Smithsonian Science for the Classroom

HOW DOES MOTION ENERGY CHANGE IN A COLLISION?

Grade 4 - Physical Science

TRAINER GUIDE

CURRICULUM PROFESSIONAL DEVELOPMENT

Smithsonian
Science Education Center

The **Smithsonian Science Education Center** (SSEC) is an education organization within the Smithsonian Institution. The SSEC's mission is to transform K–12 *Education Through Science*™ in collaboration with communities across the globe. The SSEC promotes authentic, interactive, inquiry-based K–12 STEM teaching and learning; ensures diversity, equity, accessibility, and inclusion in K–12 STEM education; and advances STEM education for sustainable development. The SSEC achieves its goals by developing exemplary curriculum materials and digital resources; supporting the professional growth of K–12 teachers and school leaders; and conducting outreach programs through LASER (Leadership and Assistance for Science Education Reform) to help schools, school districts, state education agencies, and ministries of education throughout the world implement inquiry-based science education programs.

The **Smithsonian Institution** was created by an Act of Congress in 1846 "for the increase and diffusion of knowledge . . ." This independent federal establishment is the world's largest museum, education, and research complex and is responsible for public and scholarly activities, exhibitions, and research projects nationwide and overseas. Among the objectives of the Smithsonian is the application of its unique resources to enhance elementary and secondary education.

Acknowledgments

Lead Trainer Guide Developer

Dr. Hyunju Lee

Division Director of Professional Services

Amy D'Amico, PhD, Principal Investigator, Smithsonian Science for North and South Carolina Classrooms

Assistant Division Director of Professional Services

Katie Gainsback, Project Manager, Smithsonian Science for North and South Carolina Classrooms

Addy Allred
Jacqueline Kolb
Eva Muszynski
Ariel Waldman
Katherine Blanchard
Dr. Hyunju Lee
Shellie Pick
Sherrell Williams
Katherine Fancher
Alexa Mogck
Layla Sastry

Executive Director, Smithsonian Science Education Center

Dr. Carol O'Donnell, Co-PI, Smithsonian Science for North and South Carolina Classrooms

Smithsonian Science Education Center Staff

Executive Office

Kate Echevarria
Johnny F. McInerney

Advancement and Partnerships

Holly Glover, Division Director
Denise Anderson
Inola Walston

Finance and Administration

Lisa Rogers, Division Director
Allison Gamble
Jasmine Rogers

Curriculum, Digital Media, and Communications

Dr. Brian Mandell, Division Director
Sofia Elian
Heidi Gibson
Dr. Sarah J. Glassman
Carolina Gonzalez
Dr. Emily J. Harrison
Victor Lucena
Hannah Osborn
Andre Radloff
Melissa J.B. Rogers
Logan Schmidt
Dr. Mary E. Short
Khadijah Thibodeaux
Logan Werlinger
Raymond Williams, III

Thank You for Your Support

This project was supported by the US Department of Education through an early-phase Education Innovation and Research (EIR) grant (U411C190055) to the Smithsonian Science Education Center.

How Does Motion Energy Change in a Collision?

Grade 4—Physical Science

Trainer Guide

INTRODUCTION **6**

Resources 6

How to Use This Trainer Guide 6

Room Setup 7

Workshop Overview 7

SESSION 1: INTRODUCTION AND LESSON 1 **8**

Lesson 1: Move It 10

Smithsonian Science for the Classroom Features and Carolina Science Online 13

Concept Storyline 17

SESSION 2: LESSONS 2–7 **19**

Lesson 2: Give Me Some Energy 21

Lesson 3: Supermodels 26

Group Roles 29

Lesson 4: Marble Collisions 30

Lesson 5: Sound Barrier 34

Lesson 6: Bumper Cars 39

Lesson 7: Fastest on Earth 43

SESSION 3: LESSONS 8–11 **46**

Lesson 8: The Rough with the Smooth 47

Lesson 9: Air and Space 52

Lesson 10: Bouncing Balls 55

Lesson 11: Playing Safe 59

SESSION 4: LESSONS 12–15 62

Lesson 12: Egg Drop Challenge Part 1 63

Lesson 13: Egg Drop Challenge Part 2 66

Lesson 14: Slide ‘n’ Collide Part 1 69

Lesson 15: Slide ‘n’ Collide Part 2 75

Wrap Up 78

APPENDIX 1: GROUP DISCUSSION 79

APPENDIX 2: QUESTIONING/GUIDING THOUGHT 80

APPENDIX 3: GROUP ROLES 81

APPENDIX 4: MANAGING DIFFERING OPINIONS 84

INTRODUCTION

In 2019, the US Department of Education awarded the Smithsonian Science Education Center an early-phase Education Innovation and Research (EIR) grant to support the development, implementation, and initial evaluation of evidence-based innovations to improve student achievement. The project, called Smithsonian Science for North and South Carolina Classrooms (PR# U411C190055), took place between October 2019 and September 2024 in third-, fourth-, and fifth-grade classrooms in North and South Carolina.

Between 2020 and 2023, participating teachers in implementation schools received curriculum professional development tied to two Smithsonian Science for the Classroom curriculum modules and content and pedagogy professional development tied to the content of each module to implement in their classrooms. The Center for Research in Educational Policy (CREP) at the University of Memphis evaluated the impact of these modules and professional development on student achievement using standardized assessments, classroom observations, and teacher focus groups.

This guide was developed as a support for trainers leading curriculum professional development for fourth grade teachers implementing the Smithsonian Science for the Classroom Physical Science module *How Does Motion Energy Change in a Collision?*

RESOURCES

- Teacher Guide (TG)
- Student Activity Guide (SAG)
- Smithsonian Science Stories Literacy Series: *Speed Bumps* (Reader)
- Carolina Science Online (CSO): Carolinascienceonline.com

HOW TO USE THIS TRAINER GUIDE

This guide shares important ideas and strategies for effectively introducing a Smithsonian Science for the Classroom (SSftC) module with educators, when used in conjunction with the corresponding Teacher Guide (TG). The Teacher Guide contains essential details needed to implement the module in the classroom, while this Trainer Guide outlines how to conduct professional development for that module; therefore, the two guides should be used in tandem.

The professional development plan for each section is outlined in a table at the start of each session. Within each section, there is another table. The first column shows the part of the lesson being addressed, and corresponding page numbers within the Teacher Guide, Student Activity Guide, and Reader. The second column provides the trainer with additional direction in concise bullet points.

ROOM SETUP

To set up a classroom for this workshop:

1. Move tables or desks so groups of three or four participants can work together.
2. Set module materials out on side tables where they can be easily accessed.
3. Locate the nearest restrooms and evacuation routes.

WORKSHOP OVERVIEW

This trainer guide provides direction on facilitating the curriculum sessions highlighted in the table below.

Day 1		Day 2	
10 a.m.	Welcome Session	**10 a.m.** Curriculum Session 3	Focus Questions 3-4 (Lessons 8-11)*
11 a.m. Curriculum Session 1	Introduction and Lesson 1	**12 p.m.**	Lunch
12 p.m.	Lunch	**12:45 p.m.** Curriculum Session 4	Focus Question 4-5 (Lessons 12-15)
12:45 p.m. Curriculum Session 2	Focus Questions 1-2 (Lessons 2-7)	**3 p.m.**	Closing Session
3:30 p.m.	Adjourn	**3:30 p.m.**	Adjourn

**Depending on the workshop design, this section may be led by participants if they have adequate time to prepare.*

Note: Italicized statements are intended to provide supporting information to facilitators.

SESSION 1:

Introduction and Lesson 1

In this session, the trainer leads lessons as a facilitator (wearing their "teacher hat") while teachers act as learners (wearing their "student hats").

Goal: The trainer facilitates the first lesson as an exemplar and introduces the concept storyline of the G4 Physical Science module. Participants experience Lesson 1 as learners and debrief the lesson as teachers.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Housekeeping and Introductions	10 minutes	
Lesson 1	30 minutes	
SSftC Features and CSO	15 minutes	
Concept Storyline	5 minutes	

	Key Points
Housekeeping and Introductions	**Introductions** Welcome participants to your session. Remind them that this professional learning workshop is meant to orient teachers to a new Smithsonian Science for the Classroom curriculum module. At times they will be asked to wear their "student hat" and experience lessons as their students will, and at others they'll reflect on the material wearing their "teacher hat." **Icebreaker Activity** Participants introduce themselves through an icebreaker activity. **Housekeeping** Preview the agenda. Verify the safety protocols in the classroom and locate the nearest restrooms, fire exit, tornado shelter.

	Key Points
	Establish the Tone for the Day Divide participants into small groups and ask them to think about what they want to achieve today. What norms do they think will encourage a positive learning environment? Introduce group norm ideas: • Be brave • Be present • Ask questions • Be respectful Have each small group discuss the suggested norms and add to the big group list of norms. Once everyone has added their ideas, ask if there are any changes, additions, or modifications that need to be made. When the discussion is finished, this will be the social contract the group abides by for the next two days.
	General Safety While the risk of injury is low, there should be clear safety guidelines and expectations when teaching this module. These guidelines will vary depending on the situation, but some useful examples can be found in the Stay Safe! contract included in the curriculum, and general classroom safety expectations. Safety guidelines should be discussed before every lesson. Examples of safety guidelines: • Pull hair back • No tasting anything • Wear protective eyewear from start to finish • If something spills, report it immediately to get help cleaning it up • Listen closely to instructions • No running in the classroom

Lesson 1: Move It

Moving objects have motion energy.

30 minutes

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

Group discussion among participants is very important for these lessons. Strategies for supporting group discussions can be found in Appendix 1. Strategies for furthering discussion through guiding thought/questioning can be found in Appendix 2.

On CSO, navigate to Lesson 1 using the numbers at the top of the screen.

Resource/Page #	Lesson 1
Overview TG: p. 77	Objectives: • Make observations to collect evidence that all moving objects have motion energy. Lesson Background Information: • Motion energy is the energy that all moving objects have. • This module uses the term "motion energy" throughout, rather than "energy of motion" or "kinetic energy." • In this lesson, participants identify evidence of energy and start thinking about where that energy comes from. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 78	Materials: • Chart paper (optional) Printed Materials: • Lesson 1 Notebook Sheet Digital Materials: • Crow and Walnut file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Resource/Page #	Lesson 1

Procedure: Getting Started
TG: p. 78-80
	Getting Started
	• Show the second page of the Crow and Walnut file and explain that walnuts grow on a tree inside a soft husk. The walnut has a very hard shell and inside the shell is the seed of the walnut tree.
	• Show the third page of the file, which is the image of the American crow, and explain that crows fly with the walnut in their beak. When they are over hard ground, they drop the walnut from a lower height than when they are over soft ground.
	• Ask participants to talk with a partner about why the crows do this.
	• Facilitate classroom discussion with guiding questions:
	    ◦ Why do the crows drop the walnuts?
	    ◦ Why do they do this?
	    ◦ Why do they drop the walnut from a higher height over soft ground?
	• Explain that a walnut hitting the ground is an example of a collision, and that they will learn more about what motion energy is later in this lesson.
	• Hand out a copy of the Notebook Sheet and ask them to complete this pre-assessment.

Procedure: Activity TG: p. 80	***Activity*** • Ask the group, "What objects have energy?" Let them share various responses. • Tell participants they are going to watch a video and look for evidence of energy in the video. Explain that scientists call observations "evidence," which is what they use to answer questions. An answer to a question is called a "claim." • Play 25 seconds of the Motion Energy video from CSO or the SSEC website (https://ssec.si.edu/sites/default/files/other/collisions/MotionEnergy.mp4) and ask what evidence participants observe for the energy of the objects. next page →

<table>
<tr><th>Resource/Page #</th><th>Lesson 1</th></tr>
<tr><td></td><td>Small-Group Activity:
Create groups of three to five participants.
Ask participants to draw a table (Figure 1.2 in the TG) in their notebook or on chart paper.
Ask them to play the whole video as a small group, looking for evidence of energy, and write down their observations on the table.</td></tr>
<tr><td>Procedure: Bringing It All Together
TG: p. 81-82</td><td>Bringing It All Together
Ask each group to share what they observed.
Ask guiding questions:
What was the evidence that energy was present in these objects? (They made something move. They made a sound.)
What did all the objects have in common? (They were all moving.)
Explain that all moving objects have energy called “motion energy.”
Ask participants to think about where the motion energy comes from for each object. It is okay that they do not know the answers now. At the end of the focus question, they will be able to make a claim that answers the question.</td></tr>
<tr><td>Assessment, Enrichment & Extension
TG: p. 82-83</td><td>Briefly review:
Assessment Rubrics: Pre-Assessment
Extensions: Day in Motion (Literacy, Community and Home)</td></tr>
<tr><td>Reflection</td><td>After experiencing the lesson, ask participants to put on their “teacher hat” to consider and discuss:
What student learning can you expect from this lesson?
Any potential challenges you might have in this lesson?
Any potential difficulties or misconceptions that students may struggle with in this lesson?
What strategies or supports can be applied?</td></tr>
</table>

Smithsonian Science for the Classroom Features and Carolina Science Online

15 minutes

Key Points	
TG	Hand out TGs. Briefly review the physical items that accompany a module: • Teacher Guide (1) • Student Activity Guide (8) • Smithsonian Science Stories (16) • Materials (for 32 students)
CSO	CSO is the virtual platform that hosts the Teacher Guide, digital copies of the student readers, digital readers in Spanish, and other digital resources for the module. **Set Up a Carolina Science Online Account** Before training, you should receive an email directing you to create your teacher login on CSO (www.carolinascienceonline.com). On the main page, hover over the "Teacher login" button. "Create a Teacher Account" will appear as an option. Enter the required information. Make sure you choose a password you can remember. Return to the main page and log in. At the top of the page, click "redeem code." Enter the code that was emailed to you. The account is now ready to use. On the main page, all the titles available to you will be in bright colors. Click on the module you need. The module will open in the "Module Overview" tab. The "Home" button in the top left of the screen will take you back to the main screen with all of the available titles. "Bookmarks" will open your bookmarks folder. You can bookmark any of the digital resources on CSO by clicking on the star underneath the resource. "Assignments" shows all assignments you have created using CSO digital resources. You can add a digital resource to assignments by clicking "add to assignment" on any CSO digital resource.

	Key Points
TG and CSO TG: p. 1-17	Navigate to the "Curriculum Overview" section in the TG, which is also found under the "Module Overview" tab in CSO. This section provides an introduction to the curriculum and the research-based methods integrated into Smithsonian Science for the Classroom.
TG: p. 20-21	**Concepts and Practices Storyline** Modules are broken down into areas that revolve around a single focus question. The focus questions build a storyline that provides a coherent experience that builds toward solving a problem. The storylines are carefully integrated with the 5E model and each lesson is identified as to where it fits in the model. This module has four focus questions, with the final focus question being the Science Challenge.
TG: p. 22-24	**Prerequisite Concepts and Practices** The listed items are the skills and knowledge students will lean on to incorporate new skills and content learning. Each set of concepts and practices identifies where the prerequisites should have been taught.
TG: p. 24-28	**Module Background Information** This section provides background information for the teacher. It covers content that is not directly discussed in the module but may prove useful in understanding where content or practices are headed. It also provides information that is a fundamental building block for content and practices used in the module.
TG: p. 28-31	**Common Misconceptions** Students may express misconceptions throughout the lesson. This section provides a list of common misconceptions identified in research for both content and practices, an explanation of the misconception, and a possible example of how it may come up. The number after the misconception refers to which reference the misconception is described in. next page →

	Key Points
TG: p. 31-36	Throughout the module, misconception callouts will be highlighted using the Good Thinking! bubble. Good Thinking! is a YouTube video series created by the Smithsonian Science Education Center focused on misconceptions and learning. **Materials Management and Safety** This section provides information on materials that will be provided with the module kit, needed but not supplied materials, safety concerns, and a safety contract for students. Under the "Materials Lists" section you will need to click on the hyperlink to download the materials lists. These lists show you everything that will be included in the module kit and items teachers will need to supply. The lists also show how much of each material is needed and in which lesson. In the "Safety" section, there are callouts for specific concerns for this module and a link to a Stay Safe! contract. The contract lists expectations for students to keep themselves and others safe during science investigations. It has lines for both students and guardians to sign.
TG: p. 40-41	Navigate to the "NGSS Alignment and Planner" tab in CSO. **Module Alignment to NGSS** These modules are aligned to the Next Generation Science Standards, which teachers can use as an additional tool to identify student objectives and goals for learning. next page →

	Key Points
TG: p. 42-71	**Lesson Planners** The lesson planners highlight everything that will happen in a lesson, such as: • Focus Question • Step of 5E model • Number of class periods needed • Vocabulary that will be introduced • Student objectives • Misconceptions: more information can be found in the "Module Overview" tab or TG p. 28-31 • Disciplinary core ideas: content focus • Science and engineering practices • Crosscutting concepts: ideas that are multidisciplinary • ELA and math connections: numbers reference the Common Core Standards • Extensions: additional lessons that are not necessary to move forward in the module
TG: p. 74-75	In the TG, review the callout icons itemized in the Guide to Module Investigations: • NGSS • Common Core • Misconceptions • Digital Resource • ELL Strategy • Teacher Tips and Tech Tips • Guiding Questions • Safety Notes • Class Period Break
Readers and CSO	All of the written materials (Readers, Student Activity Guides, Notebook Sheets) are available digitally on CSO. Navigate to the student readers under the "Digital Resources" tab in CSO. There are multiple versions. The on-grade reader cover has a matchstick with the round end pointing up. The below-grade reader cover has a matchstick with the round end pointing down. The Spanish reader is only available on grade. next page →

Key Points	
	The on-grade reader exists in two forms on CSO. One is an interactive book and the other is an e-book. The other readers are only available in the e-book format. Both formats have tools for students. In the interactive book, students can highlight and make notes using the tools in the toolbar. In the e-book format, students can use the text-to-talk feature by highlighting the text and selecting the speaking icon.
Support and CSO	Finally, Carolina Science Online provides a number of supports to teachers, including: • Teacher Resource videos: These videos provide an overview of the focus questions and show any lessons with a potentially tricky setup. They're available under the "Digital Resources" tab. • Tutorial videos: For help using CSO's features, choose "Support" from the vertical toolbar on the left side of the homepage. • Get Ready! Professional Learning: These short videos offer information on demand and teacher tips about the program. They can be found at: https://www.smithsonianstc.com/ssftc-get-ready-campaign-172N7-44857Z.html

Concept Storyline

Grade 4 Physical Science: *How Does Motion Energy Change in a Collision?*

5 minutes

Concept Storyline	
TG and CSO TG: p. 20–21	**Concepts and Practices Storyline** Return to the "Concepts and Practices Storyline" tab and walk through the module's structure. next page →

Concept Storyline	
	This module has five focus questions, with the final focus question being the Science Challenge. Explain each focus question with its objectives, as below: FQ#1: How does motion energy move and change? (Lessons 1-4) *Students learn what motion energy is and how motion energy can change into heat, light, and sound and move to another object.* FQ#2: How does speed affect motion energy? (Lessons 5-7) *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.* FQ#3: What causes moving objects to slow down? (Lessons 8-10) *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.* FQ#4: How can we protect our brains in a collision? (Lessons 11-13) *Students 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.* FQ#5: How can we predict how far an object will slide in a collision? (Lessons 14-15) *Students apply what they have learned about motion energy to predict how far a moving washer will move a stationary washer in a game.*

Assessment	There are four types of assessment throughout the module.
	• Pre-Assessment (Lesson 1)
	• Formative Assessment (Lessons 2-13)
	• Summative Assessment (Lessons 14-15)
	    • Written Summative Assessment
	    • Performance Summative Assessment
	• Self-Assessment (SAG): Stop & Check

SESSION 2:

Lessons 2–7

The trainer introduces Lessons 2-4 (Focus Question 1) and Lessons 5-7 (Focus Question 2).

Goal: The trainer facilitates Lessons 2-7, with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Lesson 2	25 minutes	Prepare six stations: • Flashlight Station: Flashlight Station card, flashlights, white paper • Guitar Station: Guitar Station card, plastic containers with rubber bands stretched across the top • Tap Dancer Station: Tap Dancer Station card, model tap dancer • Noisemaker Station: Noisemaker Station card, noisemakers • Wood Block Station: Wood Block Station card, mood blocks, approximately 1-meter-long string • Jumping Jacks Station: Jumping Jacks Station card
Lesson 3	20 minutes	
Group Roles	5 minutes	Make sure Group Roles poster is visible
Short break	10 minutes	
Lesson 4	25 minutes	• Identify a flat, smooth working area (approximately 1.5 meters long) • Newton's cradle demonstration • Marbles, wood blocks, plastic tubes, mat, masking tape, ruler

Sections	Minutes	Materials/Notes
Lesson 5	25 minutes	• Identify a flat, smooth working area (approximately 2 meters long) • Ramp, stopwatch, wood blocks, pie tin, cars, masking tape, rubber bumpers, ruler • Hand out Readers
Short break	10 minutes	
Lesson 6	25 minutes	• Identify a flat, smooth working area (approximately 2 meters long) • Ramp, wood blocks, car with rubber bumper, car with no bumper, washers, masking tape, meter stick
Lesson 7	20 minutes	

Lesson 2: Give Me Some Energy
Heat, light, and sound are evidence for energy.

25 minutes

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

On CSO, navigate to Lesson 2 using the numbers at the top of the screen.

Resource/Page #	Lesson 2
Overview TG: p. 85	Objectives: • Make observations to provide evidence that motion energy can move from place to place and be changed into light, sound, and heat in a system. Lesson Background Information: • Motion energy can move from a moving object to another object and cause it to move or speed up (energy transfer). • Motion energy can also change into sound, light, and heat (energy transformation). • Energy transfer and energy transformation can happen simultaneously in a collision. • In this lesson, participants observe several systems. They identify heat, light, and sound as evidence of energy. (A system in science is a collection of associated parts.) Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 86-87	Materials: • Please see below Printed Materials: • Lesson 2 Notebook Sheet A • Lesson 2 Notebook Sheet B Digital Materials: • Cricket file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* next page →

<table>
<tr><th>Resource/Page #</th><th>Lesson 2</th></tr>
<tr><td></td><td>To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should prepare six stations:

Flashlight Station

1 Flashlight Station card
3 flashlights
3 sheets white paper
3 metric rulers (optional)

Guitar Station

1 Guitar Station Card
3 plastic containers with rubber bands stretched across the top

Tap Dancer Station

1 Tap Dancer Station card
3 model tap dancers

Noisemaker Station

1 Noisemaker Station card
3 noisemakers

Wood Block Station

1 Wood Block Station card
3 wood blocks
3 lengths of string, approximately 1 meter each (fold each piece of string in half so it is double thickness)

Jumping Jacks Station

1 Jumping Jacks Station card

</td></tr>
<tr><td>Procedure: Getting Started
TG: p. 88
Reader: p. 1</td><td>Getting Started

Ask the group, “What evidence for energy did you see in the previous lesson?” Wait to hear responses. They may mention motion or sound.
Play the Cricket audio file on CSO. Ask, “What do you think this sound is?” (It is the sound of a cricket.)
Introduce the Reader, Speed Bumps. The Reader has multiple versions. They all have the same readings but in multiple forms.

next page →</td></tr>
</table>

Resource/Page #	Lesson 2
	• On-Grade Readers: 16 physical copies shipped with your supplies with Lexile scores for third grade • CSO Readers: All CSO readers can be assigned to students using the CSO system 1. Spanish Reader: on-grade reader in Spanish has notes and text-to-speech 2. Digital copy of on-grade reader with note-taking and text-to-speech 3. Below-grade reader: reader with the same information but simpler sentence structure to decrease the Lexile score by about 100 points 4. Smithsonian Science Stories: *Speed Bumps* Student Reader: e-book version of the on-grade reader with annotation toolbar • Ask participants to open the Reader to reading 1, "Nature's Noisemakers" and read the Cricket Chirps section. **Reading Summary** This reading is about how crickets and other animals (birds, snakes, and lowland streaked tenrecs) make sounds. • Ask participants to briefly discuss with a partner the question, "What happens to the motion energy in the cricket's wings when they are rubbed together?" • Tell participants that in this lesson we're going to look how motion energy moves and changes.
Procedure: Activity TG: p. 88–90	***Activity*** • Explain that participants are going to visit each station to find evidence of energy in different systems. • Explain that each station represents an individual system. • Before starting the hands-on activity, remind participants of the safety tips, as described on the slides. next page →

<table>
<tr><th>Resource/Page #</th><th>Lesson 2</th></tr>
<tr><td></td><td>Hands-On Activity:
Divide the group in half and assign one group to work on Lesson 2 Notebook Sheet A (Energy Stations 1: Flashlight Station, Guitar Station, and Tap Dancer Station), and the other group to work on Lesson 2 Notebook Sheet B (Energy Stations 2: Noisemaker Station, Wood Block Station, and Jumping Jacks Station). If the group is large, organize each group into a smaller subgroup of two or three participants.
Ask each group to visit the stations on their Notebook Sheet, read the instruction card, and observe what happens in the system. They need to find out where the objects in the system are and should carefully observe all parts of the system.
Remind them of the focus question, “How does motion energy move and change?” Ask them to observe:
Which object in the system has motion energy to start with?
Does the motion energy move to a different object in the system?
Is there evidence of other energy?
Allot nine minutes total to visit the three stations (so three minutes at each station).</td></tr>
<tr><td>Procedure: Bringing It All Together
TG: p. 91</td><td>Bringing It All Together
Ask participants to come back to the whole group.
Ask what they saw, heard, or felt in each system, and what happened in the system.
Ask, “What happened to the motion energy in each system?” Please use the evidence of energy in your answers.
After the conversation, wrap up the lesson by summarizing the list of evidence for energy: motion, heat, light, and sound.</td></tr>
<tr><td>Assessment, Enrichment & Extension
TG: p. 92-93</td><td>Briefly review, as time allows:
Assessment Rubrics: Formative Assessment
Extensions: Nature’s Noisemakers (Literacy)</td></tr>
</table>

Resource/Page #	Lesson 2
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 3: Supermodels

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

20 minutes

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

On CSO, navigate to Lesson 3 using the numbers at the top of the screen.

Resource/Page #	Lesson 3
Overview TG: p. 95	Objectives: • Develop and use a model to explain how motion energy moves and changes in a system. • Argue from evidence that motion energy can change or move to another object in a system. Lesson Background Information: • Scientists use models (drawings, physical models, games, and computer simulations) to help them explain or investigate an idea. • In this lesson, participants draw energy models of each system they observed in Lesson 2. They use these models to construct a claim that motion energy can move and change. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 96	Materials: • Chart paper (optional) Printed Materials: • Lesson 3 Notebook Sheet A • Lesson 3 Notebook Sheet B • Lesson 3 Notebook Sheet C Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Resource/Page #	Lesson 3
Procedure: Getting Started TG: p. 97	***Getting Started*** • Show an online map of the local area and explain that the map is a diagram of the local area. • Explain that diagrams are a kind of model, and that engineers and scientists often use models to explain observations or investigate an idea. • Tell participants that they are going to draw models of the energy changes they saw in Lesson 2 to explain their observations.
Procedure: Activity TG: p. 97-99	***Activity*** • Show the demonstration of tossing a soft object to a student volunteer. • Ask, "What happened to the motion energy in the arm of the person who threw the ball?" (Motion energy transferred from the arm to the ball.) • Show the Energy Model Template. Objects in the system are represented in squares and the evidence for energy in each object is represented in circles. Arrows show how the energy moves or changes. • Ask, "What do you think should go into each box and circle?" (Figure 3.4 in the TG). Small-Group Activity (10 minutes): • Organize participants into the same small groups as in Lesson 2. • Have participants find the Lesson 3 Notebook Sheets A, B, and C. • Ask them to make energy models of the three systems they observed in Lesson 2. • Allot six minutes to complete the three models (two minutes for each model).

<table>
<tr><th>Resource/Page #</th><th>Lesson 3</th></tr>
<tr><td>Procedure: Bringing It All Together
TG: p. 100-101</td><td>Bringing It All Together

Ask participants to come back to the whole group and share their completed models (allot three to four minutes).
After listening to each group share their models, tell them that as a whole group they're going to answer the question, "How does motion energy move and change?" Explain that scientists call an answer to a question a "claim" and we're going to find the claim by using supporting evidence.
Ask participants to share their thoughts about how to answer the question and develop a claim with supporting evidence. Have a volunteer write down the claim and evidence on the screen (using the annotate function on Zoom) or write on chart paper/whiteboard (if in-person).
Example of a claim: Motion energy can move from one object to another. Motion energy can change into heat, light, and sound.
Examples of evidence: Our fingers moving made the rubber bands move. The handle turning made the metal box move. The level moving made a part inside the flashlight move. We saw light. We heard sound. We felt heat.
Discuss:

Did the model help you see what happened to the energy in the system?
Were there any problems with the model?

Explain the summary of the concepts of this module.
</td></tr>
<tr><td>Assessment, Enrichment & Extension
TG: p. 102-103</td><td>Briefly review, as time allows:

Assessment Rubrics: Formative Assessment
Extensions: Washer Orchestra (Music)
</td></tr>
</table>

Resource/Page #	Lesson 3
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Many of the lessons use group roles to assign specific jobs. For strategies on using group roles effectively, please see Appendix 3.

Group Roles

5 minutes

Starting in Lesson 4, students will be assigned group roles. The assignments and a possible rotation system can be found in Appendix 3. Group roles are a common tool to build teamwork skills such as turn taking, communication, and responsibility for individual and group needs. Additionally, having a specific role can increase student involvement and confidence by ensuring they know what is expected of them in a given situation. You can learn more about collaborative groups and group roles in the Zero Barriers in STEM Education Accessibility and Inclusion Workbook found at https://ssec.si.edu/zero-barriers.

Lesson 4: Marble Collisions

Motion energy can move to another object in a collision.

25 minutes

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

On CSO, navigate to Lesson 4 using the numbers at the top of the screen.

Resource/Page #	Lesson 4
Overview TG: p. 105	Objectives: • Predict the outcome to a question about how the motion of two marbles before a collision affects the motion of the marbles after a collision. • Use evidence and develop a model to explain how the motion energy of a marble moves and changes when it collides. Lesson Background Information: • When two hard objects collide, most of the motion energy of the moving object is transferred to motion energy of the object it collides with. • When a moving marble hits a stationary marble, the stationary marble starts moving rapidly and the moving marble slows down quickly because the motion energy of the moving marble has been transferred to the stationary marble. • When two moving marbles collide head on, they both move away in opposite directions as the motion energy from each marble is transferred to the other marble. Class Periods: 1 (1 class period = about 35 minutes)

Resource/Page #	Lesson 4
Materials & Preparation TG: p. 106–107	Materials: • 1 mat • Masking tape • 2 marbles • 2 plastic tubes • 1 Newton's cradle • 2 wood blocks • Metric ruler • Chart paper (optional) • SAG Printed Materials: • Lesson 4 Notebook Sheet A • Lesson 4 Notebook Sheet B Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Identify a flat, smooth workspace. Approximately 1.5 meters of a tabletop should be adequate for one group. If necessary, groups can work on the floor. • Set up a mat. Use the folds of the mat to mark a cross using masking tape. The arms of the cross should extend to the edges of the mat. The center of the cross should be in the center of the mat. • Put two marbles and two tubes on the mat.
Procedure: Getting Started TG: p. 107–108	***Getting Started*** • Show the physical model of the Newton's cradle and ask what is going to happen when one ball is pulled back and released. • Ask what will happen when two balls or three balls are pulled back and released. • Ask participants what they think happened to the motion energy from the ball that was pulled back. Explain that in this lesson we're going to learn about how motion energy moves and changes in a collision.

Resource/Page #	Lesson 4
Procedure: Activity TG: p. 108-113 SAG: p. 1-5	***Activity*** • Tell participants that they are going to do two activities, and have Lesson 4 Notebook Sheets A and B, and the SAG ready. • Explain the first activity: There is one stationary marble in the middle of the mat and another marble that is going to be rolled through a tube on a wooden block that is 20 centimeters away from the stationary marble. Ask participants to think about what is going to happen and to write down their prediction on Notebook Sheet A. • Explain the second activity: Two marbles moving from different directions will collide. Ask participants to think about what is going to happen and to write down their prediction on Notebook Sheet B. • Divide participants into groups and introduce the group roles of Materials Manager, Organizer, Questioner, and Speaker from the Group Roles poster. Have individuals from each group take these roles. • Tell participants to follow the steps in the SAG. Ask them to repeat the experiment at least two or three times and observe carefully, especially how the speed and direction of the marbles change after the collision. Ask them to write down their observations on Notebook Sheets A and B. • Give participants eight minutes to complete both activities.
Procedure: Bringing It All Together TG: p. 114-115	***Bringing It All Together*** • Ask the Speaker in each group to briefly share their observations of each activity. • Ask, "How many times did you do each type of collision? How many times did you think you needed to do each type of collision?" Explain that scientists usually make several observations to make sure their results are accurate. They call each time they observe or measure something a "trial." next page →

Resource/Page #	Lesson 4
	• Facilitate a whole-group discussion using the following guiding questions: ◦ How did the speed and direction of the marbles change when you made a moving marble collide with a marble that wasn't moving? ◦ How did the speed and direction of the marbles change when you made two moving marbles collide? ◦ What do you think happened to the motion energy of the moving marble when it collided with a marble that wasn't moving? (The motion energy of the moving marble transferred to the stationary marble.) ◦ What do you think happened to the motion energy of the two moving marbles when they collided? (The motion energy of each marble transferred to the other marble.) • Explain the summary of the concepts of this module.
Assessment, Enrichment & Extension TG: p. 116-117	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extensions: A Game of Marbles (Literacy)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from the lessons? • Any potential challenges you might have in the lessons? • Any potential difficulties or misconceptions that students may struggle with in the lessons? • What strategies or supports can be applied?

Lesson 5: Sound Barrier

Faster objects produce more sound in a collision.

25 minutes

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

On CSO, navigate to Lesson 5 using the numbers at the top of the screen.

Resource/Page #	Lesson 5
Overview TG: p. 119	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, and 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. Lesson Background Information: • 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. • 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 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. Class Periods: 2 (1 class period = about 35 minutes)

<table>
<tr><th>Resource/Page #</th><th>Lesson 5</th></tr>
<tr><td>Materials & Preparation

TG: p. 120-122</td><td>Materials:
Each group needs

1 Rubber bumper
1 Car
1 Ramp
3 Wood blocks
1 Pie tin
1 Metric ruler
1 Stopwatch
Masking tape
SAG
Reader

Printed Materials:

Lesson 5 Notebook Sheet A
Lesson 5 Notebook Sheet B

Digital Materials:

N/A

The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.

To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should:

Identify a flat, smooth workspace. Approximately 2 meters of a tabletop should be adequate for one group. If necessary, groups can work on the floor.
Screw the rubber bumper into each car.
Set up a ramp with one block, as shown in Figure 5.3 of the TG. 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.
Fold a pie tin in half. Measure 60 centimeters from the piece of masking tape and tape the pie tin in line with the bottom of the ramp.
</td></tr>
</table>

Resource/Page #	Lesson 5
Procedure: Getting Started TG: p. 123 Reader: p. 5-8	***Getting Started*** • Read the Famous Runners section of reading 2, "Record Breakers," in the Reader. • Tell participants that they are going to investigate how speed affects motion energy. **Reading Summary** The story is about Usain Bolt, who holds the record as the fastest human. It introduces several factors, such as muscles, healthy diet, and training, and some types of shoes that help people run fast.

Procedure: Activity
TG: p. 123-129
SAG: p. 6-8
	Activity
	• Explain that participants are going to measure two things—time and sound—when the car starts from the top of the ramp and hits the sound barrier (the pie tin). Tell them they are going to test three different conditions using one, two, and three wooden blocks, creating different ramp heights.
	• Explain that the different heights generate different speeds of the car.
	• Ask participants to predict how the different heights of the ramp (and speed of the car) will affect the time and the sound.
	• Explain what fair test is:
	    • Change only one factor (variable) at a time and keep the other conditions the same (control).
	    • Controlling other factors is an important way to find a cause.
	    • Scientists and engineers do the fair tests all the time.
	• Divide participants into groups of four and introduce the group roles of Speaker, Builder, Organizer, and Recorder.
	
	next page →

<table>
<tr><th>Resource/Page #</th><th>Lesson 5</th></tr>
<tr><td></td><td>Have participants locate the SAG and Lesson 5 Notebook Sheet A to measure time and Notebook Sheet B to measure sound. Remind them to repeat each condition several times to make sure of their results.
Tell them that after the experiments, they should discuss the results and make a claim about how the speed of an object affects the motion energy of the object.
Allot 10 minutes for the small-group activity.</td></tr>
<tr><td>Procedure: Bringing It All Together
TG: p. 130</td><td>Bringing It All Together
Ask the Speaker in each group to briefly share their findings.
When the ramp is higher (so the speed is faster), it took less time for the car to reach the barrier.
When the ramp is higher (so the speed is faster), the car made a louder sound when it hit the barrier.
Explain that the variable in these experiments was the speed of the car, generated by the height of the ramp, and ask the following guiding questions about a fair test:
What would happen if a different person released the car each time?
What would happen if a different person used the stopwatch?
What would happen if the ramp was in a different place each time?
What would happen if the car was released from a different place on the ramp each time?
Facilitate a whole-group discussion to answer the question about how the speed of an object affects the motion energy. Use their answers to develop a class claim and evidence table, such as:
<table><tr><th>Claim</th><th>Evidence</th></tr><tr><td>Faster objects have more motion energy.</td><td>Faster objects made a louder sound during a collision.</td></tr></table></td></tr>
</table>

Resource/Page #	Lesson 5
Assessment, Enrichment & Extension TG: p. 131-133	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extensions: Record Breakers (Literacy)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 6: Bumper Cars
Faster objects have more motion energy.

25 minutes

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.

On CSO, navigate to Lesson 6 using the numbers at the top of the screen.

Resource/Page #	Lesson 6
Overview TG: p. 135	Objectives: • Plan and carry out an investigation using a fair test to determine the effect of speed on distance moved of a stationary object in a collision. • Represent data on distance moved of a stationary object in a table and use the table to identify cause-and-effect relationships. • Construct an explanation that faster objects have more motion energy. Lesson Background Information: • Participants use a ramp to make a moving car collide with a stationary car. • Participants use ramp height to generate different speeds of the moving car. • Participants measure how far the stationary car moves in each collision. • Participants use their data to make a final claim that faster objects have more motion energy. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 136–138	Materials: Each group needs • 4 Large washers • 1 Car with rubber bumper • 1 Car with no bumper • 1 Ramp • 1 Wood block • 1 Metric ruler • Masking tape • SAG next page →

Resource/Page #	Lesson 6
	Printed Materials: • Lesson 6 Notebook Sheet Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Identify a flat, smooth workspace. Approximately 2 meters of a tabletop should be adequate for one group. If necessary, groups can work on the floor. • Add the washers to a car with a bumper. This is the parked truck. • Set up the ramp as in Lesson 5 with one block. • Measure 30 centimeters from the bottom of the ramp. Put a 20-centimeter piece of masking tape in front of the ramp. This is the parking line. • Cut or tear a piece of masking tape approximately 75 centimeters long. Put this tape down the middle of the ramp between the third and fourth holes and extend it out to the parking line. • Put the parked truck behind the parking line. The bumper should be pointing down the masking tape.
Procedure: Getting Started TG: p. 138	***Getting Started*** • Ask participants, "What would happen if someone parked a car on a hill and forgot to put the parking brake on?" • Then ask, "What would happen if the parked car was parked higher up the hill?" • Let participants share their thoughts briefly and tell them they're going to look at how far objects moving at different speeds will move a stationary object. They will also be collecting more evidence to answer the focus question.

<table>
<tr><th>Resource/Page #</th><th>Lesson 6</th></tr>
<tr><td>Procedure: Activity
TG: p. 139-143
SAG: p. 9-13</td><td>Activity
Divide participants into groups of four and introduce the group roles of Speaker, Builder, Organizer, and Recorder.
Show a demonstration for Lesson 6 to illustrate what they're going to do.
Explain how to measure the distance from the parking line to where the truck stopped rolling. Suggest they record to the nearest half centimeter.
Before letting them start the activity, ask, "What is the variable that we are changing? What else has to stay the same for this to be a fair test?"
Ask them to write on the Lesson 6 Notebook Sheet a prediction for what is going to happen to the truck when the ramp height is changed.
Allot 10 minutes for the small-group activity.</td></tr>
<tr><td>Procedure: Bringing It All Together
TG: p. 143-144</td><td>Bringing It All Together
Ask the Speaker in each group to briefly share their findings.
Ask the following guiding questions:
How many trials did you need to do at each height?
What effect did the speed of the car have on how far the truck moved?
Was your prediction correct?
Show the Claim-Evidence table from Lesson 5 and ask for any suggestions for changes or additions to the table.
Add the evidence to the table: Faster objects moved an object that wasn't moving farther during a collision.
Explain the difference between a fair test and experimental errors.</td></tr>
<tr><td>Assessment, Enrichment & Extension
TG: p. 144-146</td><td>Briefly review, as time allows:
Assessment Rubrics: Formative Assessment
Extensions: Car Conversions (Math)</td></tr>
</table>

Resource/Page #	Lesson 6
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 7: Fastest on Earth

Plants and animals have structures that help them move fast.

20 minutes

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.

On CSO, navigate to Lesson 7 using the numbers at the top of the screen.

Resource/Page #	Lesson 7
Overview TG: p. 147	Objectives: • Obtain and combine information about internal and external structures of a plant or animal that help them move fast. • Explain how two or more structures work together to help the plant or animal survive. Lesson Background Information: • Various plants and animals have internal and external structures that work together to enable them to move quickly. • Participants read about how the internal and external structures of a plant or animal work together, resulting in fast movement. Then they prepare an explanation about how two or more structures work together to help the plant or animal survive. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 148	Materials: • Computer or tablet with Internet access • Reader Printed Materials: • Lesson 7 Notebook Sheet Digital Materials: • Cheetah file • Mantis Shrimp file • Squirting Cucumber file • Trap-Jaw Spider file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Resource/Page #	Lesson 7

Procedure: Getting Started
TG: p. 148-149
	Getting Started
	• Remind participants that we talked about speed in previous lessons and ask, "What is speed?" (How fast something moves, how much time it takes to move a certain distance.)
	• Tell them we are going to watch a video of a cheetah running and ask them to pay close attention to how the various structures of its body work together to help the cheetah move fast.
	• On CSO, navigate to the Digital Resources for Lesson 7 and play the Cheetah video.
	• After watching the video, ask guiding questions:
	    • What is the cheetah's running motion like?
	    • What parts of its body did you see the cheetah use to run?
	    • What structures that are inside the cheetah's body do you think help it run fast?
	• Tell them that in this lesson they are going to collect evidence to answer the question, "What structures help an animal move fast to survive?"

Procedure: Activity TG: p. 149-151 Reader: p. 9-18	***Activity*** • Let participants read the first paragraph of reading 3, "The Need for Speed," in the Reader. **Reading Summary** The paragraph introduces four stories: Cheetah, Mantis Shrimp, Squirting Cucumber, and Trap-Jaw Spider. It discusses different parts of their bodies and how internal and external structures of animals and plants work together to make them move or to achieve a goal. next page →

<table>
<tr><th>Resource/Page #</th><th>Lesson 7</th></tr>
<tr><td></td><td>After reading, ask the following guiding questions:
What is the reading about?
What are the structures on the outside of an animal called?
What are some examples of external structures in your body?
What are the structures that are found inside the body of an animal called?
What are some examples of internal structures in your body?
Ask participants to choose to read further about either the mantis shrimp, squirting cucumber, trap-jaw spider, or cheetah in reading 3.
Ask them to complete the section in the Lesson 7 Notebook Sheet for their reading, and work together in a small group to discuss how the structures of their animal/plant work together to help the animal/plant move fast to survive.</td></tr>
<tr><td>Procedure: Bringing It All Together
TG: p. 152-153</td><td>Bringing It All Together
Ask each group to share their reading and explain how the structures of their animal/ plant work together to help the animal/plant move fast to survive.</td></tr>
<tr><td>Assessment, Enrichment & Extension
TG: p. 153-155</td><td>Briefly review, as time allows:
Assessment Rubrics: Formative Assessment
Extensions: Animal Folktales (Literacy)</td></tr>
<tr><td>Reflection</td><td>After experiencing the lesson, ask participants to put on their “teacher hat” to consider and discuss:
What student learning can you expect from this lesson?
Any potential challenges you might have in this lesson?
Any potential difficulties or misconceptions that students may struggle with in this lesson?
What strategies or supports can be applied?</td></tr>
</table>

SESSION 3:

Lessons 8–11

The trainer introduces Lessons 8-11 (Focus Questions 3 and 4).

Goal: The trainer facilitates Lessons 8-11, with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Lesson 8	30 minutes	Ramp, wood blocks, washer, masking tape, wax paper, rulers, chart paper, mat, meter stick
Lesson 9	25 minutes	Hand out Readers
Short break	10 minutes	
Lesson 10	30 minutes	Modeling dough, masking tape, meter stick (or large ruler), hand air pump with inflating needle, prepare two balls before the class—one fully inflated and the other one partly inflated
Lesson 11	25 minutes	

Lesson 8: The Rough with the Smooth

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

30 minutes

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

On CSO, navigate to Lesson 8 using the numbers at the top of the screen.

Resource/Page #	Lesson 8
Overview TG: p. 157	Objectives: • Plan and carry out an investigation that uses a fair test to determine whether the texture of a surface affects the motion of a sliding object. • Represent data on the distance an object moves in a table and use the table to identify cause-and-effect relationships. Lesson Background Information: • When a moving object is in contact with another object, motion energy changes to heat in both objects. This is known as "friction." The amount of friction between two objects is partly determined by the texture of their surfaces. • Participants plan and carry out an investigation to compare how three different surfaces affect the motion energy of a washer. Students observe that a washer sliding over a rough surface slows to a stop more quickly than the same washer sliding over a smoother surface. Class Periods: 1 (1 class period = about 35 minutes)

<table>
<tr><th>Resource/Page #</th><th>Lesson 8</th></tr>
<tr><td>Materials & Preparation
TG: p. 158-160</td><td>Materials:
Each group needs
3 Wood blocks
1 Ramp
2 Metric rulers
1 Mat
1 Large washer
1 Sheet of chart paper
1 piece of wax paper, 60 cm long
Masking tape
Salt (optional)
Chart paper (optional)
SAG
Printed Materials:
Lesson 8 Notebook Sheet
Digital Materials:
Curling video
Washer Sliding video
The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.

To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should:
Identify a flat, smooth workspace. Approximately 1.5 meters of a tabletop should be adequate for one group. If necessary, groups can work on the floor.
Tear or cut nine pieces of wax paper into approximately 60-centimeter lengths.
Tape two rulers to the side of one ramp to form bumpers. The inside edge of one bumper should be approximately halfway between the second and third lines of holes. The inside edge of the other bumper should be approximately halfway between the fourth and fifth lines of holes.
next page →</td></tr>
</table>

Resource/Page #	Lesson 8
	- Set up the ramp on three wooden blocks. Make sure the masking tape attaching the ramp to the blocks is on the side of the ramp, not in the center of the ramp. (Tape in the center of the ramp will slow down the washer.) - Put a sheet of wax paper under the bottom of the ramp so about 5 centimeters of the paper is under the ramp. Tape the wax paper to the table. - Try sliding the washer down the ramp you have set up, flat side down. In places with very high humidity, the washer may not slide. If the washer doesn't slide, try the following: - Turn the ramp over. One side of the ramp is slightly smoother. - Raise the height of the ramp. This can be done using books or by pulling the top of the ramp past the edge of the block to make a steeper angle. - Add a strip of wax paper to the middle of the ramp. - Sprinkle salt on the ramp.
Procedure: Getting Started TG: p. 160-161	***Getting Started*** - On CSO, navigate to the Digital Resources for Lesson 8 and play the Curling video. - After watching it, ask participants: - What does the person holding the stone try to do? - Why do the players sweep the ice in front of the stone? - Why do you think the stone slows down and eventually stops?
Procedure: Activity TG: p. 161-163 SAG: p. 14-18	***Activity*** Explain that they are going to test how far a washer slides on three different surfaces: wax paper, chart paper, and a mat. Be aware that the two sides of the washer are different, and the flatter side should be facing down. next page →

Resource/Page #	Lesson 8

	• Ask questions about a fair test:
	    • What is the variable that we are changing?
	    • How do we make sure this is a fair test?
	• Divide participants into groups of four and assign the roles of Tester, Builder, Questioner, and Recorder.
	• Have participants complete Steps 1-6 in the Student Activity Guide.
	• Bring a class together and facilitate a discussion on how the investigation is a fair test using the questions:
	    • What is the variable that we are changing?
	    • How do we make sure that this is a fair test?
	• Ask participants to complete Steps 7-15 in the Student Activity Guide. Tell them that they are going to decide how many trials their group will do. Remind them to make sure to measure the distance from the bottom of the ramp to where the washer touches the stick, and that the meter stick should be parallel to the long edge of the wax paper.
	• Ask the Recorder to record their group data.
	• Allot 10 minutes for the small-group activity.

Procedure: Bringing It All Together
TG: p. 164-165
	Bringing It All Together
	• Ask each group to share their observations.
	• Ask the following guiding questions:
	    • How many trials did you need for each surface?
	    • What effect did changing the surface have on how far the washer slid?
	    • From your observations, did you hear a big difference in sound when the washer slid on the three surfaces?
	    • What do you think happened to the motion energy of the washer on each surface?
	
	next page →

Resource/Page #	Lesson 8
	• Explain that the motion energy of the washer caused the washer and the surface to heat up, although you may not feel the heat. This is called friction. Whenever a moving object touches another object, there is friction. There is less friction on smooth surfaces. This is why the sweepers in the curling game brush the ice; the ice is melted by the heat, reducing friction, so the stones slide farther. • Tell them that in the next lesson they're going to read about how motion energy can change to heat even when an object isn't touching anything.
Assessment, Enrichment & Extension TG: p. 165-167	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extensions: Surface Graphs (Math)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 9: Air and Space

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

25 minutes

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

On CSO, navigate to Lesson 9 using the numbers at the top of the screen.

Resource/Page #	Lesson 9
Overview TG: p. 169	Objectives: • Obtain evidence from a text that supports the idea that motion energy causes air to heat up. • Construct an explanation for how smooth suits help cyclists go fast. Lesson Background Information: • When objects move through the air, friction with particles in the air causes motion energy to change to heat. • A smoother surface helps reduce how much motion energy changes to heat. A smaller surface area means less of the surface is in contact with the air, so less motion energy changes to heat. • In this lesson, students read a text about how synthetic and natural objects can cause the air to be heated. They learn how humans can reduce how much motion energy changes to heat by having a smooth surface and a streamlined shape. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 170	Materials: • Reader Printed Materials: • Lesson 9 Notebook Sheet Digital Materials: • Cyclists video *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Resource/Page #	Lesson 9

Procedure: Getting Started
TG: p. 170-171
	Getting Started
	• On CSO, navigate to the Digital Resources for Lesson 9 and play the Cyclists video.
	• After watching the video, ask:
	  ◦ How does the motion energy of the cyclists change as they move?
	  ◦ Why do you think they're wearing these clothes?

Procedure: Activity TG: p. 171-172 Reader: p. 19-26	***Activity*** • Hand out the Readers and the Lesson 9 Notebook Sheets. • Organize participants into groups of two or three, and ask them to read reading 4, "Hot Air," then answer the questions on the Notebook Sheet. • Allot 10 minutes for the activity. **Reading Summary** The reading introduces examples of how motion energy is changed to heat energy by friction. Some of those examples are how rubbing hands makes them warmer; rubbing sticks together to make a spark and start a fire; and objects from outer space entering Earth's atmosphere and sparking fire, such as shooting stars and the space shuttle.

Procedure: Bringing It All Together
TG: p. 173
	Bringing It All Together
	• Ask each group to share their Notebook Sheets. Ask:
	  ◦ What evidence did you find from the reading about motion energy causing air to heat up?
	  ◦ Why does a cyclist wear a smooth, fitted suit?
	• Tell them that they will be looking at another way that motion energy can change to heat.

Resource/Page #	Lesson 9
Assessment, Enrichment & Extension TG: p. 173-175	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extensions: Mission Possible (Literacy and Technology)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 10: Bouncing Balls

Motion energy changes to heat when a soft object deforms.

30 minutes

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

On CSO, navigate to Lesson 10 using the numbers at the top of the screen.

Resource/Page #	Lesson 10
Overview TG: p. 177	Objectives: • Predict the answer to a question about how the hardness of a ball affects how high it bounces. • Plan and carry out an investigation using a fair test to determine the effect of hardness on how high a ball bounces. • Represent data on bounce height in a table and use the table to identify cause-and-effect relationships. Lesson Background Information: • Identical objects that fall from the same height have the same speed when they hit the ground. When either the object or the surface is able to deform, motion energy changes into heat in the object or on the surface. • In this lesson, students plan an investigation to show that a fully inflated (hard) ball bounces higher than a partially inflated (soft) ball when both are dropped from the same height. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 178-179	Materials: • Hand air pump with inflating needle (needed but not supplied) • Modeling dough • Reader next page →

<table>
<tr><th>Resource/Page #</th><th>Lesson 10</th></tr>
<tr><td></td><td>Each group needs:
1 Fully inflated rubber ball
1 Partially inflated rubber balls
1 Meter stick
Masking tape
SAG
Printed Materials:
Lesson 10 Notebook Sheet
Digital Materials:
N/A
The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.</td></tr>
<tr><td>Procedure: Getting Started
TG: p. 179-180</td><td>Getting Started
Ask, "If you drop the dough ball from your shoulder height, what do you think will happen?"
After hearing responses from participants, show a demonstration with a dough ball (if in-person) or use the @Home demonstration video on CSO (first five seconds).
Then ask:
What happened to the ball when it hit the table?
How did the shape of the ball change when it hit the table?
What do you think happened to the motion energy of the ball?
Tell participants they're going to learn about a way that objects slow down after a collision.</td></tr>
<tr><td>Procedure: Activity
TG: p. 180-182
SAG: p. 19-20</td><td>Activity
Tell them that they are going to test how the hardness of a ball affects how high it bounces. Show the two balls—one is fully inflated and the other one is partially inflated.
Ask them what variable they are changing and how to make sure each ball is moving at the same speed when it hits the ground.
next page →</td></tr>
</table>

Resource/Page #	Lesson 10
	• Organize participants into groups of four and have individuals from each group take the group roles of Materials Manager, Organizer, Messenger, and Speaker. • Tell them to discuss their investigation plan and predict the answer for the question before starting the tests, then carry out the investigations in the SAG and record the results on the Lesson 10 Notebook Sheet. • Allot 10 minutes for the activity.

Procedure: Bringing It All Together
TG: p. 183-184
Reader: p. 27-31
	Bringing It All Together
	• Ask each group's Speaker to share:
	    • How they set up their test
	    • What they observed
	    • What they found in the tests
	• Ask, "How did the hardness of the ball affect how high it bounced? Why do you think the soft ball didn't bounce as high?"
	• Read the section Dropping Your Dinner from reading 5, "Animals In Action," in the Reader.
	
	Reading Summary
	This reading is about how animals use collisions to get food (for example, crows drop hard-shelled nuts to break them open).
	• After sharing, explain that:
	    • Some objects change shape in a collision. This is called "deforming."
	    • Softer objects deform more than hard objects.
	    • When objects deform, motion energy causes the object to heat up slightly.
	    • Due to the loss of heat and sound energy when the collision happens, the ball now has less motion energy and bounces lower than the height from which it originally fell.

Resource/Page #	Lesson 10
Assessment, Enrichment & Extension TG: p. 184-186	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extensions: Animals in Action (Literacy)
Reflection	After experiencing the lesson, ask participants to put on their “teacher hat” to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 11: Playing Safe

It is important to protect our brain.

25 minutes

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

On CSO, navigate to Lesson 11 using the numbers at the top of the screen.

Resource/Page #	Lesson 11
Overview TG: p. 187	Objectives: • Define the problem of collisions in sports causing skull fractures and damage to the brain. • Obtain evidence from a text that softer materials help protect animal brains during a collision. Lesson Background Information: • There has been a substantial effort to develop better protective equipment for players in sports. This equipment must convert some of the motion energy of an impact into heat, thus reducing the amount of energy that is transferred to the player. • In this lesson, students read about the problem of collisions causing head injuries. They learn that soft materials can prevent injuries. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 188	Materials: • Computer or tablet with Internet access • Reader Printed Materials: • Lesson 11 Notebook Sheet Digital Materials: • Woodpecker file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*

Resource/Page #	Lesson 11
Procedure: Getting Started TG: p. 188-189	***Getting Started*** • Play the Woodpecker file, and ask, "Why is the woodpecker pecking the wood? Why doesn't this hurt its head?" • Tell them that in this lesson they're going to find information to answer the question, "How can we protect our brains in a collision?"
Procedure: Activity TG: p. 189-190 Reader: p. 32-36	***Activity*** • Divide the group into pairs or small groups. • Ask them to read reading 6, "Brain Games," in the Reader and answer the questions on the Lesson 11 Notebook Sheet. • Allot 10 minutes to complete the reading activity. **Reading Summary** The reading starts with a story about how a woodpecker's skull is structured to protect its brain when it is pecking. Then it introduces the human brain and the nervous system, and how helmets protect a human's brain.

Procedure: Bringing It All Together
TG: p. 190-191
	Bringing It All Together
	• Bring the participants back to the whole group, and ask:
	    • What is the big idea of the reading?
	    • What problem do helmets solve?
	    • Why is it important to protect your brain?
	    • What do all helmets have in common?
	• What kind of material can protect the brain?
	    • Claim: Soft materials protect the brain.
	    • Evidence: We know this because the woodpecker has a spongy skull and bicycle helmets have a soft lining.
	• Tell them that the helmets they read about were designed by engineers; engineers design solutions to problems. In the next lesson, they're going to design a model of a bicycle helmet.

Resource/Page #	Lesson 11
Assessment, Enrichment & Extension TG: p. 191-192	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extensions: Concussions (Literacy)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

SESSION 4:

Lessons 12–15

The trainer introduces the final Science Challenge (Lessons 12-15/ Focus Questions 4 and 5).

Goal: The trainer facilitates Lessons 12-15 with participants experiencing the lessons as learners and debriefing each focus question as teachers.

At various points in the training, there may be differing ideas presented by participants, especially when introducing claims and evidence. For strategies on handling differing opinions, please see Appendix 4.

AGENDA AND TIMING

Sections	Minutes	Materials/Notes
Lesson 12	25 minutes	Mats, Foam cups, Paper cone cups, Plastic cups, Packing peanuts, Eggs, Plastic egg, Metric ruler Let participants know they are free to bring or to use materials (such as, bubble wrap, popcorn, cotton balls, cardboard, or aluminum foil) for the liner of the helmet
Lesson 13	25 minutes	Hard boil eggs and bring them to the class in a safe container (two or three eggs for each small group)
Short break	10 minutes	
Lesson 14	30 minutes	Wood blocks, ramp, metric rulers, masking tape, wax paper, mat, large washers Readers
Lesson 15	30 minutes	Wood blocks, ramp, metric rulers, masking tape, wax paper, large washers, plastic container
Wrap Up	15 minutes	

Lesson 12: Egg Drop Challenge Part 1

Several solutions to a problem need to be considered.

25 minutes

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

On CSO, navigate to Lesson 12 using the numbers at the top of the screen.

Resource/Page #	Lesson 12
Overview TG: p. 193	Objectives: • Design a solution to the problem of collisions in sports causing skull fractures and damage to the brain. • Develop a model of a bicycle helmet that changes motion energy to heat. Lesson Background Information: • In this lesson, students design and build a model of a bicycle helmet using a plastic egg as a model for the head. • Students need a shell and something soft to go under the shell that stops the egg from cracking. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 194	Materials: • Eggs (raw or hard-boiled) • 2 Mats • Modeling dough Each group needs • 1 Plastic egg • 1 Metric ruler • Masking tape • Various materials: Foam cups, Paper cups, Packing peanuts • Other cushioning materials, such as, cardboard, bubble wrap, popcorn, aluminum foil (optional, not supplied) next page →

Resource/Page #	Lesson 12
	Printed Materials: • N/A Digital Materials: • Egg Drop Requirements file *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.*
Procedure: Getting Started TG: p. 195	***Getting Started*** • Explain that in Lessons 12 and 13 they are going to make a model bicycle helmet. In Lesson 12 they're going to design a model and test it with a plastic egg, and in Lesson 13 they're going to test their design with a real egg. • Ask how an egg is similar to and different from a human head, and what part of an egg represents the skull (eggshell) and brain (white and yolk).

Procedure: Activity
TG: p. 195-198
	Activity
	• Tell them that they're going to start the egg drop design challenge.
	• Explain the five criteria and two constraints of the challenge, as outlined in the TG.
	• Show what cushioning materials are available for them to choose.
	• Organize participants into groups of four and introduce them to the group roles of Materials Manager, Messenger, Builder, and Artist.
	• Explain the steps to follow:
	    • Take a look at what materials are available.
	    • Draw your own design in your notebook.
	    • In your group, compare your designs and choose one to build.
	    • Collect materials and build a helmet together as a group.
	    • Test your design with a plastic egg.
	• Allot 15 minutes for the activity.

Resource/Page #	Lesson 12

Procedure: Bringing It All Together
TG: p. 198-199
	Bringing It All Together
	• Bring the participants back to the whole group and ask them to share their designs.
	• Use the following guiding questions as needed:
	    • How does your design meet the criteria?
	    • What was the hardest constraint?
	    • What worked well and what did not go well?

Assessment, Enrichment & Extension TG: p. 199-201	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extensions: Gallery Walk (Literacy)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 13: Egg Drop Challenge Part 2

A solution to a problem needs to be tested.

25 minutes

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

On CSO, navigate to Lesson 13 using the numbers at the top of the screen.

Resource/Page #	Lesson 13
Overview TG: p. 203	Objectives: • Carry out an investigation to test a model of a bicycle helmet that changes motion energy to heat. • Argue from evidence that the best solution to the problem of skull fractures in cycling accidents is a helmet using materials that change motion energy to heat. Lesson Background Information: • In this lesson, participants transfer their model helmet to a hard-boiled egg and test it by dropping it from 1.5 meters. Participants will find that the plastic cups are most effective at protecting the egg's shell, provided there is sufficient packing between the egg and the cup. Class Periods: 1 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 204-206	Materials: • 8 Hard-boiled eggs, with no cracks • Same materials from Lesson 12 • 4 Sheets of paper • Scissors (optional) Printed Materials: • N/A Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* next page →

<table>
<tr><th>Resource/Page #</th><th>Lesson 13</th></tr>
<tr><td></td><td>To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should:
• Use the paper to make egg cups.
    • Cut or tear each piece of paper in half lengthwise.
    • Fold each half sheet of paper up from the long edge.
    • Coil the strip to make a ring 3.5 to 4 centimeters in diameter and secure with tape, as shown in Figure 13.4 in the TG.
• Cut or tear two strips of wax paper approximately 60 centimeters long.
• Identify a testing area where eggs can be dropped. The area should have a hard surface. Put the two pieces of wax paper together in this testing area so they overlap.</td></tr>
<tr><td>Procedure: Getting Started
TG: p. 207</td><td>Getting Started
• Tell them that they’re going to use a real egg in this lesson. The eggs are hard-boiled, which means they are cooked in hot water until the yolk and white are no longer liquid.</td></tr>
<tr><td>Procedure: Activity
TG: p. 207-208</td><td>Activity
• Give the following instructions:
    • Keep the same groups and roles as in Lesson 12.
    • Collect a hard-boiled egg and transfer your helmet model from the plastic egg to the real egg.
    • Although the eggs are cooked, they are still fragile. Handle them carefully.
    • Make any repairs or adjustments to your helmet, as needed.
    • Conduct a test by dropping the egg with the helmet from shoulder height over the testing area.
    • Discuss in your group what went well, what did not go well, and what needs to be improved.
• Allot 10 minutes to do the activity.</td></tr>
</table>

Resource/Page #	Lesson 13
Procedure: Bringing It All Together TG: p. 209	***Bringing It All Together*** • Bring the participants back to the whole group and ask them to share their test results. • Ask, "What is the best solution to protect the egg in a collision?" Prompt them to offer a claim and evidence. • Ask, "How well did the egg work as a model for the human head?" • Ask participants, if they're going to make a bicycle helmet, how do they want to fill in this sentence: The best materials to use were ________ for the helmet shell and ________ for the liner. This is because ________.
Assessment, Enrichment & Extension TG: p. 210-212	Briefly review, as time allows: • Assessment Rubrics: Formative Assessment • Extensions: Eggscellent Eggs (Community and Home)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 14: Slide ‘n’ Collide Part 1

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

30 minutes

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

On CSO, navigate to Lesson 14 using the numbers at the top of the screen.

Resource/Page #	Lesson 14
Overview TG: p. 213	Objectives: • Predict the answers to questions about how speed and surface affect how far an object slides in a collision. • Plan and carry out an investigation to collect evidence on how far an object slides during a collision. Lesson Background Information: • This lesson is the first part of a Science Challenge that serves as an assessment for the whole module. • Students play a game where they have to use one washer (the starter washer) to slide another washer (the target washer) a certain distance. • Students test which materials to use and collect data on the effect of speed and surface on how far the starter washer moves the target washer. Class Periods: 2 (1 class period = about 35 minutes)

Resource/Page #	Lesson 14
Materials & Preparation TG: p. 214-215	Materials: Each group needs • 3 Wood blocks • 1 Ramp • 2 Metric rulers • Masking tape • 1 Sheet of chart paper • 1 Mat • 2 Large washers • 1 Permanent marker • Student Activity Guide • Salt (optional) • Reader Printed Materials: • Lesson 14 Notebook Sheet A • Lesson 14 Notebook Sheet B Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Tear or cut nine pieces of wax paper approximately 60 centimeters long. • Set up the ramp with buffers, as described in Lesson 8. • Tape the ramp to the top of three blocks. Put a piece of wax paper under the ramp and tape it down. Put a washer about 10 centimeters from the bottom of the block, as shown in Figure 14.2 in the TG. This is the target washer. next page →

Resource/Page #	Lesson 14

	• The starter washer should slide down the ramp when it is set up on three blocks and not slide at all on one or two blocks. In places with very high humidity the washer may not slide on three blocks. If this is the case, use the following suggestions to make sure there are two ramp heights where the washer will slide freely:
	    • Turn the board over. One side of the board is slightly smoother.
	    • Raise the height of the ramp. This can be done using books or by pulling the top of the ramp past the edge of the block to make a steeper angle.
	    • Add a strip of wax paper to the middle of the ramp.
	    • Sprinkle salt on the ramp.

Procedure: Getting Started TG: p. 215-216 Reader: p. 37-40	***Getting Started*** • Tell participants to read the section on Shuffleboard Sliding in reading 7, "Let It Slide." **Reading Summary** The reading is about how shuffleboard sliding works in terms of motion energy and friction. It also introduces similar sports in which speed is affected by the friction between the objects and the surface, such as air hockey and curling. • Ask why sand-like power helps pucks slide faster. (It reduces friction.) • Tell them they are going to play a sliding game and that they will use what they have learned about how motion energy changes in collisions to play the game.

Resource/Page #	Lesson 14

Procedure: Activity
TG: p. 216-221
SAG: p. 21-25
	Activity
	1. Preparation and Prediction
	• Tell participants that the procedure is to let go of the starter washer from the top of the ramp and for it to hit the target washer. There are two questions to test:
	  • How does ramp height affect distance the target washer moved?
	  • How does the surface affect distance the target washer moved?
	• Ask participants to predict their answers for those questions.
	• Introduce the group roles of Builder, Tester, Recorder, and Questioner.
	2. Test Ramp Heights and Materials: Notebook Sheet A
	• Explain the game rules from the SAG.
	• Explain that they're going to test different ramp heights and different surface materials (mat, chart paper, and wax paper). Ask them to follow steps 4-7 in the SAG and complete Lesson 14 Notebook Sheet A.
	• Remind them that they're not measuring any distances at this point, and are just figuring out which combinations of the conditions would work best in the game.
	• Allot three to four minutes to collect materials and complete the activity.
	• After completing the activity, ask them to share which combinations worked or did not work.
	
	next page →

Resource/Page #	Lesson 14
	3. Measure the Distance of Target Washer: Notebook Sheet B • Explain how to set up a target washer. • Ask them to measure the distance of the target washer from the bottom of the ramp after it is hit by the starter washer, for the chosen combinations of the conditions. • Ask them to follow steps 8-20 in the SAG and complete Lesson 14 Notebook Sheet B. • Allot six to seven minutes to complete the activity.

Procedure: Bringing It All Together
TG: p. 221
	Bringing It All Together
	• Bring the participants back to the whole group and ask them to share the results of their tests.
	• Use the following guiding questions, as needed:
	  • With which surface and ramp height did the target washer move the farthest distance from the bottom of the ramp?
	  • With which surface and ramp height did the target washer move the shortest distance from the bottom of the ramp?
	  • Was your prediction correct?
	• Discuss as a whole group:
	  • How did the motion energy of the starter washer move and change when it hit the target washer?
	  • How did the speed of the starter washer affect its motion energy?

Assessment, Enrichment & Extension TG: p. 221-223	Briefly review, as time allows: • Assessment Rubrics: Performance Summative Assessment • Extensions: Let It Slide (Literacy)

Resource/Page #	Lesson 14
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Lesson 15: Slide ‘n’ Collide Part 2

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

30 minutes

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

On CSO, navigate to Lesson 15 using the numbers at the top of the screen.

Resource/Page #	Lesson 15
Overview TG: p. 225	Objectives: • Analyze and interpret data to identify the ramp height and surface that will move a washer a set distance. • Carry out an investigation to collect evidence to show that a ramp height and surface will cause a washer to move a set distance after a collision. Lesson Background Information: • Students are given a distance from the bottom of the ramp that the target washer must be after a collision. They use their data to decide which combination of ramp height and surface they could use. • The module finishes with a written summative assessment. Class Periods: 2 (1 class period = about 35 minutes)
Materials & Preparation TG: p. 226-227	Materials: Each group needs • 3 Wood blocks • 1 Ramp with bumpers from Lesson 14 • 1 Sheet of chart paper • 1 Piece of wax paper • 1 Meter stick • 2 Large washers • 1 Permanent marker • Masking tape • 1 Container • Reader next page →

Resource/Page #	Lesson 15
	Printed Materials: • Lesson 15 Notebook Sheet A • Lesson 15 Notebook Sheet B Digital Materials: • N/A *The materials listed here are a minimum list. Please visit CSO or the TG for more detailed information.* To help participants better familiarize themselves with the lesson setup for implementation, the group will do some materials preparation during the workshop. For this lesson, the group should: • Use the results from Lesson 14 to identify four distances for the target washer. Possible distances are 20 centimeters (low ramp plus chart paper), 25 centimeters (high ramp plus chart paper), 26 centimeters (low ramp plus wax paper), 29 centimeters (high ramp plus wax paper). However, distances can be affected by the brand of chart paper or wax paper, the surface under the paper, and the humidity in the classroom. • Tear up the sheet of paper into eight narrow strips. • Write each distance on two strips of paper. There should be two strips of paper for each distance. • Fold up each strip of paper so the distance can't be seen and put the strips in the plastic container. • Tear or cut nine pieces of wax paper approximately 60 centimeters long. • Set up the ramp on three blocks on wax paper, as in Lesson 14. Use the marker to draw a line at the bottom of the ramp and around a washer placed 8 centimeters from the bottom of the ramp.

<table>
<tr><th>Resource/Page #</th><th>Lesson 15</th></tr>
<tr><td>Procedure: Getting Started
TG: p. 227</td><td>Getting Started
Ask participants to think of a game they play at home, and ask, “What kind of rules do you follow for the game? How do you win the game?”
Remind them that even though they are playing a game, they are still scientists.</td></tr>
<tr><td>Procedure: Activity
TG: p. 227-229</td><td>Activity
Organize participants in the same groups from the previous lesson, and ask them to keep the same roles as in the last lesson.
Ask participants to choose one of the strips of paper from the container and tell them that is the distance they want to move their target washer by hitting it with a starter washer.
Tell them that the target washer is 8 centimeters from the bottom of the ramp and they need to draw the goal distance on the wax paper.
Let them choose their ramp height and surface before starting the game, because once they start the game, they can’t change it.
Explain that each player can try twice and if the washer hits the bumpers, it doesn’t count.
Allot seven minutes to play the game and complete Lesson 15 Notebook Sheet A.</td></tr>
<tr><td>Procedure: Bringing It All Together
TG: p. 229-230</td><td>Bringing It All Together
Bring the participants back to the whole group and ask them to share their game result. Use the following guiding questions, as needed:
What ramp height and surface did you use?
How many times were you successful in getting the target washer to the goal?
How could you change your setup so you would be more successful?
next page →</td></tr>
</table>

Resource/Page #	Lesson 15
	• Ask, "Why did both washers stop moving?" • Tell them that this is the end of the module, but there is one last important thing to do, which is the written summative assessment, Lesson 15 Notebook Sheet B.
Assessment, Enrichment & Extension TG: p. 230-234	Briefly review, as time allows: • Assessment Rubrics: Written Summative Assessment • Extensions: Go Fund Our Game (Literacy and Technology)
Reflection	After experiencing the lesson, ask participants to put on their "teacher hat" to consider and discuss: • What student learning can you expect from this lesson? • Any potential challenges you might have in this lesson? • Any potential difficulties or misconceptions that students may struggle with in this lesson? • What strategies or supports can be applied?

Wrap Up

Take a few minutes to check in with the group before dismissing everyone.

15 minutes

	Key Points
Q&A	Invite participants to ask any final questions about materials, implementation, strategies, or anything else on their mind.
Continuing Support	If you are willing, provide your contact information for questions and concerns that the participants may have in the future.

APPENDIX 1: GROUP DISCUSSION

The goal of group discussions is to provide an opportunity for shared learning by asking multiple people to propose connections between their individual experience and the new content of focus.

The facilitator has three primary jobs during group discussions:

1. Support individuals sharing.
   It may be unnerving for individuals to share their thoughts in a group. When facilitating group discussions, use the following techniques to boost individuals' confidence and likelihood of sharing their thoughts:
   - Pay attention to speakers.
   - Smile and nod at appropriate moments to nonverbally communicate that you are engaged.
   - Provide anonymous sharing opportunities using chart paper or sticky notes.
2. Manage group participation.
   It is important to have active and balanced participation from the group to gain as many perspectives as possible. While it is important to hear from everyone, not every person needs to comment on every question. Here are some techniques to help you manage participation of individuals during a group discussion:
   - Use small groups with a designated sharer/speaker.
     - Assigning roles: Change roles for each lesson.
   - When no one wants to speak up:
     - Use the silence. Generally someone will speak up within 15 seconds.
     - Make eye contact with someone you would like to hear from.
   - How to stop a monopolizing speaker:
     - Do not make eye contact with them.
     - Redirect comments and questions from monopolizers to others.
3. Support group thinking.
   - Record individual member suggestions or points in a central location.
   - Ask guiding questions to have the group highlight connections.
   - Summarize.

If you would like to see group discussions in practice, please visit:
TERC Inquiry Project videos: https://inquiryproject.terc.edu/prof_dev/library.cfm.html

APPENDIX 2: QUESTIONING/GUIDING THOUGHT

Questioning is a useful tool with many applications. For this application we will focus on questioning as a way to discover what people are thinking, encourage further thought, and develop group understanding.

The best questions to use are open-ended questions, which do not have a set answer and often require a sentence or more to answer. Questions like:

- What do you know about . . . ?
- Does anyone have anything to add?
- Why do you agree/disagree?

Generally the first level will be eliciting new ideas by asking questions about what people already know or can observe during the lesson:

- What did you observe?
- Has anyone ever encountered . . . ?
- What are some ways to introduce students to . . . ?

The second level is encouraging further thought by asking people to reflect on what has been said, to identify connections to the current topic:

- What do you mean by . . . ?
- Can you tell me more about . . . ?
- What is the evidence for/against . . . ?

The final level we will look at is creating a group understanding by coming to consensus on what has been discussed:

- What idea do you think best connects what everyone is saying?
- Can someone summarize for me?
- Based on what the group is saying, how would this affect . . . ?

Further suggestions for questioning:

- Give thinking time of three to five seconds after posing a question.
- Avoid saying “correct/incorrect.” Instead, let the group validate or clarify what someone is saying.
- Avoid the habit of only collecting one “correct” response and moving on. Always have at least two people answer a question, even if their answers are similar.
- Questioning can also be used to help keep time by letting people know how much longer the discussion can go on.
- Validate everyone’s input by thanking them for speaking up.

APPENDIX 3: GROUP ROLES

Each person in a group having a role can provide many positive outcomes. Some benefits of using group roles include:

- Increases participant motivation by having a unique role
- Models positive classroom behaviors
- Decreases the amount of time spent waiting for a group to decide or discuss who will do what
- If a job is assigned, it pushes participants to participate in different ways

Here are some ideas for how to begin using group roles:

- Change roles regularly to maintain interest.
- Try to give everyone a chance at each role.
- Have a system in place for assigning roles. Possible systems include:
  - Colored dots and frames—Give each person in the group a colored dot. Place a matching color frame around their role for the day. Change the frame placement as needed.
  - Numbers—Assign each member of the group a number (1-4). Place a sticky note with the corresponding number on their role for the day.
  - Badges—Give each person in the group a badge or card with their role for the day listed.
  - Desk tents—Give each person in a group a desk tent with their role for the day.

More information about group roles can be found at: https://ctl.wustl.edu/resources/using-roles-in-group-work

The chart here shows which roles are used in each lesson. The roles and rotation are based on having four members in each group. The numbers in each column suggest how to rotate roles.

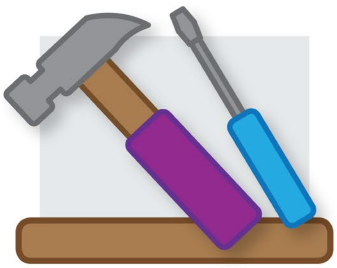
	Lesson #					
Group Role	**4**	**5**	**6**	**10**	**12–13**	**14–15**
Artist					1	
Builder		1	2		3	4
Materials Manager	1			2	4	
Messenger				3	2	
Organizer	2	3	4	1		
Recorder		4	3			2
Speaker	3	2	1	4		
Tester						1
Questioner	4					3
Gardener/Zookeeper						

For these trainings, use the roles listed in each lesson, as described on the Group Roles poster.

Smithsonian
Science Education Center

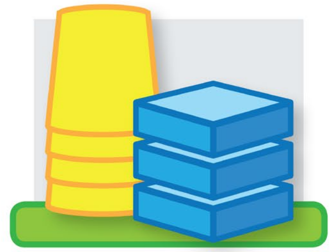
Scientists and Engineers in Our Classroom: Group Roles

Artist
Draws any sketches, diagrams, or graphs.



Builder
Takes the lead in putting together materials.

Gardener/Zookeeper
Makes sure live organisms are cared for and treated with respect.



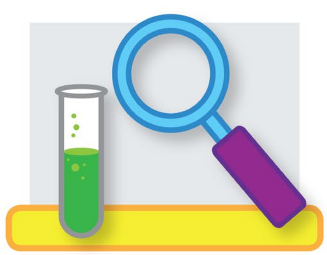
Materials Manager
Collects, cleans up, and puts away materials neatly.

Messenger
Asks questions of the teacher for the group.

Organizer
Makes sure group members work together and complete work on time.

Recorder
Writes down data, observations, and explanations.

Speaker
Shares the group's final work or ideas with the whole class.



Tester
Takes the lead in carrying out investigations and testing designs.

Questioner
Asks questions of group members to make sure all points of view are considered.

APPENDIX 4: MANAGING DIFFERING OPINIONS

At some point, it is highly likely that participants will have different opinions and thoughts. Working through these differences and coming to a point of mutual understanding is important to keep the group moving forward. This is also at the core of inquiry science and changing education practices.

Hearing different opinions and thoughts shows there is not always one “right” answer and there are multiple ways to interpret evidence. Often we are trying to come to consensus, which may require each participant to compromise or focus on where they agree and come back to the other areas.

To have meaningful conversations around different interpretations and ideas, it is important to build a culture of discussion and argumentation. At the beginning of the training, set group norms for how to interact when people do not agree, such as:

- Disagree with an idea, not the person.
- Use respectful language.
- Use phrases like “I disagree about . . .” or “I agree on . . .”
- Listen quietly to other people.
- Ask questions politely.
- Speak loudly and clearly.
- Always use evidence.

As with any other discussion, everyone needs to have the opportunity to be heard. Make sure you are allowing a variety of people to speak and that people are not cutting each other off.

Not every discussion of different opinions can come to a complete end every time. One way to table a discussion in order to move on is to take advantage of a parking lot or other idea repository. The chart on the next page lists a few ideas about when the parking lot should be used instead of having the discussion continue. Note: Every circumstance is different. These are suggested criteria, not hard rules.

Parking Lot	Keep Going
Requires input from people outside of training	Is specific to the current topic
Will be covered more in future lessons or sessions	Will likely be wrapped up in the session
Not related to the current topic	Multiple participants are highly engaged
Discussion becomes combative	Group has good evidence to come to consensus
Only one participant is speaking	

Sometimes the difference of opinions and ideas stems from a misconception. The Teacher Guide has a list of content and practice-based misconceptions that may come up in each module. Additionally, it is important to ask participants about what sources they are using, why they believe this information, or other questions to get at the root of their misconception while avoiding an accusatory or negative tone of voice. You can also use their peers' input to help clarify. If you must correct misconceptions to support learning later in the module, try using a supportive phrase such as, "Many people think that is true but the evidence so far supports . . ."

www.ssec.si.edu

Smithsonian
Science Education Center