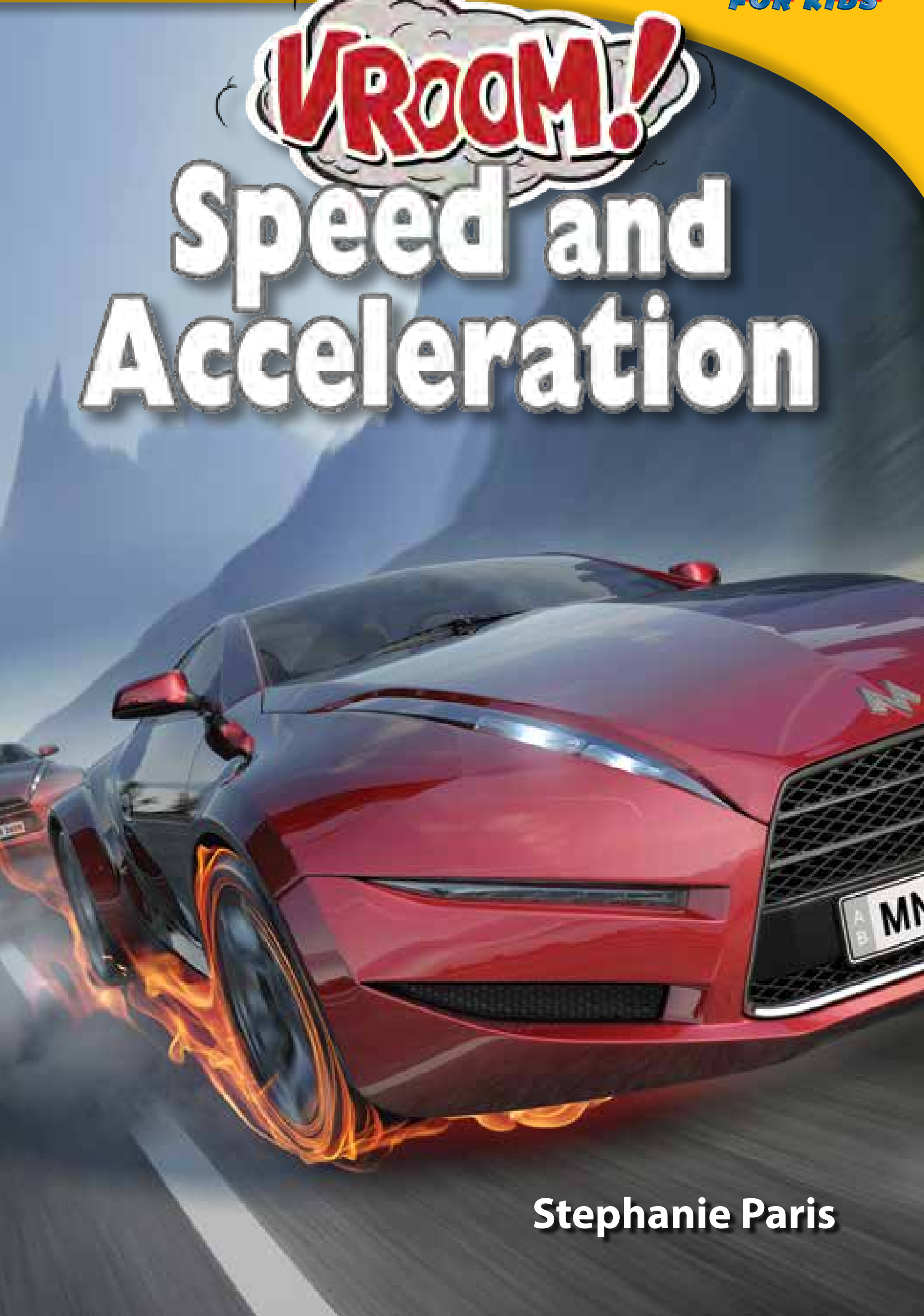
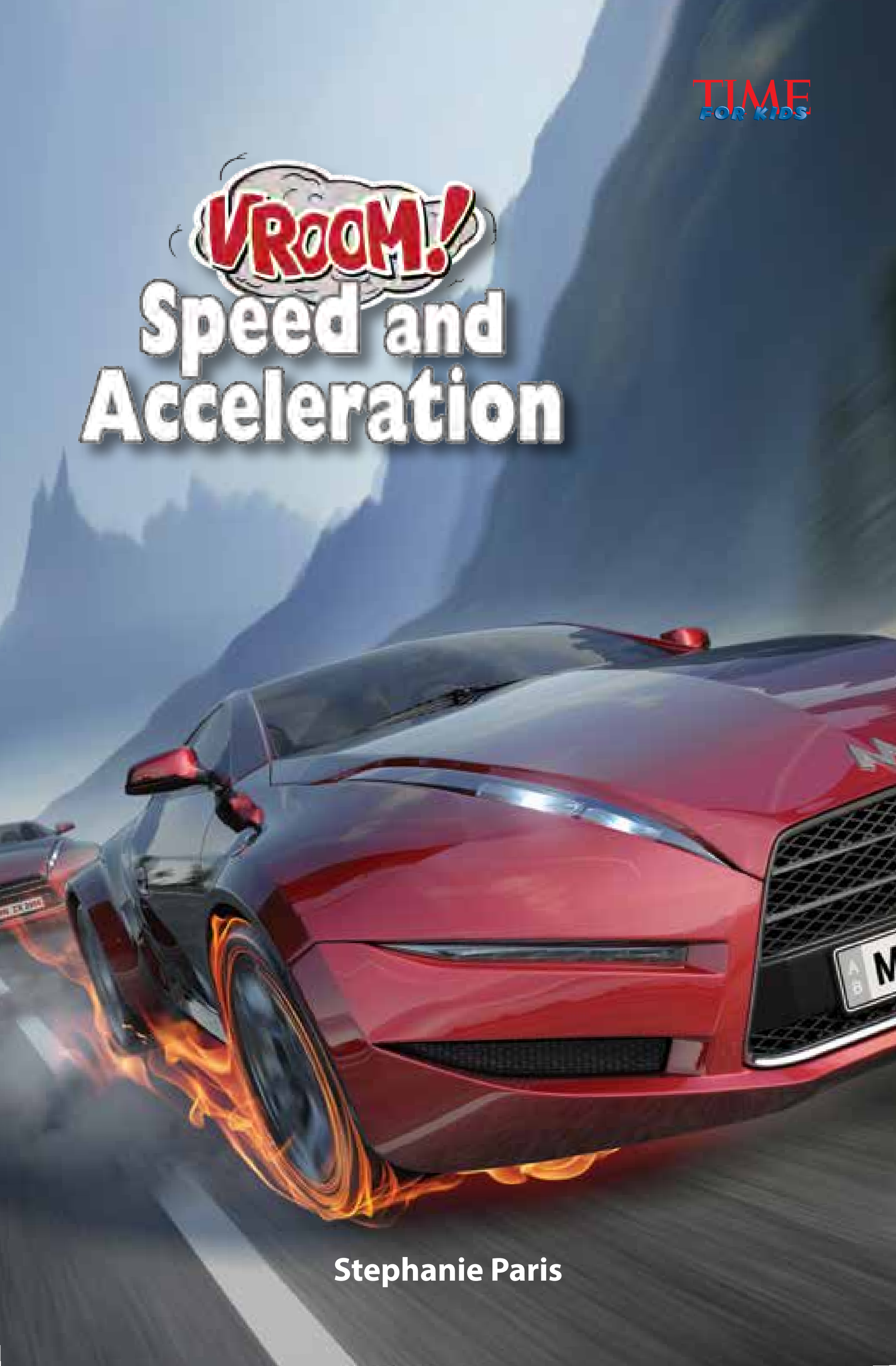
TIME FOR KIDS

Vroom! Speed and Acceleration



Stephanie Paris



Vroom! Speed and Acceleration

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What Is Speed?

Race cars zoom across the finish line, soccer balls whiz down the field, and dancers throw themselves through the air in leaps and bounds. Moving fast feels exhilarating, but how fast is fast? Kyle Petty, a record-winning race-car driver, sums it up well. "**Speed** is **relative**. Does it feel fast going 70 miles per hour down an 8-lane highway? No, probably not, but I bet it does if you are going down some single-lane dirt road. It's the same in a race car. It depends on the track." In other words, how fast something is moving depends on what it's being compared to. The fastest car appears as slow as a turtle when it's being compared to the fastest jet, but how fast is a jet when it's compared to the speed of light?

Bicycle: 81 miles per hour

Car: 267 miles per hour

The Fastest

Airplane: 2,200 miles per hour

Spaceship: 39,000 miles per hour

THINK LINK

- What does it mean to go fast?
- What affects how fast or slow an object moves?
- How can we speed up or slow down a moving object?

Light Speed

Light travels at about 186,000 miles per second. Scientists believe this is the fastest anything in our universe can travel.

How long does it take you to walk to school? The answer depends on two things: the distance you need to travel and how quickly you are moving. Speed is a way to measure how fast something is going. It is defined as a change of position over time. It describes how long it takes for something to get from one place to another.

Physics Facts

Physicists are scientists who study the universe. They use math to understand and explain why things move and change the way they do.

Stargazer

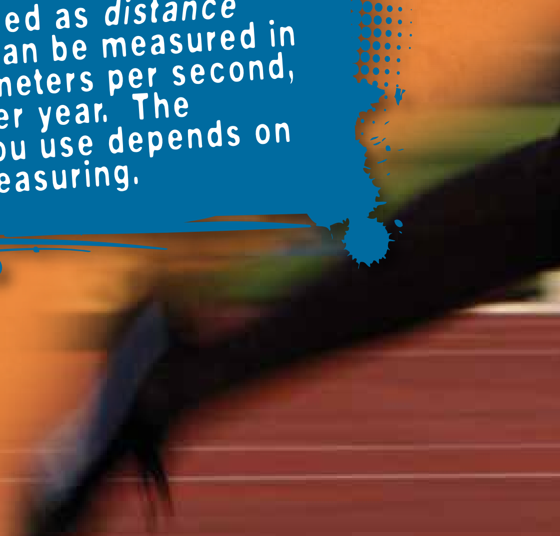
Physicist Amy Mainzer is an expert on asteroids and galaxies. She's the deputy project scientist for the Wide-Field Infrared Survey Explorer (WISE) mission, which uses an advanced telescope. She's a Harry Potter fanatic and loves math, skating, and most importantly, her job.

Measuring Speed

The point of a race is to determine who or what moves the fastest. That's exactly what some kids do each year in derbies. In these races, participants start with the same materials. They begin with a block of wood, an **axle**, and wheels, or they might use a small plastic model car. Either way, only one car can win the race.

In a race, each participant's car travels on the same track at the same time. The winner is easy to spot. Just look for the car that crosses the finish line first. But what if you want to compare the race times of your school's winner with another school's winner? You wouldn't need to race them side by side. All you would need to do is compare their speeds.

Speed is described as *distance per time*. This can be measured in miles per hour, meters per second, or millimeters per year. The measurement you use depends on what you are measuring.



Usain Bolt

Fast Formula

In 2012, Usain Bolt of Jamaica broke a new record by running 100 meters in 9.63 seconds. How many meters can Usain Bolt run in 1 second? Use this fast formula, where *S* is speed, *D* is distance, and *T* is time:

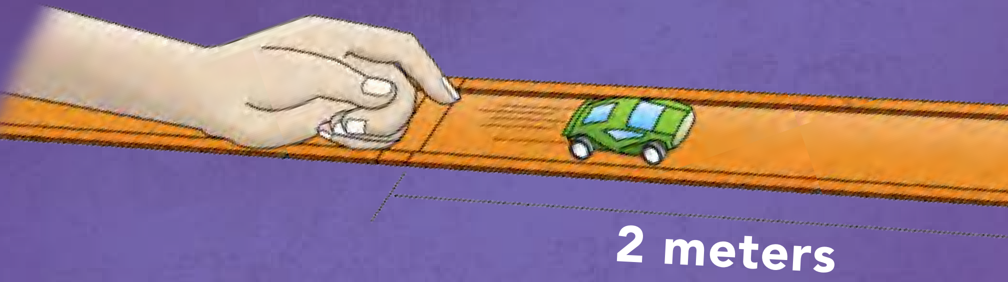
$$S = \frac{D}{T}$$

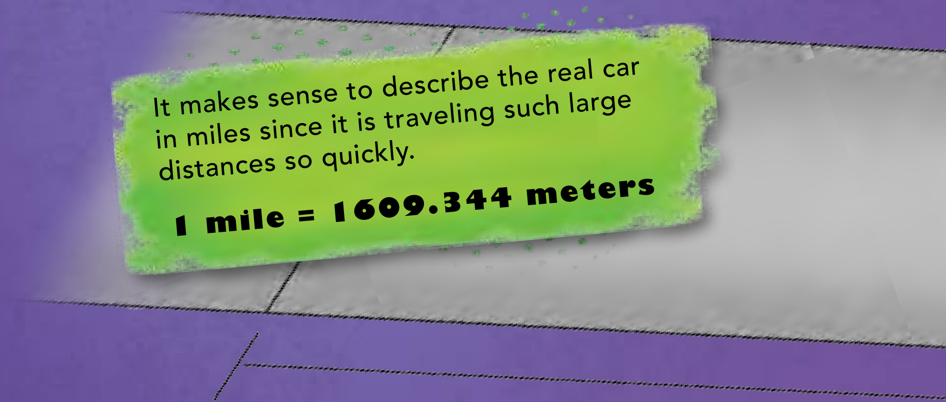
$$? = \frac{100 \text{ meters}}{9.69 \text{ seconds}}$$

$$\frac{10.3 \text{ meters}}{1 \text{ second}} \times 1 \text{ second} = 10.3 \text{ meters}$$

Units of Measurement

Imagine pushing a toy car along a track. With one strong push, the car zips down the 2-meter track in 1 second. The toy is moving at a speed of 2 meters per second. Now imagine a real car. It zooms down the highway and travels 60 miles in 1 hour. It is going 60 miles per hour.



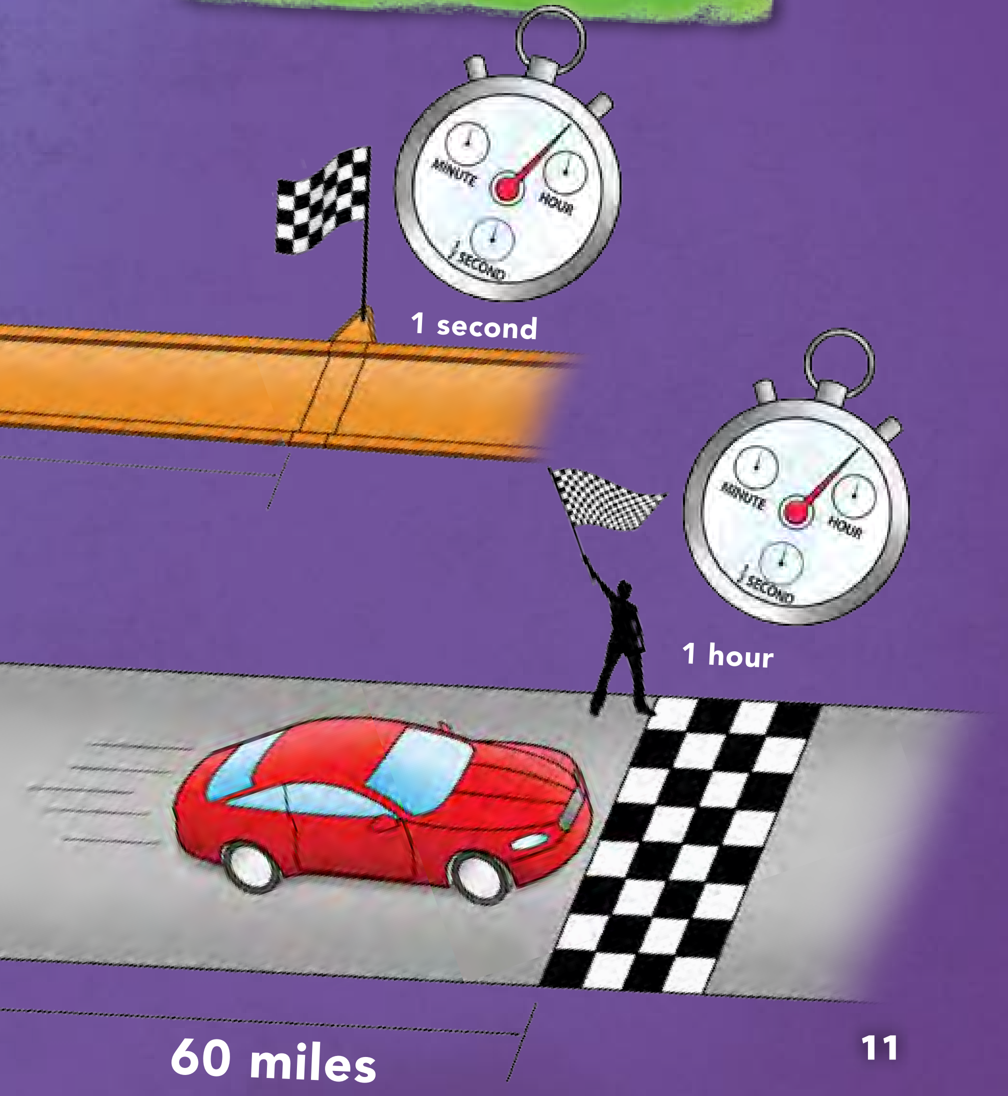


It makes sense to describe the real car in miles since it is traveling such large distances so quickly.

1 mile = 1609.344 meters

What If?

What if we described the toy car in miles per hour and the real car in meters per second? It turns out the toy car is going about 4.47 miles per hour. The real car is going 26.82 meters per second. You can express speed using any distance and time.



Velocity

Imagine a girl strapping on her skates for a big race. She gets set, the whistle blows, and the racers are off! She is going much faster than any of the others. She glides along the track, passes the judges, and continues on through the astonished audience, who jumps out of her way. Then, she skates right out the door, forgetting one important step. She never crossed the finish line! Another much slower racer crosses the finish line and wins the race. Why? The faster racer was going the wrong way! Sometimes, speed isn't the only thing that matters—direction is important, too. **Velocity** is speed plus direction.

Kicking It up a Notch

Almost every sport relies on velocity. Athletes must hit, kick, or throw a ball at the right speed and in the right direction. They must move their bodies quickly and accurately across the field and catch the ball in time. The game depends on the speed and the direction the players move in.

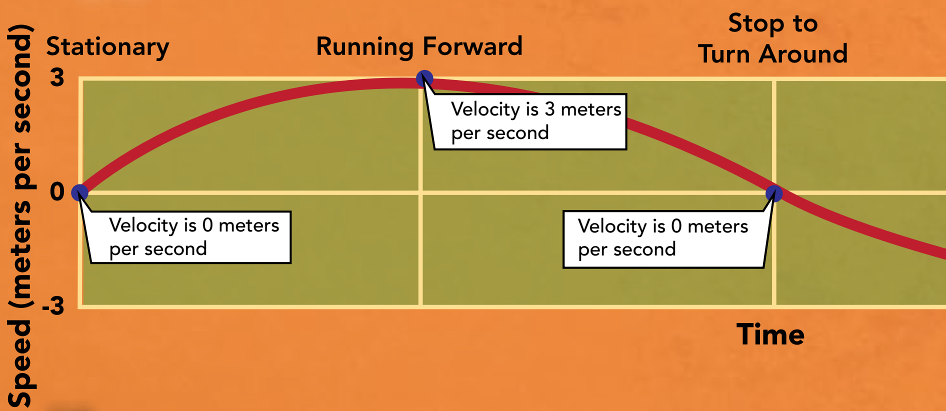
Hi-Tech Velocity

Does your favorite electronic game involve dodging fireballs or jumping on platforms? Do you have to fling birds or shoot lasers at just the right angle and moment? Then your game relies on velocity!

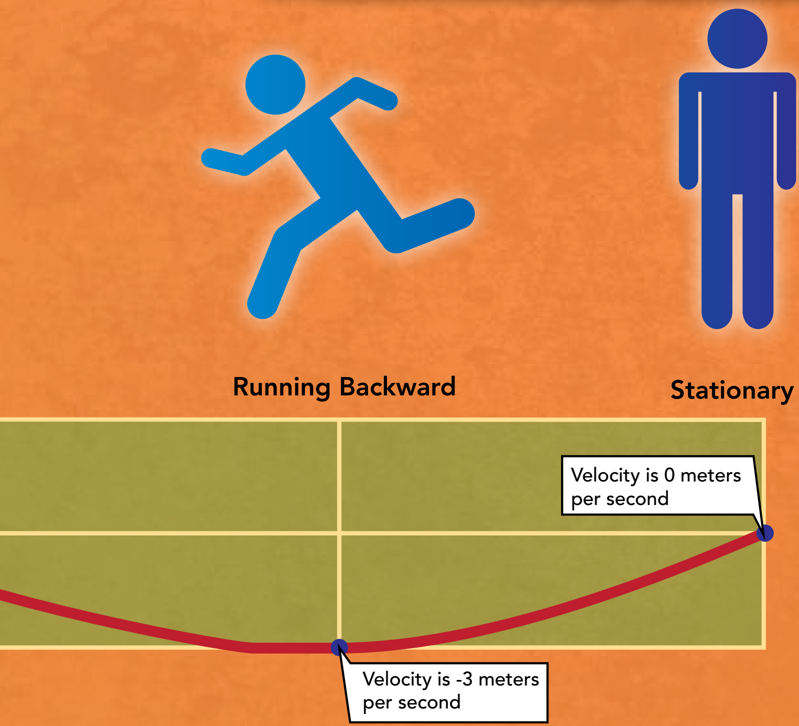
Back and Forth

Velocity is speed measured in a specific direction. Velocity works the same way with cars, spaceships, and galaxies as it does with humans. This person's velocity changes as he changes speeds and changes directions. Here, traveling to the right is a form of positive velocity. Traveling to the left is negative velocity.

maximum speed = 3 meters per second



- What would the graph look like if the character ran forward the entire time?
- What velocity does the man have when he is standing still?
- Why is the velocity expressed as -3 when the man runs backward?



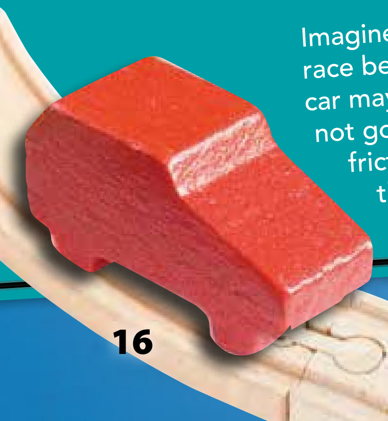
Going Faster

What makes things go? And how can we make them go faster? Every object has many forces acting on it. **Gravity** pulls down. The ground pushes up. A shove can push something forward, and **friction** may slow it down.

An object needs **energy** to move. To move fast, all that energy needs to be pushing in the same direction. The trick to making an object go faster is to maximize the forces that make it go and minimize the forces that hold it back. Think about the forces that help a model car speed up or slow down. Where does the car's energy come from? Can you think of ways to modify the car so the forces making it go faster have a stronger impact than the ones slowing it down?

Tinker's Tip

Imagine a model car without wheels. The race begins, the gate lifts, and although the car may move forward a little, it's definitely not going to win the race! The force of friction slowing the car is stronger than the force of gravity pulling it toward the bottom of the track.



Rapid Descent

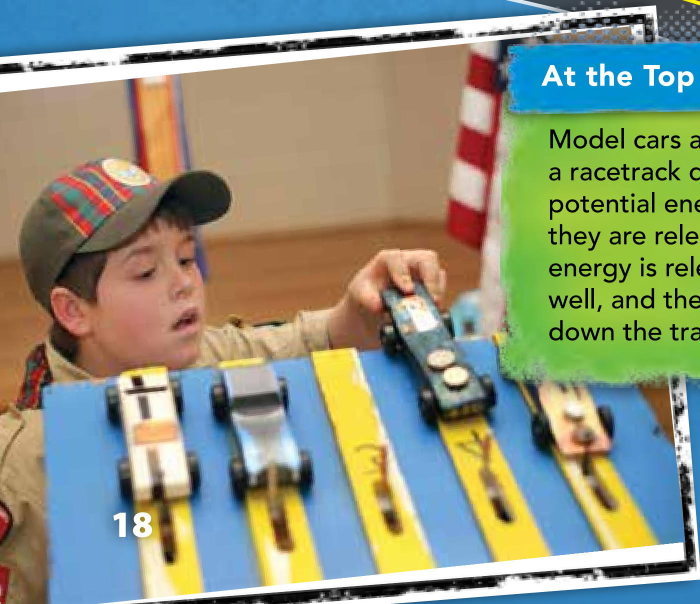
Downhill skiers try to maximize their downward force while minimizing the friction holding them back. But they must also keep safety in mind. These skiers often travel at speeds exceeding 80 miles per hour! Their skis and clothes are designed to minimize friction and help protect them in case of a crash.

Power Up

Energy is the ability to do work and make changes. There are two major kinds of energy. **Potential energy** is energy that is stored or that results from position. Nothing is changing yet, but the energy is ready and waiting to be used. A car resting at the top of a hill has potential energy.

Kinetic energy is working energy. As the car zooms down the track, the kinetic energy is the amount of work necessary to get it from its stopped position to its full velocity.

On the Track

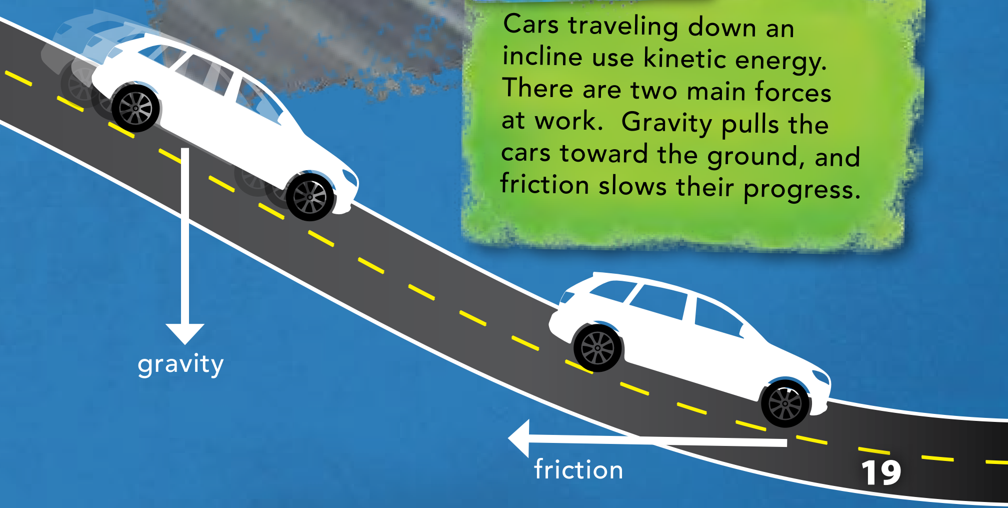


At the Top

Model cars at the top of a racetrack demonstrate potential energy. When they are released, their energy is released as well, and they zoom down the track!

On an Incline

Cars traveling down an incline use kinetic energy. There are two main forces at work. Gravity pulls the cars toward the ground, and friction slows their progress.

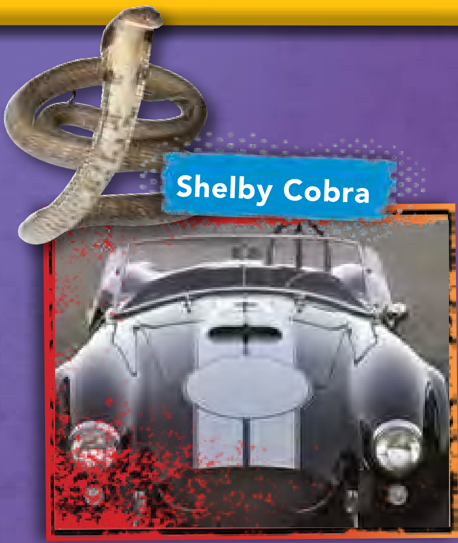


Built for Speed

Racers work hard to make their cars go as fast as possible. But in nature, moving fast isn't a game. It's a matter of survival. Animals that hunt need to be able to chase down their prey. Every second counts in the wild. Some car designers set out to model cars after speedy animals. Sometimes, the car resembles the animal's shape. Other times, the car is named after the animal that inspired it.

Jaguar

Chevrolet Impala



Fastest on Land

The cheetah holds the title as the fastest animal on land. For short bursts, it can race after prey at 65 to 70 miles per hour. It can go from 0 to 60 miles per hour in 3 seconds! It has large lungs and nostrils that take in oxygen quickly to send to its muscles as it runs. Its claws stick out to create **traction**. And its flat tail helps it make sharp turns easily.

Ups and Downs

Things don't just start off going fast, build speed, and then stop instantly. Like the cheetah that takes 3 seconds to get from 0 to 60 miles per hour, objects also need time to speed up and slow down. That's where **acceleration** comes into play. Acceleration is a change in velocity over time. When something accelerates, it speeds up or changes direction. **Deceleration** describes something that is slowing down, which can also be called *negative acceleration*. Whenever you have something that is going fast, you will eventually need it to stop. The ability to control acceleration and deceleration is important for toys, cars, animals, spacecrafts, and pretty much everything else!

G-Force

Imagine you're on a roller coaster. The force you feel as you race ahead is called **g-force**. The G stands for *gravity*. The faster you accelerate, the more your body feels as if it's fighting gravity. Although you want to move, your neck and head feel pinned to the headrest.

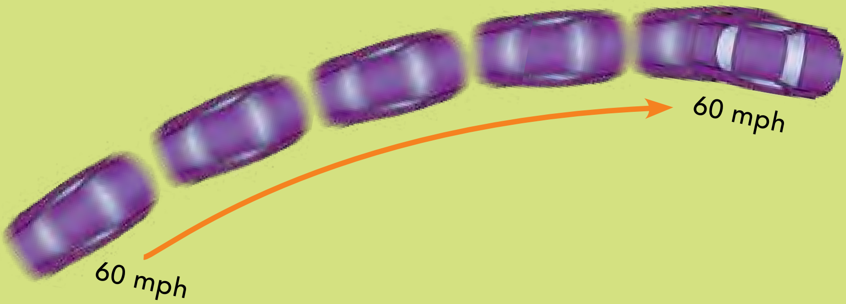
Pedal to the Metal

30 miles per hour to 60 miles per hour

The velocity is increasing, so the car is accelerating.

turning at 60 miles per hour

The car is changing direction (velocity), so the car is accelerating even though its speed stays the same.



60 miles per hour to 0 miles per hour

The car is decelerating when the velocity is decreasing. This is negative acceleration.

Newton's Second Law

Isaac Newton was a brilliant scientist who lived in the 17th century and used math to study the world around him. Later, other scientists studied his writings and created three laws of motion based on his work. Newton's Second Law of Motion relates to acceleration.

Acceleration occurs when a force acts on a **mass**. The greater the mass of the object being accelerated, the greater the amount of force needed to accelerate the object. This means that for something to speed up or slow down, it needs to have a force pushing or pulling it. It also says that the more mass an object has, the more force is needed to change its velocity. For example, it takes more force to move a bowling ball than a table-tennis ball.

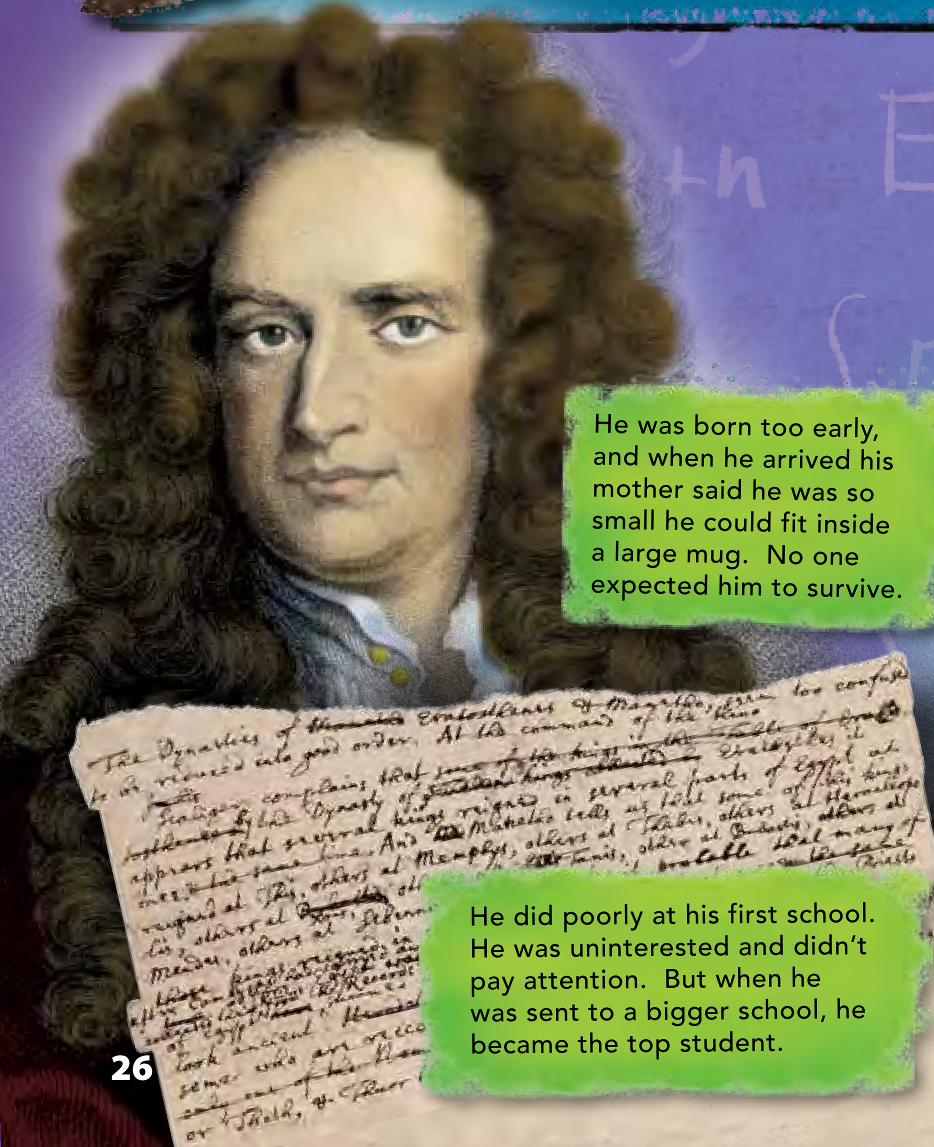
The Newton

The unit of force used in physics is named after Sir Isaac Newton. A **newton (N)** is the force it takes to accelerate 1 kilogram (kg) 1 meter (m) per second (s) squared in empty space. For example, that means if a 1 kilogram bowling ball is pushed with 1 N of force, then 1 second later, the ball is moving $1\frac{m}{s}$. Two seconds later, it is moving $2\frac{m}{s}$, and so on.

$$N = kg\ \frac{m}{s^2}$$

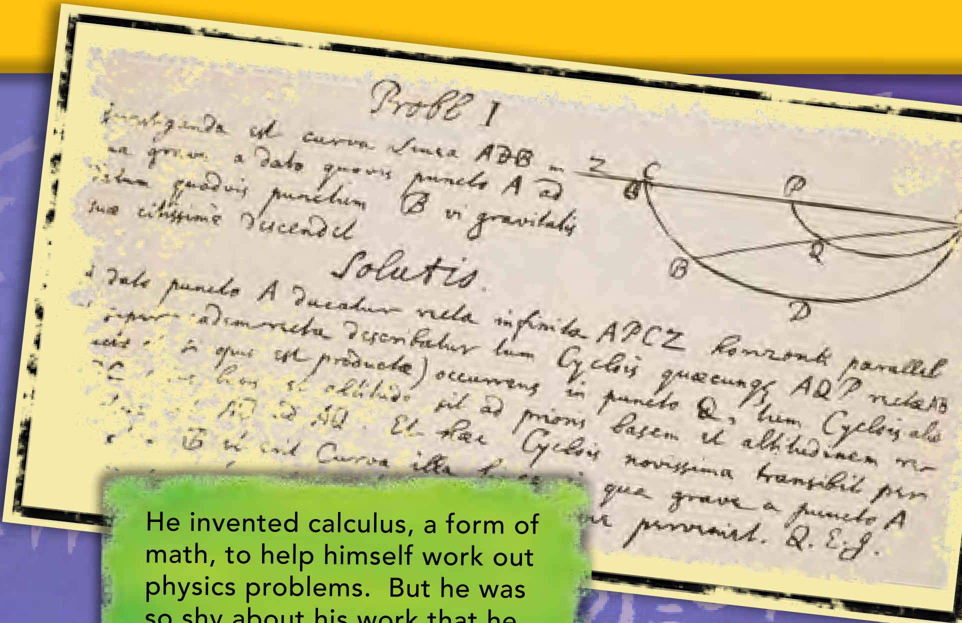
Newton News

Most people have heard of Sir Isaac Newton and his contributions to science and math. But here are a few things that many people don't know about this amazing scientist.



He was born too early, and when he arrived his mother said he was so small he could fit inside a large mug. No one expected him to survive.

He did poorly at his first school. He was uninterested and didn't pay attention. But when he was sent to a bigger school, he became the top student.



He invented calculus, a form of math, to help himself work out physics problems. But he was so shy about his work that he didn't tell anyone for 30 years!

He was elected to Parliament for a year, but in that time, he only uttered one sentence. He asked an assistant to close a drafty window.

Thrust

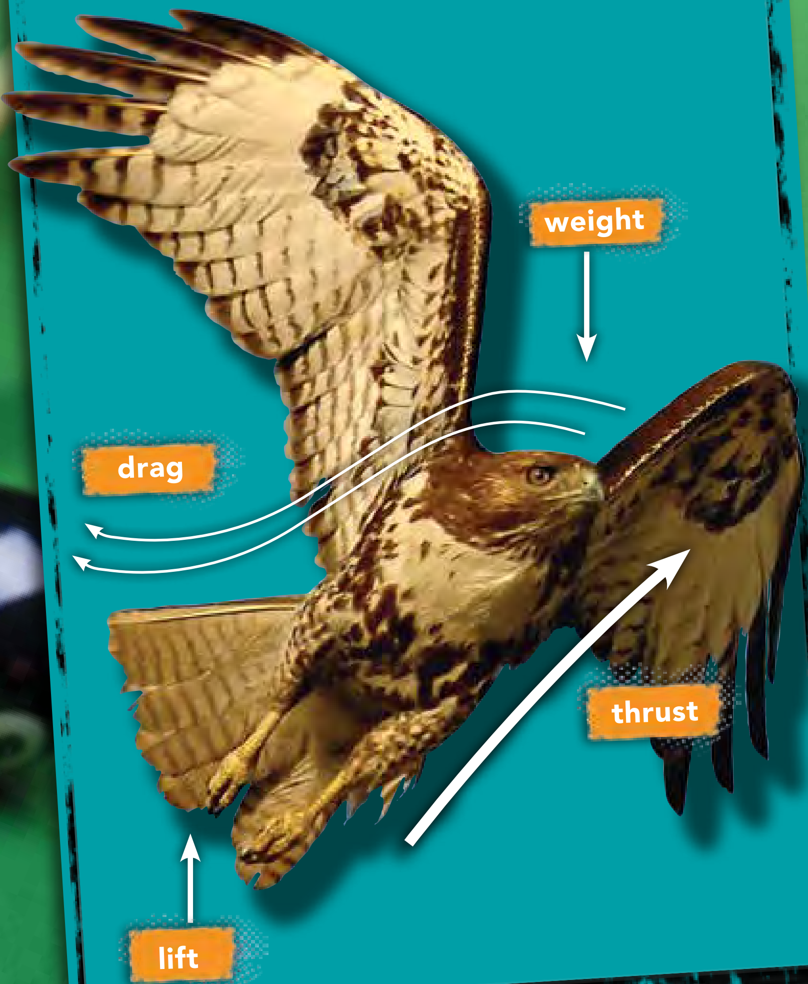
How do you get a cue ball moving fast? First, give it a tremendous push with the cue stick! Pushes that start something moving are called **thrust**. A little thrust might be a gentle push that gets you moving on a swing, or it might help you blow a bubble. And a big thrust might be powerful enough to launch a rocket! Whether the thrust is big or small, each push is using energy to get something moving in a particular direction.

On the Track

In a derby, racers are only allowed to use gravity to accelerate their model cars. But what if the rules changed? How could you use thrust to improve the speed of your car?

Take to the Sky

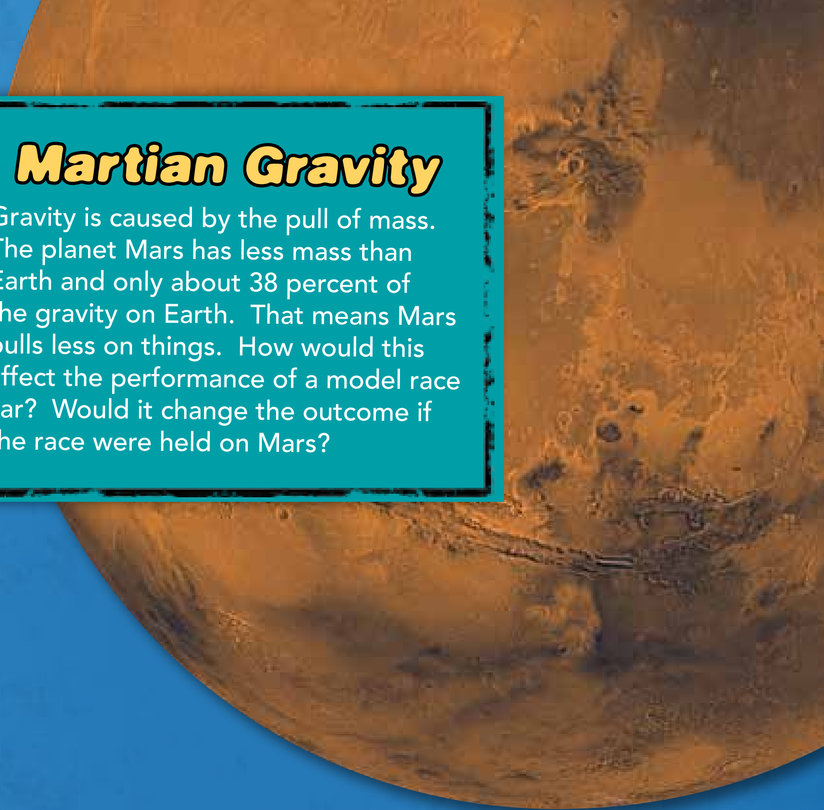
When birds flap their wings, they are using the force of thrust to stay in the air. Without thrust, a bird would crash to the ground. The larger they are, the more strength birds need to create a powerful thrust that keeps them safely in the air.



Gravity

Not only does gravity keep us tied to Earth so we don't float away but it is also useful in getting things moving. A roller coaster uses a chain to pull the coaster up to the top of a tall hill, but after that, gravity takes over. The roller coaster races down toward Earth because gravity is pulling on it. In fact, there is so much force from gravity the roller coaster has enough energy to make it up the next hill and around the next curve. Then, it races down again and is pulled by the gravity of Earth. Roller coaster engineers understand exactly how each force pulls and pushes the ride from start to finish.

An engineer tests a roller coaster filled with dummies for safety.



Martian Gravity

Gravity is caused by the pull of mass. The planet Mars has less mass than Earth and only about 38 percent of the gravity on Earth. That means Mars pulls less on things. How would this affect the performance of a model race car? Would it change the outcome if the race were held on Mars?

Tinker's Tip

Derby racers use gravity as their main force. Can you think of any way to increase the force of gravity on a model car? Most races allow participants to add weights to their cars. Does gluing weights on to the car change how the car races? Experiment a bit and see!

Magnetism

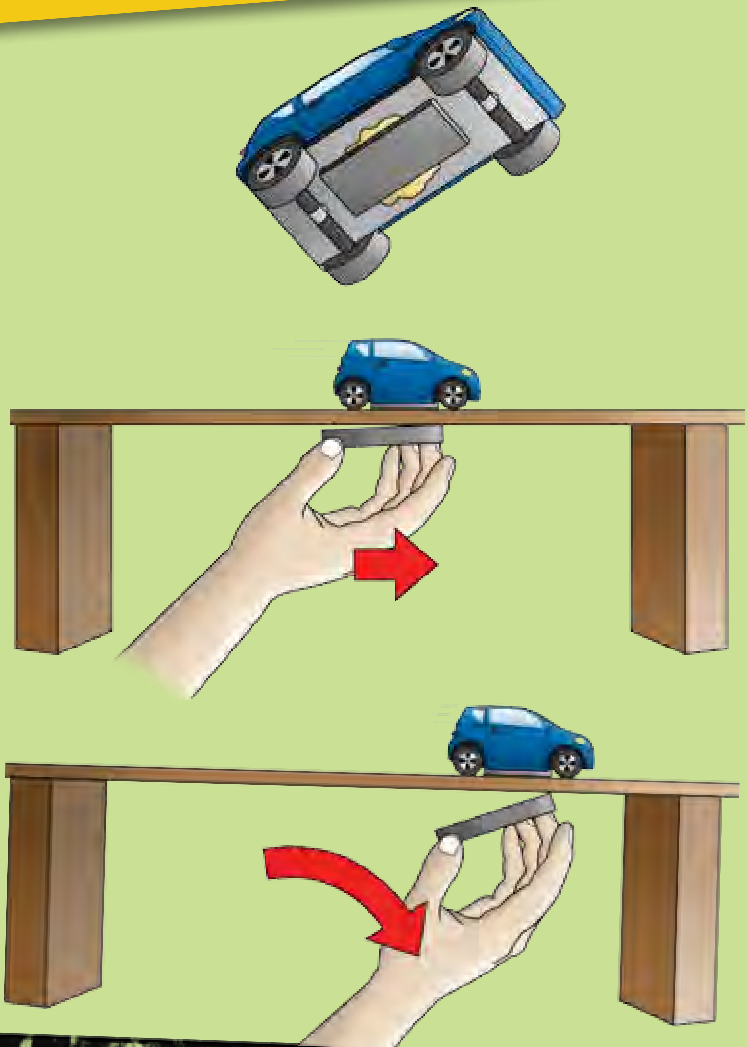
Have you ever played with magnets? Place one next to another on a table, and *zip*—the magnets slam together in the blink of an eye. **Magnetism** is another force that can change speed and velocity. Magnets are special materials that pull or push other magnetic things. Only certain metals have the right properties to become magnets. The most common metals are iron, steel, nickel, and cobalt. By using these materials, it's possible to create machines that can propel all kinds of objects very quickly.

Maglev Trains

Maglev stands for *magnetic levitation* and is a method for propelling trains. Magnets are used to create both lift and thrust, propelling a train along a track. The trains don't experience friction with the ground since they are floating! The fastest maglev trains can go 361 miles per hour. But there are currently only two maglev trains in operation. While maglev trains are being developed in Germany and Japan, the only one in operation is in China.

Try This

Find a pair of strong magnets, and attach one to the bottom of a toy car. Make sure the magnet doesn't keep the wheels from turning. Then, place your car on a raised track. Drag the second magnet under the track to pull your car. How far will the car roll once you pull the magnet away?



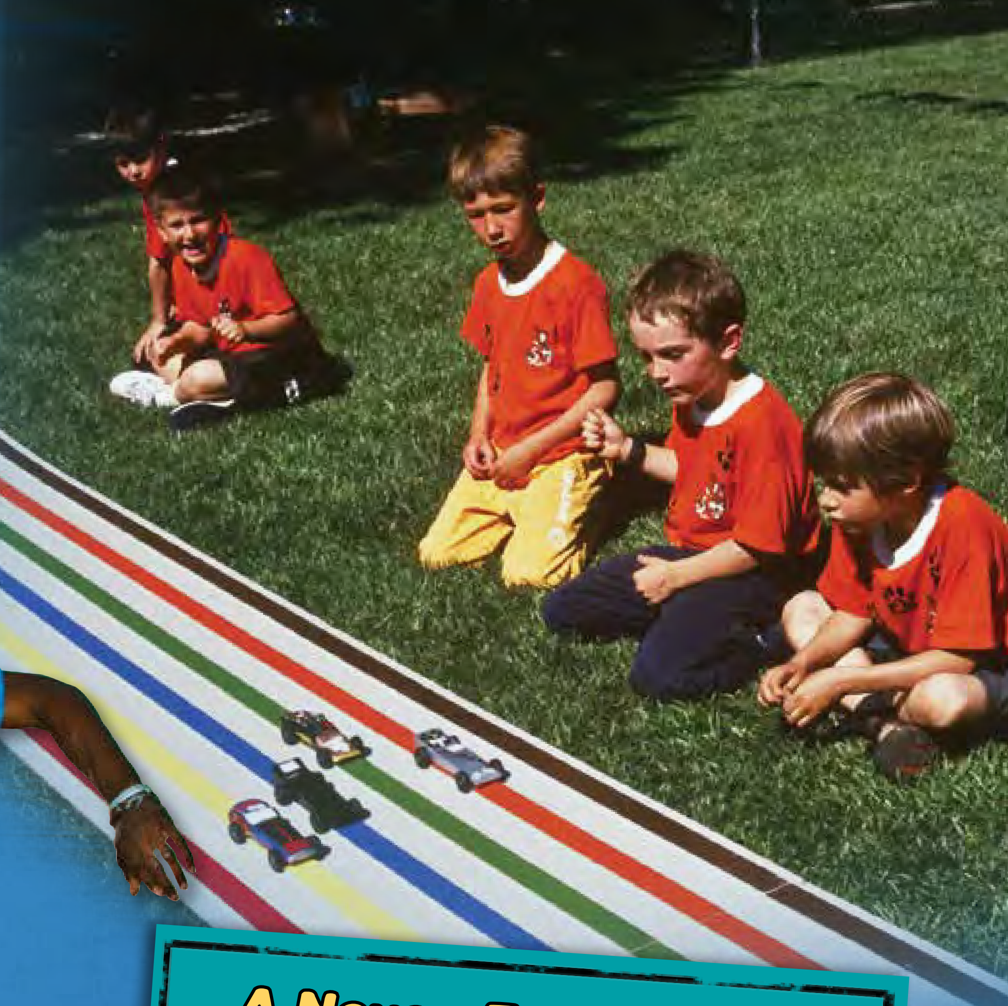
Keep It Going

One interesting thing to remember about speed is that things seem to want to keep going whatever speed and direction they are already going. That is, they will keep going the same speed unless something else actively changes the situation. It takes more energy to get something to change than it does to have it stay the same. This idea is called **inertia.** Inertia is the **resistance** to a change in motion.

Newton's First Law

Newton observed and described these facts, too. In fact, these observations were thought to be so basic and important they were written up as his First Law. Sometimes, this is called the Law of Inertia:

An object at rest will remain at rest unless acted on by an outside force. And an object in motion continues in motion with the same speed and direction unless acted on by an outside force.



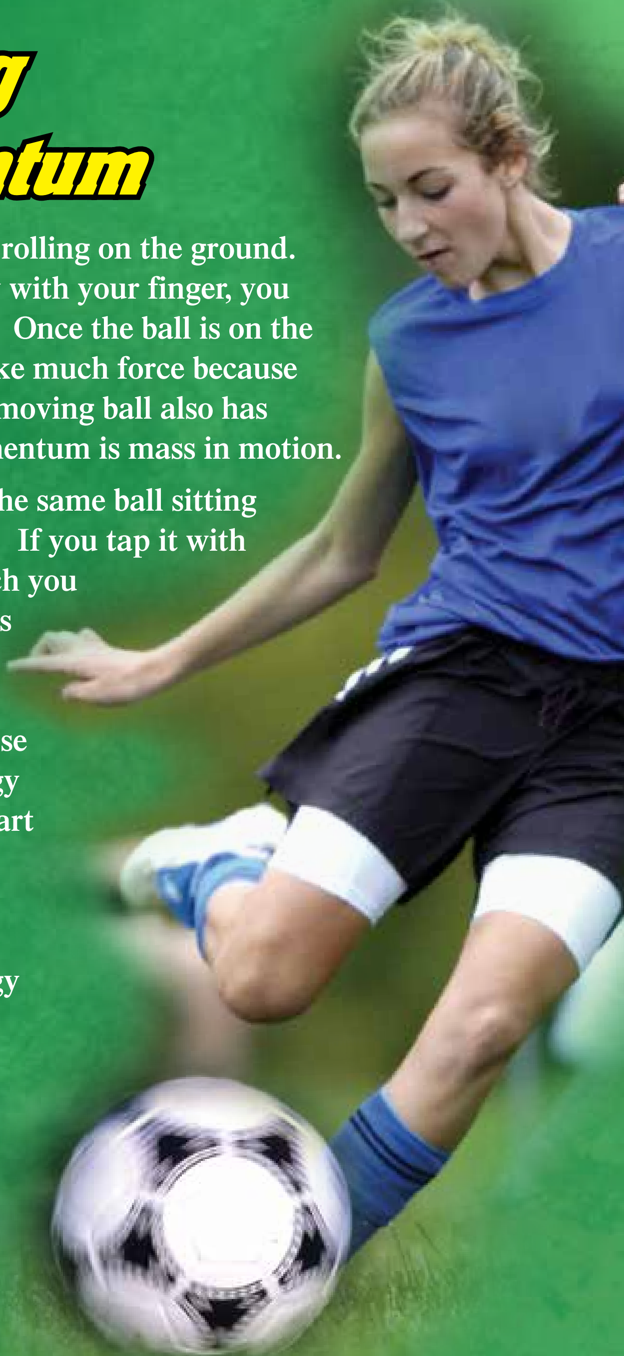
A Never-Ending Race

Imagine placing your race car on a flat track. It won't move unless something makes it move. But if you gave it a giant push, it would start to roll and continue to roll unless something stopped it, such as wind, a hill, a small bump in the road, gravity, or something else that actively changed the situation. But if you pushed the car and nothing changed the situation, it would keep rolling, and rolling, and rolling due to inertia. It could participate in a never-ending race!

Gaining Momentum

Think of a ball rolling on the ground. If you tap it lightly with your finger, you can keep it rolling. Once the ball is on the move, it doesn't take much force because it has inertia. The moving ball also has **momentum**. Momentum is mass in motion.

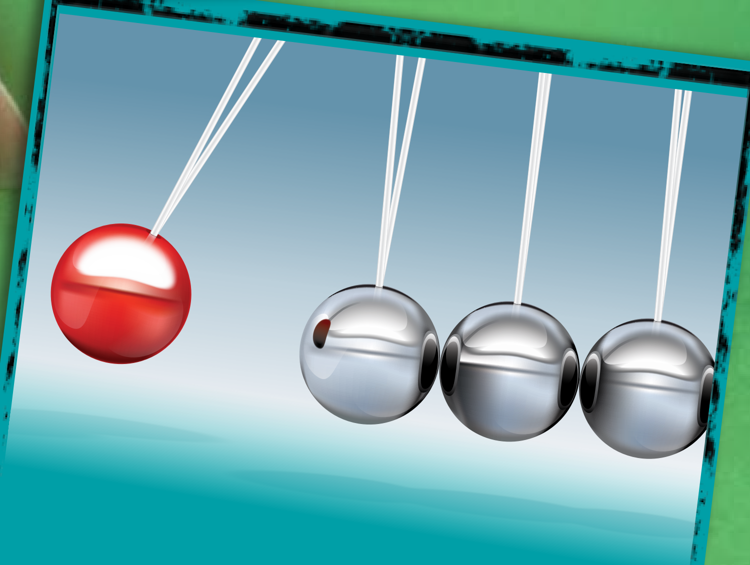
Now, think of the same ball sitting still on the ground. If you tap it with the same light touch you used as when it was rolling, it may not move at all this time. That's because it takes more energy to get the ball to start rolling than it does to keep it rolling continuously. And it takes more energy to stop the ball from rolling than it does to keep it rolling once it has started!



Physics Formula

Where *p* is *momentum*, *m* is *mass* and *v* is *velocity*:

$$p = mv$$



Marble Madness

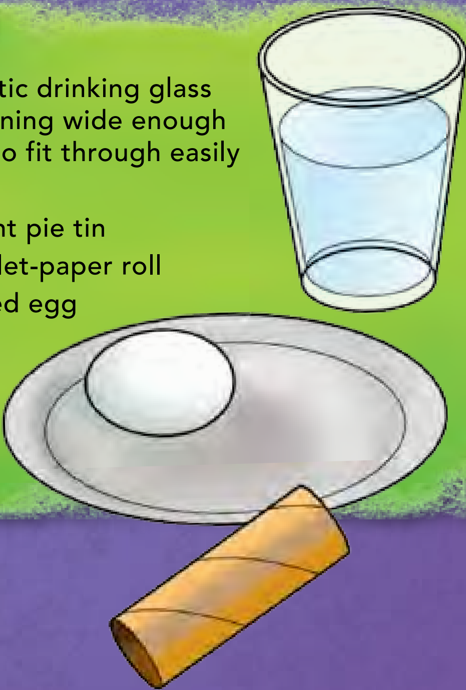
Momentum can be transferred from object to object. Check out the marbles hanging above. When the red ball hits the next ball, it will transfer its momentum. The red ball will hit the first silver ball; the first silver ball will hit the second; and the second will hit the third. As each marble hits the next, they build momentum. What do you think will happen if another ball is added to the line?

Egg Drop

In this experiment, you will see the forces of inertia and gravity at work. Pay close attention to the egg before it falls. Did it fall instantly? Why or why not? Can you think of another way to carry out the same experiment using different materials?

Materials:

- 1 large plastic drinking glass with an opening wide enough for an egg to fit through easily
- water
- 1 lightweight pie tin
- 1 empty toilet-paper roll
- 1 hard-boiled egg



Step 1

Fill the glass three-quarters full with water.

Step 2

Center the pie tin on the glass. Then, center the toilet paper tube on the pie tin. Balance the egg on the tube.

Step 3

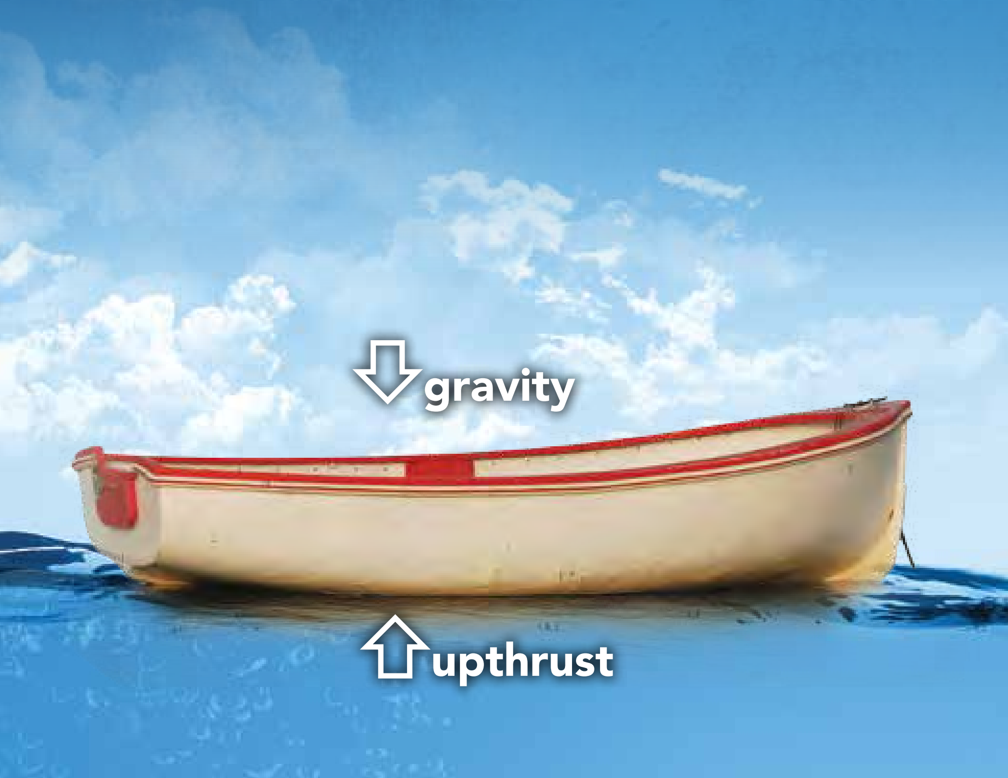
Get an adult's permission before you do this next step. With a smooth, strong, horizontal motion, hit the pie plate so it flies away from the glass. If you do it correctly, the egg will plop into the glass with a neat splash!

What's Happening Here?

The egg isn't moving when it's sitting on the tube. And when you smack the pie plate, no thrust is acting on the egg. Inertia keeps the egg at rest. But with no tube under it, of course, gravity pulls on the egg, so it falls straight down into the waiting cup.

Balancing Act

What does it mean for forces to be in balance? It means that nothing is changing. The amount something is pushing on an object in one direction is the same as the amount it is being pushed from the other direction. For instance, a boat that is floating in water is being pushed up by the **upthrust**, or buoyancy, of the water, but gravity is also pulling it down. What if the forces on the boat are unbalanced? If the force of gravity is greater than the force of upthrust, the boat will sink!



Try This

Place a book on your desk. Try pushing it lightly but not hard enough to make it move. The push you are **exerting** is one force. It is balanced by the friction of the book against the table, which is another force. The forces are in balance, so the book doesn't move. But if you push harder, the forces are no longer in balance. Your push is greater than the force of the friction. The book moves!

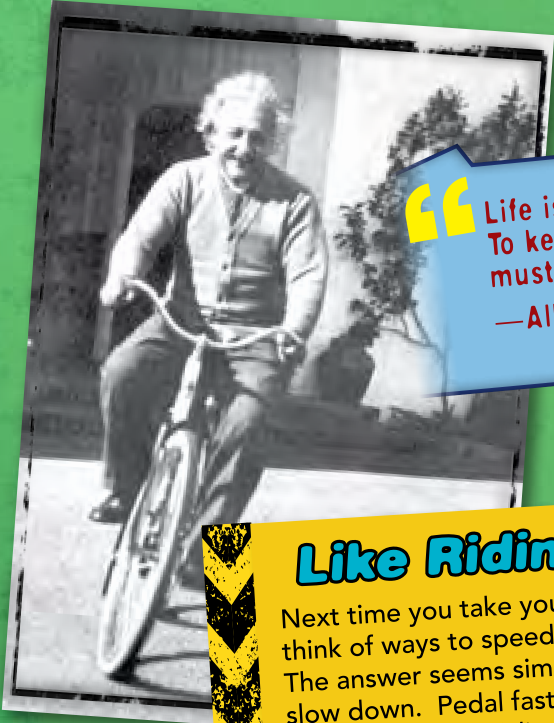
Building Blocks

Just about everyone has played with building blocks at some time. Some like to stack them as high as they can, and others like to build imaginary kingdoms. But either way, the **balancing forces** are at work, keeping the pieces stacked in place. Gravity pushes down, but the blocks push up on each other. If you keep them balanced correctly, all the blocks will stay in place. Experiment a bit and see!

Slow It Down

Think of a tug-of-war game. One team pulls the rope in one direction while another team pulls the same rope in the other direction. If the teams are evenly matched, neither moves. The forces are in balance. But what if the second team just drops the rope and walks away? The first team would have no force to resist. It could run back as fast as it wanted with the rope. The **opposing force** was slowing it down, but when the other team let go, the force disappeared.

To make something go fast, you have to maximize forces that increase speed and minimize forces that work against speed. When you want to slow down or stop, the process is reversed. You need to minimize forces that are accelerating an object and maximize those that are decelerating it.



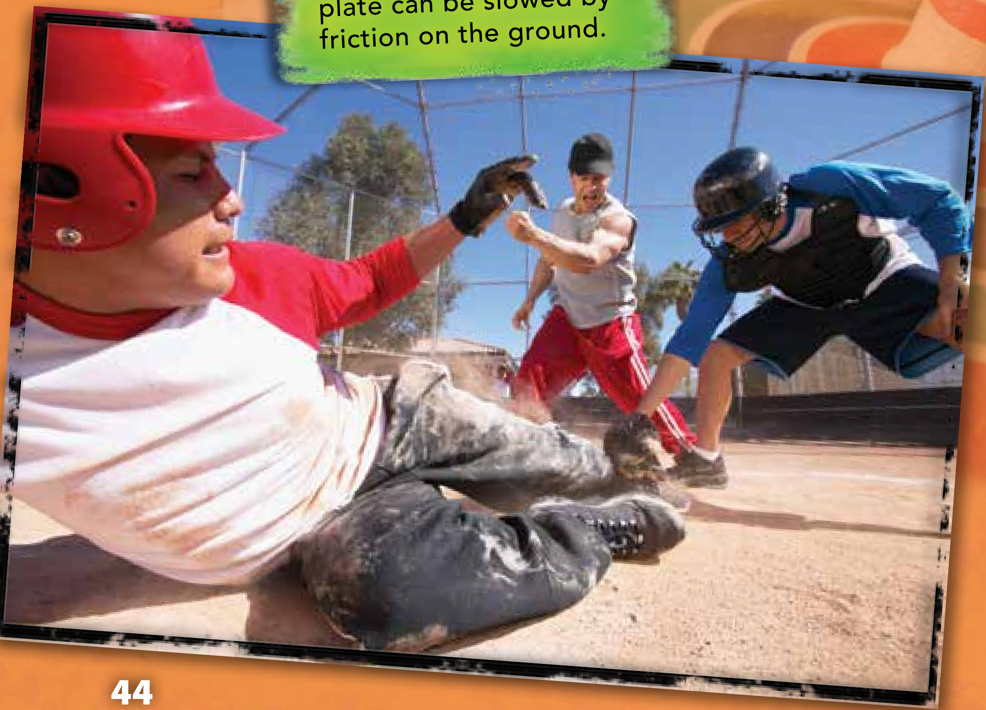
> "Life is like riding a bicycle. To keep your balance, you must keep moving."
> —Albert Einstein

Like Riding a Bike!

Next time you take your bicycle for a spin, think of ways to speed up and slow down. The answer seems simple. Stop pedaling to slow down. Pedal faster to speed up. But what if you're pedaling uphill or downhill? If you stopped pedaling while going uphill, would you slow down? If you stopped pedaling while going downhill, would you slow down? What forces are at work?

Thrust, gravity, or magnetism will tend to slow you down if they are pushing or pulling the opposite way you are going. These are called *opposing forces*, but there is another force that comes into play, too. Friction is what happens when two materials rub together. It is a force that acts on surfaces, slowing things down or stopping them from moving.

In baseball, a race to the plate can be slowed by friction on the ground.

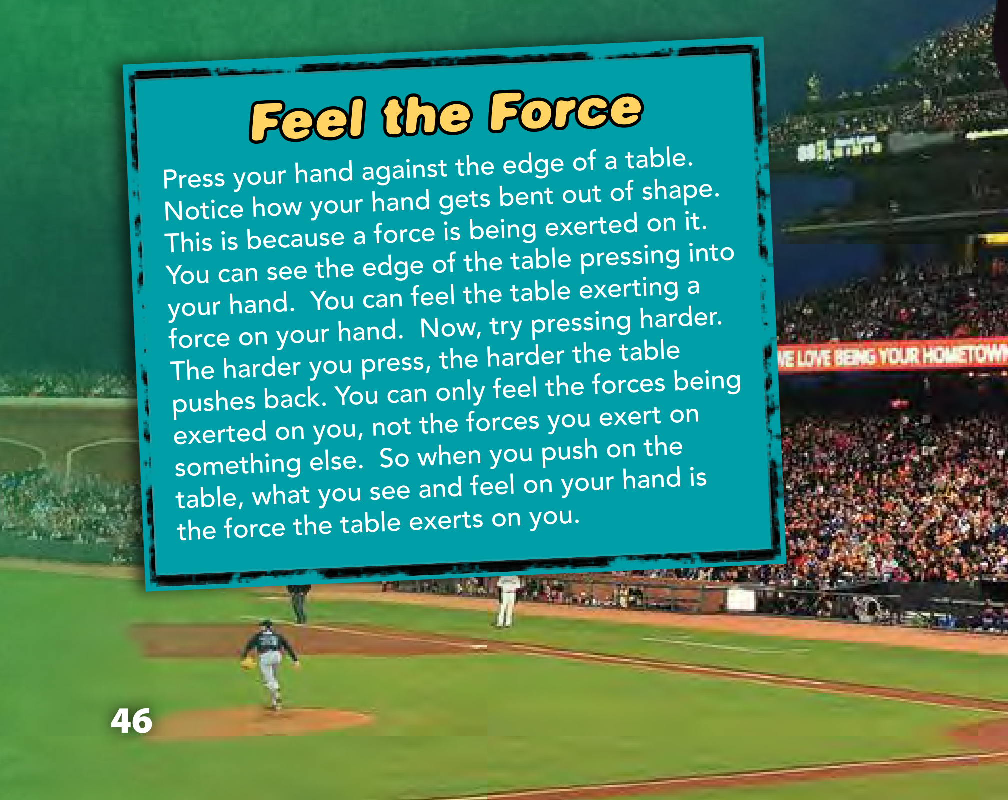


Forced Together

Think about spinning a top. What physical forces are at work? Tops stay upright as long as the forces at work are balanced. But eventually, the energy in the thrust that got the top spinning is spent. Friction slows the top down, and gravity pulls it to the ground.

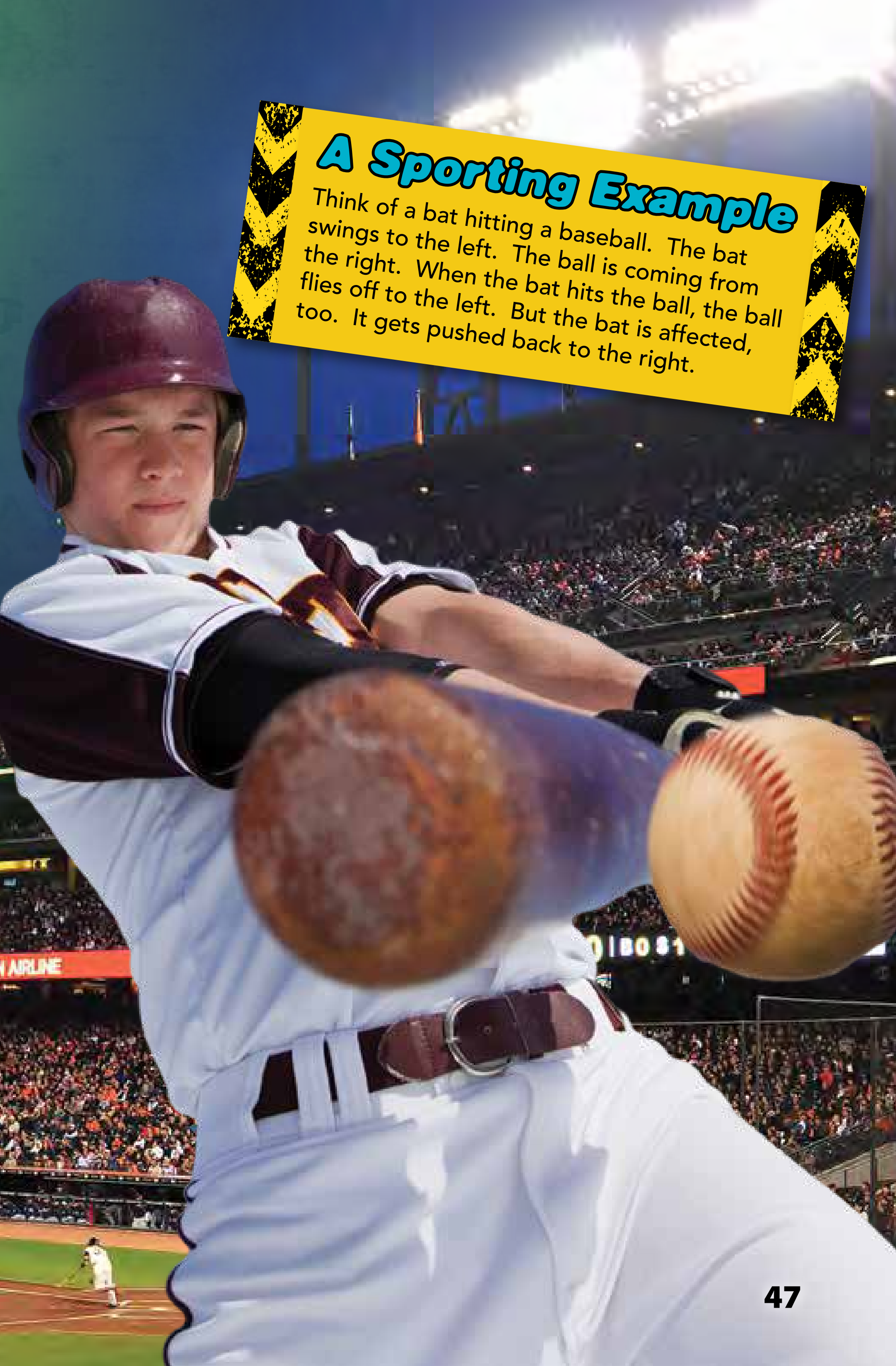
Match Up

Socks come in pairs. Twins come in pairs. Wings, arms, and eyes come in pairs. As it turns out, forces come in pairs, too! Whenever one force is applied to an object, another opposite force is also at work. These are called **action-reaction force pairs**. Newton's Third Law describes how they work. For every action, there is an equal (in size) and opposite (in direction) reaction. This is sometimes called *conservation of momentum*. If one object has momentum going in one direction, then another object receives equal momentum going the opposite way.



Feel the Force

Press your hand against the edge of a table. Notice how your hand gets bent out of shape. This is because a force is being exerted on it. You can see the edge of the table pressing into your hand. You can feel the table exerting a force on your hand. Now, try pressing harder. The harder you press, the harder the table pushes back. You can only feel the forces being exerted on you, not the forces you exert on something else. So when you push on the table, what you see and feel on your hand is the force the table exerts on you.



A Sporting Example

Think of a bat hitting a baseball. The bat swings to the left. The ball is coming from the right. When the bat hits the ball, the ball flies off to the left. But the bat is affected, too. It gets pushed back to the right.

Rub-a-dub-dub

Friction is a force that happens when things come in contact with each other. Most things are not perfectly smooth. They have little bits sticking out. They have texture to their surfaces. When they rub together, these little bits catch on each other and slow things down.

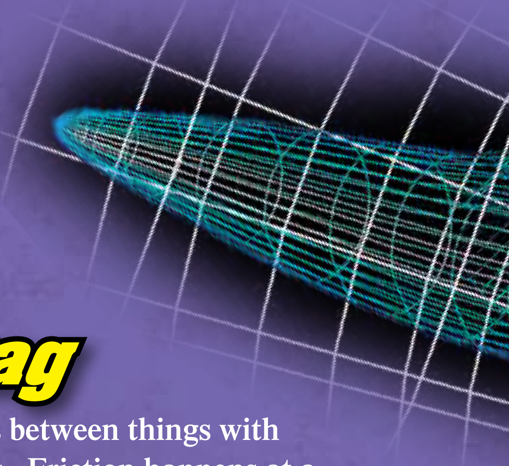
Oil can reduce friction in a bicycle and increase speed.

Hot! Hot! Hot!

Try rubbing your hands together quickly. In only a few seconds, you should start to notice them warming up. The little grooves in your skin catch on each other and create friction that changes energy into heat.

Tinker's Tip

Think about a model car again. Friction is the main force slowing it as it rolls down the ramp. So, how can you reduce the friction? First, you have to figure out where the friction is happening. In other words, what moving parts are touching? The wheels are touching the ramp. Try putting a lubricant like oil or graphite on the wheels. It will reduce friction and make your car go faster.

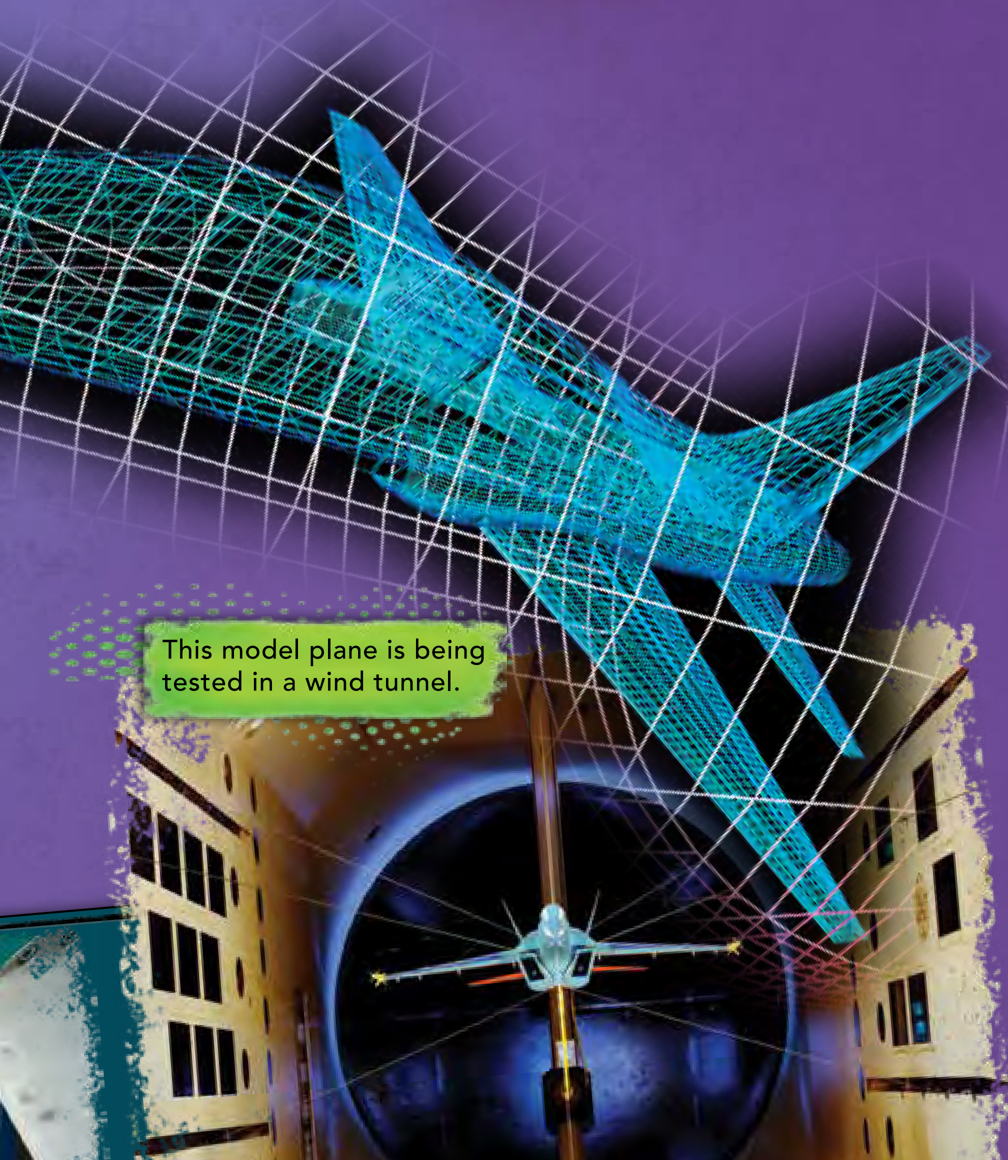


What a Drag

Not all friction happens between things with obvious bumps and grooves. Friction happens at a molecular level, too. Molecules bump and rub against each other. Think about walking into the wind. Wind is just air. It has no rough edges or grooves, but the air molecules push against you. They slow you down because they catch on the molecules in your skin. And they build up in front of you. The pull caused by the friction of a **fluid**, like air or water, is called resistance or **drag**. The force of air pushing against you is called **air resistance**.

An engineer inspects the blades of a wind tunnel.

A skier tests equipment in a wind tunnel.



This model plane is being tested in a wind tunnel.

Wind Tunnel

How can engineers tell if air is moving smoothly around something? They use a wind tunnel. The tunnel has a fan at one end that blows air in a controlled stream. The object being tested is put in the middle. Then, smoke or fog is added to the air so engineers can see how it is flowing.

Water Resistance

Have you ever tried walking in a swimming pool? The water pushes back, and it's hard to go forward. But if you turn your body to face the floor and begin to swim, you move much more easily. The force of the water as you try to pass through it is **water resistance**. When you are walking on the bottom of the pool, your body is like a big flat box. You are pushing against the water, and the water has nowhere to go. It builds up in front of you and pushes back, but when you turn lengthwise to swim, suddenly there is much less water pushing in front of you. The water slips around you easily.

Streamlining

Engineers who design cars, boats, and airplanes spend a lot of time thinking about resistance. The process of reducing resistance on an object is called **streamlining**. The idea is to move through air or water or on land without getting caught on anything.

Engineers use computers to help them predict how products will behave in air or water.

Swimming Fast

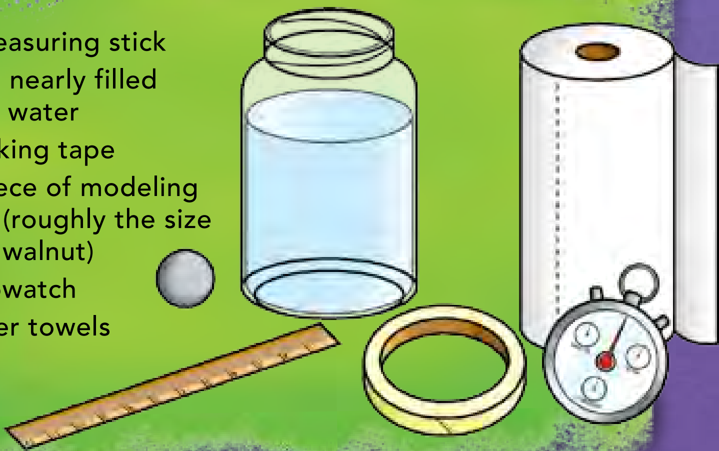
Many competitive swimmers try to make their bodies as smooth as possible. Most wear swim caps to hold down their hair so it won't create drag. Some shave off body hair before a competition. Others wear special full-body swimsuits to keep themselves as smooth as possible while they swim!

Diving Down

In this experiment, you will determine which shapes are able to slip more quickly through a fluid and which are more affected by drag. What do you notice about the shapes that fell faster compared to those that were slower? Do your observations support what you have learned about streamlining and water resistance?

Materials:

- 1 measuring stick
- 1 jar nearly filled with water
- masking tape
- 1 piece of modeling clay (roughly the size of a walnut)
- stopwatch
- paper towels

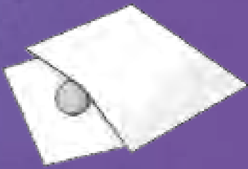


Step 1

Tape the measuring stick to the outside of the jar, leaving four inches remaining at the top. Make sure the stick is securely fastened. It shouldn't move during the experiment.

Step 2

Roll the modeling clay into a sphere. From the top of the measuring stick, drop the sphere into the water. Time how long it takes for the clay to reach the bottom of the jar.



Step 3

Gently pat the clay dry with paper towels. Take care to not let the paper stick.

Step 4

Form the clay into a long oval. Drop the new shape into the water from the top of the measuring stick, and time its descent. Remove the clay, and gently pat it dry.

To Finish

Mold the clay into a cube, a star, a flat patty, or any other shape you can think of to repeat the test. Compare your observations of each shape. Decide which shape was slowest and which was fastest. List the shapes in order from slowest to fastest.

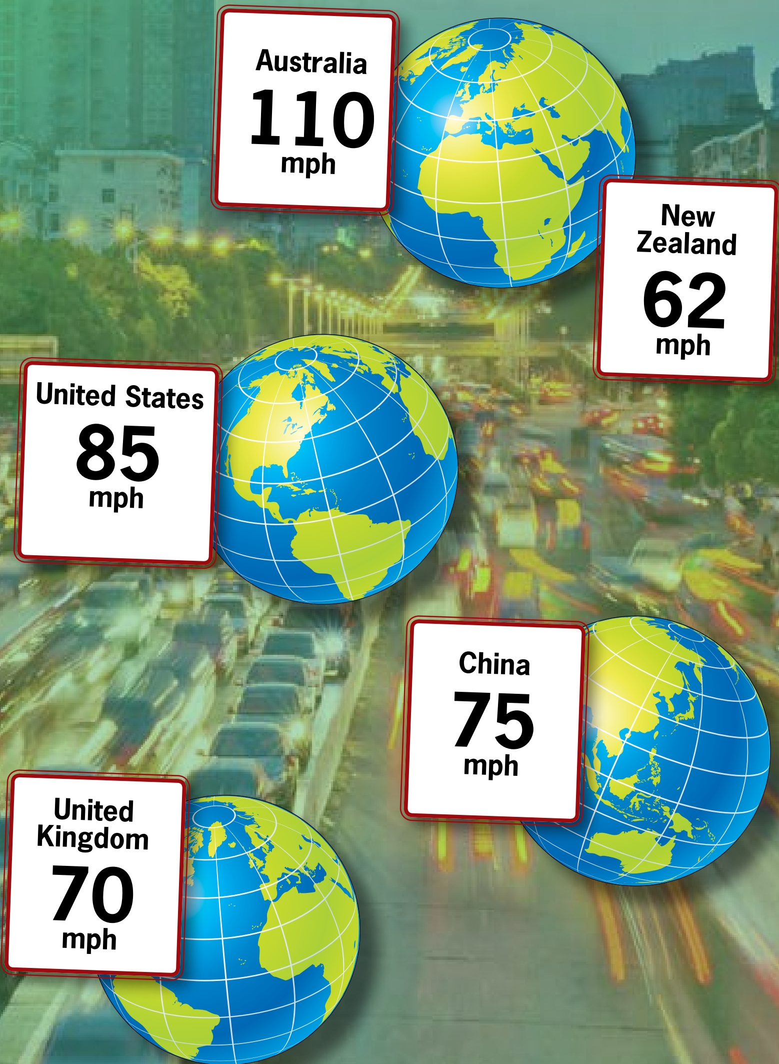
Full Speed Ahead

Nearly every roadway has a speed limit, so the speed we travel is not always up to us. But with a little knowledge of physics and plenty of energy, you can choose your own path, build up tons of momentum, and accelerate to the end of the world and back! So, experiment to find out what will take you where you want to go, and where you'll stop, no one knows!

Tinker's Tip

If something doesn't go as fast as you want it to the first time, start asking questions. Break down the motion into steps to see where you might improve the system. Then, try it again!

Speed Limits Around the World



Glossary

acceleration—the rate of change of velocity; speeding up or changing direction

action-reaction force pairs—pairs of forces that result from Newton's Third Law that states for every action, there is an equal and opposite reaction.

air resistance—the friction created as air moves past an object

axle—a fixed bar or beam on which wheels revolve

balancing forces—forces that act on each other in such a way that no change occurs

deceleration—the rate of change of velocity; slowing down or changing direction

drag—the force that acts against the motion of an object

energy—the ability to do work

exerting—putting forth

fluid—matter that has the ability to pour or flow

friction—the force that acts on surfaces in contact and slows them down or stops them from moving

g-force—the gravitational force; the force you feel when you accelerate

gravity—the pull of any object with mass

inertia—the tendency of an object to maintain its state of motion; moving things keep moving, still things stay still

kinetic energy—energy of movement

magnetism—a force that exists between special kinds of metals

mass—amount of matter something is made of

momentum—mass in motion

newton (N)—a unit used to measure force; the force it takes to move one kilogram one meter per second squared in empty space

opposing force—a force pushing or pulling in the opposite direction of another force

physicists—people who study the underlying rules of the universe, matter, and energy

potential energy—energy that is stored or results from position

relative—exists in comparison to something else

resistance—another word for *drag*; friction from a fluid

speed—change in position over time

streamlining—the process of reducing resistance

thrust—a push that gets something moving

traction—the friction of a body on a surface as it moves

upthrust—a sudden and forceful upward movement

velocity—speed in a certain direction

water resistance—the friction of water as it passes around an object

Index

Bibliography

Lepora, Nathan. ***High-Speed Thrills: Acceleration and Velocity (Theme Park Science).*** **Ticktock Media Limited, 2008.**

A theme park is the ideal place to see science in action. This book explains concepts such as force, acceleration, motion, and more, using exciting thrill rides found at amusement parks.

Spilsbury, Richard. ***Speed and Acceleration (Fantastic Forces).*** **Heinemann-Raintree, 2006.**

What's the fastest running animal on Earth? What happens when bumper cars crash? This book asks the questions you'll want answered about speed and acceleration. Charts, graphs, and hands-on experiments help bring science to life.

Sullivan, Navin. ***Speed (Measure Up!).*** **Benchmark Books, 2006.**

Learn about velocity, reaction speed, buoyancy, and gravity. Perform at-home experiments to see how familiar objects measure up.

VanCleave, Janice. ***Physics for Every Kid: 101 Easy Experiments in Motion, Heat, Light, Machines, and Sound (Science for Every Kids Series).*** **Wiley, 1991.**

Have you ever wondered what makes a curve ball curve or how magnets work? Basic physics principles are explored in these experiments. Each includes a list of materials, step-by-step instructions, the expected results, and an easy-to-understand explanation.

More to Explore

PBS Kids Physics Games

http://pbskids.org/games/physics.html

Explore the effects of friction, gravity, momentum, and other properties of physics while solving puzzles with PBS characters.

Exploratorium: Sports Science

http://www.exploratorium.edu/explore/staff_picks/sports_science/

This online museum of science features multiple web pages for investigating the different principles of physics found in sports. Some sports included are hockey, baseball, and skateboarding.

Physics Games.Net

http://www.physicsgames.net/

This is a collection of online physics-based games. Players won't even realize they're learning more about physics properties as they solve puzzles and play games.

NASA for Students

http://www.nasa.gov/audience/forstudents/index.html

Find the appropriate grade level to research interesting articles, images, and videos that show how NASA uses the Laws of Motion to plan space flights.

About the Author

Stephanie Paris is a seventh-generation Californian. She has her Bachelor of Arts in psychology from University of California, Santa Cruz, and her multiple-subject teaching credential from California State University, San Jose. She has been an elementary classroom teacher, an elementary school computer and technology teacher, a home-schooling mother, an educational activist, an educational author, a web designer, a blogger, and a Girl Scout leader. Ms. Paris lives in Germany, where she occasionally likes to drive fast on the Autobahn!

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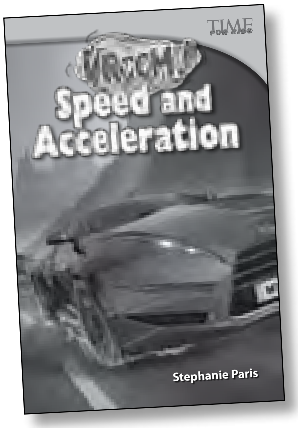

Focus Objectives

Students will be able to:

- monitor own reading strategies and make modifications.
- use text organizers to determine the main idea and to locate information in a text.

Language Objective

Students will use learning strategies to extend communicative competence.

Word Work

- **Word Study:** Similes
- **Greek and Latin Roots:** *accelerate, audience, involve, motion, pedaling, propel*
- *Greek and Latin Roots* activity sheet

Academic Vocabulary

- *acceleration*
- *gravity*
- *resistance*
- *friction*
- *inertia*

Comprehension

- **Model Lesson 1:** Monitoring Reading
- *Monitoring Reading* activity sheet
- **Model Lesson 2:** Using Text Organizers

Using Text Types

- *Vroom! Speed and Acceleration* (pages 16–33) and "Mission: Space Jump"
- List the types of forces at work in the article.

Writing

Create and write directions to a speed or acceleration experiment.

Cross-curricular Connections

- **Thinking and Reasoning:** Uses facts from books, articles, and databases to support an argument.
- **Science:** Knows that good scientific explanations are based on evidence (observations) and scientific knowledge.

Building Fluency

- **Reading the Book:** repeated readings with audio support; choral reading
- **Reading the Poem:** poetry folder; repeated readings; performance
- "What Is Physics?" poem

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Word Work

1. **Similes**—Write the sentences *The sportscar is sleek like a jaguar. The limousine was black like a panther. That truck is as fast as a cheetah* on the board. Underline the words *like* and *as.*
   - Ask students to read the sentences aloud. Ask them what they notice. Explain that the sentences are comparing cars to animals. Explain that a comparison using the words *like* or *as* is called a *simile*.
   - Give students a list of words from the book, such as *energy*, *momentum, resistance,* and *velocity,* and ask them to make sentences demonstrating similes. For example, *A race car's momentum is like a kid who had too much candy.*

Tip: Have students continue to look for similes in *Vroom! Speed and Acceleration* and other texts to add to their lists.

2. **Greek and Latin Roots**—Discuss how many words are made of a root or prefixes/suffixes with Greek and Latin roots, which can help a reader determine the meaning of the word.
   - Write *volv*, *mot*, *celer*, *ped*, *aud* and *pel*. Ask students to brainstorm words containing the word parts.
   - Discuss the meanings of each root: *volv* (roll), *mot* (move), *celer* (swift/fast), *ped* (foot), *aud* (hear) and *pel* (drive). Brainstorm a list of words that contain one of the roots (*revolve, involving, motivate, motor, locomotion, accelerate, deceleration, accelerant, pedal, pedestrian, pedicure, audible, audio, inaudible, expel, compel*, and *repel*).
   - Look in the text for words with the roots. Examples from the text include *involve*, *motion*, *accelerate*, *pedaling*, *audience*, and *propel*.
   - For additional practice with Greek and Latin roots, have students complete the *Greek and Latin Roots* activity sheet.

Academic Vocabulary

1. Develop students' vocabulary by introducing and discussing the academic vocabulary related to speed and acceleration. Write *Vroom! Speed and Acceleration* on the board or chart paper. Under it, list all the words students can name about speed. Your chart may look similar to the chart on the right.

2. Instruct students to add vocabulary words to their dictionaries. Encourage them to write a word, phrase, or sentence for each word and include a word web.

Vroom! Speed and Acceleration		
acceleration	friction	motorcycle
cheetah	gravity	resistance
energy	inertia	rocket

Model Lesson 1: Monitoring Reading

Before Reading

1. **Activating Prior Knowledge**—Have students study the cover of the book and discuss with partners what they see.
   - Ask students what they know about fast cars. Why did the illustrators choose to put a car with burning tires on the cover? What other things do you think of when you think of speed and acceleration?
   - Read the table of contents together. Then read pages 4–7 aloud.
   - Have students flip through the book and share things they already know about speed and acceleration by using the sentence frame *I already know* _____ *about* _____ *because* _____.
   - Ask students what they want to learn based on their preview. What looks interesting? Have partners share what they are wondering about the book and what they want to learn.

2. **Monitoring Reading**—Tell students that this book looks inviting but a bit overwhelming. Say, "There is a ton of new information to learn as we read. I know a little bit about speed, but acceleration I am less sure of. I want to show you some strategies for monitoring comprehension or keeping track of what is going on in the book."
   - **Model**—Read pages 8–9 aloud. Say, "I want to determine what the author is doing on these pages. I will check the big headings: 'Measuring Speed,' and the heading of the sidebar. I see that the main text looks like it tells about how the speed of things can be compared even if they are not side by side. When I start to read the first sidebar, I think about how it is related to the main part of the text. For example, when I read that the measurement you use depends on what you are measuring, I think about how my car speed is measured in miles per hour, but the ten-meter dash is measured in seconds. As I read the sidebar on page 9, I remember watching how fast the runners were in the Olympics and how their speed was measured in fractions of seconds." Also discuss the sidebar "Fast Formula" on page 9.
   - **Guided and Independent Practice**—Have students read pages 10–15 with partners, paying close attention to what they are learning about and the related sidebars. After reading, ask how the sidebars (including Dig Deeper! and Stop! Think…) were connected to the text. Also ask if there were any confusing words or parts on the pages. Encourage students to reread any confusing portions of text. Have students share one connection between the texts. What do you think was the author's purpose for including the sidebars?

English Language Support

Using the photographs and illustrations, discuss the academic vocabulary in context. For example, on pages 8–9 say, "What do you think this page has to do with speed and acceleration? What about the words *time*, *distance* and *speed*?" Allow students time to share about what they already know to help them build upon previous knowledge.

Model Lesson 1: Monitoring Reading *(cont.)*

During Reading

1. **Monitoring Reading**—Tell students that texts often use sidebars to give important and interesting details about the section they are reading. Say, "On page 19, I notice that the author is telling us important information about potential and kinetic energy. Sometimes readers look ahead and read the sidebars before reading the section. Doing that gives readers a preview of the section. After reading, they go back and reread the sidebars to check their understanding."
   - **Model**—Read the first sidebar aloud. Say, "How does this help me know what I will be reading about? I have a feeling that because the author tells us about potential and kinetic energy, it will have something to do with power and speed. I think I will read with the purpose of learning about what potential and kinetic energy have to do with speed and acceleration. I will continue reading each paragraph one sentence at a time, asking myself what each one tells me about speed? I will also look at the illustrations and captions to learn more about kinetic and potential energy. Strategies like reading the heading, rereading the sidebars and captions, and checking the illustrations help us monitor our reading."
   - **Guided and Independent Practice**—List strategies for monitoring comprehension on the board. Ask students to establish a purpose for reading. Have students share their purpose for reading and which strategies they used while reading with partners.

✓ **Assessment Opportunity—**As students read, observe which strategies they use to establish a purpose for reading.

After Reading

Monitoring Reading

- **Model**—Review your purpose for reading the section. Say, "When I first started reading this section, I wanted to determine what potential and kinetic energy had to do with speed and acceleration. I wonder if I did that. I will reread the first few sentences and think about what I learned from reading the section."
- Reread the first three sentences. Say, "After reading this page, I know that potential energy, just like the car at the top of the race track, is waiting energy. I also know that kinetic energy is working energy, which is what the car is using to go down the incline. Without that example, I might not have understood it quite so well. It makes me think of the change from potential energy to kinetic energy that happens when someone says 'go' in a race."
- **Guided and Independent Practice**—Have students flip through pages 16–41 with partners, looking at the sidebars for clues that helped them read for a purpose. For additional practice with comprehension, have students complete the *Monitoring Reading* activity sheet.

English Language Support

Put a sheet of chart paper on the board. Label one side *speed* and the other side *acceleration*. Have students sort words, illustrations, and pictures from the book into each category and then tape or glue the pictures, words, or illustrations in the appropriate column.

Model Lesson 2: Using Text Organizers

Before Reading

1. **Activating Prior Knowledge**—Ask students to take a text walk through the first 41 pages of the book to look for personal connections. What is the most interesting fact about speed and acceleration that they have learned so far? What do they know about how or why it is important from their own previous knowledge and experiences?

2. **Using Text Organizers**
   - **Model**—Tell students that one technique good readers use to help monitor their reading is to notice the way the author organizes the text and compare it to what they already know.
   - Read the sidebar on page 43 with students. Say, "This section is called 'Like Riding a Bike.' Before I read I can see that there are a number of question marks. I can then think of a text organizer for question and answer. I think of clues the author may use to indicate question and answer and skim the text to look for words like *how, what, when, where, why, who,* and *how many*." Model skimming the text and finding the word cues. Then discuss how the author poses questions but does not answer them. Discuss why the author might not provide answers.
   - **Guided and Independent Practice**—Ask students to read "Slow it Down" on page 42. Skim the text together. Ask students to identify a text organizer to use with the section or part of the section. (*compare and contrast, sequence, descriptive*)

English Language Support

Have students read "A Sporting Example" on page 47. Discuss how the example of the ball and bat is cause and effect. Use the story to model a cause and effect text organizer that has multiple effects.

Model Lesson 2: Using Text Organizers (cont.)

During Reading

1. **Using Text Organizers**
   - **Model**—Tell students that as they read, they will see the chapter titles from the table of contents throughout the text.
   - Take a text walk through the book, stopping to read each section title. Say, "Section titles keep us on track when we read because they tell us what that specific section is about. So the heading 'What a Drag' on page 50 helps me to know that I will be reading about resistance and then as I look ahead, I see that the next section on page 52 is about water resistance. I could use a Venn diagram to compare air and water resistance."
   - Read pages 50–53 aloud and model how to fill out a Venn diagram using information from the text.
   - **Guided and Independent Practice**—Have students read pages 54–55 silently. Provide student pairs with a flow chart to fill out while reading.

English Language Support

Allow extra time to build academic vocabulary. Compare verb and noun forms of the following words: *speed, speeder; race, racer; push, pusher; bowl, bowler*. Have students practice using the words in sentences.

Assessment Opportunity—When coaching individuals, ask them to show you how to use the chapter titles to predict and to summarize a section.

After Reading

1. **Summarizing and Responding**—Discuss the book. Have students use chapter titles and illustrations to take turns summarizing the main points on each page with partners.

2. **Using Text Organizers**
   - **Model**— Remind students that a text organizer can help you predict what you are going to read as well as help you remember the main points of what you have already read. Discuss why an author might include a graphic or diagram such as a flow chart (page 23). How does that visual help the reader prior to reading? How does it help the reader remember what was read?
   - Take a few minutes to discuss the "Swimming Fast" sidebar on page 53. Ask why the author chose to include this information. How do sidebars help the reader?
   - **Guided and Independent Practice**—Have students identify the formatting and organization of various sidebars with partners. What are possible reasons why the author chose to organize the text this way? How does this organization help the reader?

Comprehension Mini Lessons and Practice Opportunities

Monitoring Reading

Entire book	**Tricky Words "In" and "Around"**—Ask students to find at least two tricky words in the book. Have them sit in a circle, taking turns "teaching" one of their words to the group using at least two monitoring strategies. One strategy should involve reading "in" the word and another reading "around" the word, using context clues and illustrations. Strategies may include rereading, sounding it out, reading on, asking a friend, and looking it up.
Entire book	**Monitoring Reading Strategies Chart**—Create a wall chart that lists strategies students can use to monitor their comprehension including rereading, reading on, checking the illustrations, sounding out the word by looking in and around it, thinking of another word that would make sense, looking the word up in the glossary, and asking a friend.
Any page in the book	**Monitoring and STOPPING to Fix It!**— Have students practice making a hand motion to represent "stop" like a traffic officer. Then read aloud from any page in the book. Ask students to make their stop motion when they think you should stop to discuss a confusing word or concept. Discuss the confusing part and model various monitoring strategies that may help fix the confusion.

Using Text Organizers

Pages 16–41	**Using Text Organizers**—Have students reread pages 16–41. Have pairs or teams identify the text organization and possible reasons the author chose to organize in that way.
Entire book	**Using Captions**—Ask students to reread the captions through the text. Have pairs or teams identify important information.
Pages 14–15	**Studying a Graph**—Have students discuss the graph on pages 14–15 in teams. Have each team identify information they can learn from the graph and identify why the author chose to include it.
Page 5	**Think Link**—Invite students to think of why the author and publisher chose to include the questions. How does thinking about those help you read the text? Why did they choose to include them at the beginning? Where else could they have put them?

Using Text Types

Reread "Going Faster" (pages 16–33) of *Vroom! Speed and Acceleration*. Then read "Mission: Space Jump." Have students work in groups of three, listing the forces that worked on Austrian skydiver Felix Baumgartner during his skydive. What connections can they make between the book and the article?

Writing

Help students create and write directions to a speed or acceleration experiment.

- **Below-grade-level students:** Write a paragraph describing the goal of the experiment, materials needed, and how to perform it.
- **On-grade-level students:** Write a paragraph describing the goal and materials needed, and one paragraph describing the sequence of events to perform the experiment in some detail.
- **Above-grade-level students:** Write an introductory paragraph (goal and materials needed), one to two paragraphs of instructions on how to perform the experiment, and a concluding paragraph. Instructions should include how to do each step and use content vocabulary.

Cross-curricular Connections

Thinking and Reasoning—Discuss the idea that speed is relative. Ask students to research and present a persuasive argument either for or against the idea.

Science—Have students create a picture dictionary to explain some of the content area vocabulary throughout the book *Vroom! Speed and Acceleration.*

Building Fluency

1. **Reading the Book**—Use the choral-reading strategy to read the book several times with students, and allow students to practice reading the book silently and in pairs.

2. **Reading the Poem**—Use one or all of the following methods for fluency practice:
   - Provide copies of the poem "What Is Physics?" for students. Read the poem aloud one time so students can hear the proper rhythm.
   - Have students highlight the punctuation marks throughout the poem. Discuss how punctuation marks help the reader know how to read.
   - Have student pairs rearrange the punctuation marks, so the sentences are grouped in different ways resulting in a different rhythm. Allow pairs to read their version of the poem to the class.

Assessment Opportunities—Use the oral reading record and the fluency rubric provided in the Assessment Guide to assess students' ability to read the book and poem fluently and accurately.

Mission: Space Jump

Austrian skydiver Felix Baumgartner makes a record-breaking 24-mile jump from space

October 15, 2012 By Kelli Plasket with additional AP reporting

Austrian Felix Baumgartner—a pilot, skydiver and high-altitude jumper with the nickname "Fearless Felix"—has jumped from some of the world's tallest bridges and buildings. But on October 14, he made the jump of his lifetime from a space capsule 128,100 feet (about 24 miles) above ground, a world record-breaking height. That distance put him on the edge of space in the stratosphere, the second layer of Earth's atmosphere.

Baumgartner, 42, also broke the record for fastest jump by reaching speeds up to 833.9 miles per hour during his free fall back down to Earth. For comparison, an average Boeing 737 airliner flies at 40,000 feet at 600 miles per hour. At a press conference following the event, Baumgartner said the experience was humbling and harder than he expected. "Sometimes you have to go up really high to understand how small you are," Baumgartner said.

A Long Way Down

Baumgartner and a team of scientists, engineers and doctors spent five years preparing and training for the project, called Red Bull Stratos after the project's sponsor. For the space jump, Baumgartner wore a specially designed space suit and was carried up to his jump point by a large helium balloon from inside the Red Bull Stratos space capsule.

Even with careful planning, the mission had some obstacles. The jump was first scheduled for October 8, but it was postponed several times over the week because of weather conditions. Baumgartner finally began the ascent from Roswell, New Mexico, on Sunday, October 14. But on the way up, Baumgartner's faceplate began to fog up, making it hard for him to see. The team considered aborting the mission, but Baumgartner was able to fix the problem.

After a smooth initial jump, Baumgartner began to spin out of control while still in the stratosphere, but he eventually steadied himself. After four minutes and 20 seconds of free fall—with about a mile left to go in the jump—Baumgartner released his parachute and landed safely in the desert of New Mexico. From Earth, eight million people watched the space jump event live over a YouTube stream.

http://www.timeforkids.com/news/mission-space-jump/53181

What Is Physics?

by Sharon Coan

My big sister's taking physics;
It's a class in her high school.
She says she has to work hard,
But she thinks it's really cool.

I asked her what it's all about.
She answered mysteriously,
"Stuff like pressure and friction."
I said, "Physics isn't for me!"

"Oh, yes, it is," my sister claimed.
"Follow me!" was her demand.
We used a pump on my bike tire.
Air pressure made it expand.

Next we found my old toy cars.
I wondered where this would lead.
The surfaces on a ramp she built
Showed how friction affects speed.

She pointed to my skateboard,
And the box with the sport balls,
"Knowing about force and motion
Could help you avoid some falls."

"Physics will show you how things work.
Are you beginning to see?"
"I get it," I was forced to admit.
"I think physics *is* for me."

Name: ________________________________ Date: ___________

Greek and Latin Roots

Directions: Using a dictionary, locate words with the roots below. Read the definitions and determine the common meaning of the root. Then write the meaning in the box.

Greek and Latin Root	Meaning
1. *celer* **examples**: accelerate, decelerate	swift, fast
2. *mot* **examples**: motion, motor	
3. *volv* **examples:** revolve, involve	
4. *aud* **examples:** audible, audience	
5. *pel* **examples:** compel, repel	
6. *ped* **examples:** pedal, pedicure	

Challenge: Choose two words with a Greek or Latin root and use them in a sentence.

7. ____

____

8. ____

____

Name: ______________________________ Date: ___________

Monitoring Reading

Directions: Read the questions below about monitoring your understanding of the text. Then write your thoughts about how to boost your understanding.

What do I easily understand?

1. ____

____

2. ____

____

3. ____

____

What parts are more difficult to understand?

4. ____

____

5. ____

____

What can I do next time to help me better understand the more difficult parts of a book? (Circle one or more.)

Reread the section.	Read more slowly.
Make a flow chart.	Look at the main idea and key words.
Talk with someone about it.	Use picture clues.
Look up words I don't understand.	Make connections to what I already know.
Think about how the text is structured.	Preview the captions and sidebars.
Act it out.	Other: ________________

Multiple-Choice Test

Name: ________________________________ Date: __________

Directions: Read each question. Choose the best answer. Fill in the bubble for the answer you have chosen.

1. **Which of these is an example of potential energy?**
   - (A) a model car at the top of a ramp
   - (B) a swimmer diving deep
   - (C) a model car racing down a ramp
   - (D) a runner crossing the finish line

2. **_____ is *not* a force that affects the speed of an object.**
   - (A) Gravity
   - (B) Friction
   - (C) Kilometer
   - (D) Thrust

3. **Shelly taps a ball with her foot. Bridget kicks the ball. What can you predict?**
   - (A) The ball will go farther when Shelly taps it.
   - (B) The ball will go farther when Bridget kicks it.
   - (C) The ball will not move at all.
   - (D) The ball will roll downhill.

4. ***Drag* is another word for _____.**
   - (A) momentum
   - (B) deceleration
   - (C) gravity
   - (D) resistance

5. **_____ is a change in speed over time.**
   - (A) Acceleration
   - (B) Inertia
   - (C) Velocity
   - (D) Streamlining

6. **Sam is pushing a box filled with books. Bryan is pushing an empty box. What will probably happen?**
   - (A) Sam will need to push harder than Bryan.
   - (B) Sam and Bryan will need to use the same amount of force to push their boxes.
   - (C) Bryan will need to push harder than Sam.
   - (D) The boxes will not move.

Multiple-Choice Test *(cont.)*

Name: ______________________________ Date: ____________

7 If you have ever ridden a roller coaster, then you can understand how _____.

- (A) to use streamlining
- (B) fast the speed of light is
- (C) inertia works
- (D) gravity affects speed

8 Maddie rolls a ball down a hill. It doesn't stop until it hits a wall at the bottom of the hill. Why doesn't the ball stop sooner?

- (A) momentum
- (B) friction
- (C) deceleration
- (D) buoyancy

9 A rocket must have a powerful engine to get it into the air. That engine gives the rocket _____.

- (A) potential energy
- (B) friction
- (C) gravity
- (D) thrust

10 Sir Isaac Newton was important because _____.

- (A) he was not always a good student
- (B) his laws help us explain how forces work
- (C) he served in Parliament
- (D) he developed the first race car

11 In this book, the most important thing to remember about friction is that it _____.

- (A) is a force that increases speed
- (B) changes energy into heat when you rub your hands together
- (C) is a force that reduces speed
- (D) makes objects stick to each other

12 Suppose you want to design a new, faster race car. Which force will you need to overcome?

- (A) friction
- (B) acceleration
- (C) thrust
- (D) kinetic energy

Vroom! Speed and Acceleration

Greek and Latin Roots, p. 11

1. swift, fast
2. move
3. roll
4. hear
5. drive
6. foot
7. *Answers will vary.*
8. *Answers will vary.*

Monitoring Reading, p. 12

Answers will vary.

Multiple-Choice Test, p. 13

1. A
2. C
3. B
4. D
5. A
6. A
7. D
8. A
9. D
10. B
11. C
12. A

Using an Oral Reading Record

When taking an oral reading record, it may be useful to employ some or all of the following tips:

- Position yourself next to the student in such a way that you can hear the student easily, see the text clearly, and watch the student's eye and finger movements while he or she is reading.
- As the student reads, mark the oral reading record form with the conventions on the included coding chart on the following page.
- Errors to be marked include substitutions, omissions, insertions, and having to be told a word by the teacher.
- Self-corrections occur when a student realizes an error on his or her own and corrects it.
- Note where the errors and self-corrections are made via meaning, structure, or visual cues (defined below).
- If the student begins to read too quickly for you to follow, simply ask him or her to pause for a moment while you catch up with the record.
- Interrupt and intervene as frequently as possible in order to create the truest record.
- Wait several seconds when a student gets stuck before reading a word aloud for the student.
- If a student misreads a word, be sure to write the word he or she said above the correct word on the record form.
- Time the student to test for fluency. The Reading First standard for first grade is 60 words per minute. (It is 90 to 100 words read correctly by the end of second grade and 114 by the end of third grade.)

Meaning, Structure, and Visual Cues

Meaning. When the reader uses background knowledge and the context to identify words, he or she is using meaning (or semantic cues). On the oral reading record, mark these cues with an *M*.

Structure. When the reader applies knowledge of language structure in order to identify words, he or she is using structure (or syntax) cues. On the oral reading record, mark these cues with an *S*.

Visual. When the reader applies knowledge of letter and sound correspondence, including the look of the letter, letters, and the word itself, he or she is using visual (or graphophonic) cues. On the oral reading record, mark these cues with a *V*.

Marking Conventions Chart

Behavior	Marking Convention	Example
Accurate reading	(checkmark) above each word read	✓ ✓ ✓ This is big.
Substitution	Word read above actual word	✓ ✓ -bag This is big.
Omission	— (long dash)	✓ — ✓ This is big.
Insertion	^ and the inserted word	very This is ^ big.
Repetition of word (no error)	*R* (one repetition) *R2* (two repetitions)	R This is big.
Repetition of phrase (no error)	*R* with line and arrow at point where reader returned	→ R This is big.
Self-correction (no error)	*SC* after error	bag/SC This is big.
Appeal (Student appeals for help either verbally or nonverbally.)	*A* over word where appeal occurred	A This is big.
Told (Student is asked to try again but ultimately must be told the word.)	*T* over word student was told	T This is big.
Beginning sound read separately and then word read correctly.	Beginning sound above word followed by mark for correct	b/✓ This is big.

Scoring an Oral Reading Record

Teachers will use the information gathered while observing the student and marking the record in order to calculate rates of accuracy, error, and self-correction. The error and self-correction rates are written as ratios. The accuracy rate is a percentage. (**Note:** When the reader self-corrects, the original error is not scored as an error.)

After or while marking the oral reading record as you observe the student, tally errors and self-corrections in the columns to the right of the text. Then circle whether those errors and self-corrections are in the area of meaning (M), structure (S), or visual (V) cues.

Use any of the following data calculations as appropriate to monitor student progress and inform instruction.

- **Calculate the rate of error.** Add the total number of words read. Divide that number by the number of errors made.

  For example, if the text has 96 words and 8 errors were made, the ratio is 1:12 (one error for every 12 words read).
- **Calculate the rate of self-correction.** Add both the number of errors and self-corrections. Then divide that number by the number of self-corrections.

  For example, if there are 8 errors and 6 self-corrections, that makes 14 total. Divide 14 by the number of self-corrections (6). This gives a ratio of 1:2.3 or, rounded, 1:2. This is interpreted as one self-correction for every two errors.
- **Calculate a percentage for accuracy.** Convert the error rate to judge the difficulty of the text. Use the information in the chart below to inform text selections for students.

  For example, in a 1:12 error rate, divide 1 by 12 to get 0.08 (round to the nearest hundredth) or 8%. Subtract 8% from 100% to get 92%. This is the accuracy percentage.

  Use the information below to determine test difficulty.

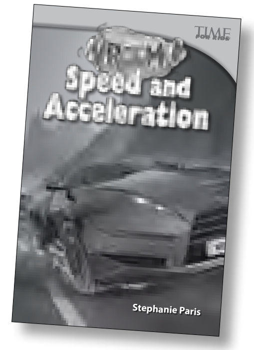
Accuracy Percentage	Difficulty of Text for Student
96% or higher	Easy
91%–95%	Instructional level
90% or lower	Challenging

Note: If you do not wish to assess with this level of detail, simply calculate the percentage of words read correctly and the number of words read correctly per minute. Both of these measures give adequate indications of word recognition and fluency. However, keep in mind that these calculations provide one kind of data for students—teachers should examine students' reading and learning in context, as individuals and as members of the larger learning group.

Fluency Rubric

Score	Accuracy	Rate (Pace)	Expression	
			Structural phrasing, pausing, smoothness, pitch, volume	**Interpretive** mood, purpose, emotion, subtleties of meaning
4	Recognizes most words and reads them correctly without hesitation.	Consistently reads at a natural, conversational pace, or as appropriate for the text.	Reads smoothly. Consistently uses meaningful phrasing and appropriate pausing. Adjusts pitch and volume to the circumstances (type of text or audience).	Recognizes different purposes for reading. Consistently conveys the appropriate mood and emotion. Distinguishes word meanings in context.
3	Recognizes pretaught and familiar words and reads them correctly. May hesitate, but can use context and apply word-attack skills.	Sometimes reads at a conversational pace, but is inconsistent. May speed up and slow down or generally read at a slightly slower pace.	Reads smoothly in general, but with some breaks or misuse of pausing. Is aware of pitch and volume.	Reads most text with emphasis appropriate for the purpose and mood of the text. May at times slip into concentrating on pronunciation, but will usually recover and resume once past the problematic area.
2	Recognizes and reads some words correctly, but hesitates. Has some difficulty using context clues and applying word-attack skills.	Reads somewhat slower than appropriate for text. May have stops and starts or have to go back and reread.	Reads unevenly. May miss punctuation clues, resulting in choppiness or run-on reading. Does not generally attend to pitch and volume.	May use natural-sounding language at times, but, in general, frequently resorts to focusing on word-by-word pronunciation without regard for the mood, purpose, or intended meaning.
1	Misreads words frequently. May not recognize words in different contexts. Is not adept at applying word-attack skills.	Reading is slow and laborious. Frequently hesitates, stops, or goes back to "start over."	Does not usually read in meaningful units, such as phrases or clauses. May read word by word with little attention to context or punctuation signals.	Reading is generally monotone and lacks a sense of awareness of mood, purpose, or emotion. May not recognize word meanings in context.

Oral Reading Record



Name: ______________________________ **Date:** __________

Assessor: ____

Word Count	Codes				
293	E = errors	SC = self-corrections	M = meaning	S = structure	V = visual

Page	Text	E	SC	Cues Used E	Cues Used SC
4	Race cars zoom across the finish line, soccer balls whiz down the field, and dancers throw themselves through the air in leaps and bounds. Moving fast feels exhilarating, but how fast is fast? Kyle Petty, a record-winning race-car driver, sums it up well. "Speed is relative. Does it feel fast going 70 miles per hour down an 8-lane highway? No, probably not, but I bet it does if you are going down some single-lane dirt road. It's the same in a race car. It depends on the track." In other words, how fast something is moving depends on what it's being compared to. The fastest car appears as slow as a turtle when it's being compared to the fastest jet, but how fast is a jet when it's compared to the speed of light?			M S V	M S V
	SUBTOTALS				

GO ON

Oral Reading Record *(cont.)*

Page	Text	E	SC	Cues Used E	Cues Used SC
6	How long does it take you to walk to school? The answer depends on two things: the distance you need to travel and how quickly you are moving. Speed is a way to measure how fast something is going. It is defined as a change of position over time. It describes how long it takes for something to get from one place to another.			M S V	M S V
8	The point of a race is to determine who or what moves the fastest. That's exactly what some kids do each year in derbies. In these races, participants start with the same materials. They begin with a block of wood, an axle, and wheels, or they might use a small plastic model car. Either way, only one car can win the race. In a race, each participant's car travels on the same track at the same time. The winner is easy to spot. Just look for the car that crosses the finish line first.			M S V	M S V
	Subtotals from previous page				
	TOTALS				

Error Rate:		**Self-Correction Rate:**		**Accuracy Percentage:**		**Time:**	

Notes