it might be hard to come up with a situation in which some kind of force is not being exerted!

Ms. Understanding

Glossary

acceleration – the change in the velocity of an object over time

balanced forces – pair of opposite and equal forces that act on an object

force – a push or pull on an object

friction – a force that opposes motion between two surfaces that are touching

gravity – the force of attraction between all objects

motion – change in the position of an object over time

newton – the unit of measure for a force, abbreviated as N

position – the location of an object

reference point – a nonmoving object that can be used to measure the rate of motion of a moving object

speed – the distance that is traveled by an object over a certain period of time

unbalanced forces – pair of opposite but unequal forces that change an object's speed or direction

velocity – the speed and direction of an object

weight – measure of the gravitational force on an object

FOCUS ON SCIENCE

Objects in Motion

Assessments

Check Understanding

Objects in Motion

In the Answer Document on this page, mark your answer in the row of circles for each question by filling in the circle that has the same number as the answer you have chosen.

1. The public library is 3 miles from Carrie's house. Carrie travels from her home to the library and back in 105 minutes.

   If Carrie spent 45 minutes inside the library, what was her average speed traveling to and from the library?

   (1) 1.5 mph

   (2) 3.0 mph

   (3) 3.5 mph

   (4) 6.0 mph

2. How is speed different from velocity?

   (1) Velocity describes the speed of an object and the direction it is moving.

   (2) Velocity and speed are different terms for the same description of movement.

   (3) Speed describes the rate of motion of an object while velocity describes how that rate changes.

   (4) Speed describes the distance traveled while velocity describes the distance traveled over time.

3. In which of these situations are the forces unbalanced?

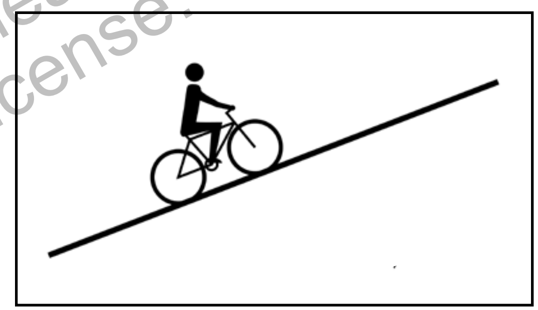
   (1) A fish floats in the water.

   (2) A girl stands at a bus stop.

   (3) A man applies the brakes to stop his car.

   (4) A boy pushes against an unmovable boulder.

4. The diagram below shows a person riding a bicycle uphill.



   Draw an arrow to show how the force of gravity is acting on the bicycle. Then, draw an arrow to show how the force of friction is acting on the bicycle.

Answer Document

1. ① ② ③ ④   3. ① ② ③ ④

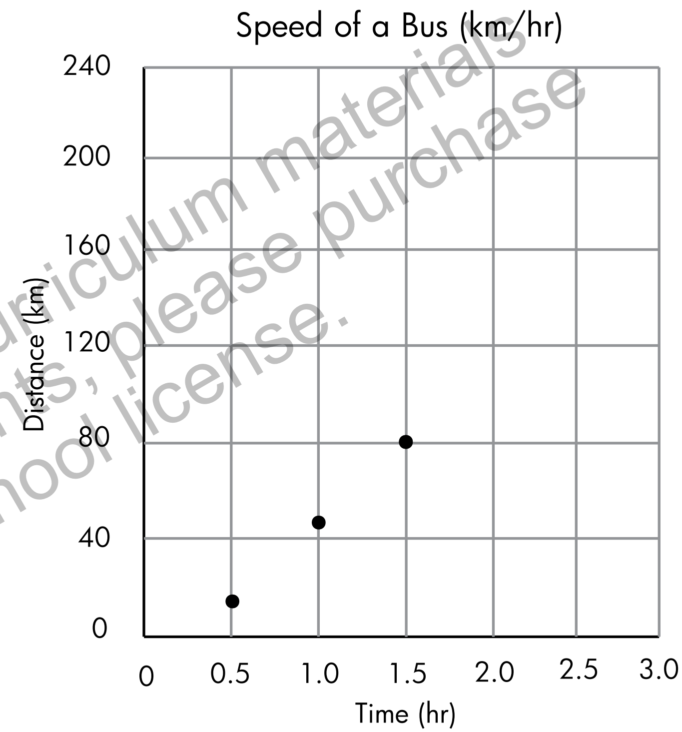
2. ① ② ③ ④

Check Understanding

Objects in Motion

5. The data table below contains information about the distance traveled every half hour on a bus. A graph of the data has been started. Use them to complete the problem.

Distance Traveled	
Time (hours)	Distance (kilometers)
0	0
0.5	15
1.0	45
1.5	80
2.0	125
2.5	180
3.0	240



Use the information in the data table to plot the last three points on the graph. Then, complete the graph by sketching the line that represents the speed of the bus over the course of its three hour trip.

FOCUS ON SCIENCE

Objects in Motion

Answer Key

Answer Key

Page 8: Starting Points
Build Background
Predict: Sample answer: You can tell if something is moving by watching it go from one place to another. Things start moving when they are pushed or pulled by a force.
Brainstorm: Answers will vary but should reflect the forces of gravity and friction.

Page 9: Starting Points
Key Vocabulary
Rate Your Knowledge: Answers will vary according to the student's prior knowledge.
Everyday Meanings: 1. Everyday Meaning: conflict; Scientific Meaning: a force created when two surfaces rub against each other; 2. Everyday Meaning: pounds; Scientific Meaning: a measure of the gravitational force on an object

Page 10: Starting Points
Key Concepts
Active Reader: Sample answers: fluttering leaves, sweeping hands on a clock, bubbles rising in an aquarium, etc.

Page 11: Chapter 1
Active Reader: 1. The reference point does not change position. If the object you are watching changes position in relation to the reference point, then you know that the object is in motion.

Page 12: Chapter 1
Active Reader: 1. the rock cliff at the lower left of the photograph
Focus Questions: 1. You can tell that an object is in motion when you see that it changes position over time when compared to a reference point.; 2. If a bus were permanently parked, it could make a good reference point. Otherwise, the bus might move, so it would not make a good reference point.

Page 13: Chapter 1
Think Like a Scientist
Visualize Motion: Drawings and descriptions will vary but could include buildings or natural features as reference points for a jet taking off.

Page 14: Chapter 1
Active Reader: 1. 54 km/hr

Page 15: Chapter 1
Active Reader: 1. Both graphs show speed and time. One graph shows the average speed of the train over 5 hours. The other shows the train's speed hour by hour.; 2. The train was not moving between hours two and three of the trip.

Page 17: Chapter 1
Active Reader: 1. Acceleration is the rate of change in velocity.; 2. $9 \text{ m/s} \div 3 \text{ s} = 3 \text{ m/s}^2$
Focus Questions: 1. The velocity of the train is highest at the 10 second mark, so its speed is also highest, at 40 m/s.; 2. A bicycle could have a speed that is measured in m/s and a velocity that is measured in m/s west. The acceleration of the bicycle could be measured in m/s^2.

Page 18: Chapter 1
Hands On Science
Speed and Acceleration: Students' tables will vary depending on the data they generate during the time trials.

Page 19: Chapter 1
Think Like a Scientist
Time Trials: 1. Sample answer: Increasing the angle of the ramp speeded up the car. This caused acceleration.; 2. Find the difference between the speed at the top and bottom of each ramp, and divide this value by the time it took for the car to travel the entire length of the ramp.; 3. 1.25 cm/sec^2

Page 20: Chapter 1
Stop and Think: 1. (1); 2. (3); 3. (3)

Page 21: Chapter 2
Active Reader: 1. Underline: A force is a push or pull on an object.; Circle: Forces often change the speed or direction of an object.; 2. Answers will vary.

Answer Key

Page 22: Chapter 2
Active Reader: 1. Gravity is pulling down on you and the ground is pushing up. Your muscles are exerting forces that move your legs up and down.
Focus Questions: 1. A force is a push or pull on an object.; 2. Gravity pulls the bus down to the ground and the ground pushes up. The engine exerts a force on the axle to cause the wheels to turn. The wheels and ground push against each other to cause the bus to move forward. The brakes and ground exert a force on the wheels to stop the bus.

Page 23: Chapter 2
Active Reader: 1. The moon is so close to Earth that Earth's gravitational force is strong enough to pull the moon into orbit around the Earth.

Page 24: Chapter 3
Active Reader: 1. Gravitational force is stronger on an object with greater mass than on an object with lesser mass. Friction increases as the gravitational force on an object increases.; 2. Friction would be greater between the grass and the ball vs. the concrete and the ball, so the ball would stop more quickly on grass.

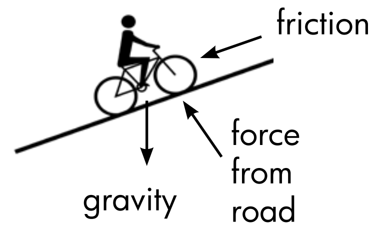
Page 25: Chapter 3
Active Reader: Speed is the distance an object travels over time. Veolcity is a measure of speed and direction. Acceleration is the rate of change in velocity.
Focus Questions: 1. Gravity is a force that pulls objects toward each other. Friction is a force that opposes the movement of objects between two surfaces that are touching.; 2. No. Friction can only act on objects that have surfaces that are touching each other.

Page 26: Chapter 2
Think Like a Scientist
Balanced and Unbalanced Forces:
Sitting in a chair: Forces are balanced; gravity pulling down is balanced by the force of the chair pushing up.
Riding a skateboard or bicycle: Forces are unbalanced. The pushing force applied by the rider is stronger than gravity or friction.
Using a rope to play tug of war: Forces are balanced as long as the two sides apply equal force. Once one side outpulls the other, the forces become unbalanced.
Pushing against a wall: Forces are balanced. Since no movement is taking place, the force that you use is equal to the force of the wall pushing on your hand.
Dribbling a soccer ball: Forces are unbalanced. The forces from your feet change the direction of the ball and can also change its speed.
Using a jump rope: Forces are unbalanced. Repeatedly pushing against the floor results in repeated up and down movement.

Page 27: Chapter 2
Stop and Think: 1. Arrows should show gravity (↓), friction (←), and force of road (↑); 2. (2); 3. (1)

Page 31: Check Understanding
1. (4); 2. (1); 3.(3)

4.



Answer Key

Page 32: Check Understanding

5.