Smithsonian | SCIENCE for the classroom

HOW DOES MOTION ENERGY CHANGE IN A COLLISION?

Overview and Lesson Sampler, Grade 4

PHYSICAL SCIENCE

INSIDE

Smithsonian Science for the Classroom, Grade 4

* Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

All New for NGSS—*Smithsonian Science for the Classroom*™ for Grades 1–5

For decades, the Smithsonian Science Education Center has been a leader in providing curriculum, professional development, and leadership development in support of inquiry-based science education. The release of the Next Generation Science Standards (NGSS) triggered key shifts in curriculum, instruction, and assessment.

The vision laid out by the NGSS explicitly requires performances that blend content, practices, and crosscutting concepts. The Smithsonian Science Education Center responded with a new generation of high-quality curriculum materials for Grades 1–5—*Smithsonian Science for the Classroom.*

***Smithsonian Science for the Classroom* was developed to:**

- Meet the Next Generation Science Standards through intentional curriculum design
- Support for teachers as they learn to implement new standards
- Incorporate findings from education research on how students learn
- Center on coherent storylines that flow logically from lesson to lesson as students work toward explaining phenomena or designing solutions to problems
- Broaden access to world-class Smithsonian collections, experts, and resources
- Include instructional supports to ensure all students can meet the standards
- Seamlessly incorporate a comprehensive assessment system to monitor student progress

Smithsonian | SCIENCE for the classroom

Smithsonian Science for the Classroom Curriculum Framework —Designed for the Next Generation Science Standards

Module titles introduce phenomena or define problems

Life Science	Earth and Space Science	Physical Science	Engineering Design
Grade 1			
How Do Living Things Stay Safe and Grow? *1-LS1-1 • 1-LS1-2 • 1-LS3-1 • K-2-ETS1-1* **Supporting:** Engineering Design	**How Can We Predict When the Sky Will Be Dark?** *1-ESS1-1 • 1-ESS1-2 • 1-PS4-2* **Supporting:** Physical Science	**How Can We Light Our Way in the Dark?** *1-PS4-2 • 1-PS4-3 • 1-LS1-1 • K-2-ETS1-1* **Supporting:** Life Science and Engineering Design	**How Can We Send a Message Using Sound?** *K-2-ETS1-1 • K-2-ETS1-2 • K-2-ETS1-3 • 1-PS4-1 • 1-PS4-4* **Supporting:** Physical Science
Grade 2			
How Can We Find the Best Place for a Plant to Grow? *2-LS2-1 • 2-LS2-2 • 2-LS4-1 • K-2-ETS1-1* **Supporting:** Engineering Design	**What Can Maps Tell Us About Land and Water on Earth?** *2-ESS2-2 • 2-ESS2-3 • 2-PS1-1* **Supporting:** Physical Science	**How Can We Change Solids and Liquids?** *2-PS1-1 • 2-PS1-2 • 2-PS1-3 • 2-PS1-4 • K-2-ETS1-1* **Supporting:** Engineering Design	**How Can We Stop Soil From Washing Away?** *K-2-ETS1-1 • K-2-ETS1-2 • K-2-ETS1-3 • 2-ESS1-1 • 2-ESS2-1* **Supporting:** Earth and Space Science
Grade 3			
What Explains Similarities and Differences Between Organisms? *3-LS1-1 • 3-LS3-1 • 3-LS3-2 • 3-LS4-2 • 3-ESS2-2* **Supporting:** Earth and Space Science	**How Do Weather and Climate Affect Our Lives?** *3-ESS2-1 • 3-ESS2-2 • 3-ESS3-1 • 3-5-ETS1-1* **Supporting:** Engineering Design	**How Can We Predict Patterns of Motion?** *3-PS2-1 • 3-PS2-2 • 3-PS2-3 • 3-PS2-4 • 3-5-ETS1-1* **Supporting:** Engineering Design	**How Can We Protect Animals When Their Habitat Changes?** *3-5-ETS1-1 • 3-5-ETS1-2 • 3-5-ETS1-3 • 3-LS2-1 • 3-LS4-1 • 3-LS4-3 • 3-LS4-4* **Supporting:** Life Science
Grade 4			
How Can Animals Use Their Senses to Communicate? *4-LS1-1 • 4-LS1-2 • 4-PS4-2 • 4-PS4-3 • 3-5-ETS1-1* **Supporting:** Physical Science and Engineering Design	**What Is Our Evidence That We Live on a Changing Earth?** *4-ESS1-1 • 4-ESS2-1 • 4-ESS2-2 • 4-ESS3-2 • 4-PS4-1 • 3-5-ETS1-1* **Supporting:** Engineering Design and Physical Science	**How Does Motion Energy Change in a Collision?** *4-PS3-1 • 4-PS3-2 • 4-PS3-3 • 4-LS1-1 • 3-5-ETS1-1* **Supporting:** Engineering Design and Life Science	**How Can We Provide Energy to People's Homes?** *3-5-ETS1-1 • 3-5-ETS1-2 • 3-5-ETS1-3 • 4-PS3-2 • 4-PS3-4 • 4-ESS3-1* **Supporting:** Physical Science and Earth and Space Science
Grade 5			
How Can We Predict Change in Ecosystems? *5-LS1-1 • 5-LS2-1 • 5-PS1-1 • 5-PS3-1* **Supporting:** Physical Science	**How Can We Use the Sky to Navigate?** *5-ESS1-1 • 5-ESS1-2 • 5-PS2-1 • 3-5-ETS1-1* **Supporting:** Physical Science and Engineering Design	**How Can We Identify Materials Based on Their Properties?** *5-PS1-1 • 5-PS1-2 • 5-PS1-3 • 5-PS1-4 • 5-LS1-1* **Supporting:** Life Science	**How Can We Provide Freshwater to Those in Need?** *3-5-ETS1-1 • 3-5-ETS1-2 • 3-5-ETS1-3 • 5-ESS2-1 • 5-ESS2-2 • 5-ESS3-1* **Supporting:** Earth and Space Science

Smithsonian Science for the Classroom Curriculum Overview

20 phenomena- and problem-based modules from the Smithsonian are **setting the standard in 3D learning and 3D assessment**

Coherent Storylines

- Coherent storylines build toward students answering a question or solving a problem
- Begin with the end in mind—students start with the big idea and then work progressively through tasks that build to a culminating science or design challenge

Teacher Support

- Investigations engage your students in 3D tasks and assessments
- Three-dimensional assessment system includes pre-assessment, formative assessment, student self-assessment, and a summative written assessment and performance assessment, accompanied by scoring rubrics
- From misconception support to ELL strategies, Teacher Guides provide everything you need to transition to NGSS and 3D instruction and assessment

Proven Results

- Research-based instruction proven to raise test scores in science, reading, and math
- Effective science and engineering instruction at every grade level
- Smithsonian Science Stories Literacy Series provides all students with access to the Smithsonian's research, scientists, and world-class collections while integrating science content and literacy

Provide Everything You Need to Meet the NGSS Standards

- Teacher support, step-by-step investigations, guiding questions, literacy, assessment, and hands-on materials

Bring the expertise of the Smithsonian's world-class collections, experts, and resources into your classroom.

AT THE SMITHSONIAN

Justin the cheetah was born at the Smithsonian Conservation Biology Institute in 2012 and was named after the famous American runner Justin Gatlin.

Speed Bumps, Grade 4 Student Literacy Reader

Lesson design supports the NGSS teacher

Keep an Eye Out!

What to Look for in a *Smithsonian Science for the Classroom* Module:

Coherent Learning Progression

- Concepts and Practices Storyline shows how concepts build from one lesson to the next within the module using the 5-E model

NGSS Support at Point of Use

- Explanations at point of use explicitly define how students are engaging in the Science and Engineering Practices and Crosscutting Concepts

Literacy and Math

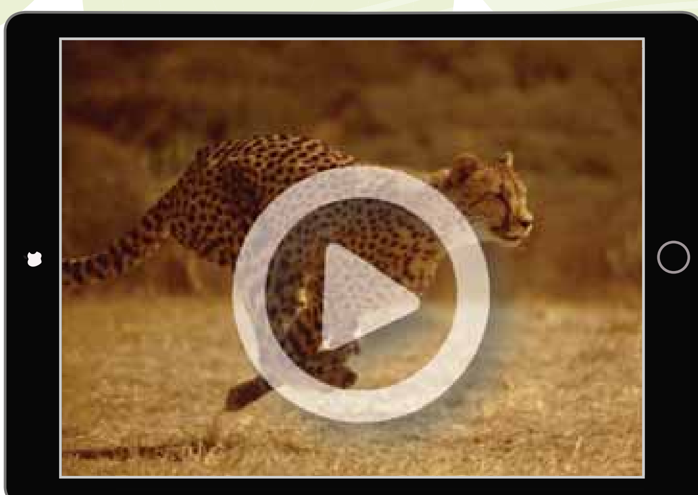
- ELA and Mathematics connections to Science overlap with student engagement in the science and Engineering Practices
- *Smithsonian Science Stories* On-Grade and Below-Grade Literacy Series
- STEM Notebooks

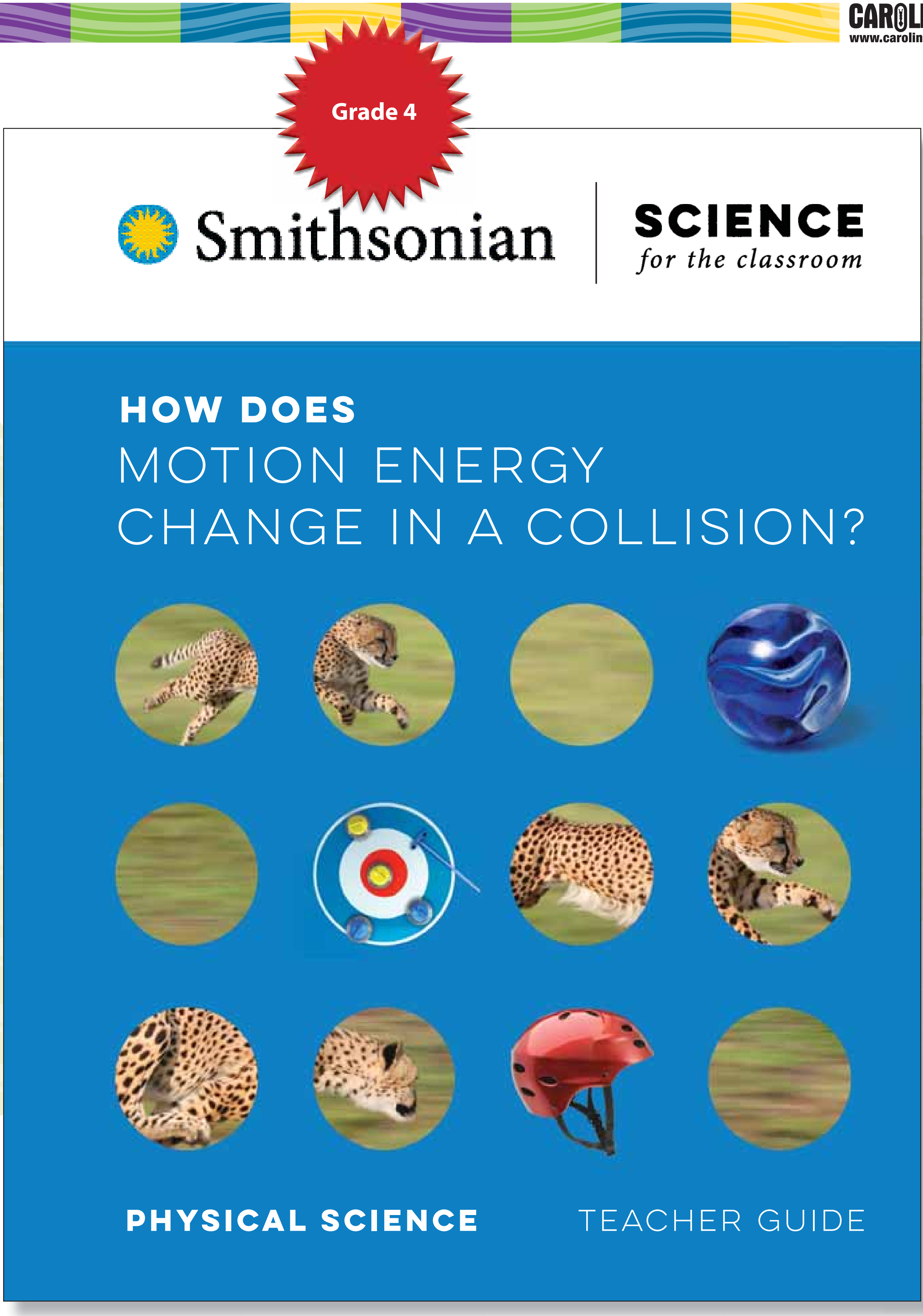
Misconception Identification

- Reveals common misconceptions students may have and offers ways to address them in the lessons

Technology Integration

- A balance between hands-on investigation and technology




Grade 4
Smithsonian
SCIENCE
for the classroom
HOW DOES
MOTION ENERGY
CHANGE IN A COLLISION?
PHYSICAL SCIENCE
TEACHER GUIDE

Summary

In this module, students explore how motion energy can move and change in a collision. In the first focus question, students learn how motion energy can change into heat, light, and sound and move to another object. In the second focus question, students use evidence from collisions to construct a claim that faster objects have more motion energy. They read about how being fast can help plants and animals survive. In the third focus question, students look at ways that motion energy can change to heat. They carry out an investigation into how the surface affects how far an object slides. They learn how air can slow objects down and construct an explanation that motion energy causes air to heat up. They learn that when objects deform, motion energy changes to heat. In focus question four, they learn that a helmet can protect our brain by changing motion energy to heat. They design a helmet using an egg as a model for the head. In the science challenge, students apply what they have learned about motion energy to predict how far a moving washer will move a stationary washer in a game.

Concepts and Practices Storyline

Focus Question 1: How does motion energy move and change?

1 **Lesson 1: Move It**

Moving objects have motion energy.

Students make observations of a video to identify similarities between objects that move.

2 **Lesson 2: Give Me Some Energy**

Heat, light, and sound are evidence for energy.

Students make observations of systems to collect evidence about how motion energy moves and changes.

3 **Lesson 3: Supermodels**

Motion energy can change into heat, light, and sound.

Students use a model to argue that motion energy can move and change in a system.

4 **Lesson 4: Marble Collisions**

Motion energy can move to another object in a collision.

Students predict an answer to a question about how changing the motion of marbles affects their motion after a collision.

Focus Question 2: How does speed affect motion energy?

5 **Lesson 5: Sound Barrier**

Faster objects produce more sound in a collision.

Students carry out an investigation to collect evidence that shows that faster objects cause louder sounds in a collision.

Featured lesson

6 **Lesson 6: Bumper Cars**

Faster objects have more motion energy.

Students plan and carry out an investigation into the effect of speed on how far a moving object is displaced and construct an explanation that faster objects have more motion energy.

7 **Lesson 7: Fastest on Earth**

Plants and animals have structures that help them move fast.

Students obtain and combine information to construct an explanation that internal and external structures of plants and animals work together to help an animal survive.

Focus Question 3: What causes moving objects to slow down?

8 **Lesson 8: The Rough with the Smooth**

Motion energy changes to heat when an object slides on a surface.

Students plan and carry out an investigation to show that a smoother surface causes an object to slide farther than a rough surface.

9 **Lesson 9: Air and Space**

Motion energy changes to heat when an object moves through the air.

Students obtain information from a text to provide evidence that when objects move through air, motion energy changes to heat.

10 **Lesson 10: Bouncing Balls**

Motion energy changes to heat when a soft object deforms.

Students plan and carry out an investigation to show that fully inflating a ball causes it to bounce higher than a partially inflated ball.

Focus Question 4: How can we protect our brains in a collision?

11 **Lesson 11: Playing Safe**

It is important to protect our brain.

Students define the problem of collisions in sport causing damage to the nervous system.

12 **Lesson 12: Egg Drop Challenge Part 1**

Several solutions to a problem need to be considered.

Students design a model of a bicycle helmet that changes motion energy to heat.

13 **Lesson 13: Egg Drop Challenge Part 2**

A solution to a problem needs to be tested.

Students carry out an investigation to test a model of a bicycle helmet that changes motion energy to heat.

Science Challenge

Focus Question 5: How can we predict how far an object will slide in a collision?

14 **Lesson 14: Slide 'n' Collide Part 1**

Speed and surface affect how far an object will slide in a collision.

Students plan and carry out an investigation to determine how speed and surface affect how far an object slides in a collision.

15 **Lesson 15: Slide 'n' Collide Part 2**

Data from an investigation can be used to move an object a set distance.

Students analyze data to find the ramp height and surface that will cause a washer to move a set distance.

Every module ends with a performance task

Daily NGSS support

Focus Question 2: How does speed affect motion energy?

LESSON 5: **SOUND BARRIER**

	Student Objectives	Good Thinking! Misconceptions	Disciplinary Core Ideas
E **Engage Explore** **Class periods:** 2 **Preparation time:** 35 minutes **Vocabulary:** fair test predict prediction variable	Carry out an investigation using a fair test to determine the effect of ramp height on how long it takes a car to travel a set distance. Carry out an investigation using a fair test to determine the effect of speed on the volume of sound produced in a collision. Represent data on sound in a table and use the table to identify cause-and-effect relationships.	It is important to change more than one variable in a given test.	**PS3.B:** Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.

Good Thinking! videos for misconception support @ ScienceEducation.si.edu/goodthinking

50 How Does Motion Energy Change in a Collision?

5

Science and Engineering Practices*	Crosscutting Concepts*	ELA and Math Connections	Extensions
Carrying out investigations **Analyzing and interpreting data** Constructing explanations	**Cause and effect** Scale, proportion, and quantity Energy and matter	**Measurement and data** Geometric measurement: understand concepts of angle and measure angles (4.MD.C.5)	**Literacy: Record Breakers** Students read about records being broken in running races. **Math: Stopwatch Fractions** Students convert times into fractions of a second in hundredths. **Math: Ramp Angles** Students measure the angle the ramp makes with different number of blocks and say what kind of angle it is. **Math: Calculating Speed** Students solve distance and time word problems.

Daily ELA and math support

* Science and Engineering Practices and Crosscutting Concepts that are assessed in the lesson are in bold.

Lesson Planner 51

Teacher notes:

5

Focus Question:
How does speed affect motion energy?

Carrying out investigations

5

Class periods: 2

LESSON 5: SOUND BARRIER

Objectives

- **Carry out an investigation using a fair test to determine the effect of ramp height on how long it takes a car to travel a set distance.**
- **Carry out an investigation using a fair test to determine the effect of speed on the volume of sound produced in a collision.**
- **Represent data on sound in a table and use the table to identify cause-and-effect relationships.**

E Engage
Explore

Vocabulary

fair test
predict
prediction
variable

Lesson Background Information

A steeper ramp has a greater vertical height than a less steep ramp. This means that objects starting from the top of a steep ramp will have greater speed at the bottom of the ramp than objects starting from the top of a less steep ramp.

In this lesson, students use different ramp heights to generate different speeds. They time how long it takes a car to travel a set distance when released from different ramp heights. They then take qualitative measurements of the amount of sound a car makes when it hits a foil barrier at different speeds. They make an initial claim that objects moving faster have more motion energy.

Teacher tip

This lesson is best done in a hallway, gym, or other area with a lot of space and a smooth surface.

Figure 5.1 A race winner covers the race distance in less time than the other runners.

5

Materials

For the teacher

- Smithsonian Science Stories Literacy Series: *Speed Bumps*
- Scientists and Engineers in our Classroom poster
- 1 Ramp
- 1 Meter stick*
- 1 Stopwatch
- 3 Wood blocks (from one group)
- 1 Pie tin
- Masking tape
- 8 Cars
- 8 Rubber bumpers

For each student

- STEM notebook*
- 1 Lesson 5 Notebook Sheet A
- 1 Lesson 5 Notebook Sheet B

For each group of four students

- 1 Meter stick*
- 1 Stopwatch
- 1 Ramp
- 3 Wood blocks
- 1 Car with rubber bumper
- 1 Pie tin
- Masking tape
- Student Activity Guide

For the class

- Scissors (optional)*

*needed but not supplied

5

Preparation

1. Write the lesson title and focus question on the board.
2. Identify a suitable working area for each group of students. Each group will need a flat, smooth workspace. Approximately 2 m of table length should be adequate for each group. If necessary, groups can work on the floor.
3. Screw the rubber bumper into each car as shown in Figure 5.2.

Figure 5.2 Make sure that the bumper is screwed in tightly so it doesn't move around.

4. Set up a ramp with one block as shown in Figure 5.3. Tape the ramp to the top block so the end of the ramp is just resting on the block. Put a piece of masking tape at the bottom of the ramp as shown.

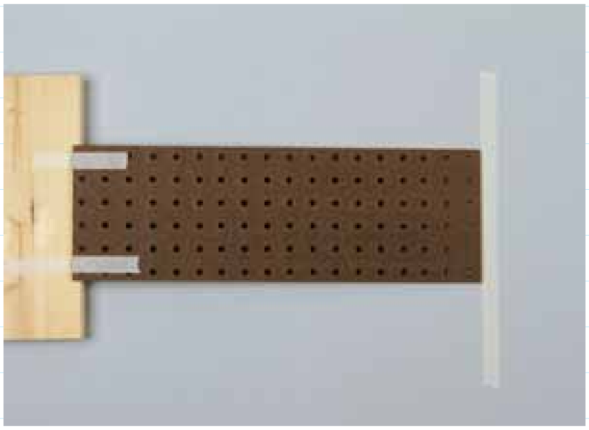


Figure 5.3 Make sure that the ramp is attached loosely but securely to the block.

5. Fold a pie tin in half. Measure 60 cm from the piece of masking tape and tape the pie tin in line with the bottom of the ramp, as shown in Figure 5.4.

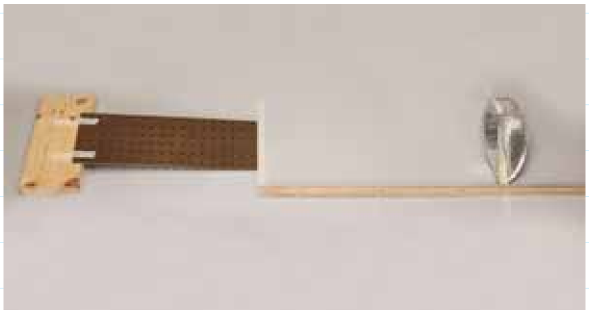


Figure 5.4 The pie tin should be 60 cm from the bottom of the ramp.

Teacher tip

Cars will roll differently on different surfaces. If the car doesn't hit the sound barrier with the ramp resting on one block, try moving the sound barrier nearer to the ramp.

5

6. Familiarize yourself with how to use the stopwatch using the instructions below and Figures 5.5 and 5.6:
   - Use the middle button to find the stopwatch mode. The stopwatch mode should have a number in the format 0:00:00 with no a.m. or p.m.
   - Use the left button to reset to 0:00:00.
   - Use the right button to start and stop.

Figure 5.5 Use the middle button to get to stopwatch mode. When in stopwatch mode, the arrows above SU, FR, and SA will be blinking.

Figure 5.6 Press the left button to reset to zero. Press the right button to start and stop the stopwatch.

7. Make sure that the Scientists and Engineers in our Classroom poster is visible to the whole class, and write the following roles on the board: Organizer, Builder, Recorder, Speaker.
8. Draw a blank claim and evidence table like the one shown in Figure 3.3 on chart paper or on the board.
9. Make one copy of Lesson 5 Notebook Sheets A and B for each student.

Procedure

Getting Started

1. Turn to “Record Breakers” in *Speed Bumps*.
2. Read aloud the section “Famous Runners”.
3. Use the following guiding questions to facilitate a discussion on speed and motion energy:
    - **Which runner covered 100 m in the shortest time?**
    (Usain Bolt.)
    - **Which runner had the highest speed?**
    (Usain Bolt.)
    - **Which runner had the most motion energy?**
    (Answers will vary. I think it is Usain Bolt.)
4. Tell students that they are going to be investigating how speed affects motion energy in the next few lessons.

5

Activity

1. Tell students that they are first going to investigate a way to generate different speeds.
2. Show students the setup with one block and a ramp. Show students how they can change the height of the top of the ramp by changing the angle of the ramp. They can change the angle by adding one or two more blocks.
3. Point out that the bottom of the ramp should be just behind the masking tape mark for each ramp height. Point out the distance of the pie tin barrier from the bottom of the ramp.
4. Tell students that you want them to time how long it takes a car to travel from the top of the ramp to the barrier for different ramp heights. Show students where to put the car at the top of the ramp. Let students know that they can use the sound the car makes when hitting the barrier to let them know when the car has reached the barrier.

Geometric measurement: Understand concepts of angle and measure angles

Misconception support

5. Remind students that they are investigating the effect of ramp height on the time it takes the car to reach the barrier. Use the following questions to facilitate a discussion on what a fair test is:

   - **What would happen if the ramp wasn't in the same place each time?**
     (The distance from the barrier would change. This would affect the time.)

   - **What would happen if the car wasn't in the same place at the top of the ramp each time?**
     (The distance from the barrier would change. This would affect the time.)

Good Thinking!

Misconception

Students may think it is important to change more than one variable in a given test (29). These guiding questions help students understand that changing something other than the ramp height will affect the results.

5

6. Let students know that scientists call an investigation where one thing changes and everything else stays the same a fair test. Tell students that the thing that changes is called a variable. In this activity the variable is the height of the ramp.

7. Organize students into groups of four.

8. Hand out a copy of the Student Activity Guide to each group.

9. Assign the following roles or ask students to agree on them: Organizer, Builder, Recorder, Speaker.

10. Ask students to complete Steps 1–3 in the Student Activity Guide. (Students set up the ramp with one block and put the sound barrier at the end of it.)

Diverse learner support

ELL strategy
It may be helpful to ask English Language Learners to discuss the goals of the activity with a peer and rewrite it in their own words (30).

Teacher tip

If students are familiar with decimals, show them how they can record a time in decimal format (e.g., 2.43 seconds).

Teacher tip

You could also do this part of the lesson as a whole class with three groups of students racing cars down ramps of different heights.

Nature of science

Students use a stopwatch to make an accurate measurement of how long it takes an object to travel a set distance.

11. Walk students through how to use the stopwatch.
12. Tell students that they need to time how long it takes for the car to travel from the top of the ramp to the sound barrier. They should use the sound the car makes when it hits the sound barrier to help them time how long it takes.
13. Suggest each role do the following:
    Speaker: Says "go"
    Builder: Lets car go when Speaker says to
    Organizer: Times how long it takes for car to hit barrier
    Recorder: Records times
14. Give students a few minutes to practice releasing the car and using the stopwatch.
15. Hand out a copy of Lesson 5 Notebook Sheet A to each student.
16. Remind students that scientists do several trials so they are sure of the results. Students will be doing three trials for each ramp height.
17. Use the following guiding questions to ensure that students are doing a fair test:
    - **What would happen if a different person released the car each time?**
      (They may release it faster or slower than another person. This would affect the time.)
    - **What would happen if a different person used the stopwatch?**
      (They may be slower or quicker than another person. This would affect the time.)
    - **What would happen if the ramp was in a different place each time?**
      (The distance to the sound barrier would be different. This would affect the time.)
    - **What would happen if the car was released from a different place on the ramp each time?**
      (The distance to the sound barrier would be different. This would affect the time.)

5

Cause and effect

Students investigate the effect of ramp height on the speed of an object.

Scale, proportion, and quantity

Students measure time in seconds.

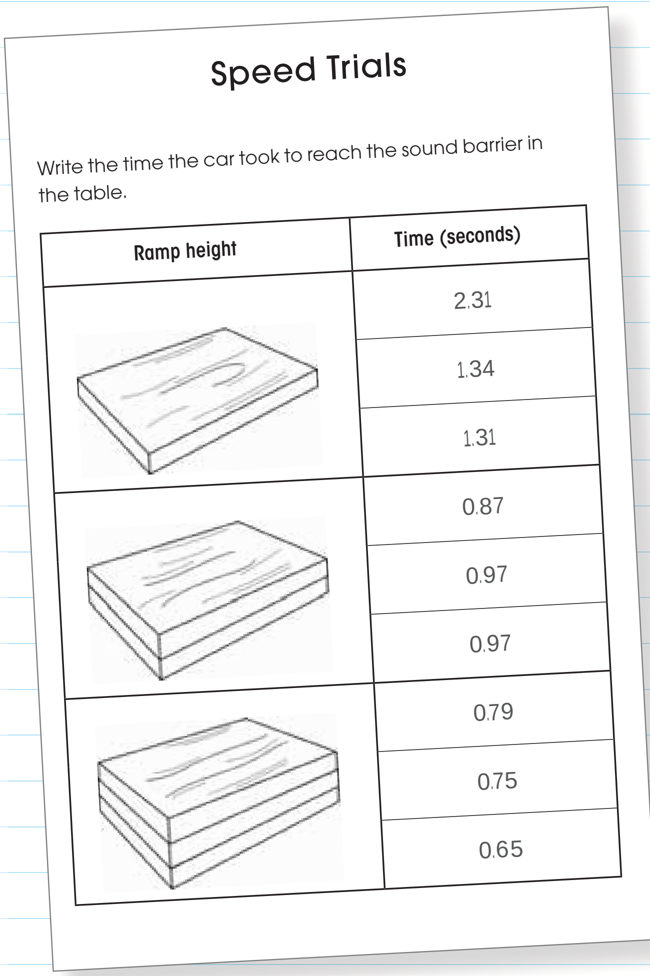
Carrying out investigations

Students investigate the effect of ramp height on the speed of an object using a fair test.

Analyzing data

5 Students represent data on time in a table to reveal a pattern of faster objects moving a set distance in less time.

18. Ask students to complete Steps 4–8 in the Student Activity Guide. (Students do three trials for each ramp height.) An example of student results is shown in Figure 5.7. (Note that results will vary for different surfaces.)



Speed Trials

Write the time the car took to reach the sound barrier in the table.

Ramp height	Time (seconds)
1 block	2.31
	1.34
	1.31
2 blocks	0.87
	0.97
	0.97
3 blocks	0.79
	0.75
	0.65

Figure 5.7 An example of student speed trials, recorded in decimals

Safety

Make sure that groups are well spaced out and remind students not to walk near the path of a rolling object.

Teacher tip

Have the Recorder record the results on their notebook sheet. Have students copy the Recorder's results at the end of the activity.

Tech tip

Let students use a stopwatch on a cell phone or tablet.

Point-of-use teacher support

5

19. Use the following guiding questions to facilitate a discussion on the results:

- **Did you get the same results for each trial?**
  (No. They were slightly different. There was one odd number.)
- **How many trials do you think you needed to do?**
  (Answers will vary. We needed to do three trials.)
- **On which ramp did the car reach the sound barrier first?**
  (The highest ramp.)
- **On which ramp was the car moving with the highest speed?**
  (The highest ramp.)

Suggested class period break

20. Tell students that you now want them to investigate how the speed of the car affects the volume of sound produced when it hits the sound barrier.

21. Use the following guiding questions to remind students what a fair test is:

    - **What is the variable that we are changing?**
      (We are changing ramp height. We are changing speed.)

    - **What else has to stay the same?**
      (Who does what. The position of the ramp. Where the car is released from.)

22. Let students know that scientists predict what will happen when a variable changes and carry out an investigation to see whether their prediction was correct.

23. Ask students to write a prediction in their STEM notebook about what will happen to the sound when the ramp height is changed.

24. Hand out a copy of Lesson 5 Notebook Sheet B to each student.

25. Explain to students how to record the volume of sound for each trial by coloring in an appropriate amount of the triangle.

26. Let students know that they will be doing two trials for each speed.

27. Ask students to complete Steps 9–16 in the Student Activity Guide. (Students carry out an investigation into the effect of speed on sound produced in a collision and make a claim about how speed affects motion energy.) Figure 5.8 shows an example of a completed student notebook sheet.

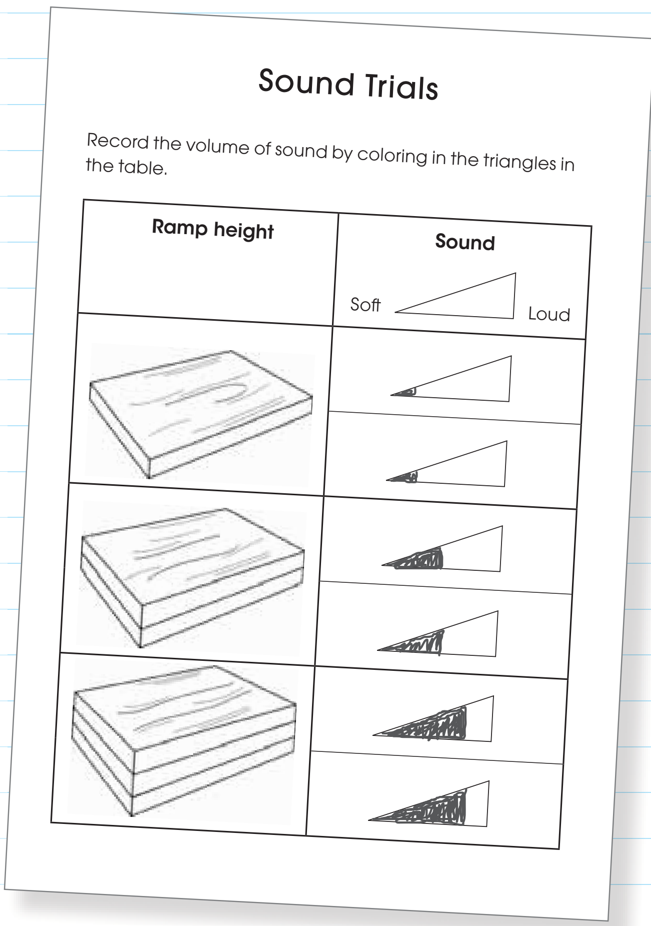


Figure 5.8 An example of student sound trials

Cause and effect

Students observe the effect of speed on the volume of sound produced in a collision.

Energy and matter

Students observe that motion energy can change into sound.

Carrying out investigations

Students carry out an investigation using a fair test into the effect of speed on the volume of sound produced in a collision.

Analyzing and interpreting data

Students represent data on sound produced in a collision in a table and identify a pattern of faster objects making louder sounds.

Constructing explanations

Students make an initial claim that faster objects have more motion energy.

Bringing It All Together

1. Bring the class back together again.
2. Facilitate a discussion on the results using the following guiding questions:
   - **Did you get the same results for each trial?**
     (Yes, the volume of sound was about the same for each trial.)
   - **How many trials do you think you needed to do?**
     (Answers will vary. Two trials was enough.)
   - **What effect did the speed of the car have on the sound?**
     (The fastest car made the loudest sound. The slowest car made the softest sound.)
   - **Was your prediction correct?**
     (Answers will vary.)

5

3. Tell students that you now want them to make a claim about how speed affects motion energy using evidence from the investigation. Ask for volunteer Speakers to share their group's claim. Remind students to use evidence to support their claim.
4. Use student answers to develop a class claim and evidence table. An example of a completed class claim and evidence table is shown in Figure 5.9.

Claim	Evidence
Faster objects have more motion energy.	Faster objects made more sound during a collision.

Figure 5.9 Example of class claim and evidence table

5. Tell students that they will be using their ramps to collect more evidence in the next lesson.

Assessment tools aligned to the three dimensions of NGSS

Assessment

Formative Assessment

Use this table to provide timely, actionable feedback for individual students on their successes and areas for improvement as well as to plan any necessary whole-class remediation. Revisit the Common Misconceptions table in the module overview to familiarize yourself with other possible difficulties.

Assessed Task Activity: Steps 18–27 (STEM notebook and Observation)		
Concepts and Practices	***Indicators of Success***	***Indicators of Difficulty***
Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.	☐ Students show an understanding that the movement of the car and sound are evidence for energy.	☐ Students do not show an understanding that the movement of the car and sound are evidence for energy.
Analyzing and interpreting data	☐ Students record their results correctly in the table—e.g., they record each trial on a separate line.	☐ Students don't record their results correctly in the tables—e.g., they record different trials on the same line.
Carrying out investigations	☐ Students do three trials to measure speed and two trials to measure sound. ☐ Students do a fair test—e.g., they keep the same roles and make sure that the ramp is behind the line each time.	☐ Students do two trials to measure speed and one trial to measure sound. ☐ Students do not do a fair test—e.g., they switch roles halfway through or do not make sure that the ramp is behind the line each time.

5

Concepts and Practices	Indicators of Success	Indicators of Difficulty
Cause and effect	☐ Students say that the faster car causes a louder sound.	☐ Students do not make a connection between the speed of the car and the volume of sound.

Differentiated learning

Remediation

Let students use the demonstration setup. Ask students to use just one block and three blocks.

Enrichment

Ask students to explain how Lesson 4 was a fair test. Students should say that the tube was at the same height throughout. Ask students to explain how Lesson 4 could be adapted so that the variable tested was speed. Students should say that the tube could be raised by using a second or third block of wood.

5

Range of reading and level of text complexity; Integration of knowledge and ideas

Research to build and present knowledge

Obtaining, evaluating, and communicating information

Students obtain information from a reading on how running race records have been broken and communicate it in a piece of writing.

Extensions

Literacy: Record Breakers

Materials

For each group of two students

- Smithsonian Science Stories Literacy Series: *Speed Bumps*

Procedure

Organize the class into pairs of students. Hand out a copy of *Speed Bumps* to each pair. Have pairs read "Record Breakers." Have students do a piece of writing explaining why records keep being broken. Students should use evidence for reading.

Math: Stopwatch Fractions

Procedure

Have students convert the times under 1 second into fractions—e.g., 0.84 seconds would be 84/100 seconds. Ask students to order the fractions by size.

Build fractions from unit fractions by applying and extending previous understandings of operations on whole numbers

Math: Ramp Angles

Materials

For each group of four students

- 1 Ramp
- 3 Wood blocks
- Masking tape
- 2 Protractors*

*needed but not supplied

Procedure

Ask students to set up their ramp. Ask students to measure the angle the ramp makes with one, two, and three wood blocks using a protractor (two students can measure at each side). Ask students to sketch each angle, mark the size of it, and to say whether it is a right, acute, or obtuse angle.

Geometric measurement: Understand concepts of angle and measure angles; Draw and identify lines and angles, and classify shapes by properties of their lines and angles

5

Math: Calculating Speed

Procedure

Give students simple word problems for distance and time and ask them to calculate the speed by division. For example: A car travels 100 m in 5 seconds. What is the speed? (20 m per second.)

Use the four operations with whole numbers to solve problems

Teacher notes:

5

Smithsonian | SCIENCE *for the classroom*

HOW DOES

MOTION ENERGY CHANGE IN A COLLISION?

PHYSICAL SCIENCE STUDENT ACTIVITY GUIDE

Lesson 5: **Sound Barrier**

We are investigating:
How does speed affect motion energy?

Materials

For each student

- STEM notebook
- 1 Lesson 5 Notebook Sheet A
- 1 Lesson 5 Notebook Sheet B

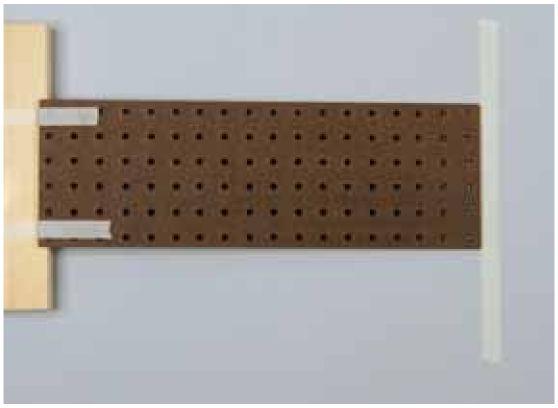
For each group of four students

- 1 Meter stick
- Stopwatch
- 1 Ramp
- 3 Wood blocks
- 1 Car with bumper
- 1 Pie tin
- Tape

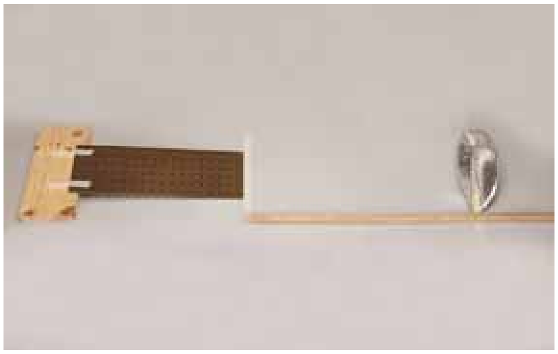
6

Procedure

1. Collect your materials.
2. Set up your ramp using one block:
   - Tape your ramp to the top of the block.
   - Mark the bottom of the ramp with tape.



3. Set up your sound barrier:
   - Fold the pie tin in half.
   - Measure 60 cm from the bottom of the ramp.
   - Tape your pie tin to the table or floor.



7

4. Let the car go from the top of the ramp.
5. Time how long it takes the car to reach the sound barrier.
6. Do this two more times.

Stop & Check Is everyone keeping the same roles?

Stay Safe! Don't get too close to other groups. Don't walk near the path of a rolling object.

7. Repeat Steps 4–6 for two blocks and three blocks.
8. Record the times on your notebook sheet.

Stop & Check Is the ramp in the same place each time?

9. Set up your ramp with three blocks.
10. Let the car go from the top of the ramp.
11. Listen for how much sound is made.
12. Do one more trial.
13. Repeat Steps 10–12 for two blocks and one block.

Group Work Make sure everyone agrees on the volume of sound.

14. Record the volume of sound on your notebook sheet.
15. Discuss your results with your group.
16. Make a claim about how the speed of an object affects the motion energy of the object.

Stop & Check Are you thinking about what happens to the motion energy of the car when it hits the sound barrier?

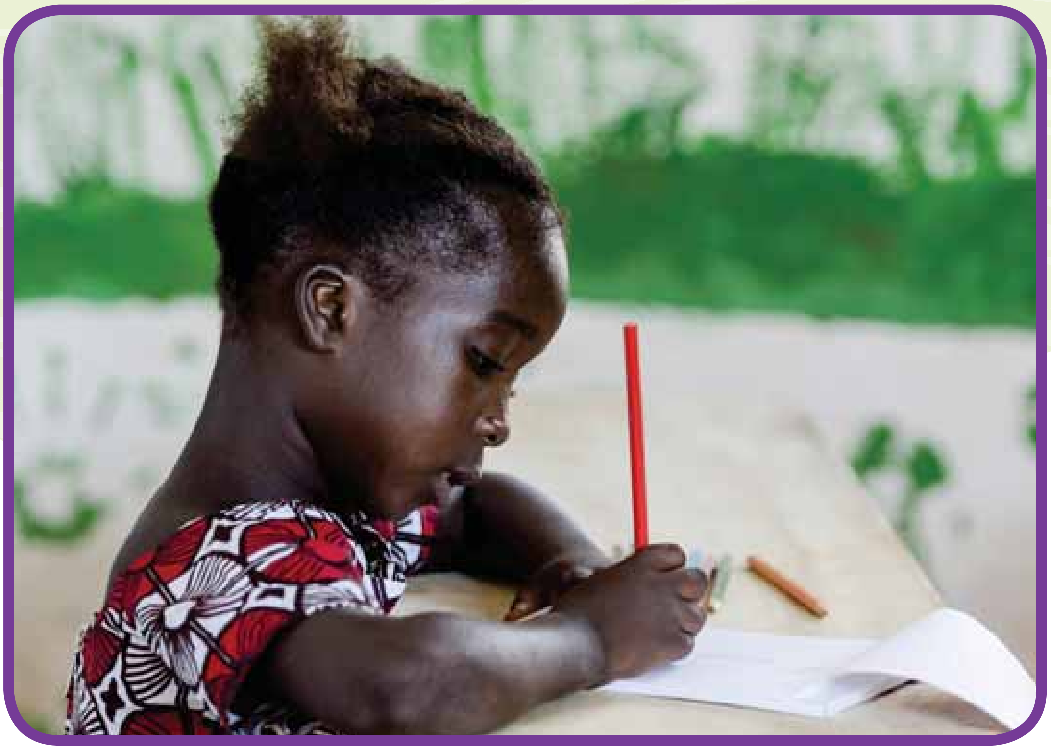
8

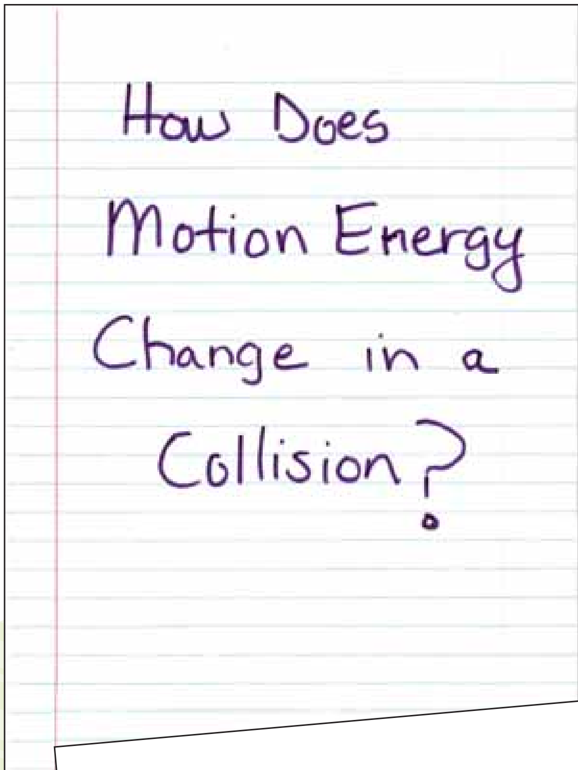
Provide Opportunities for Students to Think, Act, Reflect, and Communicate Like Scientists and Engineers

Anyone with a question can be a scientist! *Smithsonian Science for the Classroom* gets students thinking, acting, reflecting, and communicating like scientists and engineers.

Scientists and engineers explore and investigate, read to gather information, record their data, and reflect on their ideas. *Smithsonian Science for the Classroom* provides students with:

- Hands-on investigations that integrate literacy through the *Smithsonian Science Stories* Literacy Series, available in both on-grade and below-grade reading levels.
- Multiple lessons dedicated to reading, writing, speaking, and listening to gather information to support claims
- STEM Notebooks built by students to keep records of their questions, predictions, claims linked to evidence, and conclusions. Lesson notebook sheets scaffold student thinking and provide opportunities for students to explain phenomena, communicate their design for solutions, and self-assess.
- Math integrations that offer opportunities for students to represent and interpret data and quantitatively describe and measure objects, events, and processes.





How Does Motion Energy Change in a Collision?

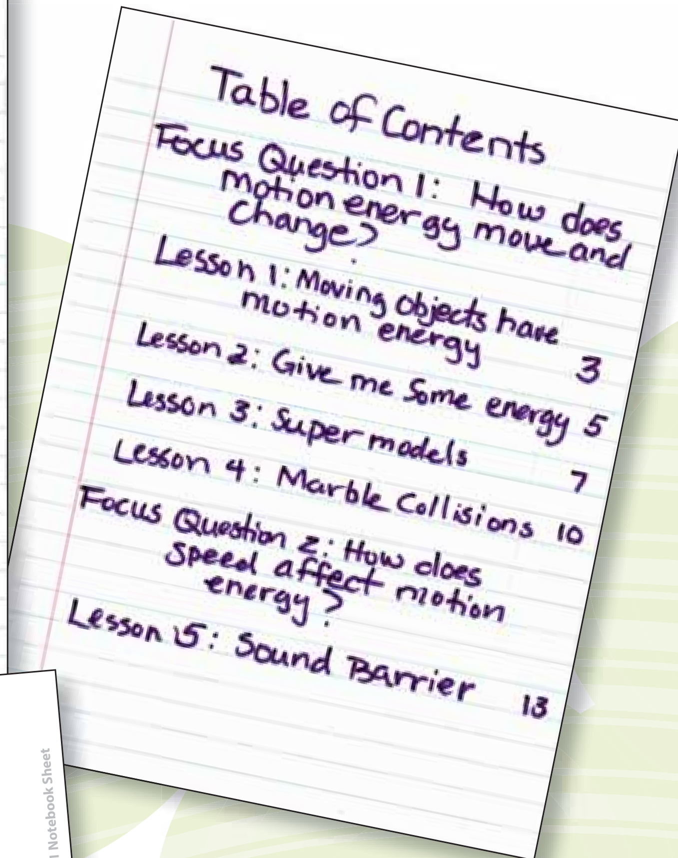
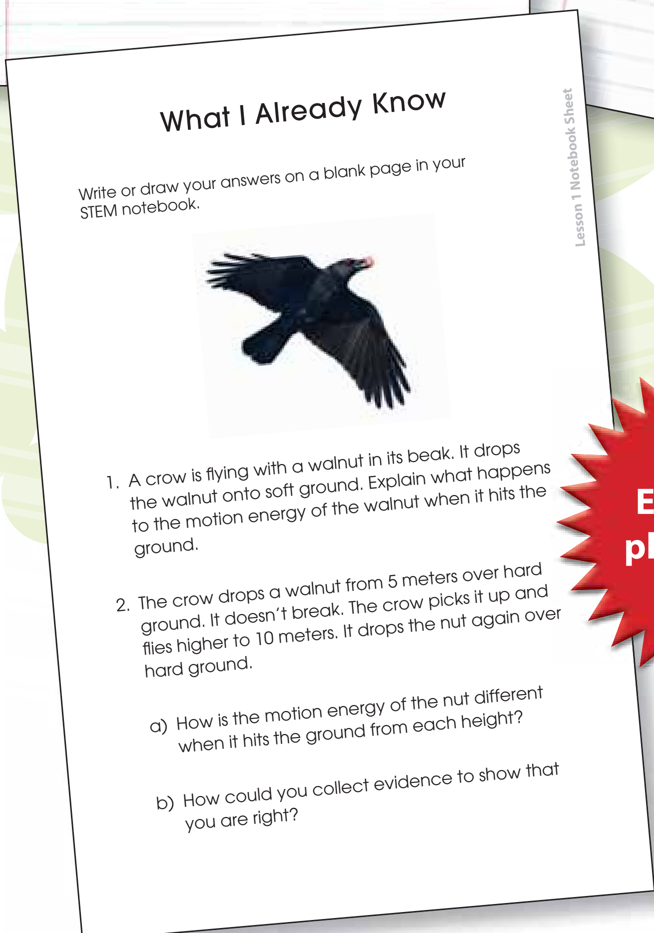


Table of Contents



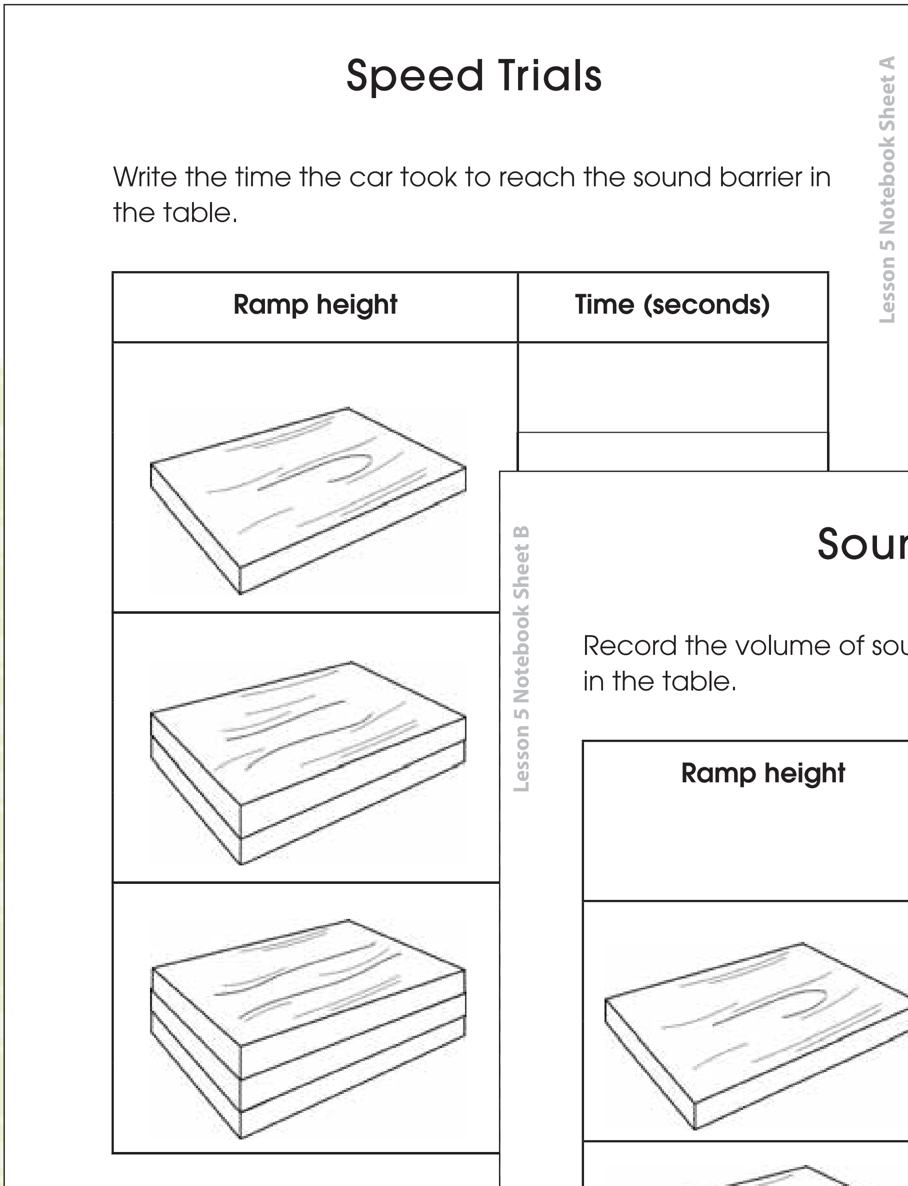
What I Already Know

Lesson 1 Notebook Sheet

Write or draw your answers on a blank page in your STEM notebook.

1. A crow is flying with a walnut in its beak. It drops the walnut onto soft ground. Explain what happens to the motion energy of the walnut when it hits the ground.
2. The crow drops a walnut from 5 meters over hard ground. It doesn't break. The crow picks it up and flies higher to 10 meters. It drops the nut again over hard ground.
   a) How is the motion energy of the nut different when it hits the ground from each height?
   b) How could you collect evidence to show that you are right?

Explaining phenomena

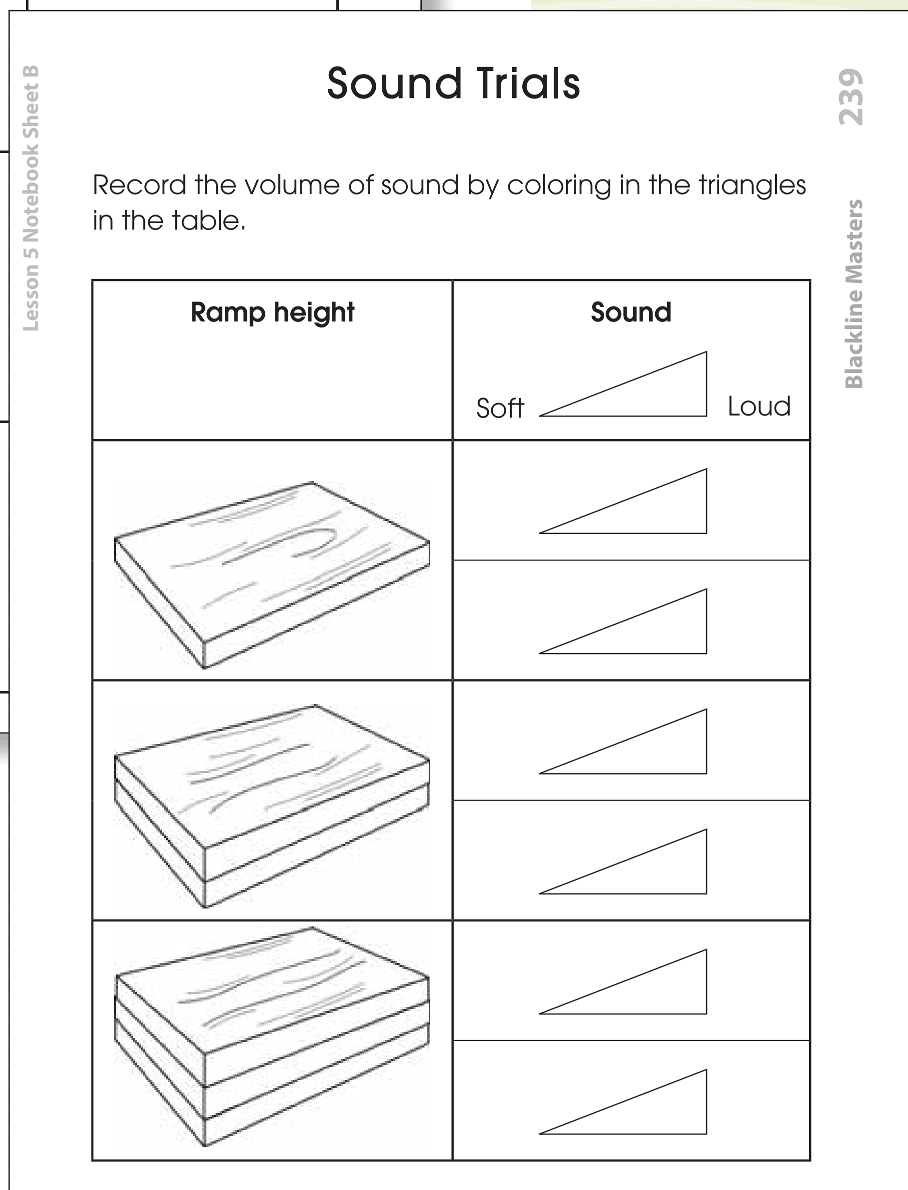


Lesson 5 Notebook Sheet A

Speed Trials

Write the time the car took to reach the sound barrier in the table.

Ramp height	Time (seconds)



Lesson 5 Notebook Sheet B

Sound Trials

Record the volume of sound by coloring in the triangles in the table.

Ramp height	Sound Soft Loud

239

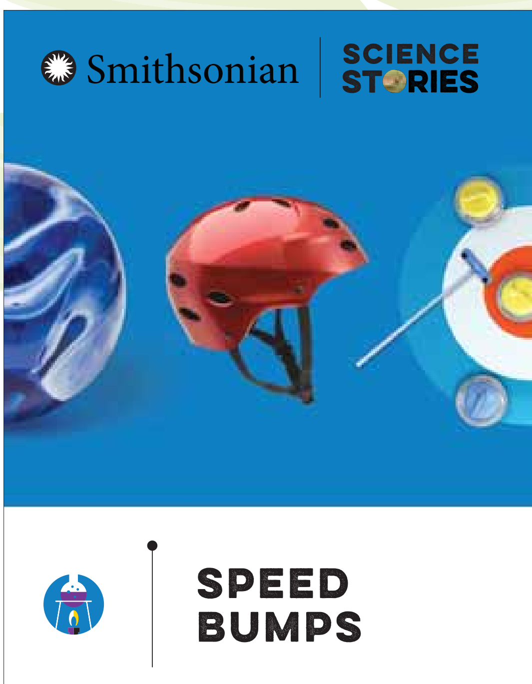
Blackline Masters

Recording, analyzing, and interpreting data

Module-Specific On-Grade, Below-Grade, and Spanish Nonfiction Literacy Supports Every Module of the *Smithsonian Science for the Classroom* Program.

Life Science: *How Can Animals Use Their Senses to Communicate?*

Earth/Space Science: *What Is Our Evidence That We Live on a Changing Earth?*



Physical Science: *How Does Motion Energy Change in a Collision?*

Engineering Design: *How Can We Provide Energy to People's Homes?*

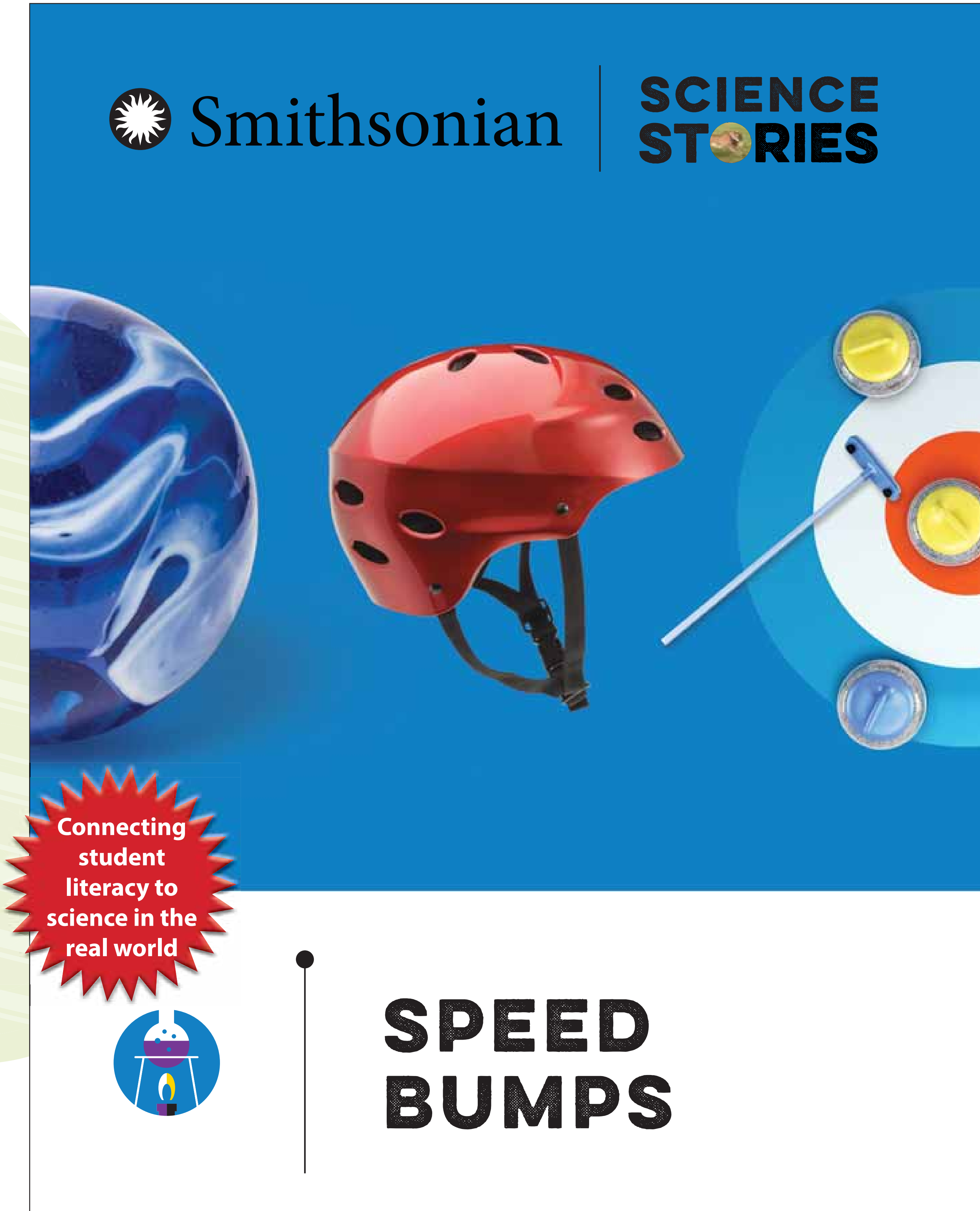

Smithsonian
SCIENCE STORIES
Connecting student literacy to science in the real world
SPEED BUMPS

TABLE OF CONTENTS

Bring the expertise of the Smithsonian into your classroom

READING 2

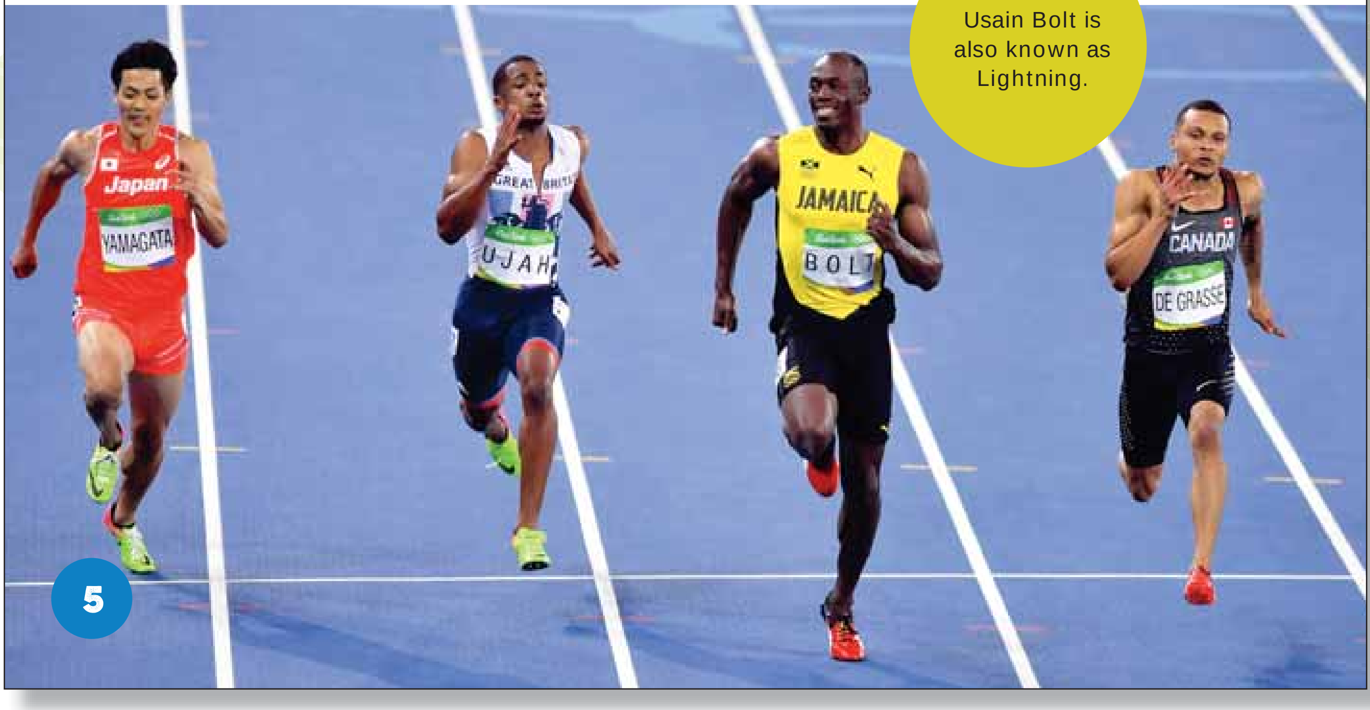
RECORD BREAKERS

Famous Runners

Usain Bolt is often called the world's fastest man. He is from Jamaica. He won eight gold medals in the races he ran in the 2008, 2012, and 2016 Summer Olympic Games. Bolt's events are the 100 meter, 200 meter, and the 4 x 100 meter relay. These races are the shortest track events at the Olympics. People who run these races tend to have the fastest **speeds**. The title of "fastest man" goes to the record holder for the 100 meter for this reason. Bolt won all eight gold medals before his 30th birthday.

It isn't just Usain Bolt who has set world records for speed. Many footrace records that were once thought to be unbreakable have since been broken.

Usain Bolt is also known as Lightning.



5

RECORD BREAKERS

This is Roger Bannister's track jersey.

Before Bolt, an American athlete was setting speed records of his own. Carl Lewis was born in 1961. Like Bolt, he ran multiple races. Lewis competed in the 100 meter, 200 meter, 4 x 100 meter relay, and 4 x 200 meter relay, plus the long jump. He won a total of nine gold medals. He competed in the Olympic Games four times. He set a world record for the 100 meter with a time of 9.86 seconds. Runners kept beating the time little by little. Bolt holds the current record at 9.58 seconds.

It was once believed no one could run a mile in less than 4 minutes. British runner Roger Bannister beat that time in 1954. He ran a mile in 3 minutes and 59.4 seconds. People thought the 100 meter was not possible to run in less than 10 seconds. American Jim Hines did it in 1968. More and more runners have followed in Hines' footsteps by running the 100 meters in less than 10 seconds. How were these runners able to do such great things? Their speed is the result of hard work, practice, and natural talent.

6

LECTURA

2

CREADORES DE RÉCORDS

Literacy available in Spanish

Corredores famosos

Usain Bolt a menudo es llamado el hombre más rápido del mundo. Nació en Jamaica. Ganó ocho medallas de oro en las carreras en las que compitió en los Juegos Olímpicos de verano de 2008, 2012 y 2016. Las carreras de Bolt son las de 100 metros, 200 metros y la de relevos de 4 x 100 metros. Son las carreras de pista más cortas en los Juegos Olímpicos. Quienes compiten en estas carreras suelen ser los más **veloces**. Por ese motivo, el título de "hombre más veloz" se otorga a quien marque el récord en los 100 metros. Bolt ganó las ocho medallas de oro antes de cumplir 30 años.

No solamente Usain Bolt marcó récords mundiales de velocidad. Muchos de los récords de carreras que alguna vez se creyeron irrompibles, han sido mejorados.

A Usain Bolt también se lo conoce como "el rayo".

5

CREADORES DE RÉCORDS

Esta es la camiseta con la que corría Roger Bannister.

Antes de Bolt, un atleta estadounidense ya marcaba sus propios récords de velocidad. Carl Lewis nació en 1961. Al igual que Bolt, corrió muchas carreras. Lewis competía en los 100 metros, los 200 metros, relevos de 4 x 100 metros, y relevos de 4 x 200 metros, además del salto en largo. En total, ganó nueve medallas de oro. Participó cuatro veces de Juegos Olímpicos. Marcó el récord mundial de 100 metros en 9.86 segundos. Poco a poco, otros corredores mejoraron esa marca. Bolt es quien marcó el récord actual, de 9.58 segundos.

En una época se pensaba que nadie podría correr una milla en menos de 4 minutos. El corredor británico Roger Bannister rompió esa marca en 1954. Corrió una milla en 3 minutos con 59.4 segundos. Las personas creían que no era posible correr los 100 metros en menos de 10 segundos. El estadounidense Jim Hines lo logró en 1968. Cada vez más corredores han seguido los pasos de Hines y han corrido los 100 metros en menos de 10 segundos. ¿Cómo es que estos corredores pudieron lograr tales hazañas? Su velocidad es el resultado de un trabajo duro, práctica y talento natural.

6

GLOSSARY

arachnologist: A scientist who studies arachnids, such as spiders

collision: When one or more things hits something else

concussion: Bruising of the brain

crustacean: An animal with no backbone, with a segmented body and a hard outer shell

engineer: Someone who uses science to solve a problem

exoskeleton: A hard, protective structure on the outside of the body

external structure: A part on the outside of an organism's body

fragile: Easily broken or damaged

friction: What causes a moving object to slow down when it is touching another object

internal structure: A part on the inside of an organism's body

limb: A part of an organism that sticks out from the body and can be used for moving or grasping

man-made satellite: A device that circles Earth

meteor: A streak of light in the sky caused by falling matter that enters Earth's atmosphere and burns up

meteorite: A rock or piece of metal from outer space that has fallen to Earth

meteoroid: A solid object moving through Earth's atmosphere

motion energy: The energy of moving objects

muscle: Internal body tissue that squeezes and releases to produce movement

nervous system: The system of nerves in the body that sends messages between the brain and other parts of the body

ossicones: Horn-like structures on the heads of some animals

space probe: A device that obtains information from space and sends it back to Earth

speed: How long it takes something or someone to travel a set distance

GLOSARIO

aracnólogo: científico que estudia arácnidos, como las arañas

colisión: cuando una o más cosas chocan contra algo

conmoción cerebral: contusión en el cerebro

crustáceo: animal invertebrado, con un cuerpo segmentado y una coraza externa dura

ingeniero: persona que utiliza la ciencia para resolver un problema

exoesqueleto: estructura rígida y de protección que se encuentra por fuera del cuerpo

estructura externa: parte localizada en el exterior del cuerpo de un organismo

frágil: que se rompe o daña fácilmente

fricción: lo que hace que un objeto en movimiento pierda velocidad cuando toca otro objeto

estructura interna: una parte localizada en el interior del cuerpo de un organismo

extremidad: parte de un organismo que sobresale del cuerpo y se la puede utilizar para moverse o agarrar

satélite hecho por el hombre: dispositivo que se mueve en círculos alrededor de la Tierra

meteoro: rayo de luz en el cielo producido por materia que cae, ingresa a la atmósfera de la Tierra y se quema

meteorito: roca o pieza de metal del espacio exterior que ha caído en la Tierra

meteoroide: objeto sólido que se mueve por la atmósfera terrestre

energía de movimiento: energía de los objetos en movimiento

músculo: tejido corporal interno que se contrae y se relaja para producir movimiento

sistema nervioso: sistema de los nervios del cuerpo que envía mensajes entre el cerebro y otras partes del cuerpo

Teacher notes:

Teacher notes:

Smithsonian | SCIENCE for the classroom

	Life Science	Earth and Space Science	Physical Science	Engineering Design
Grade 1				
	How Do Living Things Stay Safe and Grow? *1-LS1-1 • 1-LS1-2 • 1-LS3-1 • K-2-ETS1-1* **Supporting:** Engineering Design	**How Can We Predict When the Sky Will Be Dark?** *1-ESS1-1 • 1-ESS1-2 • 1-PS4-2* **Supporting:** Physical Science	**How Can We Light Our Way in the Dark?** *1-PS4-2 • 1-PS4-3 • 1-LS1-1 • K-2-ETS1-1* **Supporting:** Life Science and Engineering Design	**How Can We Send a Message Using Sound?** *K-2-ETS1-1 • K-2-ETS1-2 • K-2-ETS1-3 • 1-PS4-1 • 1-PS4-4* **Supporting:** Physical Science
Grade 2				
	How Can We Find the Best Place for a Plant to Grow? *2-LS2-1 • 2-LS2-2 • 2-LS4-1 • K-2-ETS1-1* **Supporting:** Engineering Design	**What Can Maps Tell Us About Land and Water on Earth?** *2-ESS2-2 • 2-ESS2-3 • 2-PS1-1* **Supporting:** Physical Science	**How Can We Change Solids and Liquids?** *2-PS1-1 • 2-PS1-2 • 2-PS1-3 • 2-PS1-4 • K-2-ETS1-1* **Supporting:** Engineering Design	**How Can We Stop Soil From Washing Away?** *K-2-ETS1-1 • K-2-ETS1-2 • K-2-ETS1-3 • 2-ESS1-1 • 2-ESS2-1* **Supporting:** Earth and Space Science
Grade 3				
	What Explains Similarities and Differences Between Organisms? *3-LS1-1 • 3-LS3-1 • 3-LS3-2 • 3-LS4-2 • 3-ESS2-2* **Supporting:** Earth and Space Science	**How Do Weather and Climate Affect Our Lives?** *3-ESS2-1 • 3-ESS2-2 • 3-ESS3-1 • 3-5-ETS1-1* **Supporting:** Engineering Design	**How Can We Predict Patterns of Motion?** *3-PS2-1 • 3-PS2-2 • 3-PS2-3 • 3-PS2-4 • 3-5-ETS1-1* **Supporting:** Engineering Design	**How Can We Protect Animals When Their Habitat Changes?** *3-5-ETS1-1 • 3-5-ETS1-2 • 3-5-ETS1-3 • 3-LS2-1 • 3-LS4-1 • 3-LS4-3 • 3-LS4-4* **Supporting:** Life Science
Grade 4				
	How Can Animals Use Their Senses to Communicate? *4-LS1-1 • 4-LS1-2 • 4-PS4-2 • 4-PS4-3 • 3-5-ETS1-1* **Supporting:** Physical Science and Engineering Design	**What Is Our Evidence That We Live on a Changing Earth?** *4-ESS1-1 • 4-ESS2-1 • 4-ESS2-2 • 4-ESS3-2 • 4-PS4-1 • 3-5-ETS1-1* **Supporting:** Engineering Design and Physical Science	**How Does Motion Energy Change in a Collision?** *4-PS3-1 • 4-PS3-2 • 4-PS3-3 • 4-LS1-1 • 3-5-ETS1-1* **Supporting:** Engineering Design and Life Science	**How Can We Provide Energy to People's Homes?** *3-5-ETS1-1 • 3-5-ETS1-2 • 3-5-ETS1-3 • 4-PS3-2 • 4-PS3-4 • 4-ESS3-1* **Supporting:** Physical Science and Earth and Space Science
Grade 5				
	How Can We Predict Change in Ecosystems? *5-LS1-1 • 5-LS2-1 • 5-PS1-1 • 5-PS3-1* **Supporting:** Physical Science	**How Can We Use the Sky to Navigate?** *5-ESS1-1 • 5-ESS1-2 • 5-PS2-1 • 3-5-ETS1-1* **Supporting:** Physical Science and Engineering Design	**How Can We Identify Materials Based on Their Properties?** *5-PS1-1 • 5-PS1-2 • 5-PS1-3 • 5-PS1-4 • 5-LS1-1* **Supporting:** Life Science	**How Can We Provide Freshwater to Those in Need?** *3-5-ETS1-1 • 3-5-ETS1-2 • 3-5-ETS1-3 • 5-ESS2-1 • 5-ESS2-2 • 5-ESS3-1* **Supporting:** Earth and Space Science

Smithsonian Science Education Center

CAROLINA www.carolina.com

CCPST19080509