Pendulums

Purpose

To test how the length of a pendulum's string affects its motion

Process Skills

Form a hypothesis, identify and control variables, predict, observe, measure, collect data, interpret data, draw conclusions, communicate

Materials
(per pair or small group)
- ❑ data sheet (one per student)
- ❑ 6 metal washers of equal size and weight
- ❑ string or yarn
- ❑ scissors
- ❑ ruler
- ❑ 2 craft sticks
- ❑ tape
- ❑ stopwatch

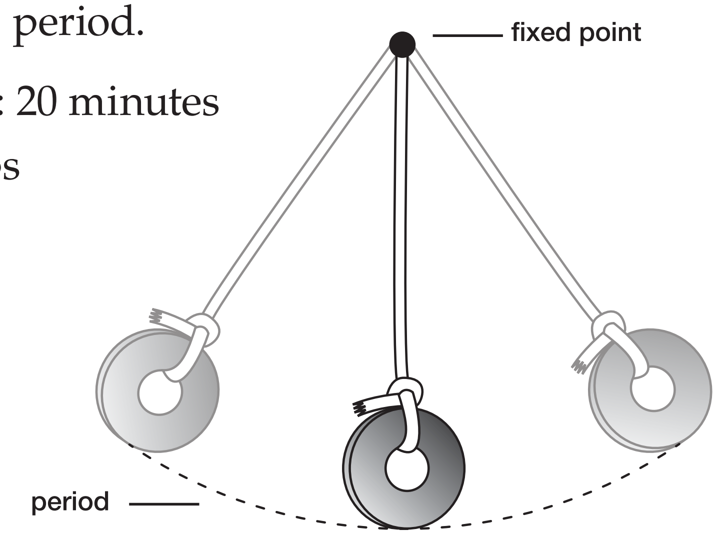
Background

A *pendulum* is an object that hangs from a fixed point so it can move freely. A playground swing is a type of pendulum. When a pendulum is pulled back, it stores up energy that can be turned into motion. When it is released, it swings back and forth along a curved path. The amount of time it takes the pendulum to swing back and forth once is called a *period*. The pendulum keeps swinging until all the energy is used up.

A pendulum's motion repeats and follows a pattern. In this experiment, you will make two pendulums of different lengths. Then you will compare the motion of the two pendulums. You will also find out how the length of a pendulum's string affects its period.

Time – Part 1: 10 minutes; Part 2: 20 minutes

Grouping – Pairs or small groups



Procedure

Part 1: Construct the Pendulums

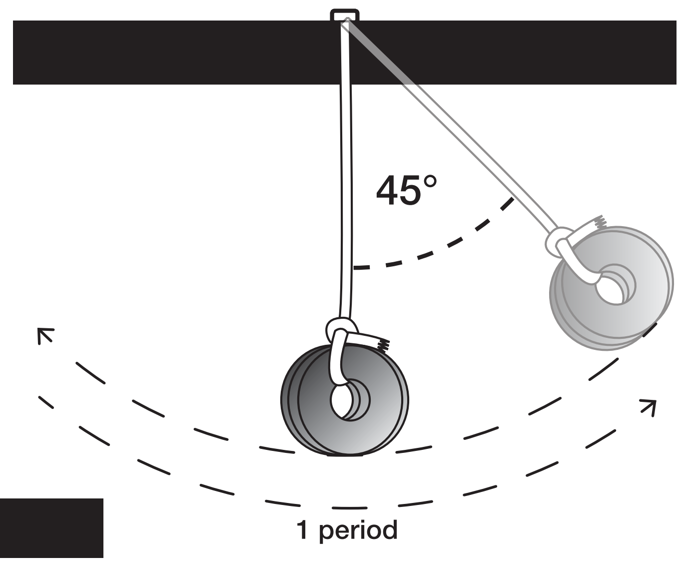
1. Measure and cut two pieces of string, each about 60 centimeters (2 ft.) long. Tie three metal washers to one end of each string.
2. Tape the nonweighted end of one string to the end of a craft stick. The length of the string from the craft stick to the top of the washers should be 25 cm (10 in.). Trim off or wrap any excess string around the craft stick.
3. Repeat step 2 by using the second string, 3 more washers, and the other craft stick so that the length of the string from the craft stick to the top of the washers is only 13 cm (5 in.).
4. Secure the craft sticks to the edge of a table with tape. Use heavy weights, such as books, to hold them in place. The sticks should each extend about 2.5 cm (1 in.) over the edge of the table with the strings hanging freely. Place the pendulums at least 60 cm (2 ft.) apart.

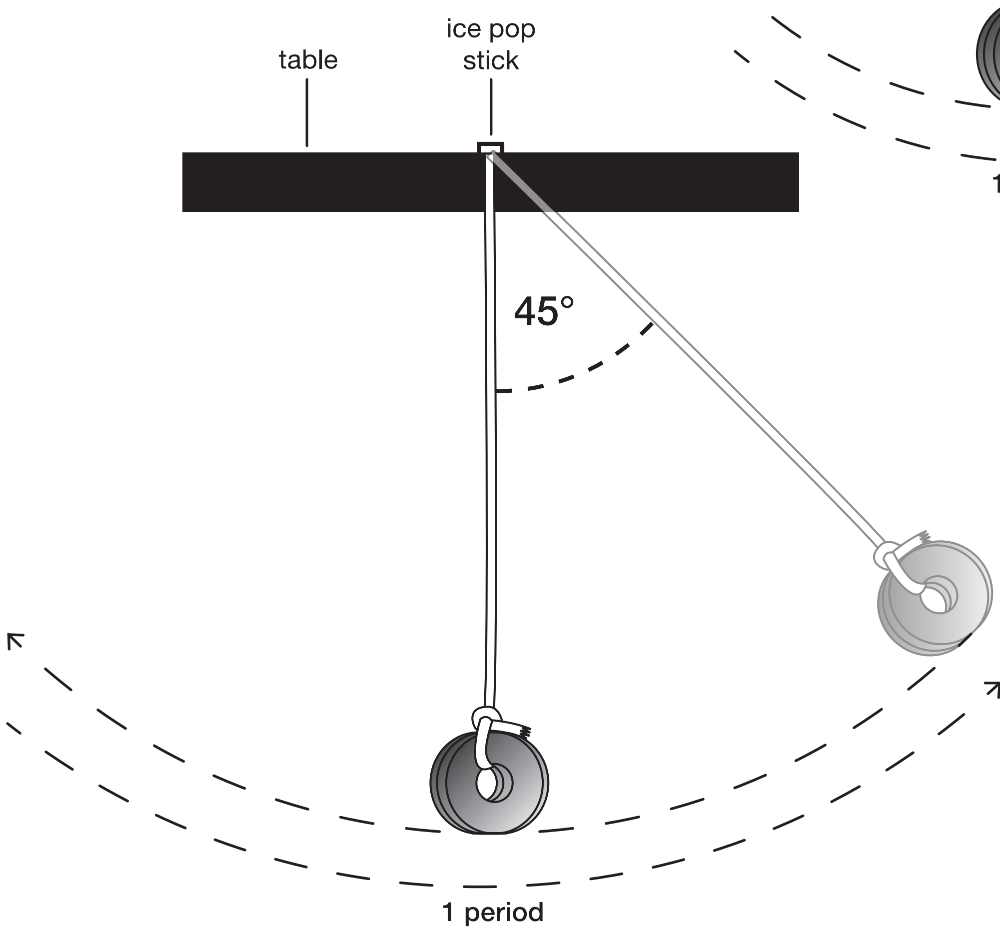
Part 2: Test the Pendulums

Hypothesis: How will the motion of pendulums of different lengths compare? Will the pendulum with the longer string have a faster or slower period than the pendulum with the shorter string? Discuss these questions with your group. Then write a hypothesis on the data sheet.

1. Use the 25 cm (10 in.) pendulum first. Pull the washers to the side at a 45-degree angle to the tabletop (see diagram). Gently let go of the washers and start the stopwatch at the same moment. Begin counting how many times the pendulum swings back and forth. **Note:** If the pendulum is not swinging with a consistent motion, stop the pendulum and try again.

2. After ten full swings, or periods, stop the stopwatch. On the data sheet, record the amount of time it took for the pendulum to complete ten periods.
3. Repeat steps 1 and 2 two more times with the 25 cm (10 in.) pendulum. Record your measurements in the table on the data sheet.
4. Now use the 13 cm (5 in.) pendulum. Repeat steps 1–3.
5. Write down anything else you observed about the motion of the pendulums at the bottom of the data sheet.
6. Clean up your work area.





Name ______________________________ Date ____________

Hypothesis: Will the pendulum with the longer string have a faster or slower period than the pendulum with the shorter string? Why do you think this will be so?

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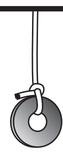
Collect Data

Pendulum Length	Trial #	Total Time (10 periods)
25 centimeters (10 inches) 	1	
	2	
	3	
13 centimeters (5 inches) 	1	
	2	
	3	

Observations: Write what you observed about the motion of the two pendulums.

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Name ______________________________ Date ____________

Analyze Data

1. Why was it important to do three trials with each pendulum?

2. Calculate the average time for 10 periods with the 25-centimeter (10 in.) pendulum. (Hint: Add the total time for all three trials and then divide that number by three.)

3. Calculate the average time for 10 periods with the 13-centimeter (5 in.) pendulum. (Hint: Add the total time for all three trials and then divide that number by three.)

Name ______________________________________ Date ____________

4. Review your answers to questions 2 and 3. Which pendulum had a slower average period?

5. Do you think the results would have been different if each of the pendulums had only one washer instead of three? Why or why not?

Name ________________________________ Date ____________

Draw Conclusions

1. Compare the results to your hypothesis. Was your hypothesis supported by the results? Explain why or why not.

2. How was the motion of the two pendulums similar, and how was it different?

3. Imagine you wanted to repeat this experiment with an even longer string. How would the pendulum move? How would the period change? Explain your thinking.

Pendulums

TEACHING TIPS

This Process Activity will help students learn about the motion of pendulums and how varying the length of a pendulum changes its swing time, or period. Students will discover that while the length of a pendulum's string affects how fast it can complete a period, its overall motion follows a pattern that can be used to predict its future motion.

SET-UP AND PROCEDURES

- Consider assigning jobs for each student within a cooperative group prior to the activity. Examples include getter, measurer, reporter, and cleaner.
- Encourage students to share their hypotheses with the small group before the experiment and to reflect on the results afterward.
- Instruct students to release the pendulum gently by simply opening their fingers and not to use any additional force. They should not throw or push the weights downward, as this may yield misleading data.

MATERIALS

- Use six equal-sized metal washers for the pendulums. Purchase washers from a hardware store or ask students to bring in matching sets from home. Students will tie three washers to the end of each string to make each pendulum. Using three washers instead of one will help keep the string taut and ensure a more complete arc with each swing.
- Check students' pendulum construction. Ensure that the two pendulums measure 25 centimeters (10 in.) and 13 centimeters (5 in.) from the top of the craft stick to the top of the washers. Any excess string can be trimmed.
- Have enough tape or heavy books on hand to secure the craft sticks to the edge of the table. The craft sticks should not move while the pendulum is swinging.
- The craft sticks should extend at least 2.5 centimeters (1 in.) from the edge of the table to prevent the string from rubbing against the table, and the sticks should be at least 60 centimeters (2 ft.) apart to avoid collisions.
- If stopwatches are unavailable, students can use a smartphone or the second hand on a clock to time the periods.

EXTENSIONS AND VARIATIONS

- *Variations:* Allow students to repeat the experiment, but this time compare different weights with the same length of string. Remind students to vary their hypothesis based on the new variable. Allow students to suggest additional experiments involving pendulums and test them in class.
- *Home Connection:* Challenge students to find examples of pendulums at home or in the community, such as the pendulum in a grandfather clock, lamps hanging from the ceiling, or fruit hanging on a tree limb. Ask them to conduct an experiment with a pendulum they find. Have them write a hypothesis, collect data, and draw a conclusion about the results. Allow them to share their results with the class.
- *Research:* Have students research Foucault's pendulum and his demonstration of Earth's rotation. Ask them to write about it and draw an illustration of the pendulum.
- *ELL/ESL:* Create a word wall. Include content vocabulary such as *experiment*, *hypothesis*, *prediction*, *observation*, *measurement*, *data*, *results*, and *conclusion*. Also include vocabulary relevant to the lesson, such as *pendulum, motion, energy*, *swing*, and *period*. For more vocabulary resources, visit **Vocabulary A–Z**.
- *Technology:* Invite students to take digital pictures or video during their experiment. Then allow them to create a digital slideshow or video presentation that summarizes their experiment, compares the results, and states a conclusion about the motion of pendulums—much as scientists might do.
- *Math:* Challenge students to use their pendulums as tools to measure the time it takes to do several activities, such as walking around the perimeter of the classroom or reciting the alphabet backward.
- *Writing:* Have students write a short story in which a pendulum is used to measure time. For extensive writing instruction, visit **Writing A–Z**.

ANSWER KEY

EXPERIMENT
Machines—Pendulums Data Sheet

Name ______________________________ Date __________

Hypothesis: Will the pendulum with the longer string have a faster or slower period than the pendulum with the shorter string? Why do you think this will be so?

Hypotheses will vary. See example below.

If I measure the period of two pendulums with strings of different lengths, the pendulum with the longer string will have a slower (or longer) period because the longer string has to swing farther than the shorter string.

Collect Data

Pendulum Length	Trial #	Total Time (10 periods)
25 centimeters (10 inches)	1	*Results will vary.*
	2	*Results will vary.*
	3	*Results will vary.*
13 centimeters (5 inches)	1	*Results will vary.*
	2	*Results will vary.*
	3	*Results will vary.*

Observations: Write what you observed about the motion of the two pendulums.

Answers will vary. Students should note that the pendulum with the longer string has a slower period than the pendulum with the shorter string, but the overall motion of both pendulums is similar and predictable. If students pull the washers back too far on the initial swing, the pendulum may waver and swing haphazardly, producing erroneous measurements.

ANSWER KEY AND EXPLANATIONS

Analyze Data

1. Why was it important to do three trials with each pendulum?

Answers will vary. Students should note that good scientific studies include multiple trials to ensure that the results are repeatable and reliable. More trials increase the accuracy of results when averages are calculated.

2. Calculate the average time for 10 periods with the 25-centimeter (10 in.) pendulum. (Hint: Add the total time for all three trials and then divide that number by three.)

Answers will vary depending on actual measurements collected during the experiment. Provide calculators if students need help with division.

3. Calculate the average time for 10 periods with the 13-centimeter (5 in.) pendulum. (Hint: Add the total time for all three trials and then divide that number by three.)

Answers will vary depending on actual measurements collected during the experiment. Provide calculators if students need help with division.

4. Review your answers to questions 2 and 3. Which pendulum had a slower average period?

It took longer for the 25-centimeter (10 in.) pendulum to complete ten periods, so it had a slower period.

5. Do you think the results would have been different if each of the pendulums had only one washer instead of three? Why or why not?

Answers will vary. Students may note that changing the number of washers will change the weight of the pendulums and will likely change the total time to complete ten periods. However, the longer pendulum should still have a slower period than the shorter pendulum.

ANSWER KEY AND EXPLANATIONS

Draw Conclusions

1. Compare the results to your hypothesis. Was your hypothesis supported by the results? Explain why or why not.

Answers will vary depending on the hypothesis each student made, but the conclusion should accurately report on whether the results supported his or her hypothesis. See examples below.

Our results did not support our hypothesis. We predicted that the pendulum with the shorter string would have the slower period. But the pendulum with the longer string had the slower period.

or

Our results supported our hypothesis. The pendulum with the longer string had the slower period.

2. How was the motion of the two pendulums similar, and how was it different?

Both pendulums swung back and forth until they ran out of energy and stopped. Both pendulums moved along a curved path as they moved downward from the starting position, moved upward, and then moved down and up again to return to the starting position. The motion was different because the pendulum with the longer string took longer to complete one period than the pendulum with the shorter string.

3. Imagine you wanted to repeat this experiment with an even longer string. How would the pendulum move? How would the period change? Explain your thinking.

The pendulum would still move along a curved path like the pendulums with shorter strings, but because it had an even longer string, it would move more slowly. Since it would move more slowly, it would also take longer to complete one period. So, the period would be slower than the periods of the pendulums with shorter strings.

Be an Engineer!

Make a simple wrecking ball using a long sock and a tennis ball. Come up with a way to suspend your wrecking ball so that it can swing like a pendulum. Next, design a building out of blocks and draw a diagram of it. Then keep the top of the sock in one place, and use your wrecking ball to knock down the building. How many swings did it take to knock it down? Did some blocks remain standing?

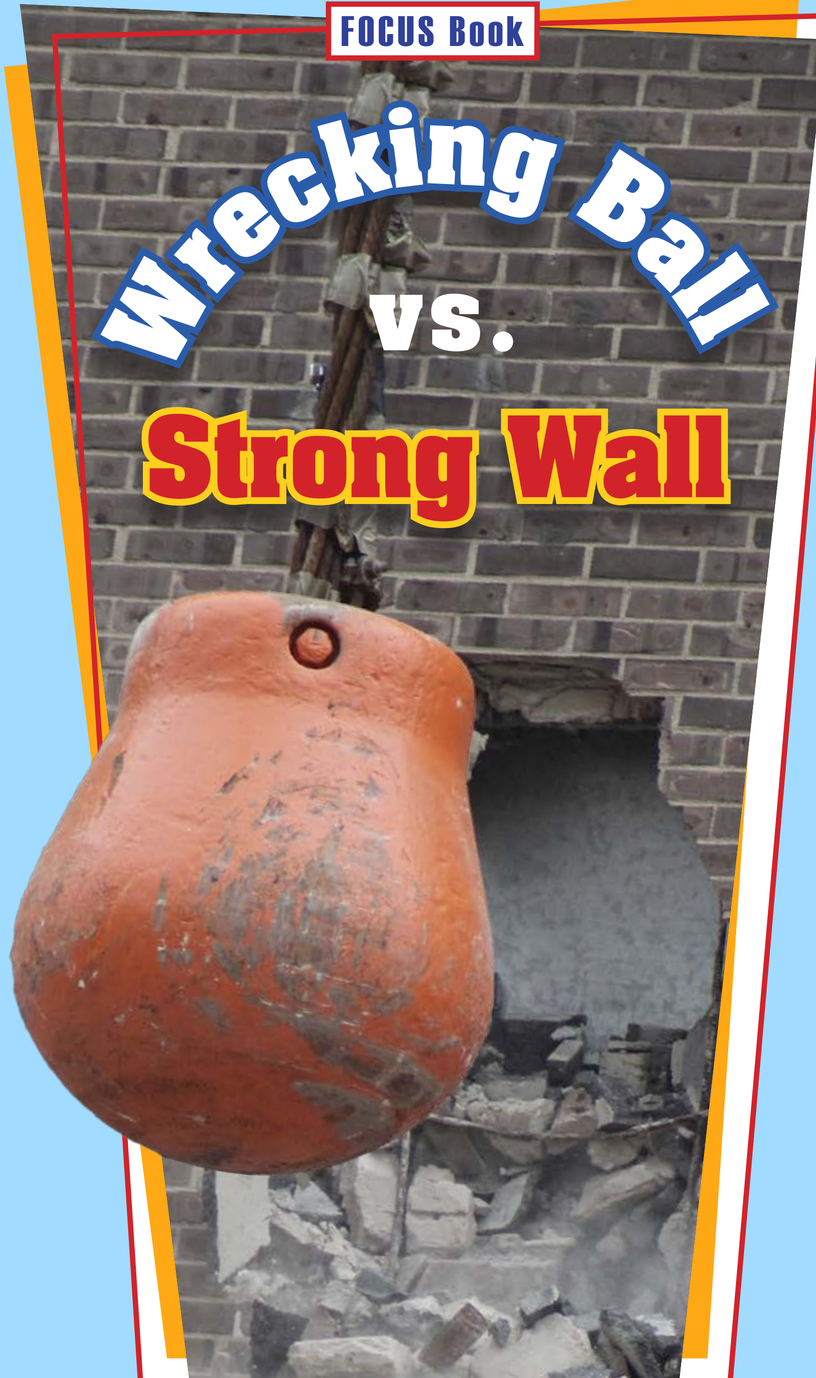
Now design a wrecking ball that knocks down your building even faster, or more completely. First, draw a diagram of it, then build it. Test your idea using the same blocks and building model. Record your observations. Were you able to make a better wrecking ball?

Beyond the Book

Use the Internet to find other examples of energy transfer. Think about how they are and are not like wrecking a building.

FOCUS Book

Wrecking Ball vs. Strong Wall



Science A–Z

Wrecking Ball vs. Strong Wall

FOCUS Question

How does a wrecking ball knock down a building?

Energy and Matter

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Reading Levels	
Learning A–Z	Q
Lexile	580L

Correlations	
Fountas and Pinnell*	N

*Correlated independent reading level

Demolition Day

Have you ever tried to knock over a sand castle? Wrecking a weak building made of sand is easy. What if your job were to demolish a strong building made of brick and concrete? You could use a wrecking ball!

Before knocking down an old building, workers first make sure that no one is inside. Then they bring a crane with a chain and a very heavy metal ball attached. This is a wrecking ball machine. Once the workers are sure that everyone is safe, they can swing the wrecking ball.

a wrecking ball machine

Gravity Drop

One way to use a wrecking ball is to drop it straight down. Think about holding a bowling ball. Suppose you could lift it over an old building and drop it straight down. It would smash through the roof! The higher the ball is lifted, the more damage it causes when it falls. This is due to *gravity.*

Gravity always pulls things down. When an object falls, gravity makes it fall faster and faster. An object that falls a long way moves with more energy than if it falls a short way.

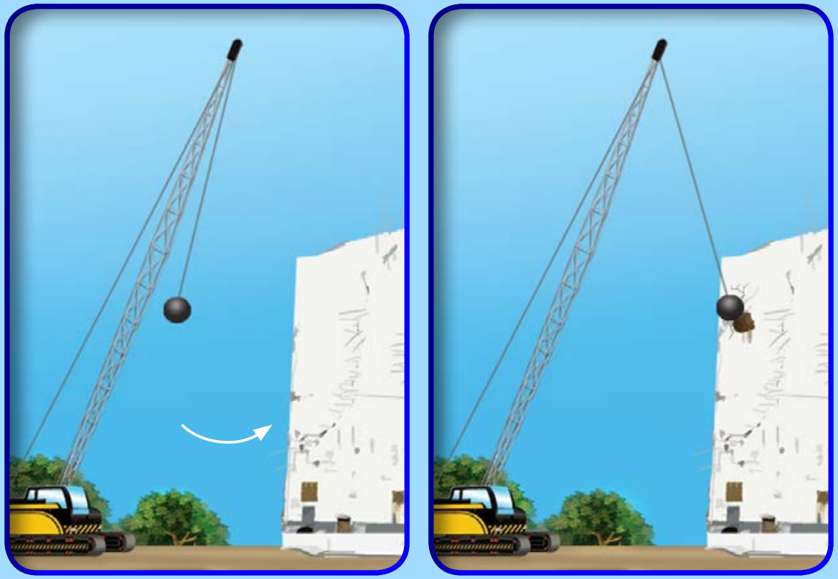
Dropping the wrecking ball straight down is often used to punch through roofs or floors.

Tall Crane, Swinging Chain

Another way to use a wrecking ball is to swing it. The ball is pulled back toward the crane. Then the ball is released. It swings forward and smashes into a wall.

The force of this forward motion is how wrecking balls knock down walls.

When a wrecking ball machine is used in this way, it acts as a *pendulum.*

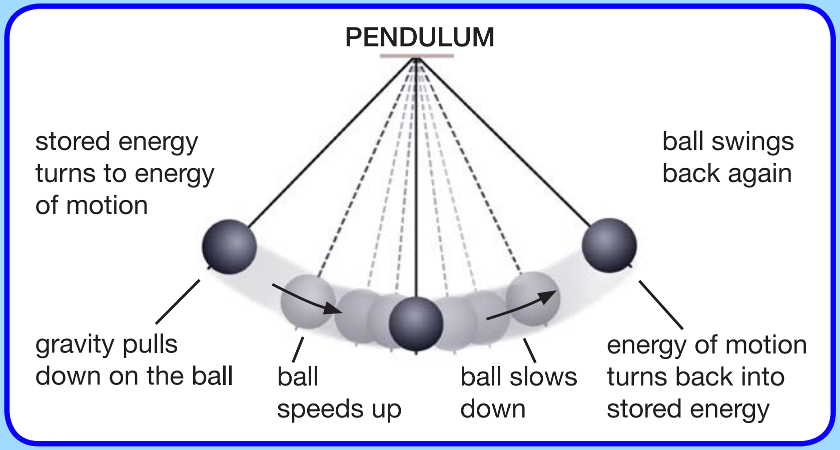


Swinging from the side is the most common way to use a wrecking ball.

Pendulums

A pendulum is an object that swings back and forth from a fixed point. It has a weight at the end of a line. When the pendulum is lifted and released, it swings back and forth in a curved path, or *arc*. At the top of its swing, gravity pulls the weight down. It speeds up as it goes down. After it passes the bottom part of its swing, the pendulum starts to move up along the arc. Gravity slows the pendulum down until it stops at the other end of the arc. Then gravity pulls it down again. It swings back in the other direction.

A wrecking ball works in a similar way. But a wall gets in the way before the ball can make one full swing through its arc.



Wrecking Ball Energy

A wrecking ball machine uses a lot of energy to demolish a building. Energy is the power to cause movement or change. When the ball is pulled back toward the crane, the machine has stored-up energy.

Whoosh! The wrecking ball swings. *Thunk!* The ball smashes into the wall. The building starts to crumble. A cloud of dust swirls into the air. Workers use other machines to haul away the rubble.

Energy from a swinging wrecking ball knocks down a building.

Energy Transfer

A moving wrecking ball has energy as it swings. This energy is passed along, or *transferred*, to the wall when it hits. It breaks the wall apart.

Have you seen a toy called Newton's cradle? The toy shows another example of *energy transfer.* A swinging ball crashes into a line of nonmoving balls. Energy is transferred to each of the balls in the middle, and then to the last one in line.

What happens next? Only the last ball flies up. The energy from the first ball was transferred to the last ball.

A Newton's cradle is an example of how energy can transfer from one object to another.

A Better Wrecking Ball

Buildings can be made out of many different kinds of materials. Some are easy to knock down. Others are more difficult. Not to worry, though. A wrecking ball machine can be adjusted for different jobs.

One way is to use a longer chain. This means that the wrecking ball can be lifted higher. A higher ball swings and hits the wall with more energy. A wrecking ball with more energy can knock down strong walls.

Think About It

What would happen if the wrecking ball were not pulled all the way back to the crane?

A wrecking ball on a short chain (above) cannot be lifted as high and hits the wall with less energy than a wrecking ball on a longer chain (right).

Workers can also use a heavier or lighter wrecking ball. A heavier ball moves with more energy than a lighter one. It has more mass. A large wrecking ball can weigh about the same as a pickup truck. A lighter wrecking ball is easier to lift higher.

Do You Know?

For certain buildings, a wrecking ball machine just is not strong enough. In this case, workers might use explosives to demolish it. *Boom!* The explosion weakens the walls. Gravity causes the building to collapse on itself.

The first wrecking balls were round. Now most are shaped more like pears. When a wrecking ball is narrower at the top, it is easier to pull out of holes in buildings.

Read-Think-Write

Write your answers on separate paper. Use details from the text as evidence.

1. Describe two ways to use a wrecking ball.
2. Look at the diagram on page 5. Where does the ball have the most energy of motion? Why?
3. Compare and contrast a Newton's cradle with a wrecking ball machine.
4. Describe an example of *energy transfer* that you have observed. What purpose did the energy transfer serve?
5. Choose the best word to complete this sentence correctly:
   The higher a wrecking ball is pulled back, the ___________ it will swing when the rope lets it go.

FOCUS Question

How does a wrecking ball knock down a building? Explain the features of the best wrecking ball machine for a big job. Describe how it uses energy to do its job.

PENDULUMS, Playground Swings, and PIRATE SHIPS

What do a pendulum, a playground swing, and a pirate ship ride have in common?

A pendulum is a weight hanging freely from a fixed point overhead. If you set the weight swinging, it will go back and forth for some time before it runs down.

A swing is a large pendulum that works the same way. After you have pumped as high as you can go, you can coast and enjoy the ride until it comes to a stop.

A pirate ship ride is a huge pendulum; a large swing, really. Once it is set into motion, the ship and its screaming passengers go back and forth again and again. It tips up one way, swings back, and then tips the other. Like the pendulum and the playground swing, each pass doesn't go quite as high as the one before it.

More than 300 years ago, an English scientist made an important discovery. Sir Isaac Newton was studying force and motion. He noticed that a moving object kept moving unless some force

What do these two swing rides have in common?

Credits: left: © amana images inc./Alamy; right: © David Batterbury/Eye Ubiquitous/Corbis

made it stop. He also observed that a motionless object didn't move unless some force acted on it to get it moving. This concept is known as inertia.

A pendulum hangs in place unless something gets it moving. A ride on a swing often begins with someone giving the rider a good, strong push. A motor moves the pirate ship upward and sets it in motion. In each case, a force overcomes inertia. And, in each case, the motion continues until a force or forces act on it to slow it down or stop it.

What forces keep pendulums and pirate ships from swinging forever? Two forces are at work: air resistance and friction. Like all substances, air is made up of particles. The particles are small and spread out, but the pendulum or swing collides with them often enough to cause it to lose energy and slow down. Meanwhile, at the pivot point overhead where the ship is attached, surfaces of the moving parts are rubbing against each other. The result is friction, another slowing force. These two forces working together gradually bring the pendulum or pirate ship to a stop.

One of the thrills of a pirate ship ride is the sensation of weightlessness. During the ride, the gravity around the ship doesn't change. The force you feel has to do with the seat you are sitting on. It is pushing on your body to counteract the pull of gravity.

As the ship swings up to the top of the curve, you begin to come off the seat. You are no longer in full contact with the seat. So, the seat no longer pushes back with the same amount of force. As a result, for a split second you feel weightless, or close to it.

DID YOU KNOW?

Pirate ship rides can be found in amusement parks all over the world. Most have names related to pirates or dragons. Smaller versions are often called **"swingboats."**

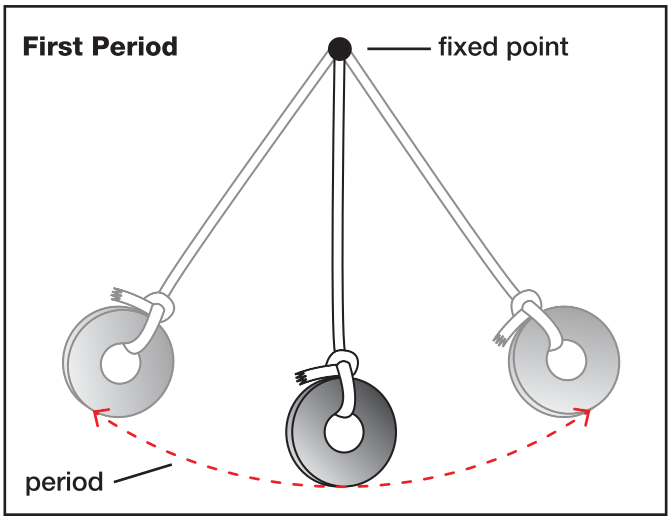
Credits: © Jeff Morgan 08/Alamy

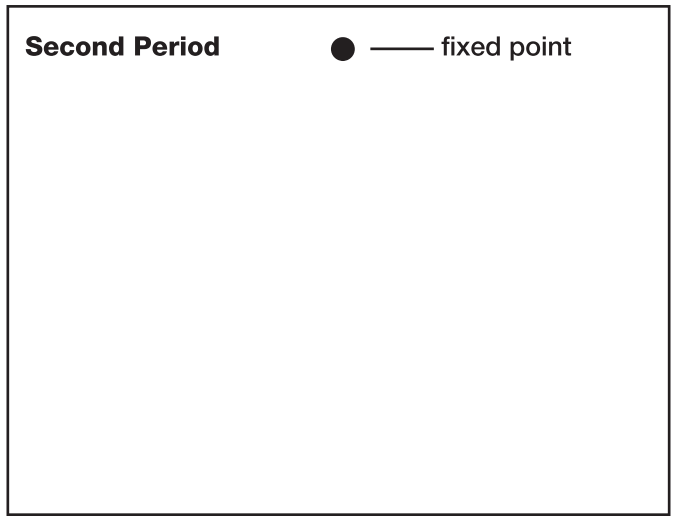
Name ______________________ Date ____________

Part 1: Use the Diagram

The diagram shows how a pendulum moved during one period. Look at the diagram and then complete the tasks.

1. In the space provided, draw a picture of the pendulum's motion during its next period.





2. Compare the motion of the pendulum during the first and second periods.

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3. How could you use the motion of this pendulum to predict the motion of a playground swing?

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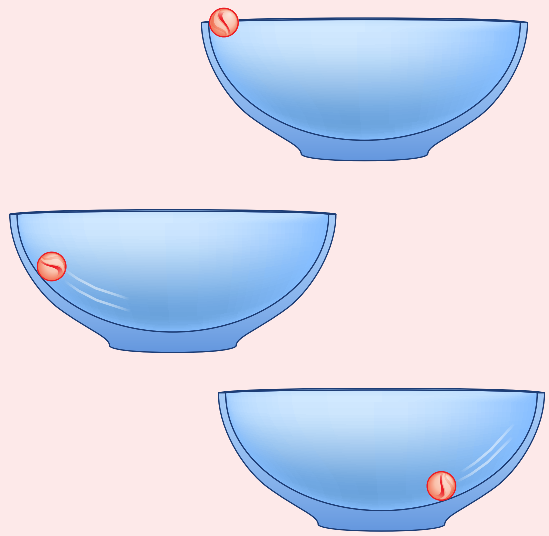
Name ______________________ Date ____________

Part 2: Describe an Investigation

Read the following plan and look at the data. Then use this information to answer the questions on the next page.



Ashley and Jalen are planning an investigation. They plan to let go of a marble from the rim of a bowl and watch how it moves in the bowl. They will repeat this step five times. Each time, they will release the marble from the same place on the bowl. They will also be careful not to push the marble as they release it. Jalen will count how many times the marble goes up and down the sides of the bowl. Ashley will use a stopwatch to measure how much time it takes for the marble to stop moving. Jalen and Ashley will write their data on a data sheet. Then they will look for patterns in the data.

Ashley and Jalen's Data Sheet

Trial	How many times did the marble roll up and back down?	How long did the marble move before it stopped?
1	5	12 seconds
2	4	11 seconds
3	6	12.5 seconds
4	5	11.5 seconds
5	4	11 seconds

Name ________________________________ Date ______________

1. What did the students want to learn about?

2. What two things did the students measure?

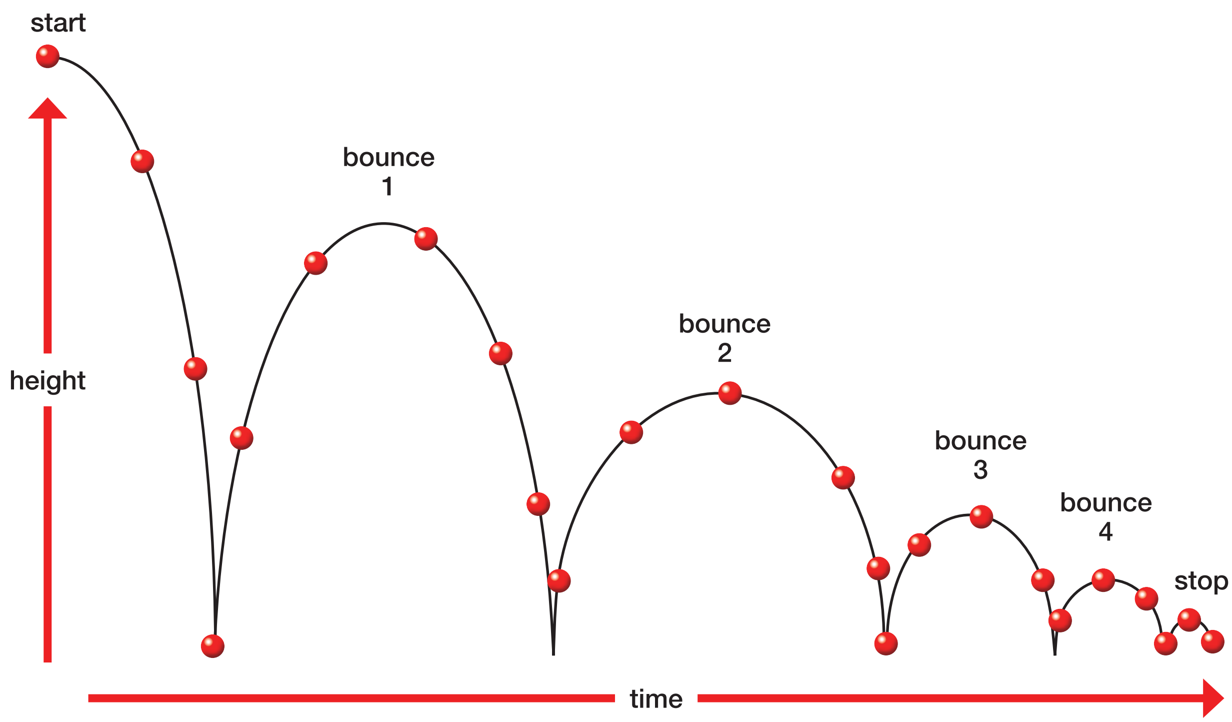
3. What *pattern* does the data show? Explain why this is a pattern.

4. Make a prediction about how a marble in a bowl would move if you repeated Ashley and Jalen's experiment.

Name ______________________________ Date ______________

Part 3: Analyze Data and Plan an Investigation

The graph shows the motion of a ball when a person dropped it. Use the graph to complete the following tasks.



1. Describe how the ball bounced. Include one pattern related to its motion.

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2. Look at the diagram. What are two things you could measure if you wanted to study how a ball moves when it bounces?

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Name ______________________________ Date ______________

3. Complete the claim by filling in the blanks.

If I bounce the ball three more times, it will move ______________ way each time because its pattern of motion can be used to ______________ future motion.

4. Draw a picture or graph that shows how you think the ball will move the next time it is dropped.

ANSWER KEY AND TEACHING TIPS

Connections to the Next Generation Science Standards*

Target Science and Engineering Practice: *Planning and Carrying Out Investigations*

- Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

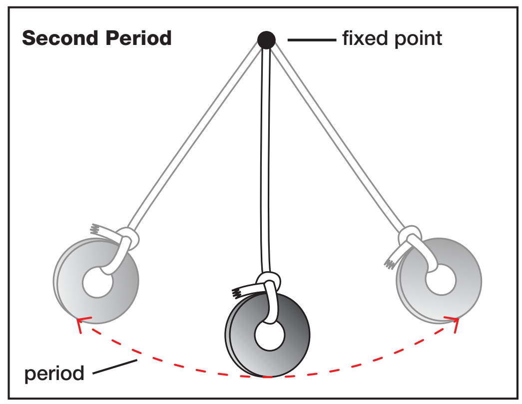
Associated Performance Expectation: *3-PS2-2. Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion.*

All questions in this assessment relate to the Disciplinary Core Ideas DCI of this Performance Expectation. Look for the SEP and CCC symbols for questions that specifically address Science and Engineering Practices and Crosscutting Concepts.

Summary

Students analyze the motion of a pendulum, describe features of an investigation while analyzing the motion of a marble, and determine how a bouncing ball's pattern of motion can be used to predict its future motion.

CCC Part 1: Use the Diagram



1. *Student drawings should look similar to the original diagram. The motion of a pendulum repeats, and therefore its motion during the second period will look very similar to its motion during the first period. Students may indicate that the pendulum did not swing quite as high before returning to the starting position since it loses energy with each period. An example is provided.*

2. The motion in the second period was about the same as the motion in the first period. The motion of a pendulum follows a pattern. It moves back and forth in an arc until it runs out of energy. *(Students may explain that in the second period, the pendulum did not swing as high before moving down again because a pendulum loses energy during each period until it stops.)*

3. Since the washer on the string and a playground swing are both pendulums, I can use the motion of the washer on the string to predict the motion of the swing. Once a person pulls it up and lets go, the swing will move back and forth in an arc until it loses energy and stops.

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SEP Part 2: Describe an Investigation

1. The students wanted to learn about the motion of a marble in a bowl.
2. The students measured how many times the marble rolled up and down the sides of the bowl and how long the marble moved before stopping.
3. CCC The tests showed that each time the marble rolls up the side of the bowl, it rolls back down. The data showed that the marble rolled up and down the sides of the bowl about the same number of times in each trial and that it moved for about the same amount of time before stopping. Both of these are patterns because a pattern is something that repeats.
4. Because the movement of the marble in the bowl showed a pattern of motion, I predict that if I ran the same experiment, I would see the same pattern. The marble would roll up and down the sides of the bowl until it ran out of energy.

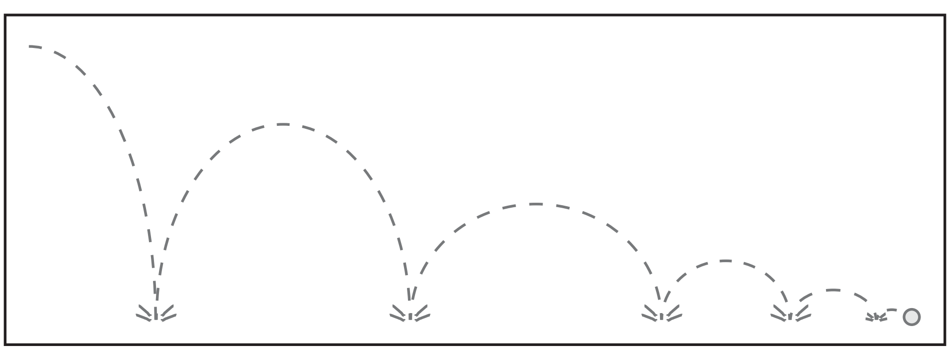
   Students may point out that variables such as the size of the marble and the bowl may affect how many times the marble will roll up and down the sides of the bowl and how long it will move before it stops. However, the marble's overall pattern of motion—rolling up and down the sides of the bowl—will be the same.

SEP Part 3: Analyze Data and Plan an Investigation

1. When the ball is first dropped, it hits the ground and bounces back up. Then it falls back down, hits the ground, and bounces up again. When the ball hits the ground and bounces back up, it doesn't go as high as the time before. Toward the end, when the ball is running out of energy, it has a very small bounce. This is a pattern. The number of times the ball bounces is also a pattern.

   (The distance between bounces also gets smaller, but this may be less noticeable to students than other features of the ball's motion.)

2. *Students should list two of the following variables in their answer: bounce height, number of bounces, distance between bounces, and time the ball moved before it stopped.*
3. *If I bounce the ball three more times, it will move* the same *way each time because its pattern of motion can be used to* predict *future motion.*
4. *Drawings or graphs will vary but should look similar to the original since the pattern repeats. For example:*



Teaching Tips

If students have trouble performing the tasks on this assessment, ask them to look back at the data they collected and the observations they made during the *Pendulums Process Activity* completed in Lesson 2. Point out that the total time for each pendulum to complete ten periods was similar across trials. This means that the motion of the pendulums was similar in each trial. Have students reread their observations from the experiment and remind them that the back-and-forth motion of the pendulum represents a *pattern*. A pattern of motion can be used to predict an object's future motion. The marble in the bowl and the bouncing ball examples also show patterns of motion. Lastly, review with students the important features of planning and carrying out an investigation, such as identifying the purpose of an experiment, defining the kinds of evidence that will be collected, outlining how the evidence will be gathered and measured, and repeating tests several times so that data can be reliably compared across trials.

Extensions

For students who complete their work early or are ready for an extra challenge, assign additional resources related to this topic found on the Grade 3 Forces and Interactions NGSS page on Science A–Z.

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