Force & Motion Activity Tub

Designed to meet these objectives:

- Students will be able to describe Newton's First, Second, and Third Laws of Motion and identify examples of these laws at work in the world around them.
- Students will know that unbalanced forces cause changes in the speed of an object's motion.
- Students will understand qualities of motion including position, velocity, acceleration, and momentum, as well as forces which hinder motion, like friction.

What's Included

- Activity guide with reproducibles
- Wall chart
- 8 experiment cards
- 25 vocabulary cards
- 12 large marbles
- 5 small marbles
- 12 straws
- 12 balloons
- 36 feet of string
- 5 feet of tubing
- Stopwatch
- Cart launcher
- 2 wooden carts
- 2 wooden ramps
- Measuring tape
- 2 pieces of sandpaper
- Storage tub

Using the Force and Motion Activity Tub

The perfect tool to set learning in motion, this all-in-one activity tub has everything you need to help students learn about force and motion. The materials in the tub give students hands-on experiences with concepts like gravity, velocity, acceleration, friction, and more. As students race cars on ramps, build roller coasters, and watch balloon rockets zoom by, they will truly see Newton's laws in action.

The easy-to-follow experiment cards, reproducibles, vocabulary cards, and other supplies are all designed to support national science standards. The activities are simple to set up and kid-friendly enough for students to do on their own or in small groups. We've also included plenty of background information on each topic, so you can dive right in to the experiments. As you teach your students about force and motion, these memorable activities will really have an impact on them!

NOTE: Each experiment or activity found in the guide or on the experiment cards features a list of the materials needed to complete it at the top. Supplies that are provided in the activity tub are shown in **bold print,** while those you need to supply yourself are in *italics*—so it's always easy to see exactly what you need.

⚠ WARNING:

CHOKING HAZARD—Item contains small parts, a marble, and balloons. Not for children under 3 yrs.

Children under 8 yrs. can choke or suffocate on uninflated or broken balloons. Adult supervision required.

Keep uninflated balloons from children. Discard broken balloons at once.

DD354
Ages 9+

(800) 428 - 4414
www.lakeshorelearning.com

Table of Contents

Background Information

Activities & Reproducibles

The Basics of Force & Motion

A **force** is a push or a pull. Much of what we know about forces and their resulting motions comes from the ideas of Sir Isaac Newton. A mathematician and scientist, Newton lived in England during the 1600s. He published his observations and theories about force and motion in 1687. Even though Newton's document is now hundreds of years old, the three "laws" he presented are still the foundation of modern physics. To explore force and motion, we need to understand Newton's three laws and be able to identify them in the world around us.

Newton's First Law of Motion

- **An object at rest tends to stay at rest, and an object in motion tends to stay in motion, unless acted upon by an outside, unbalanced force.**

Newton's First Law basically argues that objects—whether they are staying still or moving—tend to keep on doing what they're doing until something interferes. When we put something down, it tends to stay in that spot until someone or something moves it. The second part of this law—that a moving object will stay in motion—is more difficult to grasp. It's hard to picture an object in motion forever since moving objects always seem to slow down at some point.

When objects slow down or stop moving, it's always due to an outside force, like friction or air resistance. **Friction** occurs when two objects rub against each other. As a skier moves over the snow, the contact between the skis and the snow creates **sliding friction**. An object (like a skateboard) rolling over a surface creates **rolling friction**.

Newton's First Law is also called the "law of inertia." **Inertia** is another word to describe an object's tendency to stay in motion or at rest unless an outside force interferes.

Balanced and Unbalanced Forces

Newton's First Law of Motion assumes that the forces acting on the object are **balanced**. When a book is at rest on a table, the force of gravity pushing down on the book is equal to the force of the desk pushing up. The forces acting on the book are balanced, so the book stays put. The same is true of objects in motion. If the forces acting on a moving object are balanced, and no other outside forces interfere, the object would keep on moving forever.

Unbalanced forces cause a change in position or motion. If two people are arm wrestling and both exert the exact same amount of force, their arms will be deadlocked in the same spot. The balanced forces cancel each other out, causing a state of **equilibrium** where there is no motion or change. As soon as one person exerts more force, the forces become unbalanced. Unbalanced forces always result in motion. In the case of the arm wrestling, the stronger arm will overtake the weaker arm and push it down.

Once an object is set into motion, we can measure how fast it travels and calculate its **speed**. We can also calculate the **velocity**, which describes the speed and direction of a moving object. If the moving object travels at the same, unchanging velocity, it has a **constant** speed. A change in velocity (speeding up) causes **acceleration**.

Newton's Second Law of Motion

- **Acceleration of an object depends on the force and mass.**

While Newton's First Law describes how objects behave when forces are balanced, his second law is about what happens when two forces are unbalanced. Newton's Second Law says that once an object is set in motion, its acceleration will depend on two things: force and mass. In fact, this law of motion is often expressed as an equation: **Force equals mass times acceleration** (F = ma).

Force and acceleration are proportional to each other—the amount of force is equal to the amount of acceleration. The greater the force exerted on an object, the more it will accelerate. For example, the harder you kick a ball, the farther and faster it will travel.

The opposite is true of mass. The more mass an object has, the less it will accelerate. If you kick a tennis ball and a bowling ball with the same amount of force, the heavy bowling ball is going to move slower and go a shorter distance than the tennis ball. A heavier object requires more force to set it in motion.

Newton's Third Law of Motion

- **For every action, there is a reaction that is equal in magnitude and opposite in direction.**

Forces always occur in pairs, and Newton's Third Law of Motion helps us understand the relationship between pairs of forces. Every time a force, or action, occurs, it causes a reaction. We can describe the reaction in terms of its strength, or magnitude, and also its direction.

The magnitude of the action is equal to the magnitude of the reaction. For example, if you toss a pebble into the water, it's going to create a small ripple or splash. If you hurl a large boulder at the water, the splash is going to be bigger. The force of the action and reaction always match up.

While an action and its reaction are equal in magnitude, they are opposite in direction. The rock plunges down into the water, but the water splashes up. When you throw or shoot something forward, the recoil of the force pushes you backward. Every time a force acts on an object, it causes a reaction force in the opposite direction.

Kinetic & Potential Energy

Energy is the ability to do work. An object doesn't have to be in motion to possess energy. **Potential energy** is energy that's stored in an object. (In fact, it's also referred to as **stored energy**.) An object's position or circumstances give it potential energy. A spring on the bottom of a pogo stick has **potential energy** when someone is standing on the pogo stick. The coil of the spring compresses when pressure is applied, storing up energy that will later be released. The more height and mass an object has, the more gravitational potential energy it has.

Once an object is in motion, it has **kinetic energy**. When the spring compresses and releases, the kinetic energy of the spring pushes the pogo stick and its rider up into the air. When the person jumps on the pogo stick and the spring compresses again, more potential energy is stored in the spring. When the spring releases, the kinetic energy of the spring pushes the rider up once again.

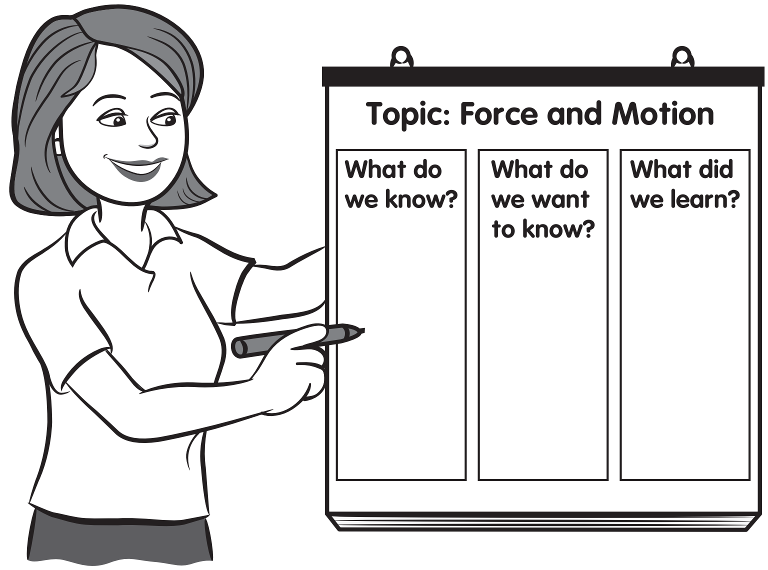
KWL Chart

Activity 1

What You Need

- *Chart paper*

Directions



Explain to your students that you are beginning a new topic in physical science. Review the differences between physical science, life science, and earth science. Tell the class that your new topic is going to be force and motion. Make a KWL Chart on chart paper (see the illustration at right).

Divide your class into groups and have each group make a KWL Chart. Ask them to list something they already know about force and motion, and then to write down things they want to find out. Bring the whole class back together and invite a member from each group to record their group's ideas on the classroom chart. Post this classroom KWL Chart where students can see it, and refer to it as the class continues to study force and motion.

Newton's First Law

Activity 2

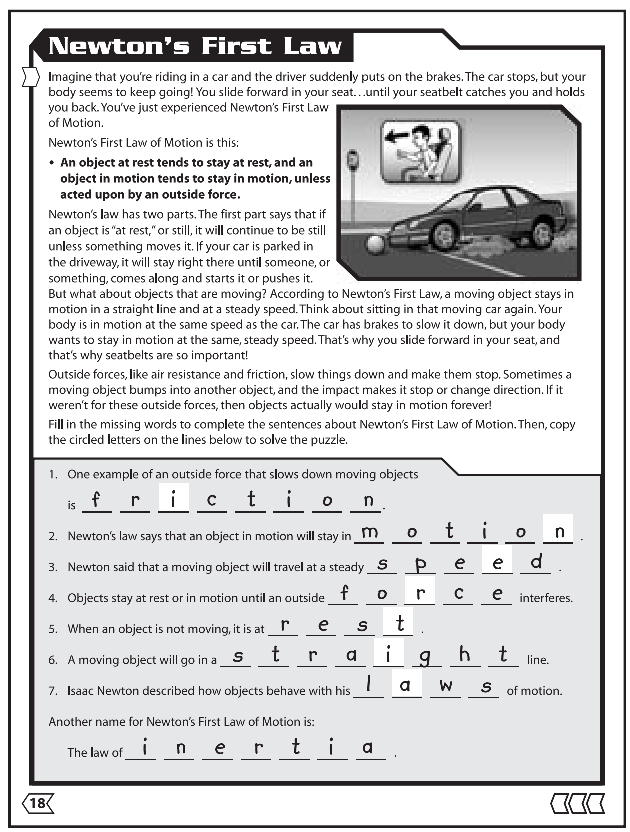
What You Need

- ***Newton's First Law*** **(page 18)**

Directions

Invite students to share what they know about Sir Isaac Newton. Some of them may recognize that he discovered the idea of gravity. Explain that Sir Isaac Newton was a scientist and mathematician who lived in the 1600s. Discuss how Newton came up with some very important explanations about force and motion that we still use today. Emphasize that Newton developed three laws of motion that explain how and why objects stop and go.

Tell students that today they are going to learn more about Newton's First Law of Motion. Pass out the reproducible and have students read the information. Invite them to discuss it with their group and then complete the puzzle. When everyone has solved the puzzle, have the class discuss what they learned about Newton's First Law. Write down their insights on the KWL Chart under "What did we learn?"



Newton's First Law

Imagine that you're riding in a car and the driver suddenly puts on the brakes. The car stops, but your body seems to keep going! You slide forward in your seat. . .until your seatbelt catches you and holds you back. You've just experienced Newton's First Law of Motion.

Newton's First Law of Motion is this:

- **An object at rest tends to stay at rest, and an object in motion tends to stay in motion, unless acted upon by an outside force.**

Newton's law has two parts. The first part says that if an object is "at rest," or still, it will continue to be still unless something moves it. If your car is parked in the driveway, it will stay right there until someone, or something, comes along and starts it or pushes it.

But what about objects that are moving? According to Newton's First Law, a moving object stays in motion in a straight line and at a steady speed. Think about sitting in that moving car again. Your body is in motion at the same speed as the car. The car has brakes to slow it down, but your body wants to stay in motion at the same, steady speed. That's why you slide forward in your seat, and that's why seatbelts are so important!

Outside forces, like air resistance and friction, slow things down and make them stop. Sometimes a moving object bumps into another object, and the impact makes it stop or change direction. If it weren't for these outside forces, then objects actually would stay in motion forever!

Fill in the missing words to complete the sentences about Newton's First Law of Motion. Then, copy the circled letters on the lines below to solve the puzzle.

1. One example of an outside force that slows down moving objects is f r i c t i o n.
2. Newton's law says that an object in motion will stay in m o t i o n.
3. Newton said that a moving object will travel at a steady s p e e d.
4. Objects stay at rest or in motion until an outside f o r c e interferes.
5. When an object is not moving, it is at r e s t.
6. A moving object will go in a s t r a i g h t line.
7. Isaac Newton described how objects behave with his l a w s of motion.

Another name for Newton's First Law of Motion is:

The law of i n e r t i a.

18

Introducing Inertia

What You Need

- **Vocabulary Cards**
- *Plastic cup* • *3 x 5 card* • *Quarter* • *Six checkers*

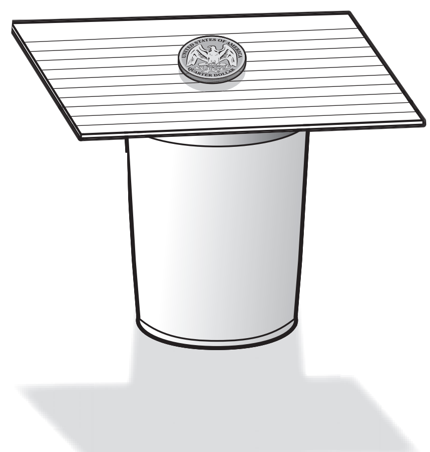
Directions

Hold up the vocabulary card with the word "inertia," and discuss the definition. You may want to refer to the *Newton's First Law* reproducible and the "law of inertia." Tell students that you are going to do two activities to demonstrate inertia. These activities can be demonstrated for the whole class at once, or you can divide students into groups and let them do the activity at a science center. After completing the inertia activities, write what the class learned about inertia on the KWL Chart.

A Curious Coin

Directions

1. Set the plastic cup on a flat surface and place the index card on top.
2. Position the quarter in the center of the index card.
3. Use your fingers to flick the card so it shoots off the cup. (Tell students to keep their eyes on the quarter!)
   - What happened to the quarter when the card slid out from underneath it?
   - How is this related to inertia?

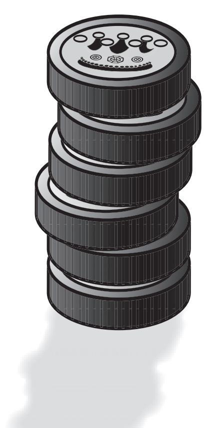


Explain to students that the quarter dropped into the cup when the card slid out from underneath it. This is because the quarter has inertia. The index card was set in motion, but the quarter was at rest. Since there was no force acting on the quarter, it stayed at rest and dropped into the cup.

Super Stack

Directions

1. On a smooth, flat surface, make a stack with five checkers on top of each other.
2. Place the last checker a few inches away from the stack.
3. Use your fingers to give a hard flick to the single checker in the direction of the stack.
   - What happened to the single checker and the stack of checkers?
   - How is this related to inertia?



Discuss how the single checker was set in motion, and stayed in motion because of its inertia. This is why the single checker pushed the stack over. Eventually, the friction and resistance made all the checkers come to a stop.

Activity 4

Force and Motion Dictionary

What You Need

- **Vocabulary cards**
- ***Vocabulary Dictionary*** **(page 19)**
- *Construction paper (9" x 12")*

Tell students that they will be making a dictionary to help learn and remember all the new words in this unit of study. Give each student two sheets of the *Vocabulary Dictionary* reproducible. Invite the class to help make a list of words they have already learned in this unit. At this point, they have probably been introduced to words like "Newton's First Law," "inertia," "force," and "motion".

Have students write down each word and its definition, and then draw a picture that shows what the word means. (Use the vocabulary cards for reference.) Students should fold the construction paper in half and label it to make a cover for their dictionary. Cut the reproducibles in half so each word is on its own page.

Have students keep their definitions inside the cover and remind them that they will be adding to it as they continue the force and motion unit. You may want to have a pile of blank dictionary pages available so students can access them easily. Encourage students to refer to their dictionary throughout the unit of study to review the words and concepts.

Activity 5

Force & Motion Experiment 1

What You Need

- ***Science Log Sheet*** **(page 20)**
- **Experiment #1 card**
- **2 carts**
- **Measuring tape**
- **Ramp**
- *15 pennies*
- *Books*

Directions

Give a copy of the *Science Log Sheet* to each student who will be working on the experiment. Review Newton's First Law of Motion using the information on the back of the experiment card. Tell students they are going to do some experiments to learn more about inertia. Explain that the more mass, or weight, an object has, the more inertia it has. Discuss how they will be working with carts and ramps, so they can see the connection between inertia and mass.

Set up your science center with the necessary materials for the experiment. Have students rotate through the center in small groups and conduct the experiment on their own. Since they will be doing three trials, students can take turns releasing the cart down the ramp. Make sure that each student records the results on his or her log sheet. When everyone has completed the experiment, come together as a class to discuss their results and observations.

Add any new information they learned to your classroom KWL Chart.

Answers to Conclusion Questions:

1. The cart that went down the ramp stayed in motion in a straight line until an outside force (the cart at the bottom) interfered and slowed it down. The inertia of the moving cart caused it to push the second cart forward as well.
2. As more pennies were put inside the cart at the bottom of the ramp, it moved a shorter distance forward when it was hit. This is because the pennies gave the cart more mass, or weight. The increased mass gave the cart more inertia, so more force was required to move it.
3. If the ramp was propped up with four books instead of three, the cart traveling down the ramp would have more force, more speed, and more acceleration, so it would push the cart at the bottom farther.

Balancing Act

Activity 6

Review with the class that a force is a push or a pull. Explain that forces act in pairs, and they can either be balanced or unbalanced. Discuss balanced and unbalanced forces as you complete the following:

What You Need

- **Vocabulary cards**
- *Empty detergent bottle or soda bottle*
- *Tissue paper*
- *Small paper cup*
- *Water*

Directions

1. After moistening the tissue paper with water, use it to plug the hole in the top of the detergent bottle.
2. Flip the cup upside down and place it over the top of the bottle.
3. Squeeze the bottle and tell students to watch what happens.

- What happened?
- Were the forces balanced or unbalanced?

Explain that when you placed the cup on the bottle, the forces were balanced, so nothing moved. When you squeezed the bottle, the air inside the bottle suddenly had more force. The forces became unbalanced, causing the cup to move.

After the experiment, show the class the "balanced force" and "unbalanced force" vocabulary cards and discuss what they learned about these concepts. Have them write the words on vocabulary definition pages and add them to their dictionaries.

What Is Friction? Experiment 2

Activity 7

What You Need

- ***Science Log Sheet*** **(page 20)**
- **Experiment #2 card**
- **2 pieces of sandpaper**
- **Measuring tape**
- **Ramps**
- **Carts**
- *Books*
- *10 pennies*

Directions

Divide students into groups and make sure each student has a copy of the *Science Log Sheet* reproducible. Explain that in this next experiment, they will learn about how some forces resist motion and slow down moving objects. Introduce the idea of "friction" and explain that friction is one of these outside forces that can cause a moving object to slow down and stop.

Answers to Conclusion Questions:

1. The cart traveled the greatest distance during trial 1, when it carried no pennies and there was no sandpaper at the bottom.
2. The cart traveled the least distance during trial 4, when it carried pennies and rolled over sandpaper.
3. As the cart rolled over the sandpaper, the friction between the wheels and the sandpaper caused the cart to slow down.
4. When the carts had pennies, they had more mass. They did not travel as far.

Set up the science center with everything students need to complete the experiment. Let students visit the center in small groups and do the experiment. Encourage them to take turns releasing the cart down the ramp for each trial. Remind students to record the results for each trial on their own log sheet. When all of your students have completed the experiment, discuss their results and observations as a class.

Use the KWL Chart to record what the class learned about friction. Then, make sure students add the word "friction" to their dictionaries.

Activity 8

What's the Speed? Experiment 3

What You Need

- ***Science Log Sheet*** **(page 20)**
- **Experiment #3 card**
- **Vocabulary cards**
- **Ramp**
- **Cart**
- **Measuring tape**
- **Stopwatch**
- **Sandpaper**
- *Books*

Directions

Divide students into groups and make sure each student has a copy of the *Science Log Sheet*. Discuss how an object's mass and the amount of friction it encounters affect its speed. Remind students that we can calculate an object's speed by timing how long it takes the object to travel a certain distance. Tell students that they will be figuring out the speed of a traveling cart in this next experiment.

Answers to Conclusion Questions:

1. During the second trial, the cart was slower and had less velocity than in the first trial. The greatest speed was shown during the third trial.
2. The sandpaper created friction and slowed the cart down in the second trial. The extra push given to the cart for the third trial made it accelerate and have more velocity in the final trial.

Leave the necessary materials out at your science center. Have students rotate through the center in small groups, with each group conducting the experiment on their own. Make sure that every member records the results on his or her log sheet! When all of your students have completed the experiment, discuss their results and observations as a class. As the class discusses their findings, list on the board the new words they learned, like "speed," "mass," "gravity," "velocity," and "acceleration". Have them fill out a vocabulary definition reproducible for each new word to add to their dictionaries.

Activity 9

Cart Launcher Experiment 4

What You Need

- ***Science Log Sheet*** **(page 20)**
- **Experiment #4 card**
- **Cart**
- **Stopwatch**
- *10 Pennies*
- **Force and Motion Chart**
- **Measuring tape**
- **Cart Launcher**
- *Masking Tape*

Directions

Give a copy of the *Science Log Sheet* to each student who will be working on the experiment. Use the Force and Motion Chart to review Newton's Second Law of Motion. Tell the class that the next experiment will show them Newton's Second Law of Motion in action.

Answers to Conclusions Questions:

1. Pulling the cart farther back with the elastic gave it more acceleration (speed).
2. Newton's law says that the more force applied to an object, the more it will accelerate (speed up). Pulling the cart back farther stretched the elastic, which launched the cart with greater force. That force made the cart speed up.
3. The cart moved more slowly when pennies were added to it. This is because when an object has more mass, it takes more force to move it. The pennies added mass to the cart, so it did not accelerate as much as when the cart was empty and had less mass.

Choose an area of the classroom with plenty of floor space for this experiment. Leave the necessary materials in the designated area and divide the class into groups. Have students rotate through the experiment area in small groups, with each group conducting the experiment on their own. Make sure that every member records the results on his or her log sheet.

When all of your students have completed the experiment, discuss their results and observations as a class. Add any new information learned to your classroom KWL Chart.

Newton's Second Law

Activity 10

What You Need

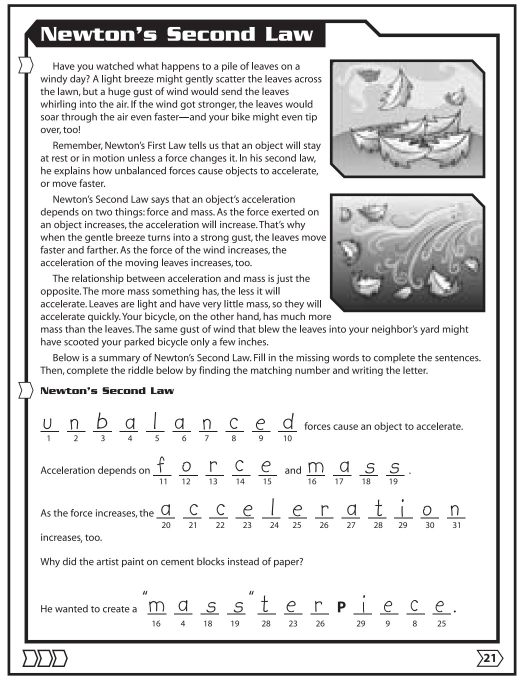
- ***Newton's Second Law*** **(page 21)**

Directions

Use the KWL Chart to review what students already know about Isaac Newton and his laws of motion. Invite students to summarize the first law of motion. Review with students how Newton's First Law explains that objects at rest will stay at rest, and objects in motion will stay in motion, as long as the forces acting on the objects are balanced. Ask students: What do you think happens when the forces around an object become unbalanced?

You may want to use the vocabulary cards for "balanced forces" and "unbalanced forces" to review these concepts. Or, students can share their own definitions of balanced and unbalanced forces from their *Vocabulary Dictionaries*.

Tell the class that Newton's Second Law is all about what happens to objects when the forces are unbalanced. Pass out the *Newton's Second Law* reproducible and have students read the information. They can work independently or in groups to solve the riddle.



Newton's Second Law

Have you watched what happens to a pile of leaves on a windy day? A light breeze might gently scatter the leaves across the lawn, but a huge gust of wind would send the leaves whirling into the air. If the wind got stronger, the leaves would soar through the air even faster—and your bike might even tip over, too!

Remember, Newton's First Law tells us that an object will stay at rest or in motion unless a force changes it. In his second law, he explains how unbalanced forces cause objects to accelerate, or move faster.

Newton's Second Law says that an object's acceleration depends on two things: force and mass. As the force exerted on an object increases, the acceleration will increase. That's why when the gentle breeze turns into a strong gust, the leaves move faster and farther. As the force of the wind increases, the acceleration of the moving leaves increases, too.

The relationship between acceleration and mass is just the opposite. The more mass something has, the less it will accelerate. Leaves are light and have very little mass, so they will accelerate quickly. Your bicycle, on the other hand, has much more mass than the leaves. The same gust of wind that blew the leaves into your neighbor's yard might have scooted your parked bicycle only a few inches.

Below is a summary of Newton's Second Law. Fill in the missing words to complete the sentences. Then, complete the riddle below by finding the matching number and writing the letter.

Newton's Second Law

u n b a l a n c e d (1 2 3 4 5 6 7 8 9 10) forces cause an object to accelerate.

Acceleration depends on f o r c e (11 12 13 14 15) and m a s s (16 17 18 19).

As the force increases, the a c c e l e r a t i o n (20 21 22 23 24 25 26 27 28 29 30 31) increases, too.

Why did the artist paint on cement blocks instead of paper?

He wanted to create a "m a s s" t e r p i e c e. (16 4 18 19 28 23 26 29 9 8 25)

21

When everyone has completed the worksheet, have the class discuss what they learned about Newton's Second Law. Write down their insights on the KWL Chart under "What did we learn?"

Newton's Third Law

Activity 11

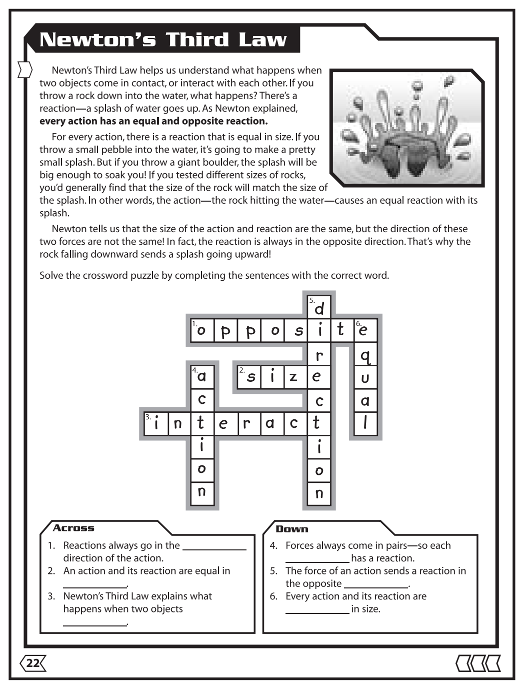
What You Need

- ***Newton's Third Law*** **(page 22)**

Directions

Use the KWL Chart or the Force and Motion Chart from the tub to review Newton's first two laws of motion. Remind the class that forces occur in pairs, as they learned when they studied balanced and unbalanced forces.

Tell the students that they are going to learn about Newton's Third Law of Motion, which will help them understand more about how forces are paired. Tell them that *Newton's Third Law* helps explain what happens when objects come in contact, or interact, with each other. It states that every action has an equal and opposite reaction.



Newton's Third Law

Newton's Third Law helps us understand what happens when two objects come in contact, or interact with each other. If you throw a rock down into the water, what happens? There's a reaction—a splash of water goes up. As Newton explained, **every action has an equal and opposite reaction.**

For every action, there is a reaction that is equal in size. If you throw a small pebble into the water, it's going to make a pretty small splash. But if you throw a giant boulder, the splash will be big enough to soak you! If you tested different sizes of rocks, you'd generally find that the size of the rock will match the size of the splash. In other words, the action—the rock hitting the water—causes an equal reaction with its splash.

Newton tells us that the size of the action and reaction are the same, but the direction of these two forces are not the same! In fact, the reaction is always in the opposite direction. That's why the rock falling downward sends a splash going upward!

Solve the crossword puzzle by completing the sentences with the correct word.

Across

1. Reactions always go in the ___________ direction of the action.
2. An action and its reaction are equal in ___________.
3. Newton's Third Law explains what happens when two objects ___________.

Down

4. Forces always come in pairs—so each ___________ has a reaction.
5. The force of an action sends a reaction in the opposite ___________.
6. Every action and its reaction are ___________ in size.

22

Pass out the Newton's Third Law reproducible and have students complete the puzzle on their own or working in small groups. When everyone has completed the worksheet, have the class discuss what they learned about Newton's Third Law. Encourage the class to come up with as many examples as they can of equal and opposite actions and reactions. Write down their insights on the KWL Chart under "What did we learn?"

Now that they've learned about Newton's Third Law, encourage the class to come up with as many examples as they can of equal and opposite actions and reactions. Write down their insights on the KWL Chart under "What did we learn?"

Rocket Race Experiment 5

Activity 12

What You Need

- ***Science Log Sheet*** **(page 20)**
- **Experiment #5 card**
- **Balloons**
- **Plastic straws (4" pieces)**
- **String**
- **Stopwatch**
- **Measuring tape**
- *Tape*

Directions

Give a copy of the *Science Log Sheet* to each student in the class. Review Newton's Third Law of Motion and discuss how a rocket is a good example of this law. (See the back of the experiment card.) Tell the class that they will make their own balloon rockets so they can see how Newton's Third Law of Motion works.

Answers to Conclusions Questions:

1. The air that was released out of the balloon was like fuel that pushed it forward on the string.
2. Answers will vary.
3. The force of the air as it came out of the back of the balloon was the "action." The reaction was that the balloon shot forward in the opposite direction.

Divide the class into groups of four or five students each. The materials for this experiment can be set up at a science center for the groups to rotate through, or all of the groups can do the experiment at the same time.

Make sure that each group has a person to operate the stopwatch during each trial. Have students record the results on their log sheets.

When everyone has finished, discuss the experiment results and observations as a class. Add any new information learned to your classroom KWL Chart.

Push and Pull Posters

Activity 13

What You Need

- **Force and Motion Chart**
- *Chart Paper*
- *Art Supplies*

Directions

Use the chart from the tub to review all three of Newton's Laws of Motion. As a class, brainstorm some examples of each of the three laws. Use the ideas shown at right to get the class started.

Divide the class into small groups, or have students work in pairs. Assign each group one of Newton's laws and have them make a poster demonstrating that law. Students might want to refer to the pictures they've drawn in their *Vocabulary Dictionaries* to get some ideas. Encourage them to use arrows to show motion and direction.

When all the groups have completed their posters, have each group present to the class and display their poster in the classroom.

Newton's First Law:

A soccer ball left on the grass will stay "at rest" until an outside force (someone kicking the ball, the wind blowing, etc.) interferes.

If you kick that same soccer ball, it will stay in motion until an outside force stops it or friction slows it down.

Newton's Second Law:

The more force you use to push a wagon, the more that wagon will accelerate.

If you kick a bowling ball with the same amount of force as you kick a tennis ball, the bowling ball won't go as fast or as far because it has more mass.

Newton's Third Law:

A rocket's fuel pushes heat and air down, which sends the rocket up in the opposite direction.

A swimmer pushes her feet back against the wall of a pool, and her body shoots through the water in the opposite direction.

Reaction Racers

What You Need

- **Balloons**
- **Tape measure**
- *Compass or circle pattern*
- *Flexible straws*
- *Marking pen*
- *Styrofoam trays*
- *Masking tape*
- *Scissors*
- *Ruler*
- *Pins*

Use the charts or students' own *Vocabulary Dictionaries* to summarize Newton's Third Law of Motion. Tell the class they are going to build a race car that demonstrates how every action has an equal and opposite reaction. Divide students into teams and guide the class through the steps for building the car.

Note: You can purchase Styrofoam® meat trays at the butcher counter for a few cents each, or ask students to bring them from home.

Directions

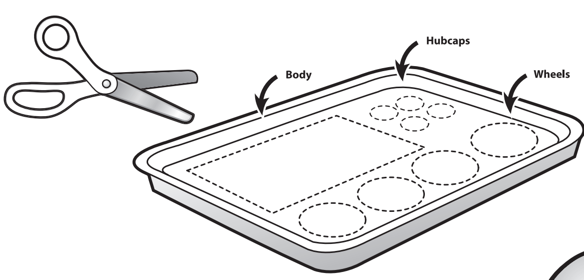
1. Have students trace the parts of the car on the Styrofoam® tray. Draw 1 rectangular car body and 4 circular wheels.
2. Cut all the parts out of the tray.
3. Inflate the balloon, and then let out the air. Tape the balloon to the short end of a flexible straw.
4. Tape the straw and balloon to the rectangular car body.
5. Use pins to attach the wheels to the car body.
6. Demonstrate how to operate the race car: Blow air into the straw to inflate the balloon and squeeze the tip of the straw to hold in the air. When the tip is released, the car zooms forward.

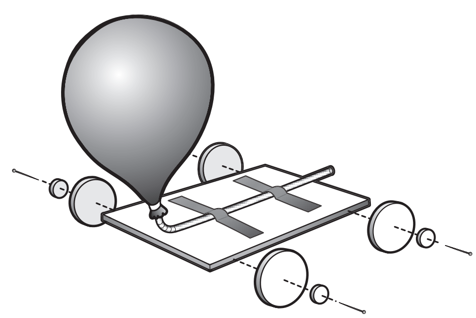
When all the teams have completed their cars, have the class bring the cars outside or somewhere with a slick floor. Use masking tape to set up a starting line. Have students place their cars at the starting line and inflate their balloons. On your cue, have all the students let go of the straws and let the cars race.
When the race is over, discuss what happened with the class:

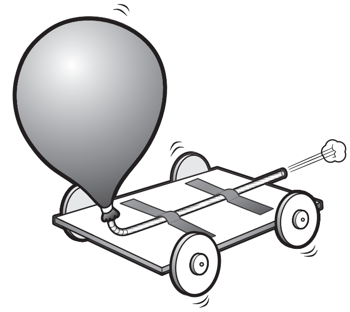
Which cars went faster than others?

Why did some cars go faster?

How did the car race show each of Newton's laws in action?







Marble Momentum Experiment 6

Activity 15

What You Need

- ***Science Log Sheet*** **(page 20)**
- **Experiment #6 card**
- **10 large marbles**
- *2 rulers*
- *Tape*

Directions

Give a copy of the *Science Log Sheet* to each student in the class. Review the information about momentum found on the back of the experiment card. Tell the class that they will be using marbles to discover how momentum works.

Answers to Conclusions Questions:

1. When you push marbles faster, the end marbles move faster.
2. The opposite of what was pushed occured at the other end. In other words, 3 were pushed out on the right and 2 were pushed out on the left—the opposite of the initial marbles.
3. The speed of an object's movement.

Divide the class into groups of four or five students each. The materials for this experiment can be set up at a science center for the groups to rotate through. Have students follow the instructions on the experiment card, making sure to record the results on their log sheets. When everyone has finished, discuss the experiment results and observations as a class.

Roller Coaster Experiment 7

Activity 16

What You Need

- ***Science Log Sheet*** **(page 20)**
- **Experiment #7 card**
- **Vocabulary cards**
- **Clear plastic tubing**
- **Small marble**
- **Stopwatch**
- **Measuring tape**
- *Tape*

Directions

Give a copy of the *Science Log Sheet* reproducible to each student who will be doing the experiment. Review the concepts of momentum and velocity and ask students how these words relate to a roller coaster. Tell the class that in the next experiment, they will design a roller coaster "track" that will help them understand the concepts of potential energy and kinetic energy.

Answers to Conclusions Questions:

1. The lower end height took the marble longer to slow down. The higher end height slowed down the marble sooner.
2. Trial 3 allowed the most potential energy.
3. The marble in the third trial had more kinetic energy.
4. The speed would be lower than the speed of the higher start height.

As you set up the materials in the class science center, you may want to demonstrate the experiment once so students can see how it should be done. Then, divide the class into groups and let them rotate through the center, conducting the experiment on their own. Make sure students fill in their log sheets as they go.

When all of your students have completed the activity, discuss their observations as a class. What kind of "track" design gave the marble the most momentum? What slowed the marble down?

Write down the class's insights on the KWL Chart, and encourage students to add "kinetic energy" and "potential energy" to their *Vocabulary Dictionaries*.

Catch That Can!

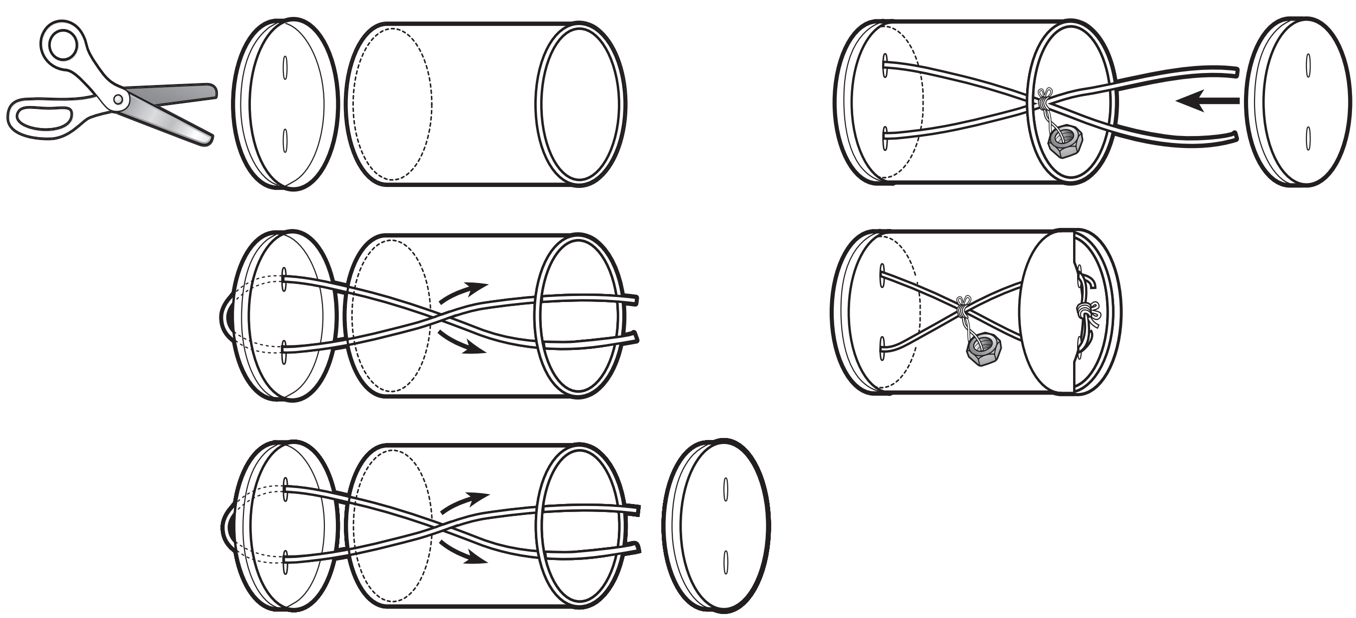
What You Need

- **Vocabulary cards**
- **String**
- *Coffee can with no ends*
- *2 plastic lids that fit the can*
- *Heavy metal nut*
- *Scissors*
- *Long rubber band*

Use the vocabulary card for "stored energy" to introduce the idea of energy. Tell the class that you are going to make a very special can that stores up energy as it rolls. Build the can together as a class, and leave it out at a science center so students can experiment with it on their own.

Directions

1. Use the scissors to cut two holes in each plastic lid. The holes should be positioned in the center of the lid, 2 to 3 inches apart.
2. Snip the rubber band once, making it one long band. Thread it through the hole on one lid and put that lid on the can.
3. Pull the ends of the band through the body of the can. Cross the ends to form an X.
4. Use string to tie a nut to the center of the rubber band.
5. Thread the two open ends of the band through the holes on the other lid.
6. Put the other lid on the end of the can and tie the rubber band ends into a knot.



Once the can is assembled, ask students what usually happens when you roll a can across the floor. Tell them to watch carefully as you roll this special can. The can should roll away, then slow down and roll back in the direction it came. Even if you roll the can down a slope, it will slow down and roll back uphill. Let students try rolling the can and catching it as it rolls back to them.

Why does the can always roll back to its starting place? Explain that as the can rolls, the rubber band inside twists up and stores energy. When the coil is as tight as it can get, the can stops rolling. It's time for all that stored energy to be released. The rubber band starts unwinding, and this pushes the can back in the direction it came.

Marble Race Experiment 8

Activity 18

What You Need

- ***Science Log Sheet*** **(page 20)**
- **Experiment #8 card**
- **Large marble**
- *Paper cup*
- *Grooved ruler*
- *Thick book*
- *Scissors*
- *Pencil*

Directions

Give a copy of the *Science Log Sheet* to each student who will be working on the experiment. Invite students to share what they know about gravity. Tell the class that they are going to do an experiment that will demonstrate how gravity affects acceleration and speed.

Set up your science center with everything the students need to conduct the experiment. Divide the class into small groups and let them rotate through the center. Remind the groups that as they conduct the experiment, each person needs to record the results on his or her log sheet. When all of your students have completed the experiment, discuss their results and observations as a class.

Answers to Conclusions Questions:

1. In the first trial (when the ruler was propped up on books), the marble exerted more force on the paper cup. With the ruler propped up on the thick book, the marble had more potential energy than when the ruler was propped up on the pencil. The steep hill made the marble accelerate more and hit the cup with greater force.
2. In both trials, gravity is the force that pulled the marble down the ruler and made it roll toward the cup.
3. If the marble was larger or heavier, it would have accelerated more and hit the cup with greater force, causing the cup to move a greater distance. If the cup was heavier, it would resist the force of the marble more and move a shorter distance after the impact.

Where's That Word?

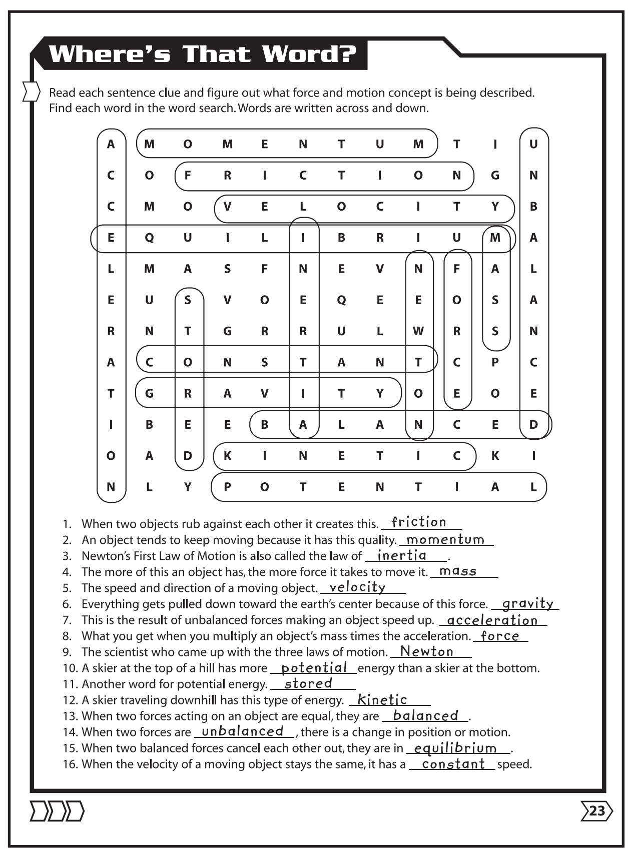
Activity 19

What You Need

- **Vocabulary cards**
- ***Where's That Word?*** **(page 23)**

Directions

Use the vocabulary cards to review important words and concepts about force and motion. Talk about words that have not yet been covered throughout the unit of study. Give a copy of the "*Where's That Word?*" reproducible to each student. Explain that the word search is a good way to review the new vocabulary words they have learned. When students have completed the puzzle, go over their answers together as a class.



Where's That Word?

Read each sentence clue and figure out what force and motion concept is being described. Find each word in the word search. Words are written across and down.

A	M	O	M	E	N	T	U	M	T	I	U
C	O	F	R	I	C	T	I	O	N	G	N
C	M	O	V	E	L	O	C	I	T	Y	B
E	Q	U	I	L	I	B	R	I	U	M	A
L	M	A	S	F	N	E	V	N	F	A	L
E	U	S	V	O	E	Q	E	E	O	S	A
R	N	T	G	R	R	U	L	W	R	S	N
A	C	O	N	S	T	A	N	T	C	P	C
T	G	R	A	V	I	T	Y	O	E	O	E
I	B	E	E	B	A	L	A	N	C	E	D
O	A	D	K	I	N	E	T	I	C	K	I
N	L	Y	P	O	T	E	N	T	I	A	L

1. When two objects rub against each other it creates this. friction
2. An object tends to keep moving because it has this quality. momentum
3. Newton's First Law of Motion is also called the law of inertia.
4. The more of this an object has, the more force it takes to move it. mass
5. The speed and direction of a moving object. velocity
6. Everything gets pulled down toward the earth's center because of this force. gravity
7. This is the result of unbalanced forces making an object speed up. acceleration
8. What you get when you multiply an object's mass times the acceleration. force
9. The scientist who came up with the three laws of motion. Newton
10. A skier at the top of a hill has more potential energy than a skier at the bottom.
11. Another word for potential energy. stored
12. A skier traveling downhill has this type of energy. kinetic
13. When two forces acting on an object are equal, they are balanced.
14. When two forces are unbalanced, there is a change in position or motion.
15. When two balanced forces cancel each other out, they are in equilibrium.
16. When the velocity of a moving object stays the same, it has a constant speed.

23

Laws of the Land: Newton & Seat Belts

What You Need

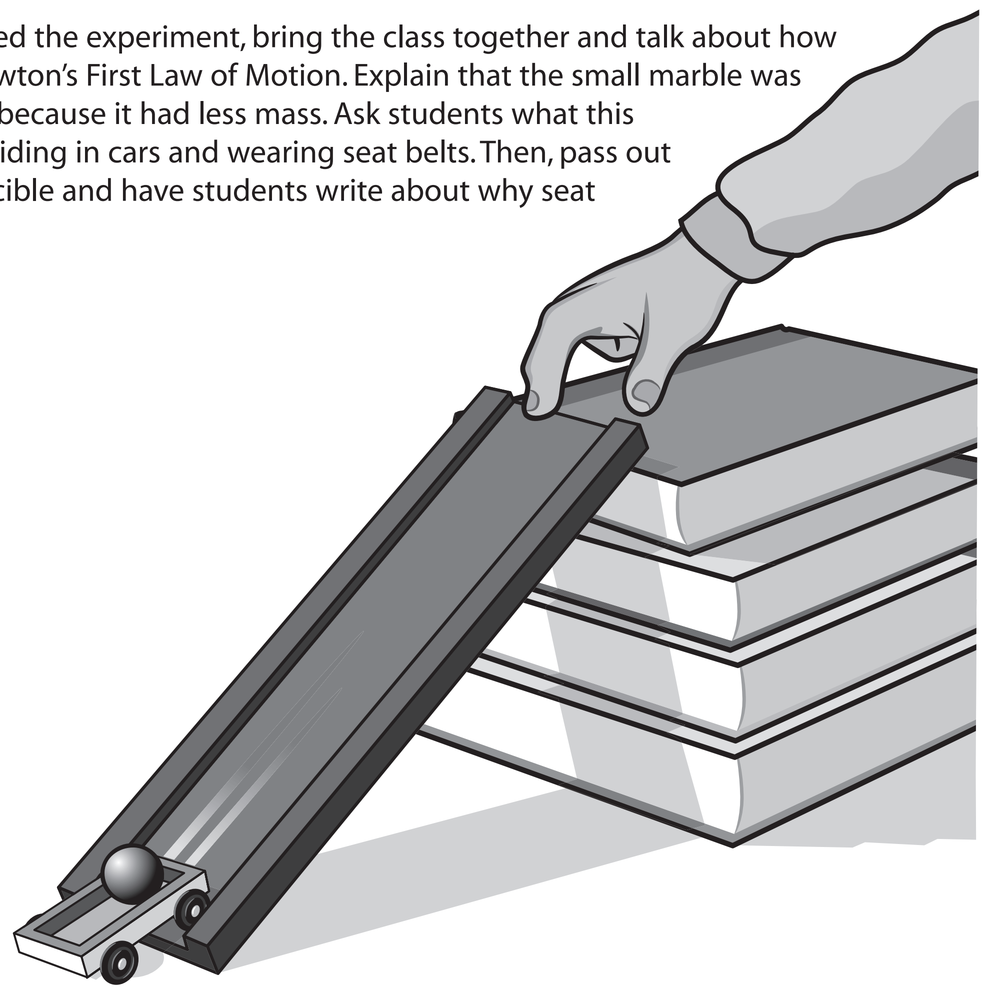
- ***Write an Article*** **(page 24)**
- **Cart**
- **Ramp**
- **1 large marble**
- **1 small marble**
- *Books*

Review Newton's First Law of Motion with the class. Tell students they are going to see how an object in motion tends to stay in motion in this next activity. Set up the materials at the science center, or do the activity together as a class. Ask them to pay attention to the marbles, and to think of the marbles as passengers inside a car.

Directions

1. Make a stack of books and prop up one end of the ramp.
2. Place one book at the bottom of the ramp to create a barrier.
3. Position the cart at the top of the ramp and place the small marble inside the cart.
4. Release the cart and let it roll down the ramp. What happens to the marble when the cart hits the book at the bottom of the ramp?
5. Repeat the experiment, this time placing the large marble in the cart. How far does the large marble travel compared to the small marble?

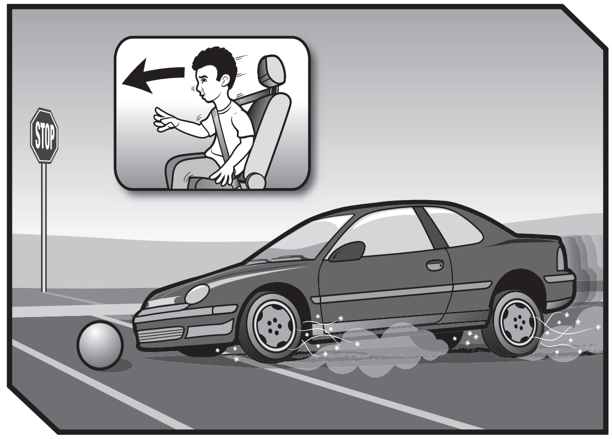
When everyone has completed the experiment, bring the class together and talk about how the marbles demonstrate Newton's First Law of Motion. Explain that the small marble was thrown farther from the cart because it had less mass. Ask students what this experiment shows us about riding in cars and wearing seat belts. Then, pass out the "*Write an Article*" reproducible and have students write about why seat belts are important.



Name: ______________________ **Date:** ______________

Newton's First Law

Imagine that you're riding in a car and the driver suddenly puts on the brakes. The car stops, but your body seems to keep going! You slide forward in your seat. . .until your seatbelt catches you and holds you back. You've just experienced Newton's First Law of Motion.



Newton's First Law of Motion is this:

- **An object at rest tends to stay at rest, and an object in motion tends to stay in motion, unless acted upon by an outside force.**

Newton's law has two parts. The first part says that if an object is "at rest," or still, it will continue to be still unless something moves it. If your car is parked in the driveway, it will stay right there until someone, or something, comes along and starts it or pushes it.

But what about objects that are moving? According to Newton's First Law, a moving object stays in motion in a straight line and at a steady speed. Think about sitting in that moving car again. Your body is in motion at the same speed as the car. The car has brakes to slow it down, but your body wants to stay in motion at the same, steady speed. That's why you slide forward in your seat, and that's why seatbelts are so important!

Outside forces, like air resistance and friction, slow things down and make them stop. Sometimes a moving object bumps into another object, and the impact makes it stop or change direction. If it weren't for these outside forces, then objects actually would stay in motion forever!

Fill in the missing words to complete the sentences about Newton's First Law of Motion. Then, copy the boxed letters on the lines below to solve the puzzle.

1. One example of an outside force that slows down moving objects is ___ ___ [ ] ___ ___ ___ ___ ___.
2. Newton's law says that an object in motion will stay in ___ ___ ___ ___ ___ [ ] .
3. Newton said that a moving object will travel at a steady ___ ___ ___ [ ] ___ .
4. Objects stay at rest or in motion until an outside ___ ___ [ ] ___ ___ interferes.
5. When an object is not moving, it is at ___ ___ ___ [ ] .
6. A moving object will go in a ___ ___ ___ ___ [ ] ___ ___ ___ line.
7. Isaac Newton described how objects behave with his ___ [ ] ___ ___ of motion.

Another name for Newton's First Law of Motion is:

The law of ___ ___ ___ ___ ___ ___ ___ .

Vocabulary Dictionary

Word:

Definition:

Illustration:

Word:

Definition:

Illustration:

Science Log Sheet

Name: **Date:**

Experiment:

Procedure:

Observations/Results:

Conclusions:

Name: ______________________ Date: ______________________

Newton's Second Law

Have you watched what happens to a pile of leaves on a windy day? A light breeze might gently scatter the leaves across the lawn, but a huge gust of wind would send the leaves whirling into the air. If the wind got stronger, the leaves would soar through the air even faster—and your bike might even tip over, too!

Remember, Newton's First Law tells us that an object will stay at rest or in motion unless a force changes it. In his second law, he explains how unbalanced forces cause objects to accelerate, or move faster.

Newton's Second Law says that an object's acceleration depends on two things: force and mass. As the force exerted on an object increases, the acceleration will increase. That's why when the gentle breeze turns into a strong gust, the leaves move faster and farther. As the force of the wind increases, the acceleration of the moving leaves increases, too.

The relationship between acceleration and mass is just the opposite. The more mass something has, the less it will accelerate. Leaves are light and have very little mass, so they will accelerate quickly. Your bicycle, on the other hand, has much more mass than the leaves. The same gust of wind that blew the leaves into your neighbor's yard might have scooted your parked bicycle only a few inches.

Below is a summary of Newton's Second Law. Fill in the missing words to complete the sentences. Then, complete the riddle below by finding the matching number and writing the letter.

Newton's Second Law

__ __ __ __ __ __ __ __ __ __ forces cause an object to accelerate.
(1 2 3 4 5 6 7 8 9 10)

Acceleration depends on __ __ __ __ __ and __ __ __ __ .
(11 12 13 14 15) (16 17 18 19)

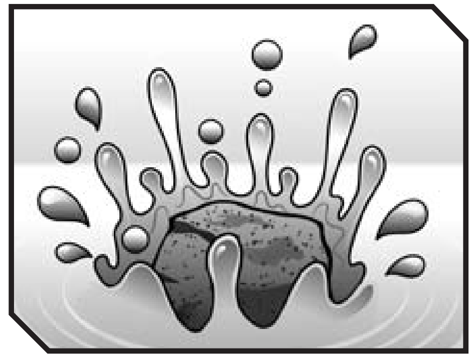
As the force increases, the __ __ __ __ __ __ __ __ __ __ __ __ increases, too.
(20 21 22 23 24 25 26 27 28 29 30 31)

Why did the artist paint on cement blocks instead of paper?

He wanted to create a "__ __ __ __" __ __ __ P __ __ __ __.
(16 4 18 19) (28 23 26 P 29 9 8 25)

Name: Date:

Newton's Third Law

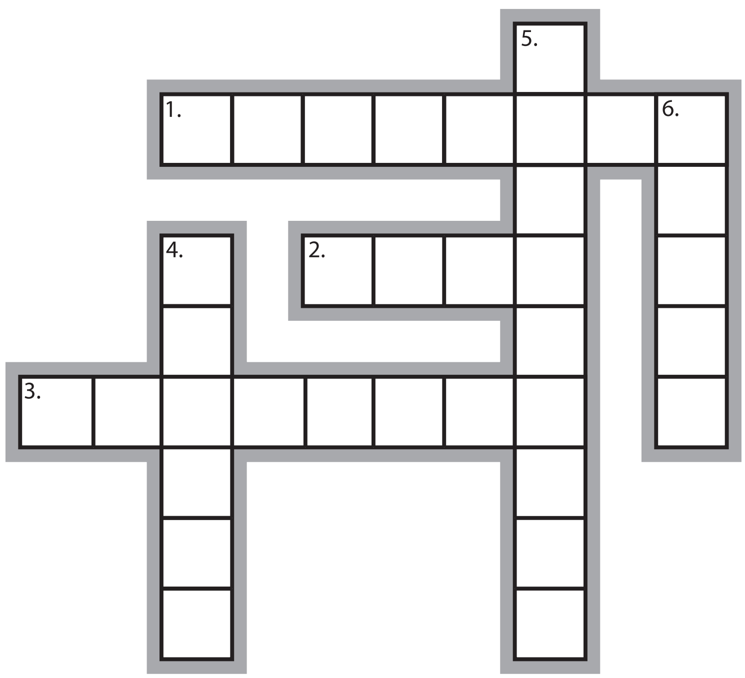


Newton's Third Law helps us understand what happens when two objects come in contact, or interact with each other. If you throw a rock down into the water, what happens? There's a reaction—a splash of water goes up. As Newton explained, **every action has an equal and opposite reaction.**

For every action, there is a reaction that is equal in size. If you throw a small pebble into the water, it's going to make a pretty small splash. But if you throw a giant boulder, the splash will be big enough to soak you! If you tested different sizes of rocks, you'd generally find that the size of the rock will match the size of the splash. In other words, the action—the rock hitting the water—causes an equal reaction with its splash.

Newton tells us that the size of the action and reaction are the same, but the direction of these two forces are not the same! In fact, the reaction is always in the opposite direction. That's why the rock falling downward sends a splash going upward!

Solve the crossword puzzle by completing the sentences with the correct word.



Across

1. Reactions always go in the ____________ direction of the action.
2. An action and its reaction are equal in ____________.
3. Newton's Third Law explains what happens when two objects ____________.

Down

4. Forces always come in pairs—so each ____________ has a reaction.
5. The force of an action sends a reaction in the opposite ____________.
6. Every action and its reaction are ____________ in size.

Name: ______________________________ Date: ______________

Where's That Word?

Read each sentence clue and figure out what force and motion concept is being described. Find each word in the word search. Words are written across and down.

A	M	O	M	E	N	T	U	M	T	I	U
C	O	F	R	I	C	T	I	O	N	G	N
C	M	O	V	E	L	O	C	I	T	Y	B
E	Q	U	I	L	I	B	R	I	U	M	A
L	M	A	S	F	N	E	V	N	F	A	L
E	U	S	V	O	E	Q	E	E	O	S	A
R	N	T	G	R	R	U	L	W	R	S	N
A	C	O	N	S	T	A	N	T	C	P	C
T	G	R	A	V	I	T	Y	O	E	O	E
I	B	E	E	B	A	L	A	N	C	E	D
O	A	D	K	I	N	E	T	I	C	K	I
N	L	Y	P	O	T	E	N	T	I	A	L

1. When two objects rub against each other it creates this. ______________
2. An object tends to keep moving because it has this quality. ________________
3. Newton's First Law of Motion is also called the law of ______________.
4. The more of this an object has, the more force it takes to move it. ____________
5. The speed and direction of a moving object. _______________
6. Everything gets pulled down toward the earth's center because of this force. ____________
7. This is the result of unbalanced forces making an object speed up. ___________________
8. What you get when you multiply an object's mass times the acceleration. __________
9. The scientist who came up with the three laws of motion. ______________
10. A skier at the top of a hill has more _______________ energy than a skier at the bottom.
11. Another word for potential energy. _______________
12. A skier traveling downhill has this type of energy. ______________
13. When two forces acting on an object are equal, they are _______________.
14. When two forces are _________________, there is a change in position or motion.
15. When two balanced forces cancel each other out, they are in __________________.
16. When the velocity of a moving object stays the same, it has a _______________ speed.

Name: Date:

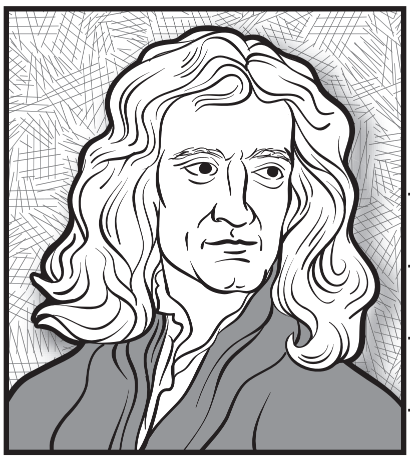
Write an Article

Directions

Using the space provided below, write a newspaper article about why seat belts are important using Newton's laws to justify your opinon.

★ ★ ★ ★ ★

FORCE & MOTION GAZETTE



Sir Isaac Newton

Sir Isaac Newton would be in favor of seat belt laws because ____________

Name: Date:

Force & Motion Assessment

Match each vocabulary word with its definition.

1. acceleration ______
2. equilibrium ______
3. force ______
4. friction ______
5. gravity ______
6. inertia ______
7. kinetic energy ______
8. momentum ______
9. potential energy ______
10. velocity ______

A An object at rest will stay at rest, and an object in motion will stay in motion unless a force is introduced.

B How fast and in what direction an object is traveling.

C A force that pulls anything on the Earth's surface toward the center of the Earth.

D Something that changes an object's state of rest or motion.

E An increase in an object's velocity.

F Energy that is stored up on an object because of its position.

G A tendency of an object to keep moving when it's in motion.

H The energy an object has because it is moving.

I The force that results from two surfaces rubbing against one another.

J A state of balance where opposing forces on an object simply cancel each other out, and the object remains stable and unchanged.

Choose the correct answer:

11. Which law of motion states that, for every action, there is an equal and opposite reaction?
    - a. Newton's First Law of Motion.
    - b. Newton's Second Law of Motion.
    - c. Newton's Third Law of Motion.
    - d. The law of reaction.

12. What is an example of how friction can be helpful?
    - a. A skateboard ramp.
    - b. A seatbelt in a car.
    - c. The brakes on a car.
    - d. The wheels on a bicycle.

13. If you kick a bowling ball and a tennis ball with the same amount of force, according to Newton's Second Law of Motion, what will happen?
    - a. The tennis ball will travel farther than the bowling ball.
    - b. The bowling ball will travel farther than the tennis ball.
    - c. The bowling ball will travel faster, but cover a shorter distance.
    - d. The balls will travel the same distance.

Force & Motion Assessment

14. According to Newton's First Law of Motion…
    a. An object in motion will slow down when moving down a hill.
    b. An object in motion will stay in motion unless acted upon by an outside force.
    c. An object in motion will always move sideways when acted upon by an outside force.
    d. An object in motion will stay in motion when it is acted upon by an outside force.

15. Which is the best example of kinetic energy?
    a. A diver standing on the edge of a high dive.
    b. A skier moving swiftly down a hill.
    c. A car sitting in a driveway.
    d. A runner who is waiting to start a race.

Fill in the blanks.

16. A skateboarder at the top of a ramp has ________________ energy.

17. The scientific study of energy and matter and how they interact with each other is called

    _______________________.

Answer the following in complete sentences.

18. Newton's Third Law of Motion states that, for every action, there is an equal and opposite reaction. Give an example of this law.

19. During the cart launcher experiment, the elastic cord was stretched back to launch the cart. Tell how this affected the cart and why.

20. If you kick a bowling ball and a golf ball with the same amount of force, tell which ball will go farther and which law of motion explains why.

Force & Motion Assessment

Answer Key

Force & Motion Assessment

Match each vocabulary word with its definition.

1. acceleration E
2. equilibrium J
3. force D
4. friction I
5. gravity C
6. inertia A
7. kinetic energy H
8. momentum G
9. potential energy F
10. velocity B

A An object at rest will stay at rest, and an object in motion will stay in motion unless a force is introduced.
B How fast and in what direction an object is traveling.
C A force that pulls anything on the Earth's surface toward the center of the Earth.
D Something that changes an object's state of rest or motion.
E An increase in an object's velocity.
F Energy that is stored up on an object because of its position.
G A tendency of an object to keep moving when it's in motion.
H The energy an object has because it is moving.
I The force that results from two surfaces rubbing against one another.
J A state of balance where opposing forces on an object simply cancel each other out, and the object remains stable and unchanged.

Choose the correct answer:

11. Which law of motion states that, for every action, there is an equal and opposite reaction?
   a. Newton's First Law of Motion.
   b. Newton's Second Law of Motion.
   (c.) Newton's Third Law of Motion.
   d. The law of reaction.

12. What is an example of how friction can be helpful?
   a. A skateboard ramp.
   b. A seatbelt in a car.
   (c.) The brakes on a car.
   d. The wheels on a bicycle.

13. If you kick a bowling ball and a tennis ball with the same amount of force, according to Newton's Second Law of Motion, what will happen?
   (a.) The tennis ball will travel farther than the bowling ball.
   b. The bowling ball will travel farther than the tennis ball.
   c. The bowling ball will travel faster, but cover a shorter distance.
   d. The balls will travel the same distance.

Force & Motion Assessment

14. According to Newton's First Law of Motion…
   a. An object in motion will slow down when moving down a hill.
   (b.) An object in motion will stay in motion unless acted upon by an outside force.
   c. An object in motion will always move sideways when acted upon by an outside force.
   d. An object in motion will stay in motion when it is acted upon by an outside force.

15. Which is the best example of kinetic energy?
   a. A diver standing on the edge of a high dive.
   (b.) A skier moving swiftly down a hill.
   c. A car sitting in a driveway.
   d. A runner who is waiting to start a race.

Fill in the blanks.

16. A skateboarder at the top of a ramp has potential (or) stored energy.

17. The scientific study of energy and matter and how they interact with each other is called physics.

Answer the following in complete sentences.

18. Newton's Third Law of Motion states that, for every action, there is an equal and opposite reaction. Give an example of this law.

Answers will vary.

19. During the cart launcher experiment, the elastic cord was stretched back to launch the cart. Tell how this affected the cart and why.

Answers will vary but may include: There was more potential energy when the elastic was stretched more. Pulling the elastic back gave the cart more acceleration and force.

20. If you kick a bowling ball and a golf ball with the same amount of force, tell which ball will go farther and which law of motion explains why.

The golf ball will go farther due to Newton's Second Law of Motion, which states that acceleration depends on force and mass. The bowling ball has greater mass and will move slower and go a shorter distance.

Notes