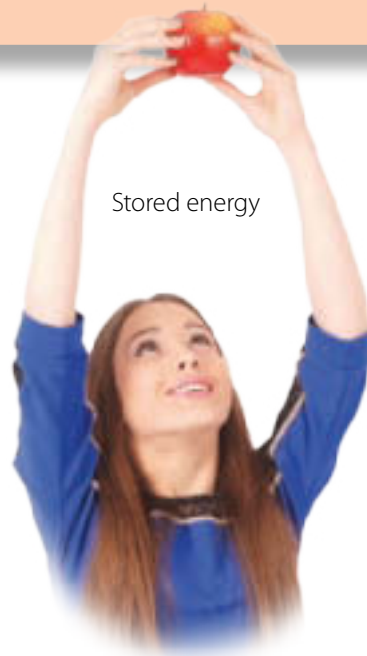


Energy Transfer and Transformation

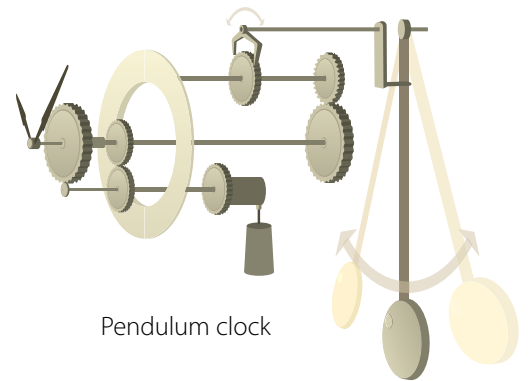
Teacher Guide



Lewis Howard Latimer



Stored energy



Pendulum clock

Energy transfer



Energy Transfer and Transformation

Teacher Guide



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ISBN: 978-1-68380-515-1

Energy Transfer and Transformation

Table of Contents

Introduction	1
Building Science Knowledge	4
Using the Student Reader	6
Using the Teacher Guide	7
Materials and Equipment	12
Sample Pacing Guide	14
Part A Introduction to Energy	17
Lesson 1 Energy Causes Change	18
Lesson 2 Forms of Energy	23
Part B Energy and Motion	28
Lesson 3 Moving Objects Have Energy	29
Lesson 4 Investigating Energy and Speed ...	33
Lesson 5 Energy and Speed Are Related	39
Part C Energy Transfer	45
Lesson 6 Sound Transfers Energy	46
Lesson 7 Energy Transfer	51
Lesson 8 Investigating Energy Transfer	56
Lesson 9 Evidence of Energy Transfer	60
Part D Collisions	64
Lesson 10 Collisions Transfer Energy	65
Lesson 11 Investigating Collisions	72
Part E Energy Transformation and Engineering for Energy	78
Lesson 12 How Can Energy Transformations Solve Problems?	79
Lesson 13 Designing Devices to Transform Energy	85
Unit Review	94
Teacher Resources	99
Activity Page and Unit Assessment Masters	101
Answer Key and Unit Assessment Evaluation Guide	137
Appendices	143
A. Glossary	143
B. Classroom Safety for Activities and Demonstrations	145
C. Strategies for Acquiring Materials	147
D. Advance Preparation for Activities and Demonstrations ..	148
E. What to Do When Activities Don't Give Expected Results. ...	149

Energy Transfer and Transformation

Teacher Guide

Core Knowledge Science™ 4

Introduction

ABOUT THIS UNIT

The Big Idea

This unit focuses on the scientific concept that whenever there is a change, there is some form of energy causing the change.

Students can see evidence of energy causing change all around them—when they flip on a light switch, feel a car start to move, or hear a phone ring. But the scientific concept of energy as the ability to cause a change can prove initially challenging. This abstract idea of the relationship between energy and change becomes clearer when students understand that

- energy exists in different forms, such as sound, light, thermal energy (heat), and electrical energy;
- these forms of energy can cause a change, such as when a high-pitched sound breaks glass or when heat melts butter;
- one form of energy can transform into another; and
- all change, in fact, is evidence of an energy transfer or transformation.

Engineers use knowledge of physical laws governing energy as they develop solutions to problems and build things that are useful to people. This lesson series incorporates learning goals that support principles and practices of engineering design (such as defining problems and evaluating and optimizing possible solutions).

Note to Teachers and Curriculum Planners

This unit introduces fourth graders to real-world examples and fundamental concepts of energy, which will be explored in greater depth in later grades. Students will learn about energy and change, forms of energy, and the energy of motion and position. The following are preliminary considerations for planning and instruction relative to this unit:

- While the unit explores energy in relation to the motion of objects, it does not use the term *kinetic energy*. Neither does this unit use the term *potential energy*. However, students develop an understanding of energy as the *ability* to cause change.
- Teachers should correct the misconception that only moving objects have energy. Nonmoving objects can also have stored energy (for example, a ball held at a height, a stretched spring, or chemical energy stored in food or a battery).
- Light and sound are explored in this unit as well as in greater depth in Grade 4 Unit 2 *Investigating Waves*.

Note to Core Knowledge Teachers

Thanks to ongoing research in the field, our understanding of how children learn continues to evolve. In the subject area of science, in particular, students benefit from not just reading about concepts and ideas, but also hands-on experiences. Following the release of the Next Generation Science Standards (NGSS), the Core Knowledge Foundation used this opportunity to update and enhance the science portion of the *2010 Core Knowledge Sequence*. The result of this effort is the revised *2019 Core Knowledge Science Sequence*.

While there have been some shifts in the grade levels at which certain topics are recommended, the fundamental principles of pedagogy inherent to the Core Knowledge approach, such as the importance of building a sequential, coherent, and cumulative knowledge base, have been retained.

Online Resources



To download the *2019 Core Knowledge Science Sequence*, use the links found in the Online Resources Guide.

www.coreknowledge.org/cksci-online-resources

This science unit, aligned to the *2019 Core Knowledge Science Sequence* and informed by NGSS, embodies Core Knowledge’s vision of best practices in science instruction and knowledge-based schooling, such as the following:

- building students’ knowledge of core ideas in life, physical, and Earth sciences, as well as engineering design
- developing scientific practices that give students firsthand experience in scientific inquiry, engineering, and technology
- connecting scientific learning to concepts across various disciplines, such as mathematics and literacy

To see how you can continue to use your current Core Knowledge materials with the 2019 CKSci curriculum, please see below an example of how this unit compares to the *2010 Core Knowledge Sequence*.

Examples of content retained from the <i>2010 Core Knowledge Sequence</i>	Examples of Core Knowledge content in this CKSci Unit
Light & Sound (Grade 3) • The speed of light: light travels at an amazingly high speed. • Light travels in straight lines (as can be demonstrated by forming shadows). • Sounds travel through solids, liquids, and gases. Electricity (Grade 4) • Electric current • Electric circuits and experiments with simple circuits (battery, wire, light bulb, filament, switch, fuse)	Introduction to Energy • Energy has many forms, including motion, light, sound, heat, and electrical energy. Energy Transfer • Energy can be transferred from place to place. For example: – Light: Transferred to Earth from the sun. – Sound: Transferred from a faraway bell or siren • Electrical currents can transfer energy from place to place and be converted into sound, light, or heat energy.
For a complete look at how CKSci relates to the 2010 <i>Sequence</i>, please refer to the full Correlation Charts available for download using the Online Resources Guide for this unit: www.coreknowledge.org/cksci-online-resources	

What are the relevant NGSS Performance Expectations for this unit?*

This unit, *Energy Transfer and Transformation*, has been informed by the following Grade 4 Performance Expectations for the NGSS topic *Energy*. Students who demonstrate understanding can:

4-PS3-1 Use evidence to construct an explanation relating the speed of an object to the energy of that object.

4-PS3-2 Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

4-PS3-3 Ask questions and predict outcomes about the changes in energy that occur when objects collide.

4-PS3-4 Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.

For detailed information about the NGSS references, follow the links in the Online Resources Guide for this unit. Use the following link to download any of the CKSci Online Resources Guides:

www.coreknowledge.org/cksci-online-resources

Online Resources



*NEXT GENERATION SCIENCE STANDARDS (NGSS) is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards were involved in the production of this product, and their endorsement is not implied.

Sources:

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By States*. Washington, DC: The National Academies Press.

National Research Council. 2012. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Committee on a Conceptual Framework for New K–12 Science Education Standards. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

What Students Should Already Know

The concept of progressions, articulated in the National Research Council's *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*, is very much aligned to the Core Knowledge principle of building new knowledge on prior knowledge. According to the NRC, students build “progressively more sophisticated explanations of natural phenomena” over the course of many years of schooling. “Because learning progressions extend over multiple years, they can prompt educators to consider how topics are presented at each grade level so that they build on prior understanding and can support increasingly sophisticated learning.” In schools following NGSS recommendations, teachers can build on the “prior understandings” captured in the following summaries of NGSS Disciplinary Core Ideas:

PS2.A: Forces and Motion

Grades K–2

- Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object's motion.

Grade 3

- Each force acts on one particular object and has both strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion.
- The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it.

PS2.B: Types of Interactions

Grades K–2

- When objects touch or collide, they push on one another and can change motion or shape.

Grade 3

- Objects in contact exert forces on each other.
- Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other.

PS3.C Relationship Between Energy and Forces

- Grades K–2**
- A bigger push or pull makes things go faster. Faster speeds during a collision can cause a bigger change in shape of the colliding objects.

PS4.A Wave Properties

- Grades K–2**
- Sound can make matter vibrate, and vibrating matter can make sound.

What Students Need to Learn

For this unit, the Core Knowledge Science Sequence specifies the following content and skills. Specific learning objectives are provided in each lesson throughout the unit. NGSS References, including Performance Expectations, Disciplinary Core Ideas, and Crosscutting Concepts, are included at the start of each lesson as appropriate.

A. Introduction to Energy

LESSONS 1–2

- Energy: the ability to cause change
- Energy has many forms, including motion, light, sound, heat, and electrical energy.
- Stored energy: the potential to cause change (for example, holding a ball at a height or the stored chemical energy within a battery)

B. Energy and Motion

LESSONS 3–5

- All moving objects possess energy of motion.
- The faster an object is moving, the greater its energy.
- People use motion energy to cause changes that accomplish useful tasks (for example, in bicycles and pendulum clocks).

C. Energy Transfer

LESSONS 6–9

- Energy can be transferred from place to place.
- Examples
 - Sound: hearing a faraway bell or siren
 - Light: energy from the sun transferred to Earth
 - Heat: feeling the warmth of a campfire or space heater
 - Electrical currents can transfer energy from place to place and be converted into sound, light, or heat energy. (For example, hydroelectric power plants convert the energy of moving water into electrical energy and then transfer it across long distances.)

- Moving objects transfer energy from place to place (for example, a rolled ball knocking over a stack of blocks).
- There are changes in energy when objects collide:
 - When objects collide, energy can transfer from one object to another and change the motion of the objects.
 - In a collision, some energy is transferred from the objects to the air as sound or heat (for example, when a bat hits a baseball).

E. Energy Transformation and Engineering

LESSONS 12–13 AND UNIT REVIEW

- One form of energy can be converted into another form of energy (for example, chemical energy in batteries can be transformed to motion, light, or sound).
- Many useful devices convert one form of energy into another (for example, toasters convert electrical energy to heat energy, and solar panels convert light energy to electrical energy).

What Teachers Need to Know

Supportive information on the content standards and the science they address is provided throughout the lessons at points of relevance:

Know the Standards: These sections, found later in this Teacher Guide, explain what to teach and why, with reference to NGSS and Core Knowledge expectations.

Know the Science: These sections provide supporting, adult-level, background information or explanations related to specific examples or Disciplinary Core Ideas.

USING THE STUDENT READER



Student Reader

The *Energy Transfer and Transformation* Student Reader has seven chapters and a student Glossary providing definitions to Core Vocabulary words. Engaging text, photographs, and diagrams encourage students to draw upon their own experiences and the world around them to understand scientific concepts. In addition to Core Vocabulary, the Student Readers include a feature called Word to Know, which provides background information to help students understand key terms, and may sometimes include additional informational boxes, such as Think About.

Explore, then read: In the CKSci program, lessons are sequenced to provide active engagement before reading. First, students explore phenomena through hands-on investigations or teacher demonstrations, accompanied by active questioning and analysis; then, students study the informational text provided in the Student Readers. The icon, shown at left, will signal Core Lesson segments that focus on Student Reader chapters.

CKSci Student Readers extend, clarify, and confirm what students have learned in their investigations. The text helps students develop a sense of the language of science, while images, diagrams, charts, and graphs deepen conceptual understanding. Use of the CKSci Student Readers supports the Science and Engineering Practice “Obtaining, Evaluating, and Communicating Information” as described in *A Framework for K–12 Science Education*.

Independent reading or group read aloud: While the text in the Student Readers is written for independent reading, we encourage group read aloud and engagement with the text. The Teacher Guide provides Guided Reading Supports to prompt discussion, clarify misconceptions, and promote understanding in relation to the Big Questions.

USING THE TEACHER GUIDE

Pacing

The *Energy Transfer and Transformation* unit is one of five units in the Grade 4 CKSci series. To meet NGSS Performance Expectations we encourage teachers to complete all units during the school year. To be sure all NGSS Performance Expectations are met, each Core Lesson should be completed, and each requires thirty to forty-five minutes of instruction time. The time it takes to complete a lesson depends on class size and individual circumstances.

Within the Teacher Guide, the Core Lessons are divided into numbered segments, generally five or six, with approximate times listed per segment. The final segment is always a Check for Understanding, providing the teacher with an opportunity for formative assessment.

At the end of this unit introduction, you will find a Sample Pacing Guide on page 14 and a blank Pacing Guide on pages 15–16, which you may use to plan how you might pace the lessons, as well as when to use the various other resources in this unit. We strongly recommend that you preview this entire unit and create your pacing guide before teaching the first lesson. As a general rule, we recommend that you spend no more than twenty days teaching the *Energy Transfer and Transformation* unit so that you have time to teach the other units in the Grade 4 CKSci series.

The Core Lessons

- Lesson time: Each Core Lesson constitutes one classroom session of up to forty-five minutes. Understanding that teachers may have less instructional time, we show a time range of thirty to forty-five minutes per lesson. Teachers may choose to conduct all Core Lesson segments, totaling forty-five minutes; may choose to conduct a subset of the lesson segments; or may choose to spend less time per segment.

- Lesson order: The lessons are coherently sequenced to build from one lesson to the next, linking student engagement across lessons and helping students build new learning on prior knowledge.

PART	LESSON	BIG QUESTION
A. Introduction to Energy	1. Energy Causes Change	Where can we observe evidence of energy causing change?
	2. Forms of Energy	What are some forms of energy?
B. Energy and Motion (4-PS3-1)	3. Moving Objects Have Energy	How are energy, change, and movement of objects related?
	4. Investigating Energy and Speed (two class sessions)	How are energy and speed related?
	5. Energy and Speed Are Related	How are energy and speed related?
C. Energy Transfer (4-PS3-2)	6. Sound Transfers Energy	What evidence shows that sound transfers energy from one place to another?
	7. Energy Transfer	What evidence shows that energy transfers from place to place?
	8. Investigating Energy Transfer	What evidence shows that light, heat, and electricity transfer energy from place to place?
	9. Evidence of Energy Transfer	What evidence shows that energy is transferred from place to place?
D. Collisions (4-PS3-3)	10. Collisions Transfer Energy	How is energy involved in collisions?
	11. Investigating Collisions (two class sessions)	What happens when objects collide? How are collisions predictable?
E. Energy Transformation and Engineering for Energy (4-PS3-4)	12. How Can Energy Transformations Solve Problems?	How do energy transformations help people?
	13. Designing Devices to Transform Energy (four class sessions)	How can I design a device that transforms energy to solve a problem?
Unit Review and Assessment	Solving Problems and Designing Solutions: Thomas A. Edison	How did Thomas Edison use his knowledge of energy transfer and transformation to solve problems?
	Unit Assessment	What have I learned about energy?

Activity Pages and Unit Assessment

Activity Pages



Black line reproducible masters for Activity Pages and a Unit Assessment, as well as an Answer Key, are included in Teacher Resources on pages 101–142. The icon shown to the left appears throughout the Teacher Guide wherever Activity Pages (AP) are referenced.

AP 1.1

AP 2.1

AP 2.2

AP 3.1

AP 4.1

AP 4.2

AP 6.1

AP 7.1

AP 8.1

AP 9.1

AP 9.2

AP 10.1

AP 11.1

AP 11.2

AP 12.1

AP 13.1

AP 13.2

AP 13.3

AP 13.4

AP 13.5

AP 13.6

AP UR.1

Students' achievement of the NGSS Performance Expectations is marked by their completion of tasks throughout the unit. However, a combined Unit Assessment is provided as a summative close to the unit.

Lesson 1—Energy Scavenger Hunt (AP 1.1)

Lesson 2—Surprise! (AP 2.1)

Lesson 2—Energy Causes Change (AP 2.2)

Lesson 3—On the Move (AP 3.1)

Lesson 4—Ramp It Up! (Day 1) (AP 4.1)

Lesson 4—Drop It (Day 2) (AP 4.2)

Lesson 6—Lesson 6 Check (AP 6.1)

Lesson 7—Lesson 7 Check (AP 7.1)

Lesson 8—Investigating Energy Transfer (AP 8.1)

Lesson 9—Examples of Energy Transfer (AP 9.1)

Lesson 9—Claims, Evidence, and Reasoning About Energy Transfer (AP 9.2)

Lesson 10—Lesson 10 Check (AP 10.1)

Lesson 11—Investigating Collisions (Day 1): Predictions (AP 11.1)

Lesson 11—Investigating Collisions (Day 2): Testing and Observation (AP 11.2)

Lesson 12—Lesson 12 Check (AP 12.1)

Lesson 13—Device Design Proposal (Day 1) (AP 13.1)

Lesson 13—Device Test Results (Day 2) (AP 13.2)

Lesson 13—Device Presentation Plan (Day 3) (AP 13.3)

Lesson 13—Device Presentation Scoring Guide (Day 4) (AP 13.4)

Lesson 13—Energy Vocabulary Crossword Puzzle (AP 13.5)

Lesson 13—Energy Vocabulary Review (AP 13.6)

Unit Review—Energy's Big Questions (AP UR.1)

Online Resources for Science

Online Resources



For each CKSci unit, the Teacher Guide includes references to online resources (including external websites and downloadable documents) to enhance classroom instruction. Look for the icon on the left.

Use this link to download the CKSci Online Resources for this unit:

www.coreknowledge.org/cksci-online-resources

Teaching Strategies

Start with the familiar.

Lead with an experience. Begin each lesson with a demonstration, activity, or question about a phenomenon to engage students and focus their attention on the topic. Start with the familiar. Every science topic introduced to students relates in some way to their known world and everyday experiences. The purpose of every lesson is to build a bridge between what is familiar to students and broader knowledge about the way the world works.

Ask the Big Question.

At the beginning of each Teacher Guide lesson, you will find a Big Question and Core Lesson segment devoted to encouraging students to think about this question as they are introduced to new science content. Use this opportunity to engage students in conversation, to think about how their own real-world experiences relate to the topic, or to participate in a demonstration that relates to the Big Question.

Encourage scientific thinking.

Approach the lessons with students not as learning about science but as learning about the world with a scientific mind. Science learning models science practice.

Throughout the lessons, encourage students to ask questions about what they observe, do, and read. Record relevant questions in a prominent place in the classroom. Guide students back to these questions as opportunities to answer them emerge from readings, demonstrations, and activities.

Use continuous Core Vocabulary instruction.

As a continuous vocabulary-building strategy, have students develop a deck of vocabulary cards, adding a card for each Core Vocabulary term as it is introduced. Students can add illustrations and examples to the cards as their comprehension of terms expands. During instruction, emphasize Core Vocabulary terms and their meanings in context rather than relying on isolated drill for memorization of definitions. Students will be given the opportunity to preview Core Vocabulary words early in the lessons and to engage in Word Work activities toward the end of the lessons. Encourage students to come up with definitions in their own words and to use the words in their own sentences.

Core Vocabulary words for each lesson, as well as other key terms teachers are encouraged to use in discussing topics with students, are provided at the start of each lesson. You can find Core Vocabulary definitions in the Word Work lesson segments, as well as in the Glossary on pages 143–144.

Emphasize observation and experience.

Lessons employ various ways for students to learn, including watching, listening, reading, doing, discussing, and writing. To meet the NGSS Performance Expectations, which are multidimensional standards, students must not only gain factual knowledge associated with Disciplinary Core Ideas, but also *use* the content knowledge they acquire.

Use science practices.

Give students opportunities to discover new content knowledge through investigation and to use their new knowledge both in problem-solving exercises and as evidence to support reasoning. Students learn what science and engineering practices are by engaging in those same practices as they learn.

Core Lesson segments are designed to reinforce the idea of science as an active practice, while helping students meet NGSS Performance Expectations. Each lesson segment is introduced by a sentence emphasizing active engagement with an activity.

Make frequent connections.

Use a combination of demonstrations and reading materials, rich with examples, to help students recognize how the science concepts they are learning apply in their everyday lives. Prompt students to relate lesson content to their own experiences, to relate the new and unfamiliar to the familiar, and to connect ideas and examples across disciplines. Refer to the Crosscutting Concepts cited in the lessons, often included in the NGSS References listed at the start of each lesson.

Monitor student progress.

Use verbal questioning, student work, the Check for Understanding assessments at the end of each lesson and the Unit Assessment at the end of the unit (see pages 129–136) to monitor progress during each lesson and to measure understanding at the conclusion of the unit. Many lessons provide tips to help you support students who need further explanations or clarifications.

Effective and Safe Classroom Activities

Conducting safe classroom demonstrations and activities is essential to successful elementary science education. The following resources provide Core Knowledge's recommendations for developing effective science classroom activities.

These resources, included at the back of the Teacher Guide on pages 145–149, consist of the following:

- Classroom Safety for Student Activities and Teacher Demonstrations
- Strategies for Acquiring Materials
- Advance Preparation for Classroom Activities and Demonstrations
- What to Do When Activities Don't Give Expected Results

Online Resources



These resources may also be accessed within the CKSci Online Resources Guide for this unit, available at

www.coreknowledge.org/cksci-online-resources

MATERIALS AND EQUIPMENT

The unit requires a variety of materials to support various ways of learning (including doing, discussing, listening, watching, reading, and writing). Prepare in advance by collecting the materials and equipment needed for all the demonstrations and hands-on investigations.

Part A: Introduction to Energy

Lesson 1

- electric pencil sharpener and unsharpened pencil
- internet access and the means to project images/video for whole-class viewing (rocket launch)
- index cards for student vocabulary deck (3 per student)

Lesson 2

- flashlight with removable batteries
- large plastic cup
- balloon (dark color)
- table salt (a pinch)
- mobile phone or mobile audio device with a small speaker
- candle
- matches or a lighter

Part B: Energy and Motion

Lesson 3

- assorted marbles
- index cards for student vocabulary deck (2 per student)

Lesson 4

- books (to elevate ramps)
- cardboard (for ramp surfaces)
- 2 small, dense rubber balls of the same size and weight
- 2 paper cups
- pennies or pebbles for place markers
- shoeboxes (1 per group)
- play sand (about 5 pounds)
- index cards for student vocabulary deck (1 per student)

Lesson 5

- books (to elevate a ramp)
- cardboard (for a ramp surface)
- rubber ball
- a few lightweight blocks
- index cards for student vocabulary deck (1 per student)

Part C: Energy Transfer

Lesson 6

- sticky note paper (approximately 3 inches square, 1 piece per student)
- plastic cups (1 per student)
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (2 per student)

Lesson 7

- index cards for student vocabulary deck (2 per student)
- flashlight
- hot plate
- spiral-cut paper plate on a string
- internet access and the means to project images/video for whole-class viewing

Lesson 8

- flashlight
- paintbrush (2–4 inches wide)
- chalk powder (finely crushed chalk)
- plate
- hot plate
- beaker
- ice cubes
- ice chest or ice box
- plastic bucket
- tongs
- tablet or cell phone (with low battery charge and a visible “charging” icon)
- tablet or cell phone charging cord
- surge protector with off/on switch

Lesson 9

- internet access and the means to project images for whole-class viewing

Part D: Collisions

Lesson 10

- 2 smaller toy cars
- 2 larger toy cars
- 2 clipboards
- 3–4 hardcover books for each ramp
- modeling clay
- index cards for student vocabulary deck (2 per student)

Lesson 11

- empty cans or water bottles (1 per group)
- plastic or wooden toy vehicles with wheels
- 2-foot-long ramps made of cardboard or wood (1 per group)
- small items such as marbles, dry beans
- internet access and the means to project images/video for whole-class viewing

Part E: Energy Transformation and Engineering for Energy

Lesson 12

- wind-up timer (or timer app on phone)
- index cards for student vocabulary deck (3 per student)

Lesson 13

A broad selection of materials from which students may choose for a design solution, such as:

- boxes
- aluminum foil
- clear plastic wrap
- craft paper
- springs
- rubber bands
- containers
- string
- table tennis and tennis balls
- cups
- sticks
- cardboard tubes of various sizes
- blocks
- glue
- clipboards for making ramps
- tape
- electric clock or pencil sharpener

SAMPLE PACING GUIDE

The sample Pacing Guide suggests use of the unit's resources across a twenty-day period. However, there are many ways that you may choose to individualize the unit for your students, based on their interests and needs. You may elect to use the blank Pacing Guide on pages 15–16 to reflect alternate activity choices and alternate pacing for your class. If you plan to create a customized pacing guide for your class, we strongly recommend that you preview this entire unit and create your pacing guide before teaching the first lesson.

Online Resources



For a yearlong pacing guide, please use the link found in the Online Resources Guide for this unit. This yearlong view of pacing also includes information about how this CKSci unit relates to the pacing of other programs, such as CKLA and CKHG in the *Core Knowledge Curriculum Series™*.

www.coreknowledge.org/cksci-online-resources

TG–Teacher Guide; SR–Student Reader; AP–Activity Page

Week 1

Day 1	Day 2	Day 3	Day 4	Day 5
<i>Energy Causes Change</i> TG Lesson 1 SR Chapter 1 AP 1.1	<i>Forms of Energy</i> TG Lesson 2 AP 2.1, 2.2	<i>Moving Objects Have Energy</i> TG Lesson 3 SR Chapter 2 AP 3.1	<i>Investigating Energy and Speed DAY 1</i> TG Lesson 4 AP 4.1	<i>Investigating Energy and Speed DAY 2</i> TG Lesson 4 AP 4.2

Week 2

Day 6	Day 7	Day 8	Day 9	Day 10
<i>Energy and Speed Are Related</i> TG Lesson 5 SR Chapter 3	<i>Sound Transfers Energy</i> TG Lesson 6 AP 6.1	<i>Energy Transfer</i> TG Lesson 7 SR Chapter 4 AP 7.1	<i>Investigating Energy Transfer</i> TG Lesson 8 AP 8.1	<i>Evidence of Energy Transfer</i> TG Lesson 9 AP 9.1, 9.2

Week 3

Day 11	Day 12	Day 13	Day 14	Day 15
<i>Collisions Transfer Energy</i> TG Lesson 10 SR Chapter 5 AP 10.1	<i>Investigating Collisions DAY 1</i> TG Lesson 11 AP 11.1	<i>Investigating Collisions DAY 2</i> TG Lesson 11 AP 11.2	<i>How Can Energy Transformations Solve Problems?</i> TG Lesson 12 SR Chapter 6 AP 12.1	<i>Designing Devices to Transform Energy DAY 1</i> TG Lesson 13 AP 13.1

Week 4

Day 16	Day 17	Day 18	Day 19	Day 20
<i>Designing Devices to Transform Energy DAY 2</i> TG Lesson 13 AP 13.2	<i>Designing Devices to Transform Energy DAY 3</i> TG Lesson 13 AP 13.3	<i>Designing Devices to Transform Energy DAY 4</i> TG Lesson 13 AP 13.4, 13.5, 13.6	<i>Solving Problems and Designing Solutions: Thomas A. Edison</i> TG Unit Review SR Chapter 7 AP UR.1	Unit Assessment AP Unit Assessment

PACING GUIDE

Twenty days have been allocated to the *Energy Transfer and Transformation* unit to complete all Grade 4 science units in the *Core Knowledge Curriculum Series™*. If you cannot complete the unit in twenty consecutive days of science instruction, use the space that follows to plan lesson delivery on an alternate schedule.

Week 1

Day 1

Day 2

Day 3

Day 4

Day 5

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Week 2

Day 6

Day 7

Day 8

Day 9

Day 10

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Week 3

Day 11

Day 12

Day 13

Day 14

Day 15

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Week 4

Day 16

Day 17

Day 18

Day 19

Day 20

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Week 5**Day 21****Day 22****Day 23****Day 24****Day 25**

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Week 6**Day 26****Day 27****Day 28****Day 29****Day 30**

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Week 7**Day 31****Day 32****Day 33****Day 34****Day 35**

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Week 8**Day 36****Day 37****Day 38****Day 39****Day 40**

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PART A

Introduction to Energy

OVERVIEW

Lesson	Big Question	Advance Preparation
1. Energy Causes Change	Where can we observe evidence of energy causing change?	Read Student Reader, Chapter 1.
2. Forms of Energy	What are some forms of energy?	Gather materials for a teacher demo. (See Materials and Equipment page 12.)

Part A: What's the Story?

Energy is the ability to cause a change. That seems simple enough. But as many an experienced teacher knows, it is a difficult concept for young students to grasp.

In Lesson 1, we start simply by engaging students in looking for changes around them and then helping them understand these changes as evidence of energy. The goal is to get students to recognize that whenever there is a *change*, there is some form of *energy* causing the change.

In relating energy to change, keep the order in mind: **energy >>> change**. For example, if you clap your hands in a silent room, a sound occurs. The energy of your muscle movement causes the change from silence to sound.

In Lesson 2, we introduce students to various forms of energy, including sound, light, electrical energy, chemical energy, energy of motion, and stored energy. While students intuitively understand sound as what they hear and light as what brightens a dark room, the goal here is to associate these familiar phenomena with *energy*. In referring to “forms of energy,” we are purposefully using an approximate term—more technically accurate explanations (for example, of light as electromagnetic radiation) are best left for later grades.

So, to repeat, **energy causes change**. Help your students grasp this concept, and you will lay the groundwork for meeting the NGSS expectations addressed in later parts of this unit regarding how energy moves from one place to another and how it transforms from one form to another.

LESSON 1

Energy Causes Change

Big Question: Where can we observe evidence of energy causing change?

AT A GLANCE

Learning Objective

- ✓ Give examples of energy causing change.

Lesson Activities

- student observation
- reading, discussion, writing
- vocabulary instruction
- teacher demonstration

NGSS References

Disciplinary Core Idea PS3.A: Definitions of Energy

Crosscutting Concept: Stability and Change

Stability and Change is important to this lesson because energy is the ability to cause change. Students begin this lesson by observing examples of change all around them and then exploring these and other examples as evidence that *energy* is around them in the real world.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

change

electrical energy

energy

evidence

forms of energy

heat

light

motion

position

sound

stored energy

transfer

transform

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above. (Note: Lesson 1 is introductory in nature. These terms and others will be taught within additional context in the subsequent lessons.)

Instructional Resources

Student Reader



Ch. 1

Activity Page



AP 1.1

Student Reader, Chapter 1 “Energy Causes Change”

Activity Page

Energy Scavenger Hunt (AP 1.1)

Make sufficient copies
for your students prior to
conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- electric pencil sharpener and unsharpened pencil
- internet access and the means to project images/video for whole-class viewing (rocket launch)
- index cards for student vocabulary deck (3 per student)

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

10 MIN

Where can we observe evidence of energy causing change? Go over the directions for the Energy Scavenger Hunt (AP 1.1). Prompt students to look at familiar objects in and around the classroom while asking themselves, “How do these things change?”

Activity Page



AP 1.1

Review the examples provided on the Activity Page. In answering the question, “How does it change?” students should follow the model of the samples and use the word *change* in their answers. Let students know that there is more than one set of correct answers for this activity.

Give students time to make and record their observations.

SUPPORT—If needed, provide an example of a question or “I wonder . . .” statement that students might write at the bottom of Activity Page 1.1. For example, “I wonder how a light bulb actually works,” or “Where does the electricity come from to move the fan?”

2. Encourage student questions.

5 MIN

Lead a discussion about the examples students recorded. Prompt students to think about the forms of energy that might be causing the changes they described. Draw attention to examples with similarities, such as all the changes involving motion, changes that require electricity, or changes that produce a sound.

3. Read and discuss: “Energy Causes Change.”

15 MIN

Student Reader



Ch. 1

Read together, or have students read independently, “Energy Causes Change,” Chapter 1 in the Student Reader. The chapter reinforces the idea of energy as the ability to cause change, illustrates different forms of energy, and presents several examples of ways that energy can change and cause change.

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read:

change

energy

stored energy

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Pages 1–2

After reading, ask: What are other examples of energy causing change?

SUPPORT—If needed, prompt students to recall examples from the Energy Scavenger Hunt activity.

Page 3

Prompt students to clap their hands three times. Ask: What forms of energy can you observe when you clap your hands? (*motion, sound, and perhaps heat as well*)

SUPPORT—If needed, prompt students to reread the descriptions of motion and sound and to think about other examples of energy causing change.

Page 4

Prompt students to think about what happens to the stored energy in batteries when they turn on a flashlight. Ask: Why do you think we sometimes have to replace the batteries in a flashlight? (*The stored chemical energy in the battery is changed into light and heat when the flashlight is turned on. Eventually the stored energy in the battery is used up. But the energy from the battery hasn’t gone away—it has been changed to light and heat.*)

Pages 5–6

Ask students to look around the classroom and identify three or more objects that have stored energy of position (for example, a book or a globe on a shelf).

4. Demonstrate examples and guide discussion.

5 MIN

Choose one or more of the following examples to stimulate further discussion. Analyze with students 1) the changes that occur in the example, 2) what causes the changes, and 3) where the energy that causes the changes comes from. (See below, **Know the Science 1** and **2**, for support with the analysis.)

- Use an electric pencil sharpener to sharpen a pencil. Ask students what changes they can observe in this demonstration.
 - » How does the pencil change? *(It becomes shorter, and its tip becomes sharper.)*
 - » How does the pencil sharpener change? *(It goes from silent to making noise.)*
 - » What makes the changes happen? *(electricity from the wall or batteries)*
- Show a video of a rocket launch. (See the Online Resources for a link to a suggested video.) Ask what changes students can observe in the launch.
 - » How does the rocket change? *(It changes from sitting still to lifting off.)*
 - » How does the area around the rocket change? *(It fills up with fire and smoke or steam.)*
 - » What makes the changes happen? *(the engine burning rocket fuel)*

Online Resources



Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

- Prompt students to link details in this analysis discussion back to the scavenger hunt and the reading selection.
 - » Did you write any examples on your scavenger hunt that are similar to the changes occurring with the pencil sharpener? How are the examples similar?
 - » Did you write any examples on your scavenger hunt that are similar to the changes occurring with the rocket launch? How are the examples similar?

Know the Science

1. What goes on inside an electric pencil sharpener? *Change.* Energy causes changes. The sound you can hear and vibrations you can feel from the moving parts are evidence of change. The different shape of the pencil before and after is more evidence of change. The newly sharpened end of the pencil might also feel warm, a change in temperature. Electrical energy powers the motor in the sharpener. (If the sharpener is battery-powered, then the stored chemical energy in the batteries is transformed to electrical energy.) The motor transforms the electrical energy to the motion energy of the turning blades. The moving blades sharpen the pencil. During this process, some of the energy of the moving blades is transformed into heat and noise.

2. What happens during a rocket launch? *Big changes!* The roaring sound you can hear and the explosive motion you can see as the rocket lifts off are evidence of change. You can see the flames of combustion from the engines, exhaust gases, and steam in the surrounding air as evidence of sudden, enormous temperature change. Energy produces all these changes. When chemicals in solid or liquid rocket fuel react, they release gases with an explosive force. Rocket engines are shaped to channel the exhaust gases, using their pressure to produce thrust.

5. Teach Core Vocabulary.

5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Have students write each term in the upper left corner of an index card and underline it (one term per card).

change **energy** **stored energy**

Word Work

- **change:** (v. to become different) Point out that *change* can be a noun or a verb. Ask volunteers to use *change* in a sentence, first as a noun and then as a verb. Encourage sentences that use *change* in relation to energy. Write two sentences on the board or chart paper (one using *change* as a noun, the other as a verb). (*Energy is the ability to cause change. Cars change from sitting still to rolling.*) Have students copy the sentences on their card and underline the word *change*.
- **energy:** (n. the ability to cause change) First, have students write the definition as you dictate it: "Energy is the ability to cause change." Then ask them to write a sentence using the word *energy*. (*Sound is a form of energy.*)
- **stored energy:** (n. energy that has the ability to cause change at a later time) Brainstorm with the class three or more examples of stored energy. Examples might include energy stored in batteries or wound springs in clocks or toys. On their cards, have students draw a picture illustrating the concept of stored energy.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

6. Check for understanding.

5 MIN

Activity Page



AP 1.1 and
Answer Key

Formative Assessment Opportunity

See the Activity Page Answer Key (AP 1.1) for correct answers and sample student responses.

- Collect the completed Energy Scavenger Hunt (AP 1.1). Scan the questions that students posed regarding energy-related changes they observed in the classroom.
- Choose one or two questions to present to the class for a brief closing discussion. Use the discussion as an opportunity to reinforce main ideas and correct misconceptions.

LESSON 2

Forms of Energy

Big Question: What are some forms of energy?

AT A GLANCE

Learning Objectives

- ✓ Identify as forms of energy: light, sound, heat, and electrical energy.
- ✓ Create a visual model that shows examples of energy causing change.

Lesson Activities

- teacher demonstration
- student observation
- discussion and writing

NGSS References

Disciplinary Core Idea PS3.A: Definitions of Energy

Crosscutting Concept: Cause and Effect

Cause and Effect is important to this lesson because energy is the ability to cause change. Students will see that energy takes many forms and that all these forms of energy can cause change. Energy is the cause, and change is the effect.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

cause and effect

change

electricity

energy

forms of energy

heat

light

model

sound

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit. The deck will include Core Vocabulary terms designated in blue above.

Instructional Resources

Activity Pages



AP 2.1
AP 2.2

Activity Pages

Surprise! (AP 2.1)

Energy Causes Change (AP 2.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- flashlight with removable batteries
- large plastic cup
- tape or rubber band
- balloon (dark color)
- table salt (a pinch)
- mobile phone or mobile audio device with a small speaker
- candle
- matches or a lighter

Cut the open end of the balloon so that it can be stretched over the mouth of the cup to make a flat drumhead. If necessary, use tape or a rubber band to secure the balloon on the cup so that it remains taut.

Prepare the mobile phone or audio device to be ready to play the selection for the sound demonstration.

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

5 MIN

Preview Core Vocabulary

Before distributing the Activity Page, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they watch and discuss the demonstration:

energy **change**

Activity Page



AP 2.1

What are some forms of energy? Distribute student copies of the Activity Page Surprise! (AP 2.1). Allow students time to read it, and then ask for volunteers to describe changes depicted in the sequence of events from one frame to the next.

- A person reaches into the doorway of a darkened room to turn on a light switch.
- The dark, quiet room becomes bright and noisy with the sounds of the surprise party.
- The candle on the cake gets shorter as it burns.

2. Demonstrate examples and guide discussion.

15 MIN

Provide examples of actions involving different forms of energy. Prompt students to think in terms of cause and effect. Because energy is the ability to cause a change, what changes (effects) occur in each example? Focus students' attention on describing what changes and identifying types of energy involved in the change. The goal is to help students understand that when they observe a change, there is a form of energy associated with it.

Example 1: What are the changes that occur when you use a flashlight?

- Start by putting the batteries in the flashlight. Let students see you doing this.
- Turn on the flashlight, and direct it at a wall or chart paper. Ask: What three changes just happened? Guide students to associate each change with a form of energy:
 - » Light energy: The light comes on and lights up the wall (or chart paper).
 - » Electrical energy: Electrical energy from the batteries makes the bulb light up.
 - » Energy of motion: Moving your thumb moved the switch on the flashlight from the "off" position to the "on" position.

SUPPORT—Emphasize cause and effect: The light energy is the cause, and the effect is that the wall is now lit up. Conclude by emphasizing that every change that students observed has a form of energy associated with it. Review the changes in the order in which they happened. (*motion energy > electrical energy > light energy*)

Example 2: What changes occur when you hear a rhythmic sound and see a material vibrating to the sound?

(Students will need to take turns approaching the sound demonstration in small groups to be able to observe the change up close.)

- Place a pinch of salt on the drumhead surface you prepared from the cup and balloon.
- Play the song on your audio device at a moderately loud volume.
- Place the speaker against the side of the cup so that the sound causes the drumhead (the stretched balloon) to vibrate, which moves the salt.
- Ask students to describe what they observe. (*The salt moves to the sound. The movement of the salt is a change. Students may also observe the movement of the drumhead.*)
- Then ask students what they can conclude from the matching patterns of the sound and the motion of the salt. (*The two are directly related.*) Guide students to note specifically that sound *causes* the salt to move.
- Ask students to describe what they observed in terms of cause and effect. What is the cause? (*sound energy*) What is the effect? (*the movement of the drumhead, which causes the salt on it to move*)

Example 3: What are the changes that occur when you see a burning candle?

- Light the candle, and hold it at a slight angle so that students can see the melted wax dripping onto a piece of paper.
- Ask students to describe what they observe. (*The wax melts and drips, and then it solidifies again on the paper.*) What is the cause? (*heat energy*) What is the effect? (*melting first and then becoming a solid as it cools*)

3. Encourage student questions.

10 MIN

Read this passage to your students, and then open a class discussion.

A popular singer steps up to a microphone at a baseball game and sings the U.S. national anthem, “The Star-Spangled Banner.” As she sings, her voice blasts over the loudspeaker and fills the stadium. She reaches the last part—do you remember the words?

*And the rockets’ red glare, the bombs bursting in air,
Gave proof through the night that our flag was still there;
O say does that star-spangled banner yet wave
O’er the land of the free and the home of the brave?*
(from “The Star-Spangled Banner,” lyrics by Francis Scott Key)

When the singer finishes singing, fireworks shoot into the air and explode in the sky above the stadium.

Remind students that any change is the result of some form of energy. In the scene just described, what changes? What forms of energy are associated with each change?

Possible answers may include:

- **Energy of (muscular) motion** changes the vocal cords, making them vibrate.
- **Energy of motion (vibrating vocal cords)** changes the air in the singer’s mouth, creating sound energy.
- **Sound energy** changes the microphone so it makes electrical energy.
- **Electrical energy** changes the loudspeakers, making them vibrate.
- **Energy of motion (vibrating loudspeakers)** changes the air, making sound energy.

Know the Standards

Explaining Phenomena: In the Evidence Statements associated with NGSS Performance Expectations, it is a recurring student performance goal that, by the end of the grade, students can articulate statements that relate given phenomena to scientific ideas. Students can practice explaining phenomena related to energy when you ask them to describe something they observe—a change—and relate it to its cause—one or more forms of energy. This is also an opportunity to discuss students’ prior experiences with the Crosscutting Concept Cause and Effect.

- **Energy of chemicals bursting in fireworks** causes bright light and loud noises.
- **Energy of light** causes changes in a person's eye, allowing them to see.
- **Energy of sound** causes changes in a person's ear, allowing them to hear.
- **Energy of motion (wind)** causes a change in the flag, making it wave.

4. Reinforce Core Vocabulary.

5 MIN

Return to Core Vocabulary Cards

Direct student attention back to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Have students access the cards they made for these terms:

energy **change**

Instruct students to write an additional example on each card based on what they have observed in this lesson.

5. Check for understanding.

10 MIN

Activity Page



AP 2.2 and
Answer Key

Explain that a diagram showing a sequence of events is a kind of model. Modeling is a way to improve our understanding of a process or phenomenon that we can't directly observe. For example, we can't see sound and heat, but we can see changes that these forms of energy cause.

Distribute student copies of Energy Causes Change (AP 2.2). Instruct students to choose one of the forms of energy discussed in today's lesson. On the Activity Page, ask students to illustrate their selected form of energy before and after a change.

SUPPORT—Ask students to refer back to Surprise! (AP 2.1) as a model.

When students finish their work, explain that they have just created a *model*. A diagram showing a sequence of events is a kind of model. Scientists use models to help them understand phenomena, such as the changes caused by energy. Scientists use models to develop further questions and explanations about phenomena and to communicate their ideas to others. Have a few students display and describe their models to the class.

Collect students' drawings to evaluate and provide feedback, to be returned in the next class session. See the Activity Page Answer Key for correct answers and sample student responses.

Prompt students to ask any new questions they may have. Discuss and answer questions as a class. Correct any misconceptions as needed.

PART B

Energy and Motion

OVERVIEW

Lesson	Big Question	Advance Preparation
3. Moving Objects Have Energy	How are energy, change, and movement of objects related?	Read Student Reader, Chapter 2. Gather materials for a teacher demo and student investigations. (See Materials and Equipment, page 12.)
4. Investigating Energy and Speed (2 days)	How are energy and speed related?	Gather materials for student investigations. Read the instructional steps on the Activity Pages in advance to prepare to facilitate the student investigation.
5. Energy and Speed Are Related	How are energy and speed related?	Read Student Reader, Chapter 3. Gather materials for student investigations. (See Materials and Equipment, page 12.)

Part B: What's the Story?

Students learned in Part A: “Introduction to Energy” (Lessons 1 and 2) that energy causes changes. Sound energy can break a glass. Heat energy can cause ice cream to melt. The chemical energy in a battery can cause a flashlight to change from off to on, putting out a beam of light. Students also learned about different forms of energy, all of which can cause change. Light energy, sound energy, heat energy (also called thermal energy), and chemical energy are just some of the forms of energy.

In Part B: “Energy and Motion” (Lessons 3–5), students will take a closer look at one form of energy, the energy associated with an object in motion, called the **energy of motion** (or motion energy).

In Lesson 3, students start by exploring how objects in motion can cause changes. They see that a basketball can cause a net to move—the moving basketball causes a change. A pebble dropped in water will cause a splash—the moving pebble causes a change. The changes caused by objects in motion are evidence that these moving objects have energy (since energy is the ability to cause a change).

In Lesson 4, students conduct a two-day investigation to explore how a moving object can cause a change. If something changes, some form of energy must be involved.

In Lesson 5, which concludes Part B: “Energy and Motion,” students learn something new about the energy of motion—an object that is moving fast has more energy than that same object moving slowly. They investigate this through hands-on experience and find out that the amount of change caused by an object’s motion depends on whether that object is moving relatively fast or slow and that the energy of a moving object is related to its speed.

LESSON 3

Moving Objects Have Energy

Big Question: How are energy, change, and movement of objects related?

AT A GLANCE

Learning Objective

- ✓ Create a visual model that demonstrates an example of motion energy causing change.

Lesson Activities

- teacher demonstration
- student observation
- reading, discussion, writing
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS3.B: Conservation of Energy and Energy Transfer

Disciplinary Core Idea PS3.C: Relationship Between Energy and Forces

NGSS Crosscutting Concept: Energy and Matter

Energy and Matter is applied across this lesson and those that follow it. Students will begin to explore the concept of motion, its energy, and the ability of moving objects to cause change. Lessons 3–5 set the stage for students to understand that all moving matter has energy.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

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cause and effect
distance

energy
energy change

energy of motion
motion

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue on the previous page.

Instructional Resources

Student Reader



Ch. 2

Activity Page



AP 3.1

Student Reader, Chapter 2
“Moving Objects Have Energy”

Activity Page
On the Move (AP 3.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- assorted marbles
- index cards for student vocabulary deck (1 per student)

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

5 MIN

How are energy, change, and movement of objects related? Prepare an area where you can roll marbles into one another as students watch. Roll one marble into one or more other marbles. Vary the ways in which the object in motion, the rolled marble, causes changes in the other marbles. Ask students to describe the changes in each demonstration:

- Ask students to note what is the object in motion.
- In each interaction, ask students what is the cause and what is the effect.
- Stress that the moving object has the energy of motion and that, time and time again, this object caused changes when it hit one or more marbles.

2. Encourage discussion.

5 MIN

Activity Page



AP 3.1

At the end of this lesson, students will produce a diagram as a visual model of motion causing change. Distribute On the Move (AP 3.1), and preview the directions with students. Ask them not to begin their diagrams yet. Have students keep the activity in mind as they discuss the demonstration you just performed.

- Discuss how the marbles changed position. Ask students to describe, in as much detail as they can, in which direction and how far the marbles that were hit moved. (*They moved in various ways but always in response to the marble hitting them.*)

3. Read and discuss: “Moving Objects Have Energy.”

15 MIN

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read about real-world examples:

motion **energy of motion**

Student Reader



Ch. 2

Read together, or have students read independently, “Moving Objects Have Energy,” Chapter 2 in the Student Reader. This chapter defines the word *energy* and provides examples of how an object’s changing position is evidence of its motion. The reading provides examples of how energy relates to motion and indicates how motion energy is useful in performing work.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Pages 7–8

Ask: What are other examples of motion? (*a clock changing time, eyes blinking, cars going down the street*) List students’ examples on the board or chart paper. Which are examples of objects causing their own motion, and which are examples of objects set in motion because something else acts on them? How can you describe the motion of the players and the ball?

SUPPORT—Help students to use the terms *speed* and *direction* to describe motion. For example, “A basketball can be pushed upward toward the hoop and move quickly if a player pushes it really hard.” Or, “A ball moves down and then up again as the player dribbles it slowly or fast.”

Page 9

Revisit students’ examples of motion that you wrote on the board or chart paper during the discussion of page 7. Ask students to identify which of their examples of motion cause a change. Emphasize that, because these changes are evidence of energy, the moving objects must have energy themselves.

Pages 10–12

Ask students to connect the three examples from the reading by identifying what they have in common. (*The hammer and nail, pendulum clock, and wind turbines all involve an object in motion. In all three cases, moving things cause a useful change.*)

4. Support the investigation.

10 MIN

Activity Page



AP 3.1

Have students return to On the Move (AP 3.1). Remind students that a model is a representation of something that can help people better understand how something works. In the case of energy, a visual model is a good way to show the cause-and-effect relationship between the energy of a moving object and a change it can cause. In this diagram, students will draw an example of motion energy causing a change. Encourage students to choose an example that differs from those they have observed in class and in the reading.

SUPPORT—Draw and describe a simple cause-and-effect relationship for students. For example, you might show a stick figure having dropped an egg, which is broken at the figure's feet. Then prompt students for any questions about the example. Preview for students, but do not complete the lesson's objective for them, that visual/drawn models can help to explain and reinforce that moving objects have energy and that the energy of motion can cause change.

5. Teach Core Vocabulary.

5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words (displayed on the board or chart paper earlier in the lesson). Ask students to write each term in the upper left corner of an index card and underline it (one term per card):

motion **energy of motion**

Word Work

- **motion:** (n. the process of an object changing position) Point out that motion is a process. Ask volunteers to use *motion* in a sentence. Encourage sentences that use *motion* in relation to the concepts of energy and change. (*A moving dart has energy of motion and can cause a change when it hits a balloon.*) Have students write on their card a definition of *motion* in their own words.
- **energy of motion:** (n. the energy an object possesses while it is moving) Ask students to recall the definition of *energy* (Lesson 1).

SUPPORT—If needed, students can refer to the *energy* card in their Core Vocabulary deck for precise words. Then ask students to write a sentence using the term *energy of motion* that also identifies a change the energy can cause. (*The energy of motion of a meteoroid will cause a crater to form on impact with our moon.*)

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

6. Check for understanding.

5 MIN

Activity Page



AP 3.1 and
Answer Key

Collect and evaluate the visual models that students have drawn on Activity Page 3.1. See the Activity Page Answer Key for correct answers and sample student responses. Look for evidence of the following:

- an example of motion, an object changing position
- a change caused by the energy of an object in motion when it hits something

SUPPORT—For students who have not effectively modeled motion energy causing a change, revisit the Activity Page, and ask them how they might modify the visual to show a cause-and-effect relationship.

LESSON 4

Investigating Energy and Speed

Big Question: How are energy and speed related?

AT A GLANCE

Learning Objective

- ✓ Conduct an investigation to show how the speed of a moving object is related to its energy.

Lesson Activities (2 days)

- teacher demonstration
- student investigation
- reading, discussion, writing
- vocabulary instruction

NGSS References

Disciplinary Core Idea PS3.A: Definitions of Energy

Crosscutting Concept: Energy and Matter

Science and Engineering Practices: Constructing Explanations and Designing Solutions

Constructing Explanations and Designing Solutions are important to this lesson because students will be identifying and using evidence as part of their two-day investigation. Students will study the relationship between energy and speed and in doing so will prepare to meet or exceed Performance Expectation **4-PS3-1** as part of Lesson 5. Throughout the investigation, students will be looking for evidence that supports an explanation that an object has more energy when it is moving at higher speed.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

motion

position

speed

variable

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue on the previous page.

Instructional Resources

Activity Pages



AP 4.1
AP 4.2

Activity Pages

Ramp It Up (Hands-on Investigation, Day 1) (AP 4.1)

Drop It (Hands-on Investigation, Day 2) (AP 4.2)

Make sufficient copies for your students prior to conducting the lesson. Read the instructional steps on the Activity Pages in advance to prepare to facilitate the student investigation.

Materials and Equipment

Collect or prepare the following items:

- books (to elevate ramps)
- cardboard (for ramp surfaces)
- 2 small, dense rubber balls of the same size and weight
- 2 paper cups
- pennies or pebbles for place markers
- shoeboxes (1 per group)
- play sand (about 5 pounds)
- index cards for student vocabulary deck (1 per student)

THE CORE LESSON TWO DAYS, 45 MIN EACH

1. Day 1: Focus student attention on the Big Question.

5 MIN

How are energy and speed related? Have students clap their hands together softly ten times. Then have them clap their hands hard ten times while asking themselves, “What is different when I clap my hands softly or hard?”

Ask students how they know energy was involved in clapping. (*Energy causes a change. The energy of motion (hands) caused a change from no sound to sound.*) Then ask students how they could tell if soft clapping or hard clapping involved more energy. (*Since the sound was louder with hard clapping, there was a greater change. So there must be more energy involved in hard clapping than in soft clapping.*)

2. Encourage student questions.

10 MIN

Have students consider questions about energy and speed. Prompt them to think about which has more energy of motion, a ball rolling fast or the same ball rolling slowly. Ask students to come up with three different investigations that could show if the speed of two identical objects affects the energy of motion of those two objects.

Preview Core Vocabulary Terms

Before students perform their investigations, write the term **speed** on the board or chart paper. Encourage students to pay special attention to this term as they discuss and investigate on Days 1 and 2.

3. Preview the investigation.

10 MIN

Activity Page

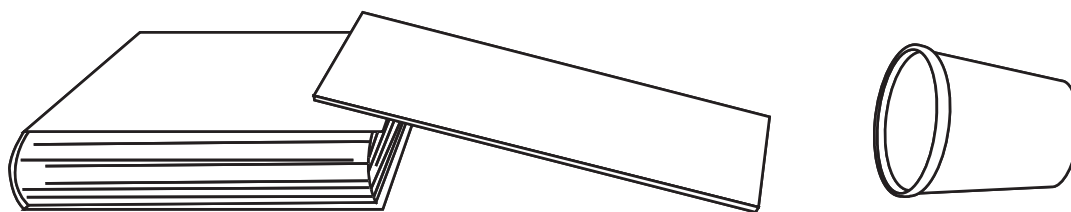


AP 4.1

Distribute the Ramp It Up (AP 4.1). Review the Activity Page with students. Tell students they will use a rubber ball to investigate how the speed of a ball is related to the amount of energy of a ball's motion. (See **Know the Standards** and **Know the Science 1**.) Students will investigate this concept by doing the following:

- conducting a demonstration
- recording observations
- making changes to the demonstration
- conducting the modified demonstration
- collecting and organizing evidence from multiple trials
- writing explanations

Model the ramp setup for students, and assign groups of students to adequate floor space on which to conduct their trials.



The height, and therefore the slope, of the ramp is the variable determined by students. The cup's position will change, too, as the dependent variable.

Know the Standards

In this lesson, students understand that speed corresponds to the energy of a moving object—specifically, more speed equals more energy **if** the mass of the ball remains the same. Students do not need to perform quantitative measures of changes in the speed of an object, so their investigations will be limited to observations of compared and contrasted incidents rather than measurements. Students will use their contrasting observations (qualitative indicators) as evidence that speed and energy are related to meet the Performance Expectation.

Know the Science

1. What is one factor that indicated the energy of the ball? *Speed is an indicator of energy.* This lesson focuses on speed as an indicator of energy. The faster a given object is moving, the more energy it possesses. Avoid introducing the misconception, though, that all objects moving at the same speed have the same amount of energy. They do not; a more massive object has greater energy than a less massive object moving at the same speed. However, students can make the desired, and accurate, connection about the direct relationship between speed and energy by varying the speed of a **single** object so that mass as a variable does not enter the discussion at this point.

4. Facilitate the investigation.

20 MIN

Divide students into two large groups. Provide each group with the following materials:

- 1 book
- 1 piece of cardboard
- 1 rubber ball
- 1 paper cup

As students work on their Day 1 demonstrations, circulate around the room to ensure groups are only using the materials provided. (See **Know the Science 2.**)

As students make their observations, ask them to think about things such as the speed of the ball and how far it pushes the cup away from the ramp.

SUPPORT—Clarify that speed and distance are not measured in precise units in this activity. Students will use phrases such as “farther than” and “away from” to describe the movement of the cup in relative terms between the trials.

Give students time to complete the investigation and record observations on their worksheets.

1. Day 2: Focus student attention on the Big Question.

5 MIN

Activity Page



AP 4.2

How are energy and speed related? Distribute Drop It (AP 4.2), and go over it with students. Explain that they will continue their investigation by modifying the demonstrations they performed and making additional observations. In this variation, students will drop the same ball twice from different heights.

Know the Science

2. What are variables? *Factors that can be changed during an experiment.* When scientists conduct investigations, they control and change independent variables to see how the results change. For example, when conducting a test to see how speed affects the motion energy an object has, a scientist will change the speed of the object. In this case, the speed is the independent variable. Sometimes scientists may change the weight or mass of the object. Changing independent variables can help scientists better understand how an object’s state or properties contribute to its motion energy. In this investigation, students should change the height of the ramp and the height from which the ball is dropped as a means to produce greater speed. But the object set into motion, the ball, should remain the same in each trial.

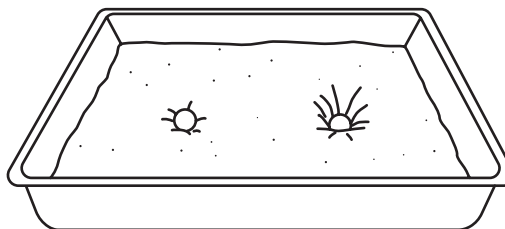
2. Support the investigation.

10 MIN

Have students convene into their same groups from the previous day. Provide each group with the following materials:

- 1 rubber ball
- 1 box of sand

Within the groups, each student will use the box of sand and ball to complete their own demonstrations. Students will take turns dropping the ball from various heights into the box of sand and recording their detailed observations. Then, they will compare their observations with those of their peers and draw conclusions.



Students control the variable of the height from which the balls are dropped and therefore the speed at which the balls are travelling at impact. The size of the crater is the dependent variable.

As students work on their Day 2 demonstrations, circulate around the room to ensure students are appropriately taking turns with the materials within their groups.

SUPPORT—As students make their observations, ask them to think about how the height from which the ball is dropped affects its speed and how the ball's speed relates to its energy.

3. Summarize and discuss.

10 MIN

Once students have had time to conduct their investigations and complete their Activity Page, bring the class back together, and hold a whole-class discussion to summarize what students discovered. Students should be able to explain their observations and support them with evidence.

Ask if the ball had energy of motion during both drops. (yes)

- » How do you know it had energy of motion? (*It caused a change when it hit the sand from either height.*)
- » Which time was the ball moving faster when it hit the sand? (*when it was held higher*)
- » Which time did the ball have more energy of motion when it hit the sand? (*when it was held higher*)
- » What evidence is there to indicate that the ball with more speed had more motion energy? (*The sand moved more when the ball with more speed landed.*)

Elicit from students that speed and energy are related.

Ask if students have any questions about the demonstrations, and address any misunderstandings.

4. Teach Core Vocabulary.

10 MIN

Prepare Core Vocabulary Card

Direct student attention to the Core Vocabulary word **speed** (displayed on the board or chart paper from the previous day). Have students write the term in the upper left corner of an index card and underline it.

Word Work

speed: (n. a measurement of the distance an object travels over an amount of time) Ask students to recall the definition of *speed*: a measurement of the distance an object travels in an amount of time. Have students write a sentence using the word *speed*. (*In a race, a runner beats a turtle because the runner's speed is faster.*) When they have finished, ask volunteers to share their sentences with the class. Have students draw an example of what speed looks like.

SUPPORT—Draw students' attention to the clarification that *speed* doesn't always mean "fast." Provide additional examples that demonstrate how scientists and engineers use the term *speed* to measure exactly how fast or slowly an object is moving. For example, a car can be moving slowly at a speed of five miles per hour (mph) or quickly at a speed of fifty-five mph.

Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

5. Check for understanding.

10 MIN

Formative Assessment Opportunity

As students finish the Core Vocabulary task, collect their completed hands-on Activity Pages: Ramp It Up (AP 4.1) and Drop It (AP 4.2). Scan the evidence that students collected through their observations, and review the answers to the questions.

- Day 1: Students should describe that there was a difference in the speed of the ball depending on the variable: if the height of the ramp was higher (more speed) or lower (less speed) than in the first demonstration. To meet the Performance Expectation, students should describe that when the ball had a greater speed it had more energy and make the connection, using evidence, that a faster-moving ball caused a greater change (moved the cup farther).
- Day 2: Students should record that the greater the height from which the ball was dropped, the more the ball disrupted the surface of the sand. Their conclusions should relate the height of the ball's release to greater speed during the ball's descent and subsequently to greater energy of motion.

See the Activity Page Answer Key for correct answers and sample student responses.

Activity Pages



AP 4.1

AP 4.2

Answer Key

LESSON 5

Energy and Speed Are Related

Big Question: How are energy and speed related?

AT A GLANCE

Learning Objective

- ✓ Use evidence to explain the relationship between the energy of a moving object and its speed.

Lesson Activities

- student observation and discussion
- reading
- teacher demonstration
- vocabulary instruction

NGSS References

Performance Expectation 4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object.

Disciplinary Core Idea PS3.A: Definitions of Energy

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Constructing Explanations and Designing Solutions in Grades 3–5 builds on Grades K–2 experiences and progresses to the use of evidence (e.g., measurements, observations, and patterns). Student explanations should specify variables that describe and predict phenomena. During engineering tasks, students should design multiple solutions to design problems.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

energy of motion evidence **speed**

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader



Ch. 3

Student Reader, Chapter 3
“Energy and Speed Are Related”

Materials and Equipment

Collect or prepare the following:

- books (to elevate a ramp)
- cardboard (for a ramp surface)
- rubber ball
- a few lightweight blocks
- index cards for student vocabulary deck (1 per student)

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

5 MIN

How are energy and speed related? Remind students that in the previous lesson, they conducted an investigation to explore how energy is related to speed. To begin this lesson, ask students to describe the differences between the following experiences. Specifically, have them describe how speed affects the amount of motion energy in each example:

- a ball thrown slowly and the same one thrown faster (*A ball moving slowly has less motion energy than a ball moving fast.*)
- a tennis ball bounced hard against the ground and the same one bounced more slowly/gently (*The ball bounced hard has more motion energy than the one bounced gently.*)
- a slow, gentle breeze and a strong, fast wind (*A slow, gentle breeze has less motion energy than a strong, fast wind.*)

Now ask students how they can tell, in each case, that the object with more speed has more energy than the same object moving at a slower speed.

2. Encourage student questions.

5 MIN

Invite students to pose questions about energy and speed. Record selected questions on the board or chart paper to revisit after the reading.

SUPPORT—Model a student question. (*Why is going fast in a car or on a bike more dangerous than going slowly?*)

3. Read and discuss: “Energy and Speed Are Related.”

20 MIN

Student Reader



Ch. 3

Read together, or have students read independently, “Energy and Speed Are Related,” Chapter 3 in the Student Reader. This chapter reinforces what students have observed in their investigations during the previous lesson, that the faster an object moves, the more energy it has—provided it is the same object. The examples in the selection also model for students how evidence of greater or lesser motion energy can be inferred by the changes caused (energy causes change).

Preview Core Vocabulary Terms

Before reading, write the following terms on the board or chart paper. Have students identify the words as they read. Stop and discuss the meaning of each term in context.

energy of motion **speed**

Guided Reading Support

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Page 13

After reading, ask: What is speed? (*the distance something moves in an amount of time*) How can you describe the speed of objects? (*fast, slow*)

Pages 14–16

Prepare students with a few givens, ideas that can be considered fact, from which to construct their comparisons and build understanding. (See **Know the Standards**, **Know the Science 1** below.)

Page 14: Given—objects that are thrown (or bounced) harder have greater speed. You may not be able to directly/effectively observe and compare speed, but you **can** compare the changes the object causes when it moves at different speeds.

Page 15: Given—objects that roll down steeper ramps have greater speed than those that roll down less steep ramps. You may not be able to directly/effectively observe and compare speed, but you **can** more directly/effectively observe changes the object causes when it moves at different speeds from different slopes.

Page 16: Given—objects such as rubber balls that bounce higher have greater energy of motion. You may not be able to measure the speed of a ball before or after its bounce, but you can readily observe how high it bounces, an indication of the change the object causes when it is moving at different speeds toward its impact with the ground.

SUPPORT—Ask: What other examples do you know that can show the relationship between energy and speed? (*A strong rainstorm drops more rain in a short time than a gentle rain. Riding a bicycle up a long, steep hill takes more time than riding downhill.*) What kinds of changes do your examples cause? (*A strong, fast rain makes more water overflow than a gentle rain. Pedaling a bicycle uphill takes more energy and time than coasting downhill.*)

Know the Standards

How will students compare the speed of objects? The assessment boundary for 4-PS3-1 clarifies that students at this level are not required to quantitatively measure speed or energy. They need only explain the direct relationship between speed and energy, noting that when one is greater, by definition then so is the other. To do this, though, students need observable characteristics to compare when differences in the speed of objects they observe are not really visibly discernable.

Know the Science

1. Energy relates to both speed and mass. The energy of motion of any object is related to **both** its speed and mass. NGSS, and this lesson, do **not** include the role of mass at the 3–5 grade level. A baseball moving at 100 mph and a train moving at 100 mph do not have the same energy of motion. The speed is the same, but the train has greater mass and, correspondingly, greater energy. So be sure when discussing speed and motion energy that you make comparisons only between the same object moving at different speeds. In every example you deal with, vary only the speed, but keep the object you are talking about the same.

4. Demonstrate examples and guide discussion.

5 MIN

In a quick demonstration, repeat rolling the ball down the ramp as students did in their investigation during the prior lesson. This time place a small stack of blocks in the path of the ball. Guide students to observe the difference in the changes to the blocks when the ball rolls at different speeds. Change the slope of the ramp, and repeat the demonstration, prompting students to describe the differences they can observe. Help students to understand that, by comparing the changes, they can compare the motion energy of the ball in different trials.

- Ask students if they see a pattern in the results of your demonstration and their prior investigation. (*When the height of the ramp is raised, the speed of the ball at the bottom of the ramp is greater.*) See **Know the Science 2** below.
- Ask guiding questions to help students link the details in this demonstration back to their own investigations and the reading selection (Chapter 3). For example, ask the following:
 - » How were the results of today's demonstration *similar* to the results of your investigation in the last lesson? (*The investigations and demonstration showed that movements from greater heights have greater motion energy.*)
 - » How were the results *different*? (*Different materials and different motion energies were used, so some objects were moved more or less than others.*)
 - » What happened to the motion energy of the ball when it hit the blocks? (*The ball slowed down.*)
 - » Why did the ball slow down when the blocks started to move? (*Bumping into the blocks decreased the ball's motion energy.*)

Know the Science

2. Why did the obstacle move the distance it did each time? *Speed*. The faster an object is moving, the more energy it has. As a result, it will be able to transfer more energy to any obstacle it contacts. The higher the ramp is raised, the faster the ball will roll and the farther it will move the blocks. Because it is rolling faster, it has more energy of motion. When an obstacle is placed in its path, it will collide with that object and transfer energy into it. The faster it's rolling, the more energy it contains to transfer, resulting in the obstacle moving farther than if the ball were moving more slowly. Though students will investigate collisions more closely later in the unit, the outcomes of these collisions are what students can observe as evidence.

5. Teach Core Vocabulary.

5 MIN

Return to Core Vocabulary Cards

- Have students locate their card for the term **energy of motion**.
- Ask students to write a one-sentence explanation, using evidence, describing why we know that an object in motion has energy. (*It can cause a change.*)
SUPPORT—Remind students that the many examples they have read, watched, and discussed can serve as evidence, or proof, that their explanations are correct.
- When they have finished, have students share their explanations and evidence with the class.
- Ask students to draw an example of what they have written in their sentences.
- Have students safely store their vocabulary cards in alphabetical order. They will add more Core Vocabulary to the deck in later lessons.
- Reinforce, through discussion and additional context for vocabulary, that the greater an object's speed, the more energy that object has. Refer to the ball and blocks examples as evidence. Ask: How does motion energy relate to speed? (*The greater the speed, the greater energy of motion the object will have, provided it is the same object in each case.*)

6. Check for understanding.

5 MIN

Formative Assessment Opportunity

Review student questions recorded at the beginning of the lesson, and discuss any that remain unanswered.

If time allows, prompt students to look back at their responses to Activity Page 4.2 from Lesson 4. Have students consider any additions or revisions to their last response, their description of the relationship between energy and speed, based on new learning from today's lesson.

PART C

Energy Transfer

OVERVIEW

Lesson	Big Question	Advance Preparation
6. Sound Transfers Energy	What evidence shows that sound transfers energy from one place to another?	Gather materials for 2–3 groups to conduct the investigation. (See Materials and Equipment, page 12.)
7. Energy Transfer	What evidence shows that energy transfers from place to place?	Read Student Reader, Chapter 4.
8. Investigating Energy Transfer	What evidence shows that light, heat, and electricity transfer energy from place to place?	Gather materials for group investigations to occur in 3 stations. (See Materials and Equipment, page 13.)
9. Evidence of Energy Transfer	What evidence shows that energy is transferred from place to place?	Scan student work on Activity Page 8.1 from Lesson 8. Prepare to support students as they write summaries and make claims about their observations.

Part C: What's the Story?

Energy causes change when it moves from place to place or from object to object. Although students know this intuitively, it is often hard for them to understand the concept of energy transfer. To make the concept more concrete, this series of lessons leads students through observations, investigations, and discussions that explore the transfer of energy by sound, light, heat, and electricity.

Lesson 6 incorporates an activity through which students can observe sound energy causing a change over a distance. They also explore other examples of how sound energy is transferred from place to place and then apply the concept to recognize more examples in their everyday lives.

Lesson 7 extends the concept of energy transfer to light, heat, and electricity through examples in a reading selection. Students explore and discuss evidence that different forms of energy can move from place to place.

In Lesson 8, students investigate three stations involving light, heat, and electrical energy transfer. This lesson provides hands-on experience with different types of energy transfer. Activity Pages for each station prompt students to make observations about each type of transfer and to discuss the changes that take place when energy moves from place to place.

In Lesson 9, students will summarize their observations and generate more examples of energy transfer. By making and supporting claims after their experiences in Lessons 6–8, they will satisfy the NGSS Performance Expectation 4-PS3-2 by providing evidence that energy can be transferred from place to place by sound, light, heat, and electricity.

LESSON 6

Sound Transfers Energy

Big Question: What evidence shows that sound transfers energy from one place to another?

AT A GLANCE

Learning Objective

- ✓ Explain that sound energy is transferred from place to place.

Lesson Activities

- student activity and discussion
- vocabulary instruction
- optional video demonstrations

NGSS References

Performance Expectation 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Disciplinary Core Idea PS3.A: Definitions of Energy
Science and Engineering Practices: Constructing Explanations and Designing Solutions

Crosscutting Concept: Energy and Matter

This Crosscutting Concept is important to this lesson because sound and the evidence of changes it causes are clear examples that energy can be transferred from one place to another.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

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energy transfer **sound** transfer

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue on the previous page.

Instructional Resources

Activity Page



AP 6.1

Activity Page

Lesson 6 Check (AP 6.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following:

- sticky note paper (approximately 3 inches square, 1 piece per student)
- plastic cups (1 per student)
- internet access and the means to project images/video for whole-class viewing
- index cards for student vocabulary deck (2 per student)

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

10 MIN

What evidence shows that sound transfers energy from one place to another?

Write the big question on the board or chart paper.

- Circle the word *energy*, and ask students to recall the meaning. (*the ability to cause a change*)
- Circle the word *sound*, and remind students that sound is one form of energy they were introduced to when they read Chapter 1. Have students identify forms of sound, such as music, humming, talking, and the effects of objects clanking together.
- Circle the word *transfer*, and ask students what they believe that word means based on what they can tell from the sentence; “from one place to another” provides the context clue. Use this term to explain that sound can travel through a distance, and segue into the clarification that *distance* means space between two things.
- Circle the word *evidence*, and ask students to explain in their own words what they think evidence is. (*details that provide clues or proof in support or refutation of an idea*) Let students know that they will do an activity to help them notice evidence and answer the Big Question.

2. Encourage discussion.

5 MIN

Discuss the prefix *trans-* with students. Explain that the prefix means across, beyond, or through. When using this prefix, it changes the meaning of a root word to express movement from place to place. As a whole class, brainstorm three to five words that have the prefix *trans-*. (*transfer, transmit, transportation*)

Underline the circled words *sound* and *transfer* in the Big Question on the board or chart paper. Point out that students will complete Core Vocabulary cards for the terms *sound* and *energy transfer* by the end of today's lesson.

Preview Core Vocabulary

Before the demonstration, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they watch and discuss the demonstration:

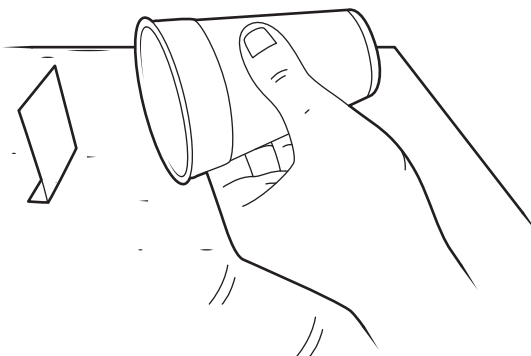
energy transfer **sound**

3. Facilitate the investigation.

10 MIN

Before supplying materials, demonstrate the setup that each student will implement. Emphasize that it is important for students to pay close attention to the procedure so they will be able to see the evidence.

- Fold the sticky note into an L-shape so that the adhesive strip sticks to the surface of the desktop. The remainder of the sheet stands perpendicular to the desktop so the desktop and the upright sheet form a right angle.
- Demonstrate holding the cup with the open end a few inches from the upright note. Point out that the cup should not touch the paper.



Stress that students' bodies should not bump the desks in any way and that they must be quiet and move as little as possible during the investigation. Big body movements will produce small breezes in the room that may cause the note papers to flutter, which will interfere with students' ability to observe the cause-and-effect relationship specifically between sound from the cup and motion of the paper.

Distribute materials. Coach students through tapping the bottom of the cup with a pencil, with the open end of the cup aimed at, but not touching, the sticky note.

SUPPORT—As needed, help students as they identify the changes they observe during the demonstration. Consider other examples of cause-and-effect relationships that students may already know that can help them to explain their understanding of what is happening and why.

Use guiding questions to help students interpret their observations as evidence. (See **Know the Science** for support with the analysis.)

- » Identify a cause and an effect in the demonstration you just performed.
(*A tap on the bottom of the cup caused the paper to move slightly.*)
- » How is this an example of energy causing a change? (*The sound waves from tapping the cup pushed air from the cup to the sticky note.*)
- » What evidence was there that sound transferred energy from place to place?
(*The sticky note was not touched, but it moved.*)

4. Teach Core Vocabulary.

5 MIN

Prepare Core Vocabulary Cards

Have students begin preparing cards for their Core Vocabulary decks for the terms you emphasized on the board or chart paper. Instruct students to write each term in the upper left corner of a card and underline it (one term per card), reserving space on the card for notes.

energy transfer **sound**

Word Work

- **energy transfer:** (n. movement of energy from one object to another or one place to another)
- **sound:** (n. a form of energy that comes from a vibrating object)

Examples of sound energy involve sound waves through air, water, wood, metal, and other mediums. Tell students to work in groups to describe two ways that sound is a form of energy transfer. (*When a guitar string is plucked, the potential energy changes to sound waves, which vibrate to make the sound of a note. When a ship sounds an underwater alarm, the sound wave vibrations cause ripples in the water.*)

Clarify that sound, the energy example students are exploring today, is just one type of energy transfer. They should reserve space on the card to add additional examples in future lessons.

Know the Science

What goes on with the cup drum? Vibrations. Sound travels out from a vibrating source in all directions. The shape of the cup and its proximity to the paper will focus the disruption of air by the vibration so that that air disruption (a sound wave) visibly pushes on the paper.

Students will learn more specifically about sound as mechanical (compression) waves and vibration in another unit. For now, the emphasis is on one form of energy, sound, transferring from place to place and evidence of that phenomenon.

5. Demonstrate more examples and guide discussion.

10 MIN

Remind students that they have seen a demonstration in an earlier lesson similar to the one they performed in this lesson. Invite students to recall the introductory demonstration of vibrating salt on a drum made from a cup covered with a balloon. (You may choose to repeat that demonstration here for reinforcement.)

Online Resources



Use this link to download the CKSci Online Resources Guide for this unit, where specific links to video clips that provide examples of energy transfer via sound may be found:

www.coreknowledge.org/cksci-online-resources

Show students clips of more examples of sound causing change across a distance (energy transfer). Keep in mind that the underlying explanations for the following phenomena are beyond grade level, but they provide students with glimpses of additional examples of energy transfer via sound:

- vocal sounds through a tube causing visible motion of a laser light
- specific frequencies of sound from a speaker disrupting a stream of water from a hose
- “singing” test tubes
- breaking a glass with sound
- acoustic propulsion

If you have time and access to the equipment and materials, you may choose to perform one or more of these demonstrations live in your classroom.

6. Check for understanding.

5 MIN

Formative Assessment Opportunity

Review student questions, and identify any that remain unanswered.

Activity Page



AP 6.1 and
Answer Key

Distribute and ask students to complete Lesson 6 Check (AP 6.1). Collect the assessment, and check students’ answers before the next lesson to identify concepts with which students are still struggling. Incorporate adjustments as you open Lesson 7. See the Activity Page Answer Key for correct answers and sample student responses.

LESSON 7

Energy Transfer

Big Question: What evidence shows that energy transfers from place to place?

AT A GLANCE

Learning Objective

- ✓ Describe evidence that light, heat, and electricity transfer energy from place to place.

Lesson Activities

- reading
- discussion
- teacher demonstration
- vocabulary instruction

NGSS References

Performance Expectation 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Disciplinary Core Idea PS3.A: Definitions of Energy
Science and Engineering Practice: Planning and Carrying Out Investigations

Planning and Carrying Out Investigations in Grades 3–5 builds on Grades K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

cause and effect
change

energy transfer
evidence

forms of energy

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue on the previous page.

Instructional Resources

Student Reader



Ch. 4

Activity Page



AP 7.1

Student Reader, Chapter 4 “Energy Transfer”

Activity Page

Lesson 7 Check (AP 7.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- index cards for student vocabulary deck (2 per student)
- flashlight
- hot plate
- spiral-cut paper plate on a string
- internet access and the means to project images/video for whole-class viewing (electricity generation)

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

10 MIN

What evidence shows that energy transfers from place to place? Remind students that in the previous lesson they observed the transfer of sound energy from a vibrating source, through the air, causing a piece of paper to move. The motion of the paper is a kind of change, which is evidence of the effect of energy.

- Explain that in this lesson, students will be looking at the ways in which energy transfers (moves) from one place to another in the form of light, heat, and electricity. They will identify evidence of energy transfer by observing that a change occurs.
- Encourage students to ask questions and to answer others’ questions. Try to get students to start using evidence statements and making claims when discussing the topic of energy transfer so they can become familiar with how to support their discussions with facts or observations. For example, if a student makes a claim that sound energy can cause motion, ask the student, “How do you know that sound energy resulted in motion? What evidence do you have?” (*I blew a horn toward a window, and the window rattled.*)
- When discussing energy transfer, you may need to help students differentiate energy transformation from energy transfer. The lesson focuses on energy transfer, not transformation. (See **Know the Standards 1.**)

Know the Standards

1. What is the difference between energy transfer and energy transformation? The NGSS standards emphasize the distinction between transfer and transformation. Transfer of energy is energy moving from place to place or from object to object. Transformation of energy is when energy changes from one form to another.

2. Read and discuss: “Energy Transfer.”

15 MIN

Student Reader



Ch. 4

Read together, or have students read independently, “Energy Transfer,” Chapter 4 in the Student Reader. The selection describes ways that energy is transferred from one object to another or moves from place to place. It offers examples and evidence that heat, light, and electricity are all forms of energy and that each transfers energy from place to place.

Preview Core Vocabulary

Before reading, write the Core Vocabulary word **energy transfer** on the board or chart paper. Have students look for the term as they read.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Page 17

- What is energy transfer? (*movement of energy from one object to another*)
What is evidence of energy transfer? (*a push that makes something move*)

Ask students to recall the word *evidence* (first introduced in Lesson 5). Explain to students that evidence is not a science-specific word. It is a word that is used in all areas and in our everyday conversations. However, it is a word that frequently comes up in science. Then, prompt students to consider these guiding questions, one at a time:

- What do you think *evidence* means?
- What are some examples of evidence?
- Why do you think evidence is important in science?
- How do you think scientists use evidence?

Pages 18–21

- What does it mean for objects to be “in contact” or to “make contact?” (*to touch or collide*)
- What evidence shows that energy has transferred? (*Examples of energy transfer can be seen when a ball moves from a kick, a light comes on from a flashlight, a sound is heard from an explosion, and a cup gets hot when hot soup is poured into it.*)

SUPPORT—If needed, prompt students to identify the evidence of change in each Student Reader example.

- What changes when energy transfers? (*The object that is touched moves or changes position.*)

- What different forms of energy are in the hydroelectric power plant?
(*the flow of water, a downhill movement, a push on the turbine blades, a transfer of energy to the generator, and electrical energy to the power plant*)
- What evidence shows that energy was transferred in this example?
(*Electricity goes through power lines to provide light and power from place to place.*)

3. Demonstrate examples and guide discussion.

10 MIN

Choose one of the following, or a similar example, to stimulate further discussion. (If time permits, use all three.) Analyze the evidence that energy transfer is involved in the changes that occur.

Option 1: Turn the lights off in the classroom, and shine a flashlight onto the wall. Then turn the flashlight off. Turn it on and off a couple more times to demonstrate how light energy transfers from the bulb, the light source, to the wall and then to students' eyes.

- » Is light a way in which energy is transferred? (*yes*) How do you know?
(*The light goes from the flashlight to the wall and to our eyes.*)
- » How do you know energy is involved? (*Something has to give power to the flashlight—the batteries.*)

Option 2: Use a hot plate and a spiral cutout of a paper plate hanging on a string. Demonstrate that the source of heat transfers energy to the air, which causes the air to move and then causes the plate to spin.

- » Why does the plate spin? (See below, **Know the Science**, for support.)
- » How do you know energy is involved? (See below, **Know the Standards 2.**)

Know the Science

Why does the plate spin? Energy transfers over a distance. In the previous lesson, students saw a demonstration in which sound moved a piece of paper that was not touching the sound source. Energy can move from place to place when two objects are not touching. In this case, heat causes air to heat up and move, and the motion energy of the air causes the plate to spin.

Know the Standards

2. A full explanation of heat transfer, specifically conduction, through the air is not a target for Grade 4 students. If you are interested in learning more about how/why the plate spins in this demonstration, please see the links in the Online Resources Guide for this unit.



Option 3: Show a video of how electricity is generated. (See the Online Resources for a link to a suggested video, at www.coreknowledge.org/cksci-online-resources.) Ask how electricity transfers energy.

- » What observations can you make as evidence that electricity transfers energy? (*Electricity allows lights, appliances, and machines to work when they are turned on.*)
- » How do you know energy is involved? (*When something moves or makes a machine come on, there is always a source of that energy.*)
- Use additional guiding questions to help students link details in this analysis discussion back to the reading selection.
 - » Did you read about any of these examples in the chapter?
 - » What are some other examples of energy transfer that happen every day? (*Electricity or a battery makes a computer come on. A person's physical energy makes a bicycle move.*)
- Challenge students to brainstorm ways they could use their knowledge that energy moves from place to place to create new devices or machines.

4. Revisit Core Vocabulary.

5 MIN

Return to Core Vocabulary Cards

- Have students sort through their vocabulary decks and find all the cards with words related to Chapter 4 of the Student Reader and this lesson's demonstrations. Students should select the cards for these terms:

**energy
change**

**motion
energy of motion**

energy transfer

They may identify others, as well.

- Record the list of the words on the board or chart paper, and have volunteers explain how each term relates to the lesson. Prompt students to add notes to each card that is discussed, extending their previous definitions with more examples.

5. Check for understanding.

5 MIN

Formative Assessment Opportunity

Review student questions, and identify any that remain unanswered.

Have students complete Lesson 7 Check (AP 7.1). Collect the assessment, and before progressing to Lesson 8, check students' answers to identify students who need more support and concepts that need clarification. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson.



LESSON 8

Investigating Energy Transfer

Big Question: What evidence shows that light, heat, and electricity transfer energy from place to place?

AT A GLANCE

Learning Objective

- ✓ Conduct an investigation to provide evidence that energy is transferred from place to place.

Lesson Activities

- teacher demonstration
- student investigation
- student observation
- writing

NGSS References

Performance Expectation 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Disciplinary Core Idea PS3.A: Definitions of Energy
Science and Engineering Practice: Planning and Carrying Out Investigations

Planning and Carrying Out Investigations to answer questions or test solutions to problems in Grades 3–5 builds on Grades K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. No new Core Vocabulary terms are introduced during this lesson.

electricity

heat

light

Instructional Resources

Activity Page



AP 8.1

Activity Page

Investigating Energy Transfer (AP 8.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- flashlight
- paintbrush (2–4 inches wide)
- chalk powder (finely crushed chalk)
- plate
- hot plate
- beaker
- ice cubes
- ice chest or ice box
- plastic bucket
- tongs
- tablet or cell phone (with low battery charge and a visible “charging” icon)
- tablet or cell phone charging cord
- surge protector with off/on switch

Learning Centers

Set up each learning station as detailed below. (See below, **Know the Science**, for support.)

Note: Teacher supervision of all stations, especially Station 2 and Station 3, is required for student safety.

Station 1

Students will use chalk dust to observe a beam of light from a flashlight, providing evidence of light transferring from a source (a flashlight) to another place/object (the wall). In a dark corner of the classroom, in front of a wall, prepare chalk powder by placing it onto a plate. Set a large paintbrush, 2–4 inches wide, and flashlight beside the plate.

Station 2

Students will melt ice cubes over heat, observing evidence that heat transfers energy from a heat source to another place/object (ice, which melts into liquid water). Set up the hot plate so it is on a low heat, heating a beaker to which students will add ice. Have the ice cubes available in the ice chest/ice box. Place the tongs on the table for students to use.

Station 3

Students will connect and disconnect a charging cord and turn a surge protector on and off to note that an electronic device plugged into a wall outlet begins to indicate a charging battery. Place tablet, cell phone, or other rechargeable device on a table. Plug the device’s charging cord into a surge protector, with the surge protector plugged into the wall.

Know the Science

How are energy transfers and changes to matter related? At Station 1, chemical energy in the batteries in the flashlight is changed into electricity. This electrical energy is then transferred to the filament in the bulb, where it changes into light energy. At Station 2, the heat energy from the hot plate transfers to the beaker. The ice cube makes contact with the beaker, and the heat energy starts to transfer to the ice cube, causing it to change from a solid to a liquid. At Station 3, electrical energy from the outlet is transferred to the charger, through the charging cord, and into the electronic device.

1. Focus student attention on the Big Question.

10 MIN

What evidence shows that light, heat, and electricity transfer energy from place to place? Show students the location of each learning station in the classroom. Go over the instructions for each of the three centers for student investigations.

- Emphasize proper safety protocols for students near the hot plate and electrical outlets. Students will not handle the hot plate at Station 2 nor plug the power cord into the electrical socket at Station 3.
- Explain the goal at each station—to look for evidence of an energy transfer. Preview how each station ties back to the Big Question and the concept of energy transferring from place to place.

2. Preview the investigation.

5 MIN

Activity Page



AP 8.1

Distribute Investigating Energy Transfer (AP 8.1) to students. Describe how they should use and fill out the observation record for each station. Explain that the pages are divided according to station and that, at each station, they should 1) record their observations and 2) answer the questions about what they have observed at the station.

- Read through the steps with students.
- Referring to the Activity Pages, show students where they should record their observations for each station. Discuss types of observations that students should make, including changes, causes and effects, and patterns.
- Draw attention to the questions that students should answer following the recording tables.

Notes About Safety

Instruct students not to remove the beaker from the hot plate themselves. The teacher or other adult aide should supervise this station and handle the beaker and hot plate for students.

Instruct students not to touch the surge protector or wall socket. They should only handle the electronic device and the end of the charging cord that plugs into the device.

Establish a Scientific Mindset

Discuss with students the importance of group roles in the different stations. Make sure that each student has a chance to participate in each station, as well as a chance to be the recorder or observer. Students can assign roles on their teams, or you can assign rotating roles for each as they arrive at each of the three stations. Explain that sometimes students might want to repeat an investigation to answer a question. Tell them that this is okay, as long as there is time to do so.

3. Facilitate the investigation.

25 MIN

- Place students into three groups, and have each group start at a different station. Tell students that they will have about five minutes to work at each station. When they hear your cue, it is time to clean up their station and rotate to the next one.
- Emphasize to students that they are applying the information they learned in the previous lessons on various forms of energy transfer through these hands-on investigations.
- Remind students of lab safety practices.
- Prompt students to relate the hands-on activities to their own experiences. For example, you might ask:
 - » How many of you charge a computer, a phone, or another electrical appliance when you are at home?
 - » How many of you have ever touched a cup or plate that was hot and it made you pull your hand away?

SUPPORT—If needed, ask the following questions to help students identify evidence that energy is transferred:

Station 1—What changed when the flashlight was turned on?
(*The light came on.*)

Station 2—How did the ice cube change? (*It melted.*) What event could have caused that change? (*heating it up*)

Station 3—What changes did you see when the surge protector was turned on? (*When it was off, the stored energy did not transfer. When it was turned on, the electrical energy flowed to the objects plugged in.*)

4. Check for understanding.

5 MIN

Formative Assessment Opportunity

Activity Page



AP 8.1 and
Answer Key

Once students have completed all of the investigations, have them return to their desks and complete any remaining parts of the Activity Page.

Circulate around the room, and review the types of answers students are writing. Provide assistance by helping students remember or recall what they did at the various stations, but without giving them correct answers. For example:

- » At the station with the hot plate, were you seeing how heat transfers to colder objects or how cold transfers to warmer objects?
- » When you were working with the surge protector, what did you notice was happening to the electricity?

SUPPORT—If needed, ask students to return to the Student Reader, Chapter 4, to support their answers with additional examples and appropriate use of Core Vocabulary.

LESSON 9

Evidence of Energy Transfer

Big Question: What evidence shows that energy is transferred from place to place?

AT A GLANCE

Learning Objective

- ✓ Organize evidence to support a claim about energy transfer.

Lesson Activities

- student observation and discussion
- writing

NGSS References

Performance Expectation 4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.

Disciplinary Core Idea PS3.A: Definitions of Energy
Science and Engineering Practice: Planning and Carrying Out Investigations

Planning and Carrying Out Investigations in Grades 3–5 builds on Grades K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

change

claim

electricity

energy

energy transfer

evidence

heat

light

observation

reasoning

sound

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue on the previous page.

Instructional Resources

Activity Pages



AP 9.1
AP 9.2

Activity Pages

Examples of Energy Transfer (AP 9.1)

Claims, Evidence, and Reasoning About Energy Transfer (AP 9.2)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- internet access and the means to project images for whole-class viewing

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

5 MIN

What evidence shows that energy is transferred from place to place? Open with a whole-class discussion about the investigations from the previous lesson. Ask students to discuss the evidence they gathered at each station that demonstrated energy transfer from place to place. Encourage students to ask questions and answer others' questions.

SUPPORT—Prompt students to identify where the energy originated at each station. How was the energy transferred? What changes did the energy cause? Continue to support students as they identify evidence of changes seen at each station and determine how these observations can be used to support their claims about light, heat, and electricity.

- Write the words *claim*, *evidence*, and *reasoning* on the board or chart paper. Tell students that a *claim* is a statement that answers a question or proposes a solution to a problem. Ask two to three students to provide examples of claims. (Explain that you can make a claim about why something happens, such as why a light bulb is no longer working when it worked fine yesterday.) Claims in science are supported by *evidence*, which scientists and engineers also call data. Prompt students to recall examples of evidence and data they have learned about so far. (Remind them that when an object changes, this is evidence that energy is causing that change.)

Tell students that scientists and engineers use a process called *reasoning* to connect their claims and evidence. For example, a person using their scientific mindset may use the reasoning that the light bulb no longer works today because he or she observed that the small filament inside the bulb was broken. Prompt students to keep this reasoning process in mind across this lesson, as they will practice making claims, identifying supporting evidence, and crafting reasoning statements on Claims, Evidence, and Reasoning About Energy Transfer (AP 9.2) at the end of the lesson.



- Ask students to review “Energy Transfer,” Chapter 4, in the Student Reader. Review compelling examples of energy transfer, including electrical, heat, and light energy from the previous lessons in this unit. For example:
 - A hydroelectric power plant offers an example of various forms of energy transferring from object to object or place to place.
 - Hot tea offers an example of heat energy transfer moving from the tea to the cup and spoon.
 - Shining a light on a wall through chalk dust shows light energy transferring from place to place.

SUPPORT—If needed, prompt students to identify the evidence of change in each Student Reader example.

2. Demonstrate examples and guide discussion.

5 MIN



Provide additional examples of sound, light, heat, and electricity energy transfer.

Use this link to download the CKSci Online Resources Guide for this unit, where specific links to the images may be found:

www.coreknowledge.org/cksci-online-resources

Use one (or, if time permits, both) of the following:

Option 1: Display an image of a toaster to support discussion about transfer of electricity and heat.

Option 2: Display an image or video of distant fireworks to support discussion about transfer of light and sound energy.

SUPPORT—If needed, prompt students using the guiding questions to help students think about the examples being discussed:

- » What are the forms of energy in these examples? (*electrical, heat, sound, chemical*)
- » What are the sources of energy in these examples? (*electricity, fire*)
- » How are these examples similar to what you observed during the previous lesson’s investigations? (*Every transfer of energy has a source and an outcome.*)
- » What evidence do these examples provide that energy moves from place to place? (*A toaster works because it uses electricity. Fireworks make big sounds when they are ignited.*)

3. Encourage discussion.

10 MIN



Ask students to complete the table found on Examples of Energy Transfer (AP 9.1). Model for students how to complete the table, asking volunteers to recall their learning from Lesson 7 and their investigations of sound. Encourage them to think of examples that have not already been discussed in class or in the Student Reader.

SUPPORT—If students cannot think of examples of energy transfer that they see every day, have them come up with an example of how they would model energy transfer to a friend.

4. Use continuous Core Vocabulary instruction.

10 MIN

As students complete Activity Page 9.1, remind them to use the Core Vocabulary terms learned throughout this unit:

energy transfer
electricity

heat
sound

light

This is also a good time to review other key terms, including the following:

claim

evidence

5. Demonstrate examples and guide discussion.

5 MIN

Model for students how to make a scientific claim about energy. Identify the parts that a claim must have, including an “I know . . .” statement and evidence that supports the claim. Explain to students that many claims have the word *because* in them. For example:

“I know heat energy moved from the soup to the bowl *because* the bowl started out at room temperature but later felt hot when I touched it.”

Distribute Claims, Evidence, and Reasoning About Energy Transfer (AP 9.2). Explain that this type of writing assignment helps show what a student knows about energy transfer.

- Part 1—students review the important terms *claims*, *evidence*, and *reasoning*.
- Part 2—students develop their own claims about energy transfer using evidence and reasoning in response to prompts.

SUPPORT—If needed, remind students that *reasoning* is the use of reason to make and support an argument. An example that students should be familiar with is cause-and-effect reasoning. A statement such as “The pavement gets hot (effect) when light from the sun strikes the pavement (cause)” adheres to this model. Additionally, remind students to review their answers on Activity Page 9.1 to help them complete Part 2 of 9.2.

5. Check for understanding.

10 MIN

Activity Pages



AP 9.1

AP 9.2

Answer Key

Formative Assessment Opportunity

Circulate around the room, and see how students are progressing through the scaffolded Activity Page Claims, Evidence, and Reasoning About Energy Transfer (AP 9.2). As students get closer to writing their individual claims, check their work to see that they are following the prompt of “I know . . . because. . .” Emphasize and clarify with students the type of evidence they are using.

Invite students to read their claims out loud to the rest of the class. If time permits, discuss the claims as a group, paying particular attention to the evidence used to support their claims.

Collect students’ Activity Pages, and provide feedback to each student before the next class session.

PART D

Collisions

OVERVIEW

Lesson	Big Question	Advance Preparation
10. Collisions Transfer Energy	How is energy involved in collisions?	Read Student Reader, Chapter 5.
11. Investigating Collisions (2 days)	What happens when objects collide? How are collisions predictable?	Gather materials for student investigations on Day 1 and Day 2. (See Materials and Equipment, page 13.) Read the instructional steps on the Activity Pages in advance to prepare to facilitate the student investigation.

Part D: What's the Story?

Energy is the ability to cause a change. Energy can be transferred from one object to another. These concepts are difficult for some students to grasp, but this section allows students to extend their learning from Part C: “Energy Transfer” (Lessons 6–9) by observing and exploring collisions. Students work with concrete evidence of energy transferring between objects and changing from one form to another.

In Lesson 10, we start by engaging students with a teacher demonstration on collisions. Discussion helps them understand that the changes that result from collisions are evidence that one or more of the objects in motion had energy. The goal is to get students to recognize that motion energy, brought into a collision, will transfer from one object to another (or often change to sound, heat, or light).

In relating energy to change, keep the order in mind: **motion energy >>> collision >>> change**. For example, if a rubber ball crashes into a stack of blocks, the blocks will come tumbling down. The **motion energy of the rubber ball >>> collision >>> some energy gets transferred to the blocks, which change by moving**.

In Lesson 11, students investigate what happens when objects collide and gather more evidence. This two-day lesson invites students to plan and conduct investigations, make predictions about what changes will occur during a collision, and then test those predictions across multiple trials. Although students will have seen demonstrations of this in Lesson 10, now they have an opportunity to define and change some independent variables to see the cause-and-effect relationship involved in collisions. The goal here is for students to see that **several factors**, such as speed or weight, **affect energy transfer and changes during collisions**.

Lesson 11 also sets the stage for Part E: “Energy Transformations and Engineering for Energy” (Lessons 12–13). As the investigation progresses, students begin to ask questions about the changes in sound and heat that also occur when objects collide.

LESSON 10

Collisions Transfer Energy

Big Question: How is energy involved in collisions?

AT A GLANCE

Learning Objective

- ✓ Describe energy changes that can occur when objects collide.

Lesson Activities

- teacher demonstration
- student investigation
- reading, discussion, writing
- vocabulary instruction

NGSS References

Disciplinary Core Ideas:

PS3.A: Definitions of Energy

PS3.B: Conservation of Energy and Energy Transfer

PS3.C: Relationship Between Energy and Forces

Science and Engineering Practice: Asking Questions and Defining Problems

Crosscutting Concept: Energy and Matter

Pay attention to **Asking Questions and Defining Problems**. To satisfy PE 4-PS3-3, students must have the opportunity to ask questions as a basis for making predictions based on observable patterns.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

collide
collision

contact
energy transfer

motion
position

sound
speed

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue on the previous page.

Instructional Resources

Student Reader



Ch. 5

Activity Page



AP 10.1

Student Reader, Chapter 5
"Collisions Transfer Energy"

Activity Page

Lesson 10 Check (AP 10.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

Collect or prepare the following items:

- 2 smaller toy cars
- 2 larger toy cars
- 2 clipboards
- 3–4 hardcover books for each ramp
- modeling clay
- index cards for student vocabulary deck (2 per student)

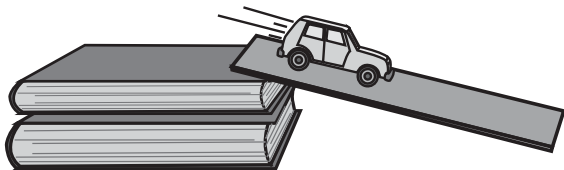
THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

5 MIN

How is energy involved in collisions? Demonstrate and discuss several collisions between two toy cars. The goal of this demonstration is to show the effects of a collision between two toy cars. So, energy of motion is involved in collisions, but as this lesson will show, other forms of energy are involved as well. Encourage questions and guide discussion as you work through the demonstration.

Low Ramp: First, set up low ramps facing each other (for example, creating the inclines using stacks of books with the clipboards slanted from the top of the books down to a desk).



- Explain that you are going to place the toy cars at the top of each ramp and let them roll down. Ask students what they think will happen when the toy cars crash into each other.

- Perform the demonstration. Ask students questions about what they observe, such as the following:
 - » What happens to the cars? (*They crash into one another.*)
 - » How does the collision change the motion of each car? (*They stop moving forward.*)
 - » What other forms of energy does the collision transform the motion energy of the cars to? (*sound*)

Medium Ramp: Next, prepare to show the toy cars rolling faster, down steeper ramps (for example, using stacks of several books to create higher inclines). Have students practice guessing (forming predictions) about what they expect to happen in this demonstration.

- » Will the speed of the cars change? How? (*They will go faster on a higher ramp.*)
- » Will the cars move the same way after the collision? (*They may bounce back more distance than before.*)
- » Will the second collision sound the same as the first? (*It will make a louder crashing sound.*)

High Ramp: Repeat the demonstration with higher ramps.

- Ask students to explain whether their predictions were accurate. (See **Know the Standards 1** below.)
- Call attention to observations that correctly relate the steeper ramps to greater speed of the cars and thus to the greater energy of motion of the cars and the stronger impact of the collision. Address any misconceptions about common uses of the term *energy*. (See **Know the Standards 2** below.)
- Address any student questions listed on the board or chart paper that remain unanswered after the discussion.

Know the Standards

1. Why are we making predictions? To better understand cause and effect. There is a cause-and-effect relationship between an object's energy of motion and the ability to cause change. Remind students that energy can be transferred from place to place, or object to object, and that it can be transferred by sound, light, heat, and electricity (4-PS3-2). **To support scientific mindset.** Remind students that if a scientist makes a prediction that turns out to be incorrect, that does not mean the scientist has failed. The whole point of making predictions is to test them and observe the results to determine how fully we understand, with degrees of certainty, how things work. In science, the point of predicting is not to "guess the right answer" but to test to see what the reality is.

2. How is energy involved in all of this? Stored energy becomes energy of motion that becomes other forms of energy. The Evidence Statements for 4-PS3-3 are typically the result of a collision in relative terms, that is to say that sound and heat are produced, but in small, hard-to-measure quantities. As the cars collide, some of the energy is transformed into sound energy, the noise the cars make in the collision that can be easily heard. Some of the energy is converted into heat energy, though in these trials, it is a very small amount of heat energy that would be difficult to measure. Some of the energy will still be energy of motion as the cars bounce away from each other after the collision.

2. Read and discuss: “Collisions Transfer Energy.”

20 MIN

Student Reader



Ch. 5

Read together, or have students read independently, “Collisions Transfer Energy,” Chapter 5 in the Student Reader. The selection shows that energy is all around us and that objects are colliding all around us, both in planned and unplanned ways. (See **Know the Science 1.**)

Preview Core Vocabulary Terms

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read:

collide

collision

sound

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Pages 25–26

After reading, have students act out some examples given on the page. They can clap their hands, stomp their feet on the floor, and tap pencils on their desks. Discuss after each one how it is an example of a collision.

Ask: What happens in every type of collision? (*Something changes.*)

Ask: What kinds of changes happen when you clap your hands, stomp your feet, or tap a pencil? (*hearing a sound, feeling a vibration*)

SUPPORT—Ask students to identify other objects that collide and make contact with each other in the real world. Prompt and support students to use the terms *contact* and *collision* in their responses.

Page 27

Prompt students to discuss that some objects change shape during a collision, while other objects do not change shape. Ask: Which object is harder or stronger: the clay or the brick wall?

SUPPORT—You can provide more examples beyond the ones in the reading, such as a baseball colliding into a glass window (and shattering the window).

Know the Science

1. What happens to energy during collisions? Energy moves from one object to another during a collision. The energy of motion of one object may be transferred to another during a collision. Some energy of motion is transferred from the objects to the air as sound or heat during a collision (example: when you hear the crack of a bat connecting to a ball).

Tell students that a bass drum is big and is typically carried or placed in a stand. Special frames with straps hold the drum in place when used for marching. This keeps the drum from moving very much when struck with a mallet, but the drum vibrates. (See **Know the Science 2.**) Emphasize that a surface vibrating in place transfers the vibration to the air around it.

SUPPORT—Address any misconceptions about empty space, such as that found in outer space. Some students may think that space is made up of air. Air in our atmosphere contains matter, but empty, outer space does not contain matter. Matter is needed for there to be sound.

Speed does not always mean the same thing as *fast*. Make sure students understand that *speed* can refer to things that move slowly or quickly. Words such as *fast* and *slow* may have to be used carefully in class.

Ask students to offer more examples, from their own experience, of variations in collisions they have observed that are attributable to differences in both the speed and weight of objects. (See **Know the Science 3.**)

3. Demonstrate examples and guide discussion.

5 MIN

What evidence proves energy has been transferred or transformed in a collision?

Demonstrate and discuss several collisions that provide evidence of energy transfer or transformation as a result of the contact. Have students practice guessing (forming predictions) about what they expect to happen in this demonstration. Encourage questions and guide discussion as you work through the demonstration.

Collisions Transfer Energy: First, set up a low ramp with a block of modeling clay at the bottom. Explain that you are going to place the smaller toy car at the top of the ramp and let it roll down. Ask students what they think will happen when the toy car crashes into the modeling clay. Perform the demonstration. Ask students questions about what they observe, such as the following:

- » What happens to the car? (*It stops by running into the clay.*)
- » What happens to the modeling clay? (*It gets pushed in a little.*)
- » Is there evidence of a change happening? (*yes*) If so, what is the evidence? (*The car stops, and the clay has a dent where the car hit.*)

Know the Science

2. How do bass drums work? Bass drums do not move very much as a result of strike collisions. Energy from the collision is transferred to the surrounding air as sound. If the drum could move more when it was hit, more energy from the strike would convert to motion energy and less would transfer to the air and convert to sound.

3. Why did the objects produce different outcomes? Weight and the energy of motion. The weight (mass) of an object affects its energy of motion. If two similarly sized objects are moving at the same speed, the one with the greater weight will have more energy of motion.

Set the ramp higher, and place a block of modeling clay at the bottom. Ask students to use what they have learned in the Student Reader and from their observations of the previous trial to make a prediction about what will happen to the clay. Ask students questions about what they observe, such as the following:

- » What happens to the modeling clay in this trial? (*The clay has a larger dent.*)
- » Did this collision transfer more or less energy than the first trial? (*more energy*)
- » What evidence supports your answer? (*The car moved faster and hit the clay with more force.*)
- » How did your prediction compare to the trial result? (*They were the same.*)
- » What pattern might you see if we kept using taller and taller ramps? (*The energy, or force and speed of motion, will increase.*)

More Cars Colliding: Next, set up identical ramps facing each other as in the first demonstration in this lesson. Show students the smaller and larger cars. Tell students you will be colliding different-sized cars into each other. Have students practice guessing (forming predictions) about what they expect to happen when the different combinations of toy cars collide. Ask students questions about what they predict, such as the following:

- » Will the sound be different between each collision? (*Some of the collisions will sound very similar, but the larger cars will tend to make louder sounds than the smaller cars.*)
- » What will be the difference in sound between each collision? (*A medium-sized car and large car will make a bigger sound than a small car and a smaller car.*)

Have students move so they cannot see the collision but can hear the collision. Tell students you will be doing three collisions and that they should compare the sounds they hear during each collision. First, perform the collision with the two smaller toy cars. Then, perform the collision with the two larger toy cars. Finally, perform the collision with one smaller and one larger toy car. Ask students to use what they have learned in the Student Reader and from their observations to answer questions such as the following:

- » Which cars were used in each collision? (*The bigger car was used in the greater collision. The smaller car was used in the softer, gentler collision.*)
- » What evidence supports your answer? (*The larger or heavier cars make louder collisions, and the smaller or lighter cars make quieter collisions.*)
- » When you watched each of the two cars collide with the clay, how did their impacts differ? (*The cars bounce away differently after the impact. One car bounced away farther than the other.*)
- » If the two objects are about the same size and they were moving at about the same speed, why would they transfer different amounts of energy? Get students to focus on the differences in weight between the two objects. (*One car must be heavier than the other car.*)

4. Teach Core Vocabulary.

5 MIN

Prepare Core Vocabulary Cards

Direct student attention to the Core Vocabulary words **collide**, **collision**, and **sound** written on the board or chart paper earlier in the lesson. Have students locate the Core Vocabulary card that they have already prepared for *sound*, and have them write each of the remaining two terms in the upper left corner of an index card and underline it (one term per card).

Word Work

- **collision:** (n. an instance of colliding) Ask students to share what they understand *collision* to mean. Have students write this definition on their cards: “an instance of colliding.” Have students write a sentence on their cards using the word *collision*. Encourage students to add a simple drawing of a collision.
- **collide:** (v. to come together with impact) Point out that, when two objects make contact in a collision, they *collide*. Have students add the word *collide* to the card and use it in a sentence. Identify synonyms for *collide* (*crash, hit, bump, strike, smash*). Identify forms of the verb *collide* (*collision, colliding, collided*).
- **sound:** (n. a form of energy that comes from a vibrating object) Ask students to share what they understand *sound* to mean. Have students compare this definition to what they have written their cards: “a form of energy that comes from a vibrating object.” Have students write on their cards a sentence using the word *sound*.

Ask students to share their definitions and sentences for *collision*, *collide*, and *sound*. Have students safely store their deck of Core Vocabulary cards in alphabetical order. They will add to the deck in later lessons.

5. Check for understanding.

10 MIN

Activity Page



AP 10.1 and
Answer Key

Formative Assessment Opportunity

Have students complete Lesson 10 Check (AP 10.1). Collect the assessment, check students' answers to identify concepts that need further clarification, and provide the support needed. See the Activity Page Answer Key for correct answers and sample student responses.

LESSON 11

Investigating Collisions

Big Questions: What happens when objects collide? How are collisions predictable?

AT A GLANCE

Learning Objective

- ✓ Predict what will happen in a collision and conduct an investigation to test those predictions.

Lesson Activities (2 days)

- discussion, writing
- student investigation
- teacher demonstration

NGSS References

Disciplinary Core Ideas:

PS3.A: Definitions of Energy

PS3.B: Conservation of Energy and Energy Transfer

PS3.C: Relationship Between Energy and Forces

Crosscutting Concept: Cause and Effect

Cause-and-Effect relationships will be explored during this lesson as students discuss collisions. Students will investigate and explore the transfer of energy due to collisions, as well as observe and make early predictions about the changes (transformations) in energy that occur when objects collide. This lesson introduces transformations of energy through investigation only. Explicit instruction about energy transformations is reserved for the four-day engineering design process in Lesson 13.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

collision

prediction

variable

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue on the previous page.

Instructional Resources

Activity Pages



AP 11.1

AP 11.2

Activity Pages

Investigating Collisions (Day 1):
Predictions (AP 11.1)

Investigating Collisions (Day 2):
Testing and Observation (AP 11.2)

Make sufficient copies for your students prior to conducting the lesson. Read the instructional steps on the Activity Pages in advance to prepare to facilitate the student investigation.

Materials and Equipment

Collect or prepare the following:

- empty cans or water bottles (1 per group)
- plastic or wooden toy vehicles with wheels
- 2-foot-long ramps made of cardboard or wood (1 per group)
- small items such as marbles, dry beans
- internet access and the means to project images/video for whole-class viewing

THE CORE LESSON TWO DAYS, 45 MIN EACH

1. Day 1: Focus student attention on the Big Question.

10 MIN

What happens when objects collide? Review what students have learned about collisions. Introduce Newton's cradle, which shows motion energy transferred to motion energy.

Online Resources



- **Newton's Cradle:** Show students a Newton's cradle demonstration (live, video, or both) to illustrate transfer of energy of motion from one ball, through several others, and back. (See **Know the Science 1.**) Remind students that Sir Isaac Newton was a scientist who observed and described laws of motion and gravity.
- Use this link to download the CKSci Online Resources Guide for this unit, where a specific link to this resource may be found:

www.coreknowledge.org/cksci-online-resources

Tell students that they will perform an investigation where they make a prediction about the energy relationships that occur because of a collision and test whether their predictions are correct.

Know the Science

1. What's going on in a Newton's cradle? Newton's cradle is a device that shows transfer of energy through collisions in a predictable pattern. While most of the energy of motion is transferred back and forth between the balls, some of the energy of motion in these collisions is converted (transformed) to sound. Always keep this in mind: **motion energy >>> collision >>> changes.**

2. Encourage student questions.

5 MIN

Lead a discussion about making predictions. Prompt students to think about why making predictions is an important skill. Draw attention to real-life examples of ways that predictions are used. Tell students that a prediction is more than a random guess; a prediction is based on what you have previously observed and what you already know (even if your knowledge is partial and still taking shape as you continue to investigate and learn more).

3. Preview the investigation.

10 MIN

Activity Page



AP 11.1

Introduce Investigating Collisions (Day 1): Predictions (AP 11.1), and show students the materials they will use for their investigations (see Materials and Equipment, page 13). Explain that they will be investigating the changes that occur when objects collide and looking for evidence and patterns that explain how motion energy is transferred in a collision. Tell students that today, Day 1, they will study the materials, as well as ask and answer questions about the investigation, including making a prediction. Then, on Day 2, they will get to conduct their tests to see if their predictions are correct. (See **Know the Standards**.)

Model for students how to complete the Activity Page by going through the questions for Day 1. Tell students that you will model how to use the Activity Page for their investigation later.

4. Support the investigation.

15 MIN

Activity Page



AP 11.1

Split students into groups, and give them time to work on their Investigating Collisions (Day 1): Predictions (AP 11.1). Allow students to look at the materials that they will get to work with, as this will help them answer the questions and formulate their predictions. Tell students that they do not have to use all the materials available to them. They can pick and choose the ones to test for their investigations.

As students work on their Activity Page, circulate around the room, and provide support. Ask students what factors they need to think about to make predictions about the results of a collision. As needed, prompt students to consider the following:

- What do you already know about collisions? (*They can be loud or quiet, hard or soft, or fast or slow.*)
- How do objects change because of a collision? (*They can be damaged and cause damage to other objects.*)

Know the Standards

Asking questions is an important skill for scientific discovery. Good investigation questions are specific, testable, and lend themselves to answers that can be quantitatively measured or qualitatively observed. Asking questions and predicting reasonable outcomes support the Performance Expectation as a means of addressing phenomena of the natural world.

- What happens to the motion energy of the objects that initiate a collision? *(Motion energy can gain speed or strength before the collision if an object is moving downhill or dropping from a height.)*
- How does motion energy move from object to object or place to place during a collision? *(Each impact transfers energy to the object that is hit.)*
- What energy forms can exist before, during, and after a collision? *(before: motion; during: sound, motion, perhaps heat; after: motion)*

SUPPORT—If necessary, model for students how to make predictions by telling them to do the following:

- » Think about what you already know.
- » Make observations, and look for patterns and data.
- » Write a statement that starts with “I think . . . ”
- » Test the prediction, and see what happens.

5. Summarize and discuss.

5 MIN

Bring the class back together after students finish completing their Day 1 Activity Page. Ask volunteers to read their predictions. Draw attention to any similarities. Allow students to ask questions and address any misconceptions. Tell students that in their next class session, they will continue this lesson and perform the investigations to see if their predictions are correct.

1. Day 2: Focus student attention on the Big Question.

5 MIN

- Ask students if they have any questions about the first part of the investigation that they completed. Students may be wondering about whether they wrote proper predictions. Invite some students to share their predictions with the class.
- Go over the Big Question again: **What happens when objects collide? How are collisions predictable?** Review what students did in the previous class session (asked and answered questions and made predictions). Prompt students to ask themselves, “How will I know if my prediction is correct?” Let students know that they will get to test their predictions today and that there are no points that are awarded or taken away based on if the predictions are correct or incorrect.
- Tell students that today they will carry out their investigations and decide whether their predictions were correct.

2. Preview the investigation.

5 MIN

Establish a Scientific Mindset

Students now get to build their investigations and perform tests to carry them out. Make a connection to science and engineering. Ask students: How do scientists and engineers use investigations? *(Scientists perform investigations and tests to learn more about the natural world; engineers perform investigations and tests to see how designs work and come up with solutions to problems.)*

Ask students to discuss any personal experience with investigations:

- Have you ever performed a test before? What kind? (*Sample answer: placing objects in water*)
- What were you trying to find out? (*which objects sink or float*)

Discuss good investigation protocols, such as the following:

- assigning roles in teams (i.e., two people build the design, another person starts the test, another person records the information)
- taking turns in teams
- communicating respectfully with teammates (i.e., listening to each other)
- recording exactly what you observe and not changing the results

Have students take out Investigating Collisions (Day 2): Testing and Observation (AP 11.2). Inform students that today they will complete Day 2, which consists of the following:

- carrying out a test
- assessing whether their predictions are correct

Model for students how to complete the Activity Page for Day 2 by going through the questions as well as the observation/data recording table. Give students examples of the kinds of information they could write there, such as the following:

- evidence of energy transfer
- patterns
- measurement data

Tell students that they can also use this table to draw pictures that show how the collisions worked in the investigation.

Activity Page



AP 11.2

3. Revisit Core Vocabulary.

5 MIN

Return to Core Vocabulary Card

Tell students to locate their existing Core Vocabulary card for the word **collision**. Have students add to the card one sentence describing a low-impact collision and one sentence describing a high-impact collision. Explain that the strength of the impact depends on the conditions, or variables, of each situation. (See **Know the Science 2.**)

Know the Science

2. How does changing the conditions affect the impact of collisions? Changing the conditions changes the outcomes of tests. In collision tests, speed may be a variable. Students increased the speed of the moving object (by increasing the elevation of the ramp) and noticed different changes, such as a more forceful impact with more energy transfer, evidenced by a bigger crash. Changing **only** one variable at a time allows students to identify patterns or attribute a cause-and-effect relationship to the changes that they observe. In this investigation, speed is an independent variable that students can change to predict and observe how speed affects the results of a collision.

4. Support the investigation.

25 MIN

Have students gather materials and use the Activity Page to roughly carry out their investigations. Circulate around the room, and provide support as they conduct their investigations. Draw students' attention to things that they can observe and specifically measure, including the following:

- how fast the objects were travelling (relatively speaking)
- whether a stationary object moved as a result of the collision
- whether there was (relatively speaking) a strong or weak transfer of motion energy from the first object to the second object and what caused this difference

5. Check for understanding.

5 MIN

Activity Pages



AP 11.1

AP 11.2

Answer Key

See the Activity Page Answer Key for correct answers and sample student responses.

- Collect the completed Activity Pages after students complete their investigations on both Day 1 and Day 2. Evaluate the predictions that students posed regarding collisions (AP 11.1) and their subsequent work on the investigation (AP 11.2).
- Students should predict a reasonable outcome of the collisions that they plan, based on prior observations. Then, having carried out the planned collisions, they should be able to articulate what happened, describing the energy transfer in qualitative terms. Incorrect predictions are part of the scientific process.

PART E

Energy Transformation and Engineering for Energy

OVERVIEW

Lesson	Big Question	Advance Preparation
12. How Can Energy Transformations Solve Problems?	How do energy transformations help people?	Read Student Reader, Chapter 6.
13. Designing Devices to Transform Energy (4 days)	How can I design a device that transforms energy to solve a problem?	Gather materials for the student-made devices. (See Materials and Equipment, page 13.)

Part E: What's the Story?

Energy is the ability to cause a change. In previous lessons, students learned that energy can transfer (move) from object to object and from place to place. Energy can also transform (be converted) from one type to another.

In Lesson 12, students begin by reading about energy transformation. The goal is to get students to understand that energy can change from one form of energy to another, such as electrical energy transforming (or converting) to heat energy or stored energy converting to motion energy.

To meet the Performance Expectation 4-PS3-4, students must be able to recognize different forms of energy, energy transformations, and how those transformations can be helpful to people or society. For example, transforming stored energy from a battery to light energy in a flashlight helps people see in the dark.

In Lesson 13, students apply their knowledge of energy conversions to the process of designing and testing a device to solve a problem. This four-day lesson allows students to move through the engineering and design process to 1) brainstorm ideas, 2) design energy transforming devices, 3) test their devices, and 4) evaluate how well the devices work to transform energy and make improvements. This lesson prepares students to meet or exceed Performance Expectation 4-PS3-4 and emphasizes the importance of defining the criteria and constraints during the design process that is used to solve a problem.

So, to reiterate, **people can transform energy from one form of energy to another to solve problems**. This concept will lay the groundwork for your students to meet or exceed other NGSS expectations related to engineering design and engage students to identify problems and design solutions as they come up in later units of CKSci Grade 4.

LESSON 12

How Can Energy Transformations Solve Problems?

Big Question: How do energy transformations help people?

AT A GLANCE

Learning Objective

- ✓ Describe how energy conversions are used in devices that help people.

Lesson Activities

- reading, discussion, writing
- vocabulary instruction
- hands-on activity

NGSS References

Disciplinary Core Ideas:

PS3.B Conservation of Energy and Energy Transfer

PS3.D Energy in Chemical Processes and Everyday Life

ETS1.A Defining Engineering Problems

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Crosscutting Concept: Energy and Matter

Pay special attention to the inherent expectations in **Constructing Explanations and Designing Solutions**. It is common, in a time-crunched classroom, to use reading and demonstration to teach facts associated with DCIs. In order to satisfy PE 4-PS3-4, students must have the opportunity to design, test, evaluate, and refine a design solution to a problem.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

convert/conversion
design problem

design solution
energy transformation

engineering design
forms of energy

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue above.

Instructional Resources

Student Reader



Ch. 6

Student Reader, Chapter 6

“How Can Energy Transformations Solve Problems?”

Activity Page

Lesson 12 Check (AP 12.1)

Make sufficient copies for your students prior to conducting the lesson.

Activity Page



AP 12.1

Materials and Equipment

Collect or prepare the following items:

- wind-up timer (or timer app on phone)
- index cards for student vocabulary deck (3 per student)

THE CORE LESSON 45 MIN

1. Focus student attention on the Big Question.

10 MIN

How do energy transformations help people? Write the following two lists on the board or chart paper:

Design		Factors Designers Need to Consider
toaster	cell phone	materials
wind-up clock	light bulb	cost
generator	ceiling fan	time
rechargeable battery	lawn mower	safety
solar panel	electric toothbrush	
electric car		

Quickly go around the room in a “lightning round,” and have each student answer one of the following questions, rotating through the terms on the Design list:

- What problem does a (toaster, wind-up clock, etc.) solve? (*browns toast, tells time*)
- What are two or more forms of energy that are used by a ()? (*electrical energy, heat energy*)
- How does a () use energy transformation? (*A toaster transfers electrical energy to heat energy.*)
- What are some factors engineering designers had to consider when they were designing the ()? (*the size of bread or bagels, safety*)
- What other factors not listed might an engineering designer need to consider? (*materials, colors, size, shape, time required*)

Support students to correct any misconceptions as they offer explanations and the class considers the examples.

CHALLENGE—If time allows, or as homework, challenge your students to select a device that they can find at home and answer these same questions independently.

Preview Core Vocabulary

Prepare students to approach the reading by drawing their attention to terms they will use as they explore ways that people make use of energy changes.

Before students read, write these terms on the board or chart paper. Encourage students to pay special attention to these terms as they read:

convert/conversion engineering design energy transformation

Have students write each term in the upper left corner of an index card (one term per card). They will revisit the cards later in the lesson to add notes about what the words mean.

Write *energy transfer* on the board or chart paper, apart from the grouping of the four terms above. Ask students to recall the meaning of *energy transfer*. Point out that *energy transfer* and *energy transformation* share the word part *trans-*. This is a clue that the terms have something in common, which students should think about as they read.

2. Read and discuss: “How Can Energy Transformations Solve Problems?”

25 MIN

Student Reader



Ch. 6

Read together, or have students read independently, “How Can Energy Transformations Solve Problems?” Chapter 6 in the Student Reader. The chapter will give students ideas of different ways energy is transformed from one form to another to solve human wants and needs.

Establish a Scientific Mindset

Discuss with students examples of technology within the framework of problems and solutions. Draw attention to the captions on pages 31–34 of Chapter 6. Tell students that, whether the words *problem* and *solution* are spelled out in a description or not, every human-made device they have ever used began with the identification of a problem that a designer wanted to try to solve. Designers use their knowledge of the world and scientific concepts to support their solutions. This interdependence between science and engineering will continue to be explored in Lesson 13 and the Unit Review.

Guided Reading Supports

When reading aloud as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

Pages 31–32

After reading both pages, ask: What is an energy transformation? (*It means to change forms of energy, such as when motion energy causes a loud crash and changes to sound energy.*) Think about other examples of energy transformations—how are these used to solve problems?

SUPPORT—If needed, prompt students to think about things they use every day, such as cell phones or kitchen appliances, such as a toaster. Use familiar examples based on your students’ experiences so concepts are easier to grasp and discuss.

Ask students to notice the meanings of *conversion* and *transformation*. Acknowledge that these words mean essentially the same thing. Scientists and engineers use both terms, so it is important for students to learn both and that they refer to the same process.

Page 33

Ask volunteers to summarize what they read in previous chapters about wind turbines and hydroelectric dams. In both of these examples, students read that motion energy was **transferred** from moving air or water to produce motion of parts inside mechanical devices. Inside these devices’ generators, the motion energy is **transformed** to a different type of energy, electrical energy.

Page 34

After reading the page, ask the following:

- » What problems are solved by batteries? (*They allow an object to be moved from place to place without needing to plug the object into a wall socket.*)
- » How is energy transformation used in the solution to those problems? (*The stored energy in the battery is transformed to sound, light, and motion.*)
- » What additional problems are solved by rechargeable batteries? (*The batteries will rarely, if ever, need to be changed.*)

Page 35

Ask students to identify small solar-powered devices with which they might be familiar. Two common examples might be pocket calculators and lights along walkways that help you to see a path. Discuss the energy transformations that occur within students' examples. (*Solar cells convert light to electrical energy, which the calculator requires to operate and display its calculations. Solar cells in sidewalk lanterns charge batteries [convert light to stored energy], which, in turn, convert the stored energy to electrical energy. This electricity enables the lights to shine after the sun sets [yet another conversion, back to light energy].*)

SUPPORT—Draw attention to the differences in size and scale of the solar cells, as illustrated by the examples on the Student Reader page. Note for students that certain designs have to fit in a certain amount of space. Discuss other examples of technology that must fit within a certain amount of space.

Page 36

After reading the page, ask students how they might consider whether or not an idea for a solution to a problem constitutes a **workable** idea. Emphasize that the engineering design process involves not only identifying a problem to be solved, but also asking and answering many questions about what is practical and would make the **best** solution, given what engineers have to work with. The last two paragraphs, which discuss many factors that must be considered in the designs of electric cars, provide an informal introduction to the notion of criteria and constraints in engineering design. (See **Know the Standards** below.)

Know the Standards

Prerequisites to Hands-on Problem Solving: In the lesson that follows, Lesson 13, students will design, test, and evaluate a device that uses an energy transformation to solve a problem. Defining a problem is just the first step in the engineering design process; proposing possible solutions requires consideration of limitations (constraints and criteria) before any building or testing takes place. In that sense, solutions can begin to be classified as “good ideas to try” or “probably unsuccessful” before any actual hands-on work commences.

ETS1.A: Defining Engineering Problems: Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each design meets the specified criteria for success or how well each takes the constraints into account.

3. Teach Core Vocabulary.

5 MIN

Word Work

Direct student attention to the Core Vocabulary cards that they started prior to reading Chapter 6.

convert/conversion

energy transformation

engineering design

- **convert** and **conversion**: (v. to change form; n. the process of being converted or changing form) Ask students to write in their own words one sentence that uses the word *convert* and one sentence that uses the word *conversion*. (*You convert energy when you change it from one form to another. Conversion of energy is the process of energy being converted.*)
- **energy transformation**: (n. the change of one form of energy to another form of energy) Discuss *energy transformation* as one form of energy changing into another. Suggest examples such as a toaster converting electric energy into heat, light, sound, and motion. Have students choose another example of energy transformation that they commonly see around them and produce an illustrated example on their card.
- **engineering design**: (n. a process used to develop a solution to a problem) Ask students to share what they understand about *engineering design*. Have students write one or two sentences on their card for this term. Instruct students to use the words *want*, *need*, *problem*, and *solution* in their written explanation. (*People want and need things. They use engineering design to find solutions to problems.*)

Have students store their deck of Core Vocabulary cards in alphabetical order. They may use the deck during their completion of the Lesson 12 Check, and they will use it during later review of the unit.

4. Check for understanding.

5 MIN

Activity Page



AP 12.1 and
Answer Key

Formative Assessment Opportunity

Have students complete Lesson 12 Check (AP 12.1). If you have a wind-up timer handy, display its operation while students work. Explain that it is a demonstration of a device mentioned in the lesson check (and not intended to time their work!).

Collect the assessment, and check students' answers to identify concepts with which students are still struggling. See the Activity Page Answer Key for correct answers and sample student responses. Incorporate adjustments as you open the next lesson. Provide additional guidance for students who need more support.

LESSON 13

Designing Devices to Transform Energy

Big Question: How can I design a device that transforms energy to solve a problem?

AT A GLANCE

Learning Objectives

- ✓ Design a device that transforms energy from one form of energy to another.
- ✓ Test, evaluate, and refine the device's design to solve a problem.

Lesson Activities (4 days)

- hands-on investigation
- discussion, writing
- vocabulary instruction
- student presentations

NGSS References

Disciplinary Core Ideas:

PS3.B: Conservation of Energy and Energy Transfer

PS3.D: Energy in Chemical Processes and Everyday Life

ETS1.A: Defining Engineering Problems

Crosscutting Concept: Energy and Matter

Science and Engineering Practice: Constructing Explanations and Designing Solutions

Constructing Explanations and Designing Solutions are important as students will be designing devices that apply energy transformations to solve a problem.

For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Core Vocabulary

Core Vocabulary words are shown in blue below. During instruction, expose students repeatedly to these terms, which are not intended for use in isolated drill or memorization.

Language of Instruction: The Language of Instruction consists of additional terms, not considered a part of Core Vocabulary, that you should use when talking about and explaining any concepts in this lesson. The intent is for you to model the use of these words without the expectation that students will use or explain the words themselves. A Glossary on pages 143–144 lists definitions for both Core Vocabulary and Language of Instruction terms and the page numbers where the Core Vocabulary words are introduced in the Student Reader.

convert
design solution

energy transformation
engineering design

forms of energy

Core Vocabulary Deck: As a continuous vocabulary instruction strategy, have students develop a deck of vocabulary cards that will be used in various activities across this unit as a part of Word Work. The deck will include the Core Vocabulary terms designated in blue on the previous page.

Instructional Resources

Student Reader



Ch. 6

Student Reader, Chapter 6

"How Can Energy Transformations Solve Problems?"

Activity Pages

Device Design Proposal (Day 1) (AP 13.1)

Device Test Results (Day 2) (AP 13.2)

Device Presentation Plan (Day 3) (AP 13.3)

Device Presentation Scoring Guide (Day 4) (AP 13.4)

Energy Vocabulary Crossword Puzzle (AP 13.5)

Energy Vocabulary Review (AP 13.6)

Make sufficient copies for your students prior to conducting the lesson.

Activity Pages



AP 13.1

AP 13.2

AP 13.3

AP 13.4

AP 13.5

AP 13.6

Materials and Equipment

Collect or prepare the following:

- boxes
- aluminum foil
- clear plastic wrap
- craft paper
- springs
- rubber bands
- containers
- string
- table tennis and tennis balls
- cups
- sticks
- cardboard tubes of various sizes
- blocks
- glue
- clipboards for making ramps
- tape
- electric clock or pencil sharpener

The listed materials are suggestions, but you may wish to modify the materials as necessary. Have the materials out for student consideration on Day 1, Step 3, when they start on Device Design Proposal (AP 13.1).

Preparation and Rationale

The design process used throughout this lesson's activities can make for a challenging classroom environment. Keep the following in mind as you prepare to guide your class to work through the lesson:

- Students likely will not be proficient with the design process at this time, but the Activity Pages are set up to help students work through a design problem in a grade-appropriate way.
- The Performance Expectation requires an open-ended activity, but students at this level will benefit from additional guidance.
- Review the Activity Pages AP 13.1–AP 13.4 ahead of time to fully understand the problems presented to students and their likely responses before you begin.
- The materials list provides basic supplies for students to make a solar oven for Scenario #1 and a machine to replace a doorbell in Scenario #2. Encourage students to think of other materials that may be useful, depending on what you have available, as they work on their design solutions.

1. Day 1: Focus student attention on the Big Question.

5 MIN

How can I design a device that transforms energy to solve a problem? In the previous lesson, students learned about ways energy transfers and transformations can solve problems. Explain that today students will begin to develop plans for the device they will build in which they will utilize energy transformations.

2. Demonstrate examples and guide discussion.

10 MIN

Lead a discussion about examples of everyday energy transformations that solve problems. Break the class into groups of four to six students that will design a device. Present students with the following scenarios:

Scenario 1: There is a power outage, and you need to heat up some food. What sort of device can you design to heat the food without electricity? (*a wood, coal, or propane grill or a fireplace*)

Scenario 2: A friend is hearing impaired and cannot hear the doorbell ring. What sort of device can you design to let them know someone is at the door without them seeing the door or hearing the bell? (*Wire a light to the doorbell so it flashes when the doorbell rings.*)

Assign each group a scenario to develop a device. This will allow groups to compare and contrast their devices later on in the lesson.

SUPPORT—If students are having trouble developing a device plan, have them reference examples from Lesson 12.

Distribute and go over Device Design Proposal (AP 13.1). Review the categories listed on the design plan with students to explain what they should record in each section.

Activity Page



AP 13.1

3. Support student activity.

20 MIN

In their small groups, have students brainstorm possible devices for each of the problems. Assign a problem to each group. Recommendation: Make sure more than one group creates a device for each problem to compare multiple solutions that accomplish the same goal. Have students explore materials they could use to build their devices.

Establish a Scientific Mindset

- Discuss the standards by which to judge the device.
 - » Review the standards students identified in the previous lesson.
 - » Explain that student solutions will be evaluated based on how well they meet the criteria.
 - » Identify and discuss criteria for creating the group solution.
- Discuss what limitations students noted in planning to create their devices.
 - » Brainstorm and discuss constraints for creating each group solution.
 - » Brainstorm possible solutions to each problem.

Give students time to complete the Device Design Proposal (AP 13.1) in their groups.

4. Check for understanding.

10 MIN

Summarize learning. Ask several groups or, if time allows, have all groups share their revised idea(s) for solving the problem. Use the discussion to determine if students understand criteria and constraints, and plan any needed reteaching.

- Review student questions, and identify any that remain unanswered.
- Prompt students to express any new questions they may have and add them to the list. Discuss strategies for answering remaining questions.
- Review students' Device Design Proposal (AP 13.1) for appropriate criteria and constraints. Make sure the plans have identified energy transformations.

SUPPORT—If student understanding is insecure, have them examine a device, such as an electric clock or pencil sharpener. Have them describe what powers the device and how the energy that powers the device changes to movement, sound, or any other form of energy.

Activity Page



AP 13.1

Know the Science

Refresh students' memory about the difference between energy transfer and energy transformation. Energy transfer occurs when energy moves from one place or object to another, such as when a kickball is kicked. The motion energy of a child's foot is transferred to the ball. This transfer sets the ball in motion. Energy transformation occurs when energy is changed from one form to another, such as when a flashlight is turned on. Energy in the battery is transformed from chemical energy to electrical energy when the switch is turned to the *on* position. As electrical energy flows through the bulb, it is transformed into light and heat energy.

1. Day 2: Focus student attention on the Big Question.

5 MIN

How can I design a device that transforms energy to solve a problem? In direct support of the Performance Expectation, on this second day of the lesson, students will also consider the more specific question **How can my device be tested?** Explain that today students will first present their design plans from Day 1. Using the feedback they receive, they will build and test their devices.

SUPPORT—Before each group presents their plan, ask the class to imagine a test that can be used specific to each scenario. For example, for Scenario #1, students could test their devices by fully melting an ice cube or placing an unwrapped crayon across two small blocks and timing how long it takes for the crayon to melt enough to touch the base of the device. For Scenario #2, students could have an observer wearing ear protection to muffle their hearing sit in another room and test if the device works by signaling someone at the door.

2. Facilitate group presentations.

10 MIN

Have each small group present its design plan, including the following:

- identifying the problem that will be solved by the device
- identifying the transformations that will be applied, including the initial and final forms of energy
- explaining how the device will work
- identifying needed materials
- explaining how it will be built

Have the class identify the transformation that will be demonstrated and offer suggestions as to how the device might solve the problem in the scenario.

3. Support group activity.

15 MIN

Activity Page



AP 13.2

Distribute Device Test Results (AP 13.2). Review the Activity Page with students, and model for them how to complete the table.

Have groups build their devices. Provide space for each group to conduct at least three trial tests. Circulate around the room. Ask each group the following questions:

- » How are you meeting the criteria? (*Students should be able to clearly describe their criteria, purposes, and plans.*)
- » What is the problem you are solving?
- » What energy transformation are you using?
- » What problems are you having building your device?
- » How are you dealing with the constraints you identified?
- » What do you need to finish?

Give students time to test and record their data.

4. Revisit Core Vocabulary.

5 MIN

As a review of key concepts, have students go through the vocabulary cards they began at the end of Lesson 12. Invite students to add examples to their cards from what they have read and observed. For example, they can list different energy transformations and some processes considered in developing engineering designs.

convert/conversion **energy transformation** **engineering design**

Have students safely store their deck of Core Vocabulary cards in alphabetical order.

5. Check for understanding.

10 MIN

Evaluate each group's progress to determine if students understand criteria and constraints, and plan any needed reteaching.

Activity Pages



AP 13.1
AP 13.2

- Review Device Test Results (AP 13.2) that students completed to determine if each group is meeting the criteria and constraints of the activity. Identify students who need more support and concepts that need clarification. Incorporate adjustments as you plan for Day 3.
- Review student questions, and identify any that remain unanswered.
- Prompt students to express any new questions they may have, and add them to the list. Discuss strategies for answering remaining questions.

SUPPORT—Reteach, if needed. If student understanding is insecure, reinforce the steps of the Device Design Proposal (AP 13.1), and remind students of the importance of testing a design. Emphasize that the devices will be evaluated on how well they meet the criteria and constraints each group established earlier in the lesson.

1. Day 3: Focus student attention on the Big Question.

10 MIN

Student Reader



Ch. 6

How can I design a device that transforms energy to solve a problem? Explain that today students will refine their designs. Invite students to ask questions about their designs and tests. Record selected questions on the board or chart paper to revisit after the activity.

Review paragraphs or sections of “How Can Energy Transformations Solve Problems?,” Chapter 6 of the Student Reader, including page 36 on how engineering design solves problems.

If time permits, remind students of the evolution of the phone and how the solution to the problem of communication over distances has been refined and improved over time. Emphasize that many different people have contributed to the development of phones, as well as other devices. Have students describe how other devices such as light bulbs have been improved over time. You may wish to use the term *optimize* when discussing improving a design.

2. Encourage student questions.

5 MIN

Lead a discussion about the descriptions students have shared of other devices. Prompt students to think about why it is important to improve the designs of devices over time. Review any questions, and encourage new questions and insights. Discuss refinements student groups will make to improve their designs and better meet the criteria for the problem's solution.

3. Facilitate student refinements and retests.

10 MIN

Activity Page



AP 13.2

Have students review their device test results. Prompt them to discuss their results with other students, using Activity Page 13.2 and asking for constructive feedback. Have students brainstorm changes they can make to address any issues that were discovered in the tests.

Give students time to make the refinements and retest.

4. Plan for presentations.

10 MIN

Activity Page



AP 13.3

Distribute and review the Device Presentation Plan (AP 13.3) guidelines, modeling for students how to complete the plans, if necessary. Allow time for students to plan their presentations.

5. Check for understanding.

10 MIN

Summarize learning. Have students summarize what they have learned about engineering design and testing.

Before moving on to Day 4, review the Device Presentation Plans for each group to check if students are meeting the criteria and constraints they identified earlier in the lesson. Identify students who need more support and concepts that need clarification. Incorporate adjustments as you plan for Day 4.

Review the student questions that you have listed on the board or chart paper. Prompt students to express any new questions they may have, and add them to the list. Discuss strategies for answering remaining questions.

1. Day 4: Focus student attention on the Big Question.

5 MIN

How can I design a device that transforms energy to solve a problem?

Explain that today students will present, explain, and demonstrate their devices for the class.

Review student questions from the beginning of the series of lessons. Identify questions that have and have not been answered. Discuss how to find the answers to remaining questions.

Discuss your review of each group's Device Presentation Plan (AP 13.3).

- Point out positive elements of each plan, such as how well the criteria and constraints are being met and if they have identified the initial and final forms of energy.
- Ask any questions you have about the plan, and allow students an opportunity to address any feedback that you offer each group.

Activity Page



AP 13.3

2. Present student designs.

25 MIN

Distribute copies of Device Presentation Scoring Guide (AP 13.4), one for each presentation. Review with students how to complete the rubrics so that they can adequately score their peers.

Using Device Presentation Plan (AP 13.3), give each group five minutes to present their devices to the class. Make sure students address the following points:

- » What is the problem you are solving?
- » What want or need are you meeting?
- » What were the criteria (limitations)?
- » What was the initial form of energy in the energy transformation?
- » What was the final form of energy?
- » Was there one or more than one kind of energy transformation?
- » How did your team build it?
- » What were the test results?
- » How did you refine your device?
- » Complete and have students complete a scoring guide after each presentation.

Activity Pages



AP 13.3

AP 13.4

3. Summarize and discuss.

10 MIN

After all groups have made presentations, compare how each group built and refined their device.

- Have students identify the energy transformations that were similar and different.
- Discuss how each device solved the problem.

4. Check for understanding.

5 MIN

Summarize learning. Have students summarize what more they have learned about energy transformation and engineering design from building their devices.

- Review student questions, and identify any that remain unanswered. Prompt students to express any new questions they may have, and add them to the list. Discuss strategies for answering remaining questions.
- Review the Device Presentation Scoring Guide (AP 13.4) pages that students completed for each presentation. Identify concepts that need clarification. Incorporate adjustments as you open the next lesson.

SUPPORT—Reteach, if needed. If student understanding is insecure, review the scoring guides individually. Address positive elements of the guide, and ask students to explain how their devices and presentations could have been improved after seeing other presentations. Have students describe the key elements of the activity: the problem to be solved, the energy transformation, and the criteria and constraints.

Activity Pages



AP 13.5

AP 13.6

Answer Key

- For optional independent Core Vocabulary review, send home Energy Vocabulary Crossword Puzzle (AP 13.5) and Energy Vocabulary Review (AP 13.6) prior to conducting your in-class Unit Review and Unit Assessment.

UNIT REVIEW

Solving Problems and Designing Solutions: Thomas A. Edison

Big Question: How did Thomas Edison use his knowledge of energy transfer and transformation to solve problems?

AT A GLANCE

Learning Objectives

- ✓ Use examples from the Student Reader to apply the unit Performance Expectations.
- ✓ Use examples from the chapter about Edison to review the unit Big Questions.

Lesson Activities

- student observation
- reading, discussion, writing
- vocabulary instruction

NGSS References

This unit addresses the following Grade 4 Performance Expectations for the NGSS topic *Energy*.

- Use evidence to construct an explanation relating the speed of an object to the energy of that object. **(PE 4-PS3-1)**
- Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents. **(PE 4-PS3-2)**
- Ask questions and predict outcomes about the changes in energy that occur when objects collide. **(PE 4-PS3-3)**
- Apply scientific ideas to design, test, and refine a device that converts energy from one form to another. **(PE 4-PS3-4)**

The Unit Review is intended to support students as they summarize their learning about these PEs and prepare for the Unit Assessment. For detailed information about the NGSS References, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

The Big Idea

Engineers use knowledge of energy as they develop solutions to problems and build things that are useful to people. This lesson incorporates the principles and practices of engineering design (such as defining problems and evaluating and optimizing possible solutions) and reapplies learning objectives from earlier in the unit.

This lesson also reviews many of the Big Questions students have seen throughout the unit that focus on the scientific concept of *energy as the ability to cause a change*. Students can see concrete manifestations of energy all around them—when they flip on a light switch, ride in a car, or answer a cell phone. The scientific concept of *energy as the ability to cause a change* can prove initially challenging. This abstract idea of the relationship between energy and change becomes clearer when students understand that

- energy exists in different forms, such as sound, light, thermal energy, and electrical energy;
- energy can transfer from object to object and place to place;
- one form of energy can transform to another;
- these forms of energy can cause a change, such as when a high-pitched sound breaks glass or when heat melts butter; and
- all change, in fact, is evidence of energy transfer or transformation.

Core Vocabulary

Language of Instruction: During instruction, remind students of their prior exposure to the following terms.

change
collide
collision
conversion

convert
energy
energy of motion
energy transfer

energy transformation
engineering design
motion
sound

speed
stored energy

Core Vocabulary Deck: Students should refer to their full set of Core Vocabulary cards during the review discussion.

Instructional Resources

Student Reader



Ch. 7

Activity Page



AP UR.1

Student Reader, Chapter 7
“Solving Problems and Designing Solutions: Thomas A. Edison”

Activity Page
Energy’s Big Questions
(AP UR.1)

Make sufficient copies for your students prior to conducting the lesson.

Materials and Equipment

No materials are required for this lesson other than the Instructional Resources. Consider supporting your students with a review of several examples used in Lessons 1–13.

1. Focus student attention on the Big Question.

10 MIN

How did Thomas Edison use his knowledge of energy transfer and transformation to solve problems? Explain to students that, although they will be reading about a specific inventor, discussing the chapter will give them an opportunity to apply what they have learned throughout all the lessons about energy.

Preview Core Vocabulary

Have students take out the Core Vocabulary card decks they have completed throughout the unit. Instruct students to quickly scan the cards as a reminder of terms to look for during today's reading and Unit Review discussion. Have students place the deck at the top left corner of their desks. When they encounter any term in the deck during reading or discussion, they should move the card for that term to the top right corner of the desk. Emphasis in this lesson is for students to use Core Vocabulary in context in the discussion and to be aware of their use of the terms.

Conduct a quick, informal "Edison scavenger hunt." Let students know they will be looking at familiar objects but will be looking for a specific reason—to find examples of battery-operated devices and electric lights.

- Let students know that there is not one set of correct answers for this activity. Encourage students to safely look for battery compartments around the room and to turn lights on and off.
- Discuss four or five examples that students identify and how each makes use of energy transfer and transformation.
- Ask students to consider how people met the need for the problem these devices solve before there were batteries or light bulbs.

2. Read and discuss: "Solving Problems and Designing Solutions: Thomas A. Edison."

20 MIN

Student Reader



Ch. 7

Read together, or have students read independently, "Solving Problems and Designing Solutions: Thomas A. Edison," Chapter 7 in the Student Reader. The selection is a brief overview of Edison's life, focusing on his contributions to the inventions of the light bulb and the alkaline battery.

Guided Reading Supports

When reading aloud together as a class, always prompt students to follow along. Pause for discussion. Ask the following questions, and use the following prompts:

- What problems did Edison try to solve as he designed his light bulb? (*It is difficult to see in the dark. A candle, lantern, or fire provides light but can be dangerous.*)

Page 37

- Think about your home. Where do you find light bulbs in your home? (*lamps in every room, ceiling lights, new light bulbs stored in a cabinet*)

Pages 38–39

- What is an open flame? (*light that is not contained*)
- Why did Edison place the filament inside the bulb? (*to reduce the chance of buildings catching on fire*)
- Do you think light bulbs are safer than candles or lanterns? (yes) Why or why not? (*Open flames are a fire hazard, but when a bulb burns out or breaks, it will no longer light.*)
- Look closely at the picture of Edison’s light bulb. Where do you think the transformation of electrical energy to light energy happens in his device? (*inside the bulb*)
- When a light bulb turns on, what evidence shows that energy has transformed in the light bulb? (*The electrical energy in the filament produces light energy in the light bulb, so the light comes on.*)

Pages 40–41

- During Edison’s time, electric car batteries were heavy. Why do you think Edison wanted to create a battery that was lighter?
- What energy transformations happen in a modern car? (*The stored energy that is in fuel and batteries makes a transformation to motion energy when the car is started and begins to move.*)
- Think about your home. What are some examples of devices in your house that use size AA or size AAA batteries? How do they transform energy?

SUPPORT—Note to students that electric cars are not new technology. The first commercial electric car came out in 1884, roughly four years after the first commercial gasoline-powered car. The batteries were heavy, and the cars did not have a long range. By the end of the 1910s, gasoline-powered engines had been improved enough that they offered greater range and more power than electric cars. As a result, cars with gasoline-powered engines became more popular.

- Think about the word *persistence*. What do you think it means to *persist*? (*to keep trying to solve a problem*)

CHALLENGE—If students would like to learn more, consider asking them to find out more about Edison’s early electric car batteries. Have students compare and contrast Edison’s electric car to those of today.

Page 42

- What advantages and disadvantages does the design of the traditional light bulb have? (*It might be less expensive and might fit into some older sockets.*)
- What advantages and disadvantages does the design of the CFL bulb have? (*It uses little heat, but the light is not very bright.*)
- What advantages and disadvantages does the design of the LED bulb have? (*It gives off a lot of light and very little heat, using little energy.*)

- Which examples in this chapter model Edison’s persistence as a designer and an engineer? (*He identified problems and worked hard to develop solutions. He tested more than 6,000 materials to use for filaments. He made the first alkaline battery in 1901.*) Have you ever had to *persist* and try again and again to accomplish something? (*Yes; examples will vary.*)

SUPPORT—The bulbs shown are all similar in form but function much differently. To ensure students understand that not all lights need to be shaped like a traditional bulb, ask them to identify lights that are not shaped like a bulb, such as the classroom lights, which may be fluorescent or LED tubes, a flashlight, or the light on a cellphone, which will be an LED light.

3. Check for understanding.

15 MIN

Activity Page



AP UR.1 and
Answer Key

Distribute Energy’s Big Questions (AP UR.1).

- Assign students to work in pairs to discuss and develop written answers to the unit’s Big Questions. Assign each pair one or two Big Questions to answer from the Activity Page.
- Instruct students to draft their answers first on scrap paper as they work with their partner.
- Challenge students to use references from Chapter 7 in their answers where appropriate.

Before the next class session, the Unit Assessment, collect and evaluate the Activity Page. Address any misguided or incomplete responses.

Return the Activity Page to students, and have selected students read their responses to the whole class. Reviewing these Big Questions will support students in preparation for the Unit Assessment.

See Teacher Resources pages 141–142 for guidance in administering the Unit Assessment to conclude the unit.

Teacher Resources

Activity Pages

• Energy Scavenger Hunt (AP 1.1)	101
• Surprise! (AP 2.1)	102
• Energy Causes Change (AP 2.2)	103
• On the Move (AP 3.1)	104
• Ramp It Up! (Day 1) (AP 4.1)	105
• Drop It (Day 2) (AP 4.2)	106
• Lesson 6 Check (AP 6.1)	107
• Lesson 7 Check (AP 7.1)	108
• Investigating Energy Transfer (AP 8.1)	109–111
• Examples of Energy Transfer (AP 9.1)	112
• Claims, Evidence, and Reasoning About Energy Transfer (AP 9.2)	113–114
• Lesson 10 Check (AP 10.1)	115
• Investigating Collisions (Day 1): Predictions (AP 11.1)	116
• Investigating Collisions (Day 2): Testing and Observation (AP 11.2)	117–118
• Lesson 12 Check (AP 12.1)	119
• Device Design Proposal (Day 1) (AP 13.1)	120–121
• Device Test Results (Day 2) (AP 13.2)	122
• Device Presentation Plan (Day 3) (AP 13.3)	123
• Device Presentation Scoring Guide (Day 4) (AP 13.4)	124
• Energy Vocabulary Crossword Puzzle (AP 13.5)	125–126
• Energy Vocabulary Review (AP 13.6)	127
• Energy's Big Questions (AP UR.1)	128

Unit Assessment: <i>What Have I Learned About Energy?</i>	129–136
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Activity Pages Answer Key: <i>Energy Transfer and Transformation</i>	137–140
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Unit Assessment: Teacher Evaluation Guide	141–142
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Appendix A: Glossary	143–144
Appendix B: Classroom Safety for Activities and Demonstrations	145–146
Appendix C: Strategies for Acquiring Materials	147
Appendix D: Advance Preparation for Activities and Demonstrations	148
Appendix E: What to Do When Activities Don't Give Expected Results	149

Name _____

Date _____

Activity Page 1.1

Use with Lesson 1.

Energy Scavenger Hunt

Change is all around you! **Energy** causes changes. Explore the space you are in. Look for things that change in some way. (Hint: Almost everything can!)

Find three examples of things that change. Complete the table to describe your choices.

Three samples have been done for you.

Something That Changes	How Does It Change?
a light bulb	It changes from not bright to bright.
an electric fan	It changes from not moving to moving.
the grass outside	It changes from short to tall.

Write two questions that you have about your examples.

1. _____

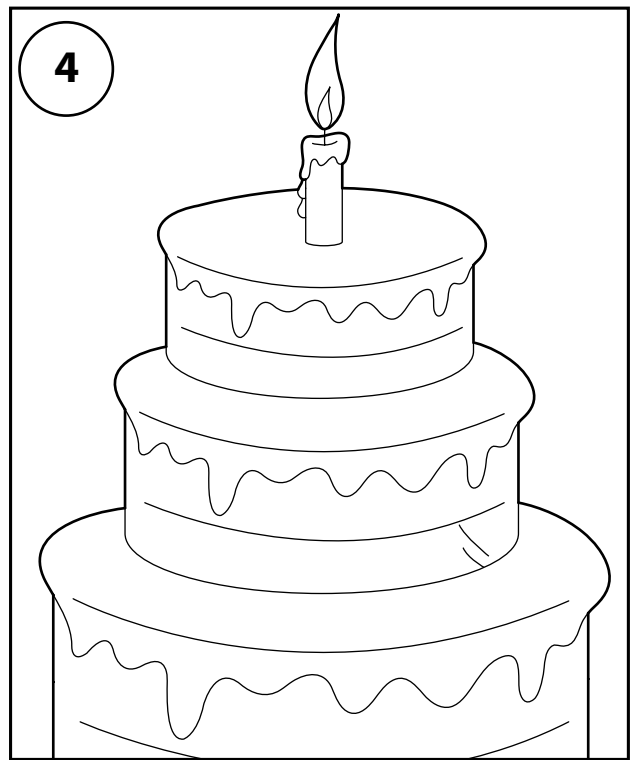
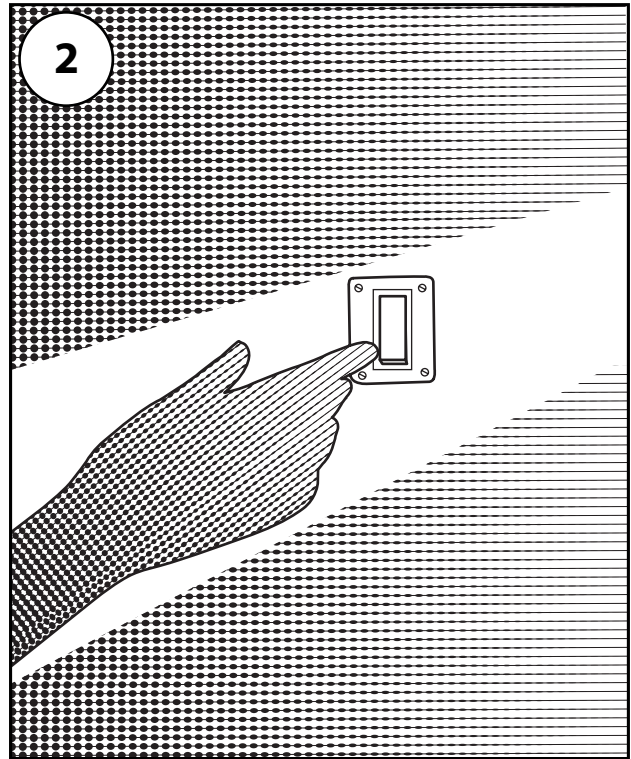
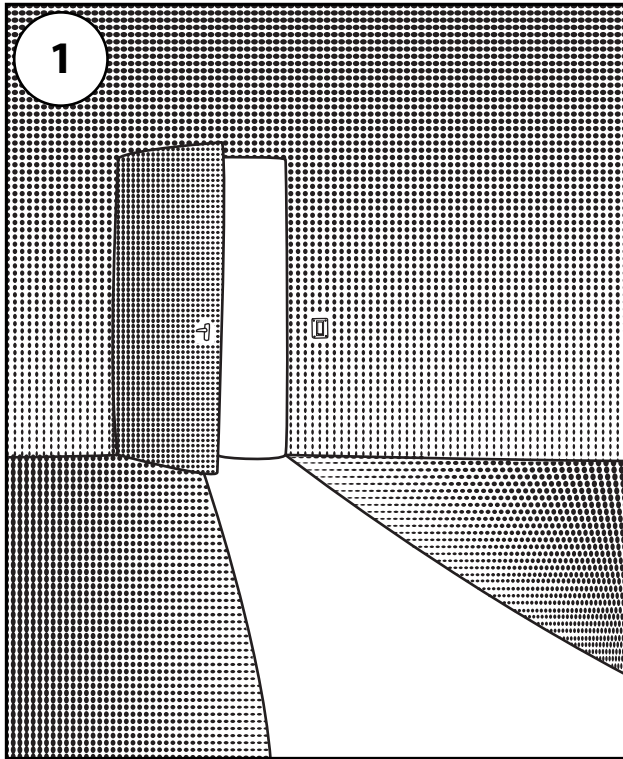
2. _____

Activity Page 2.1

Use with Lesson 2.

Surprise!

What changes occur in the party pictured here?



Name _____

Date _____

Activity Page 2.2

Use with Lesson 2.

Energy Causes Change

light

sound

electrical energy

motion energy

stored energy

Choose one form of energy from the box above. Circle your choice.

What change can this form of energy cause?

Draw a “before and after” cartoon to show a change, and indicate the form of energy that causes the change.

BEFORE	AFTER
--------	-------

Explain the cause and effect shown in your “before and after” cartoon.

What causes the change? What changes? (In other words, what is the cause, and what is the effect?)

Name _____

Date _____

Activity Page 3.1

Use with Lesson 3.

On the Move

Things are on the move everywhere that you look. Those moving objects can cause changes.

Identify an object that you know moves often.

Draw before and after diagrams to show how the motion of this object can cause a change.

BEFORE

AFTER

Write descriptions to explain your model.

Ramp It Up (Day 1)

Different objects are moving at different **speeds** all around you! From the cars on the road to balls on the playground, all moving objects have speed and energy.

Is there a connection between speed and energy? You are about to find out!

STEP 1: Build a low ramp from cardboard propped at one end by a book. Place the cup a short distance from the bottom of the ramp (about the length of your foot).

STEP 2: Trial 1 Place your ball at the top of the ramp. Release the ball so it rolls down the ramp into the cup. Notice how far the ball causes the cup to move. Place a marker to show how far the cup moved.

STEP 3: Add books to make your ramp steeper so your ball will roll from a greater height. Place the cup in the same position in front of the ramp as you did before.

STEP 4: Trial 2 Place your ball at the top of the ramp. Release the ball so it rolls down the ramp into the cup. Notice how far the ball causes the cup to move.

STEP 5: Use your observations to complete the table.

	Trial 1	Trial 2
In which trial was the ramp height higher ? In which trial was it lower ?		
In which trial did the ball roll with greater speed ? In which trial did it roll with lesser speed ?		
In which trial did the ball move the cup more ? In which trial did it move less ?		
In which trial did the rolling ball have more energy ? In which trial did it have less energy ?		

STEP 6: Summarize your conclusion. Describe the relationship between energy and speed in your investigation. Use evidence to support your explanation.

Name _____

Date _____

Activity Page 4.2

Use with Lesson 4.

Drop It (Day 2)

Dropping an object from different heights produces different falling speeds for the object.

Does the relationship between speed and energy remain the same as what you observed when rolling a ball down a ramp?

STEP 1: Smooth the sand in the box so that there are no dents in the surface of the sand.

STEP 2: Trial 1 Hold the ball above the sand near one end of the box (not in the middle). Hold the ball at about knee-height.

STEP 3: Drop the ball into the sand. Gently pick the ball out of the sand without disrupting the sand. Notice the size of the crater that the ball's impact made in the sand.

STEP 4: Trial 2 Hold the ball above the sand near the opposite end of the box. Hold the ball at about waist-height.

STEP 5: Drop the ball into the sand again. Gently pick the ball out of the sand without disrupting the sand. Notice the size of the crater that the ball's impact made in the sand this time.

STEP 6: Use your observations to complete the table.

	Trial 1	Trial 2
In which trial was the ball dropped from higher position? In which trial was it dropped from a lower position?		
In which trial did the ball drop with greater speed ? In which trial did it drop with lesser speed ?		
In which trial did the ball have a greater impact on the sand? In which trial did it have less impact?		
In which trial did the falling ball have more energy ? In which trial did it have less energy ?		

STEP 7: Summarize your conclusion. Describe the relationship between energy and speed in your investigation. Use evidence to support your explanation.

Name _____

Date _____

Activity Page 6.1

Use with Lesson 6.

Lesson 6 Check

Write captions on the picture to explain what is happening.

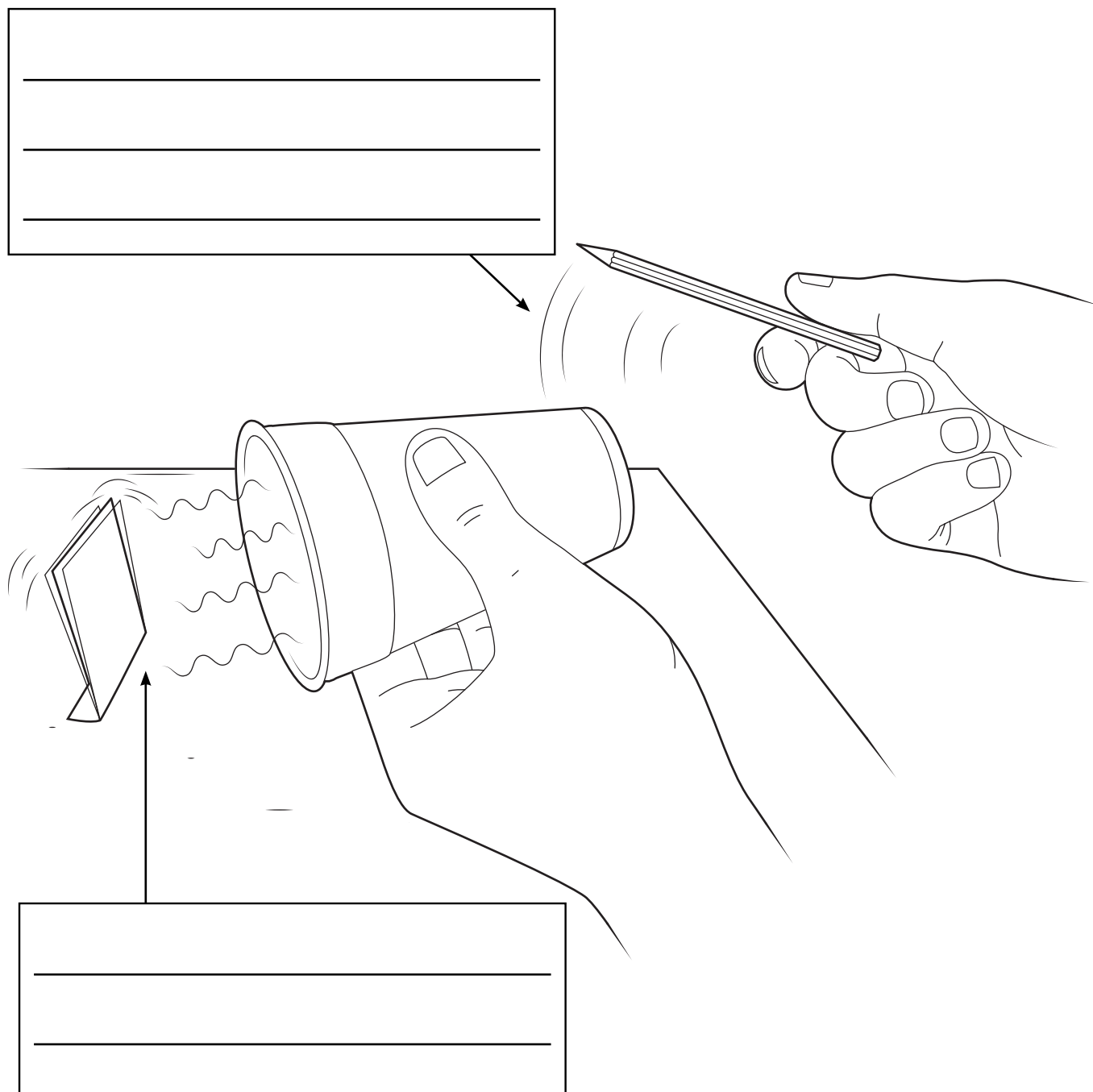
Use each of these words at least one time in your captions.

sound

energy

evidence

transfer



Name _____

Date _____

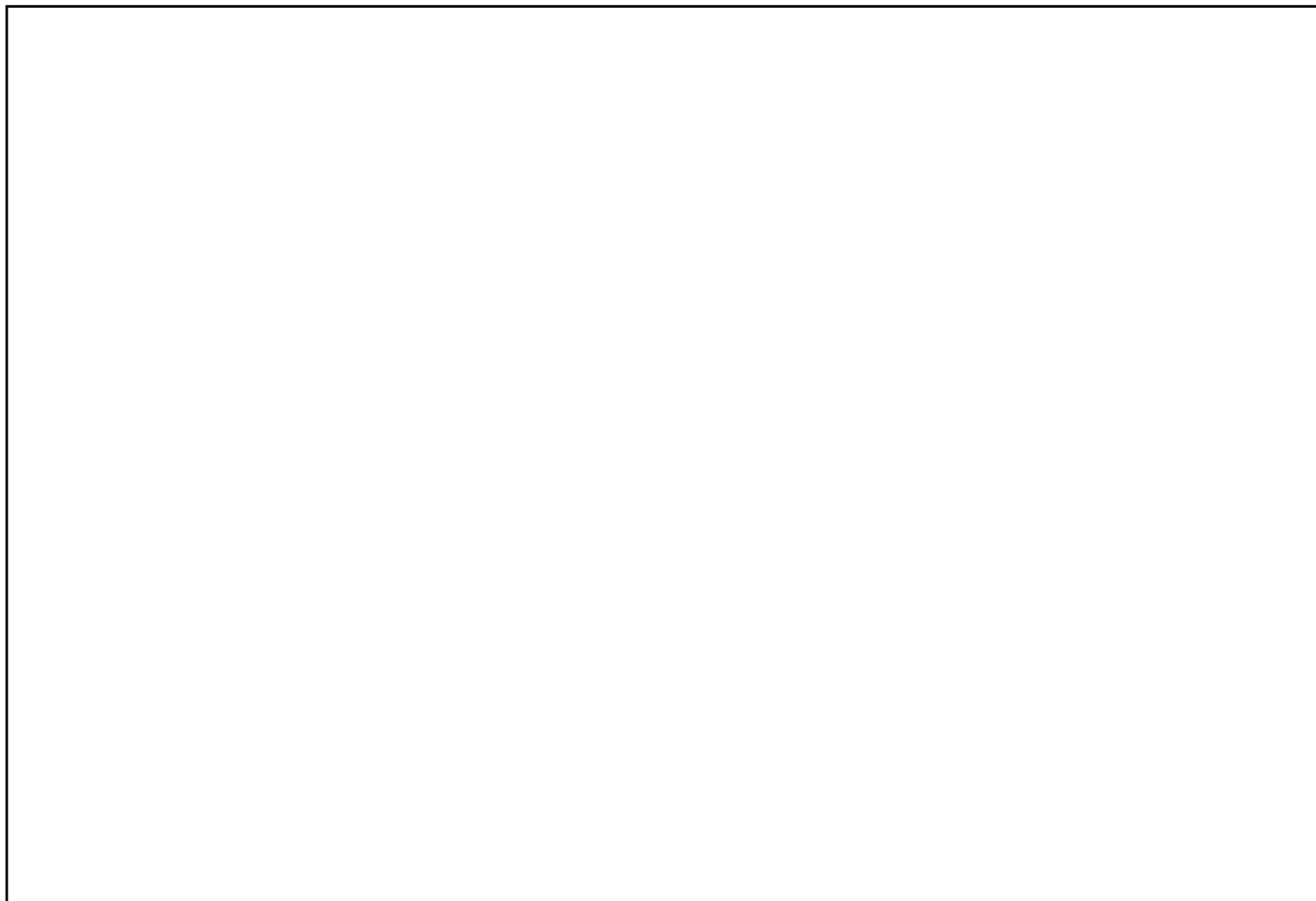
Activity Page 7.1

Use with Lesson 7.

Lesson 7 Check

Answer the items below to show what you have learned.

1. Which of the following is **evidence** of energy transfer? Circle all that apply.
 - a) a ball sitting at the top of a ramp
 - b) the sound from a vibrating tuning fork
 - c) a lighted wall across the room from a lamp
 - d) a crater produced by a meteorite impact
2. Draw a picture showing **energy transfer** from one object to another object by heat or electricity. Write a caption on the lines below to explain your drawing. Use the word **evidence** in your caption.



Name _____

Date _____

Activity Page 8.1 (Page 1 of 3)

Use with Lesson 8.

Investigating Energy Transfer

Station 1: Light Transfers Energy

STEP 1: Turn the flashlight on, and shine it at the wall so that its beam passes above the plate of chalk powder.

STEP 2: Gently dip the paintbrush bristles into the plate of chalk powder. Be careful to not make a mess!

STEP 3: Tap the brush gently with your free hand so the chalk powder falls back onto the plate. Watch as the chalk falls between the flashlight and the wall.

STEP 4: Describe what you see happen in terms of motion energy, chemical energy, electrical energy, and light energy.

STEP 5: Leave the station ready for the next group.

- Turn the flashlight off.
- Place the paintbrush back on the table.
- Be sure to let your teacher know if there is not enough chalk powder left on the plate. Other groups will need to repeat the same activity after you!

STEP 6: Answer the questions below about what you observed. Repeat the investigation if you need to.

1. Can you see a beam of light between the flashlight and the wall without the chalk dust?

2. How does the chalk dust change what you are able to observe?

3. What evidence did you observe that energy transferred from place to place?

Station 2: Heat Transfers Energy

SAFETY NOTE: Do not touch the hot plate or the beaker.

STEP 1: Use the tongs to place four ice cubes from the icebox/cooler into the beaker.

STEP 2: Watch what happens to the ice cubes.

STEP 3: Describe what you see happen in terms of electrical energy and heat energy.

STEP 4: When you are finished observing, let your teacher know to ready the station for the next group.

STEP 5: Answer the questions below about what you observed. Repeat the investigation if you need to.

- 1. What would happen if the temperature of the hot plate was decreased? How might this change the result?

- 2. Would the results change if you added more ice cubes? Why or why not?

- 3. What evidence did you observe that energy transferred from place to place at this station?

Station 3: Electricity Transfers Energy

SAFETY NOTE: Do not handle the surge protector power cord that is plugged into the wall electrical socket.

STEP 1: Observe the electronic device sitting on the table. Unplug the device from its charging cord. Notice what happens. Plug the charging cord back into the device. Notice what happens.

STEP 2: Trace the cord all the way to the surge protector. Switch the surge protector into the *off* position. Study the electronic device. Switch the surge protector back to the *on* position. Notice what changes.

STEP 3: Describe what you see happen in terms of electrical energy and stored energy.

STEP 4: Prepare the station for the next group.

- Plug the device back in (if it is unplugged).
- Turn the surge protector to the *on* position.
- Place the device on the table.

STEP 5: Answer the questions below, and repeat the investigation if you need to.

1. What causes a change in the device?

2. What happens when you turn the surge protector off? What happens when you turn it on?

3. What would happen if there were not a wire connecting the surge protector to the device?

4. What evidence did you observe that energy transferred from place to place at this station?

Name _____

Date _____

Activity Page 9.1

Use with Lesson 9.

Examples of Energy Transfer

You can observe examples of energy being transferred every day.

Identify and record some real-life examples in the table below.

Type of Energy	Description of Energy Transfer
Sound	
Light	
Heat	
Electricity	

Name _____

Date _____

Activity Page 9.2 (Page 1 of 2)

Use with Lesson 9.

Claims, Evidence, and Reasoning About Energy Transfer

Part 1

Let's take a moment to review the important terms **claims**, **evidence**, and **reasoning**:

1. Claim:

What is a **claim**?

Why do people make **claims**?

2. Evidence:

What is **evidence**?

What are some types of **evidence**?

3. Reasoning:

Describe an example of scientific **reasoning**.

Why do you think people use **reasoning** in science?

Part 2

Now it's time to write a claim of your own.

1. Choose one example of energy transfer that you have learned about or investigated. Describe an example of how this form of energy transfers from one place to another.

2. What kind of evidence (data, observations, facts) was there that energy transfer took place?

3. Write a scientific claim about energy transfer. Follow this model: "I know _____ because _____."

Name _____

Date _____

Activity Page 10.1

Use with Lesson 10.

Lesson 10 Check



1. What two objects are about to collide in the picture above?

2. What form of energy can be observed before the collision happens?

3. What forms of energy would you expect to observe as a result of this collision? Support your answer with evidence.



4. What two objects are about to collide in the picture above?

5. What form of energy can be observed before the collision happens?

6. What forms of energy would you expect to observe as a result of this collision? Support your answer with evidence.

Name _____

Date _____

Activity Page 11.1

Use with Lesson 11.

Investigating Collisions (Day 1)

Predictions

Plan your investigation by completing the items below.

1. What do you want to find out? (Example: I want to find out what happens to energy when objects collide.)

2. What materials will you use for your investigation?

3. How will you make them collide?

4. Make a prediction. What do you think will happen when the objects collide?

5. What evidence might you observe that indicates energy transfers from one object to another?

Name _____

Date _____

Activity Page 11.2 (Page 1 of 2)

Use with Lesson 11.

Investigating Collisions (Day 2)

Testing and Observation

Complete your investigation by completing the items below.

1. Use the materials you chose on Day 1, and build your ramp.
2. Conduct the investigation.
 - Place the objects on the ramp.
 - Roll the top objects down the ramp, and observe what happens.
3. Record your observations in the table below under Test 1.

Test	Observations of Energy Transfer
Test 1	
Test 2	

4. Change one variable (i.e., height or speed) in your design. Which variable will you change?

5. Make a new prediction. What do you expect to see now that you changed this variable?

6. Build your second design.
7. Perform the test again with the changed variable.
8. Record the new observations for Test 2 in the table.

9. Study the observations in the table. Answer the following questions:

- Was any energy transferred? Use evidence to support your answer.

- What are the differences between the two tests?

- Do you see any patterns? If so, what are they?

- What is the cause-and-effect relationship that you see? Write your answer as an *If, Then* statement.

If _____ ,

then _____

10. Evaluate the predictions you made before each test. Were your predictions accurate? Why or why not?

Name _____

Date _____

Activity Page 12.1

Use with Lesson 12.

Lesson 12 Check

Answer the questions to show what you know from this lesson.

1. What is the Big Question for this lesson?

2. Name a device that converts stored chemical energy of natural gas to heat energy to help people cook food.

3. What energy transformation(s) takes place in a smoothie blender?

4. What problem does a wind-up kitchen timer solve? Use the word *solution*, as well as *want* or *need* (or both), in your answer.

5. Describe two energy transformations that happen in a wind-up kitchen timer.

6. How do people use a conversion from electrical energy to light energy in helpful ways in a kitchen or school classroom?

Name _____

Date _____

Device Design Proposal (Day 1)

Plan a device to solve a problem using an energy transformation.

Problem to Be Solved: _____

Device Name: _____

Energy Transformation:
Initial Form(s) of Energy

Final Form(s) of Energy

How will your team’s device solve the problem by transforming (converting) energy?

How will you know whether your device solves the problem or not?

Criteria: _____

Constraints (limitations): _____

Materials: Circle the materials your team will use. Write in any additional materials used on the lines below.

aluminum foil	cardboard tubes	cups	springs
ball	clear plastic wrap	glue	sticks
blocks	containers	ramps	string
boxes	craft paper	rubber bands	tape

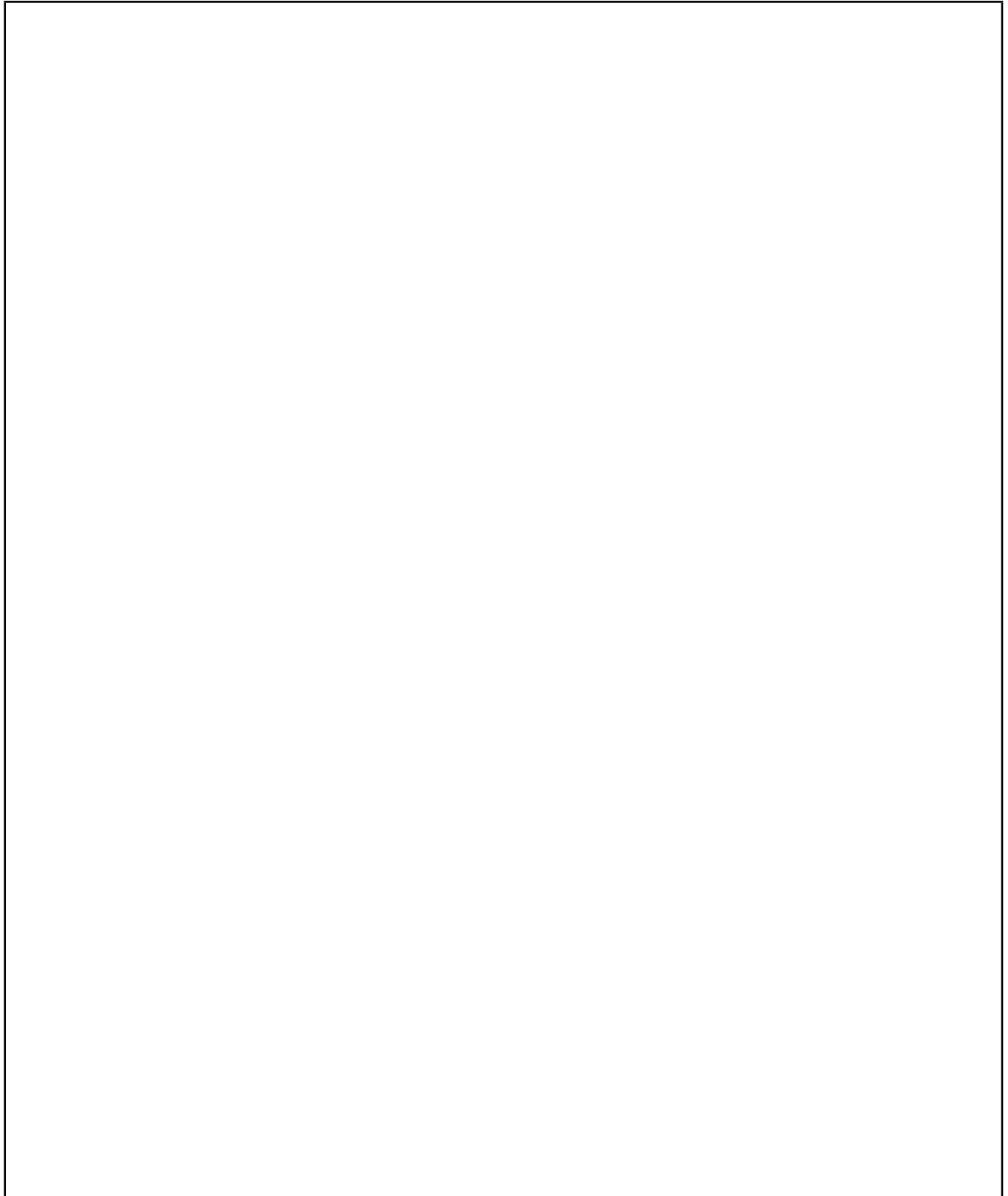
Name _____

Date _____

Activity Page 13.1 (Page 2 of 2)

Use with Lesson 13.

Draw your device, and add labels to help show how your device will work.

A large, empty rectangular box with a thin black border, intended for a student to draw a device and add labels to show how it works.

Device Test Results (Day 2)

Trial Test your device multiple times.	Results Briefly describe whether your device worked or not.	Observations About Energy Transfer and Transformation What evidence do you have that your device worked?	Improvements or Fixes How can you refine your device to work better in the future?
1.			
2.			
3.			

Make a claim about whether testing your device is important or not. Use your observations as evidence and reasoning to support your claim.

Name _____

Date _____

Activity Page 13.3

Use with Lesson 13.

Device Presentation Plan (Day 3)

Review your work on Activity Page 13.2 (Day 2). Summarize your work so far by answering these questions.

Problem to Be Solved: _____

Device Name: _____

Energy Transformation:

Initial Form(s) of Energy

Final Form(s) of Energy

How well did your device solve the problem? _____

How did you build your device? _____

What were the results of your tests? _____

How did you refine your device? _____

Describe whether your revisions made your device work better or worse. Support your ideas by summarizing observations and evidence from each of your test trials.

Device Presentation Scoring Guide (Day 4)

Use this guide as you listen to your classmates present their devices. For each line of the guide, give the team a score that reflects how well their presentation covered that section. For example, a score of 3 for “Defines the problem to be solved” would mean the presentation clearly told others of the problem to be solved.

Description	3	2	1
Defines the problem to be solved			
Meets the criteria defined for the device			
Meets the constraints or limitations defined for the device			
Identifies the initial and final forms of energy in the energy transformation			
Describes how the solution converts energy from one form to another to solve the problem			

I like your group’s design because _____

What other questions would you ask about the device?

Name _____

Date _____

Activity Page 13.5 (Page 1 of 2)

Use with Lesson 13.

Energy Vocabulary Crossword Puzzle

Use the words in the word bank to complete the crossword puzzle. Review the cards in your Core Vocabulary deck before you begin.

light	change	evidence	energy	motion	forms of energy*	position
sound	convert	heat	stored energy*	energy transfer*	electricity	
speed	energy of motion*	distance				

*Spaces that appear between words in terms above do not appear in the puzzle.

Across

2. when energy moves from one object to another or from one place to another
4. a type of energy that makes things hot
8. different types of energy, such as sound, heat, or light
11. the energy an object has while it is moving
12. to change
13. form of energy that powers lights in modern homes
14. how fast an object is moving
15. anything that helps prove or disprove an idea
16. to become different

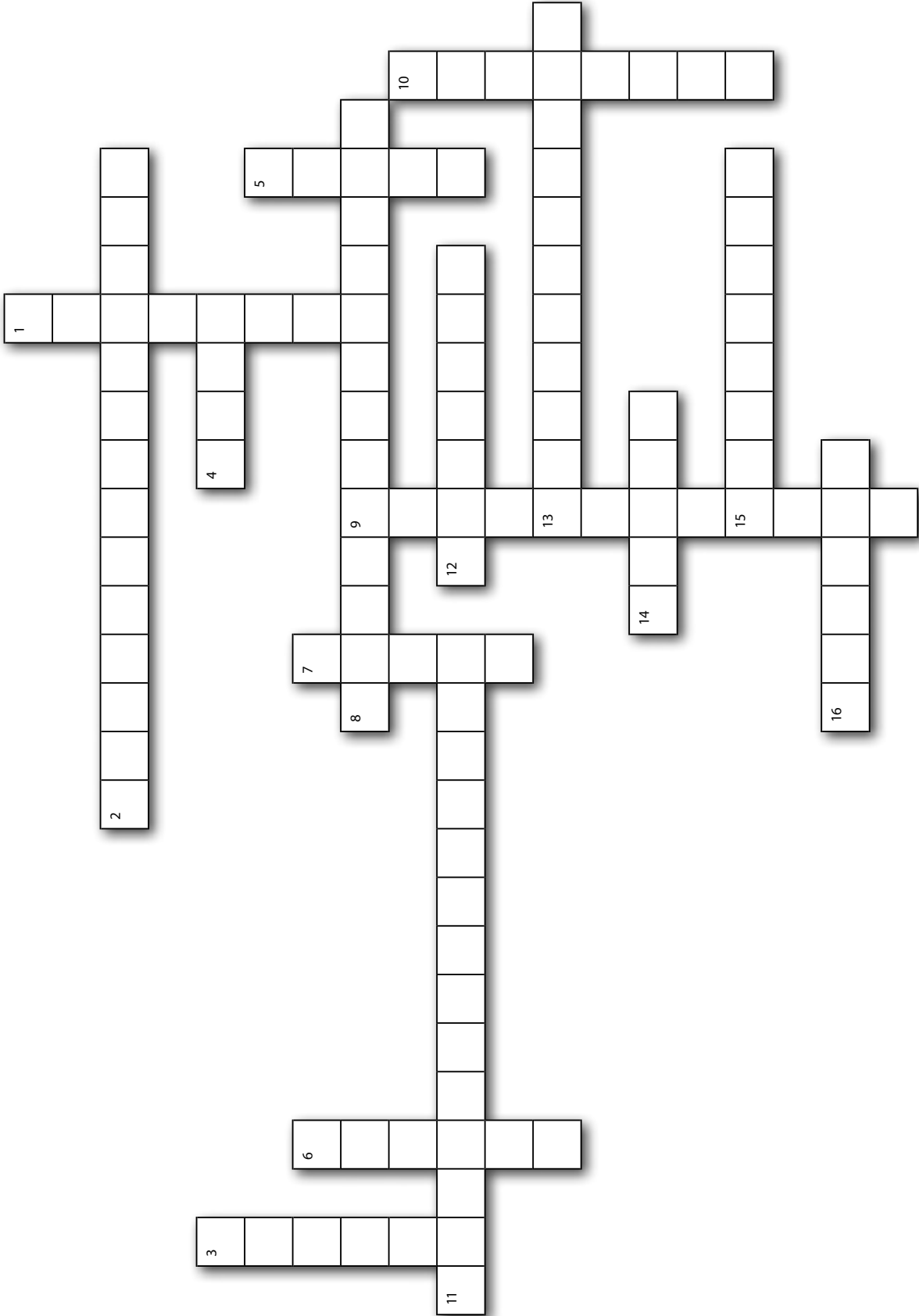
Down

1. where something is in space
3. the process of an object changing position
5. a type of energy you can see with your eyes
6. the ability to cause change
7. a type of energy you can hear with your ears
9. energy that has the potential to cause change at a later time
10. how far apart objects are

Name _____

Date _____

Energy Vocabulary Crossword Puzzle



Name _____

Date _____

Activity Page 13.6

Use with Lesson 13.

Energy Vocabulary Review

Complete each sentence with the correct Core Vocabulary term or phrase. Not every word in the word bank will be used, and some may be used more than once. Review the cards in your Core Vocabulary deck before you begin.

change	energy	forms of energy	stored energy	evidence	heat	light
motion	position	sound	transfer	collision	electricity	observation
model	speed	distance	energy of motion	convert	energy transformation	

1. When you add hot soup to a cold bowl, _____ energy transfers from the soup to the bowl.
2. If a book is falling off a shelf, the book has _____ because it is changing its _____.
3. Playing a drum produces _____, which is a form of energy that you can hear.
4. Energy can _____ from one object to another object.
5. When a bowling ball hits the bowling pins, a sound rings through the bowling alley. The change from motion energy to sound energy is an example of a(n) _____.
6. Energy is the ability to cause _____.
7. Heat, light, and sound are examples of _____.
8. A marble at the top of a ramp has _____, because at any moment it can move down the ramp.
9. Computers are powered by _____.
10. _____ is a measure of how fast an object is moving, and _____ is a measure of how far apart objects are.
11. When light energy is converted to heat energy, this is known as _____.

Name _____

Date _____

Activity Page UR.1

Use with Unit Review.

Energy's Big Questions

The table below contains most of the Big Questions you have explored in the unit *Energy Transfer and Transformation*.

Circle the question that was assigned for you to answer.

Where can we observe evidence of energy causing change?	What evidence shows that energy is transferred from place to place?
What are some forms of energy?	How is energy involved in collisions?
How are energy, change, and movement of objects related?	What happens when objects collide?
How are energy and speed related?	How are collisions predictable?
What evidence shows that sound transfers energy from one place to another?	How do energy transformations help people?
What evidence shows that light, heat, and electricity transfer energy from place to place?	How did Thomas Edison use his knowledge of energy transfer and transformation to solve problems?

Write three or four sentences to answer the Big Question that was assigned to you and your partner.

Prepare a rough draft of your answer first on scrap paper, and then write your final draft below. Underline any terms in your answer which have a card in your Core Vocabulary deck.

Name _____

Date _____

Unit Assessment: What Have I Learned About Energy?

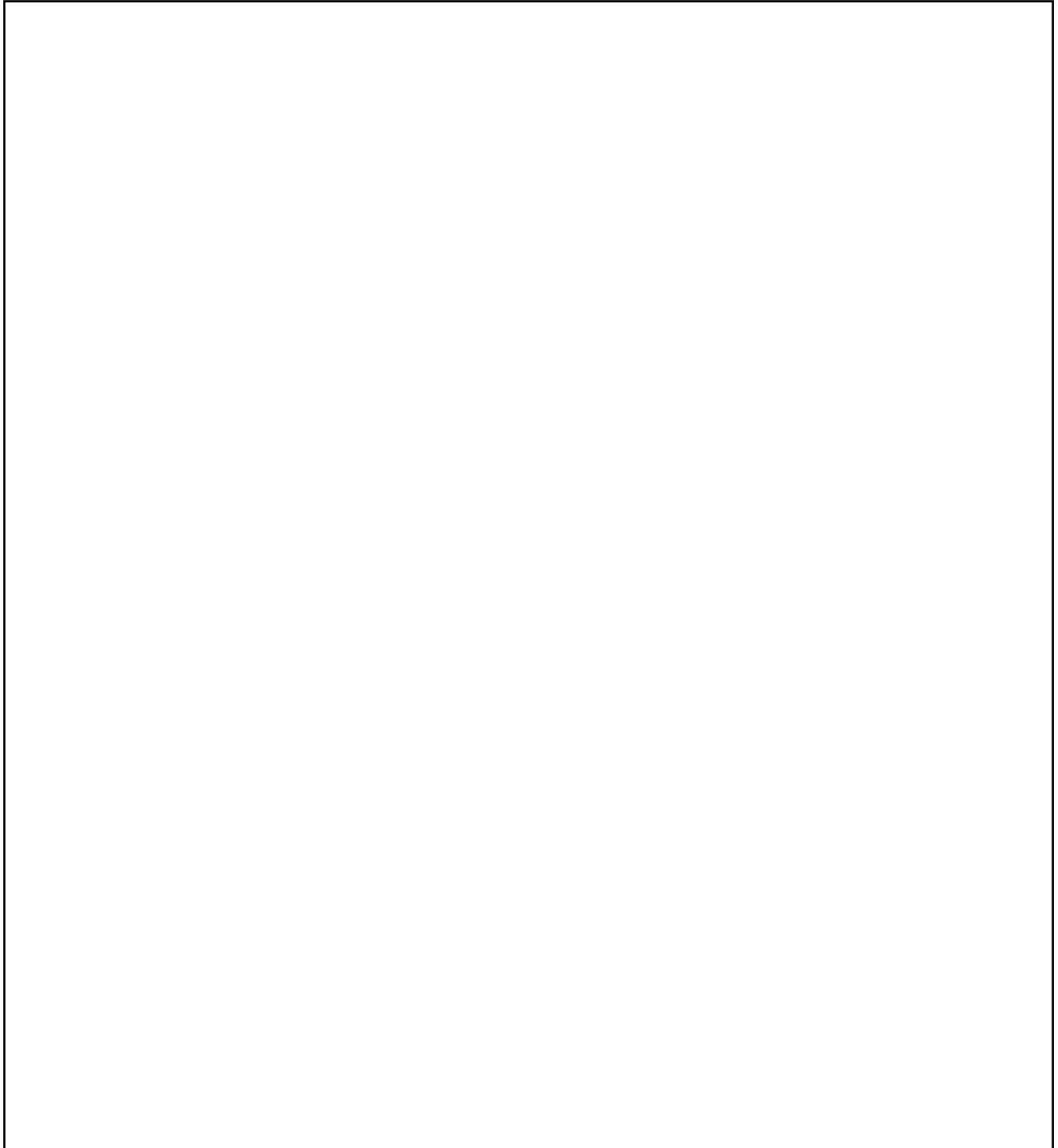
Answer the items below to show what you have learned.

1. Which sentences describe evidence of energy causing change? Circle the letter for each correct answer.
 - a) A basketball smashes into a backboard.
 - b) Electricity jumps from your fingertip to a doorknob, giving you a shock.
 - c) When the school bus starts up, you can hear the engine make a sound.
 - d) A stick of dynamite explodes.
2. Write the form or forms of energy described in each sentence below. Some sentences may describe more than one form of energy.

light	heat	motion	sound	electrical
-------	------	--------	-------	------------

- a) The sun is shining on a nice summer day. _____
- b) A firework explodes in the sky. _____
- c) You kick a soccer ball at the goal. _____
- d) You're happy and you know it, so you clap your hands. _____
- e) You buckle your seat belt, and the school bus takes off to the school. _____
- f) You turn on a battery-powered flashlight. _____

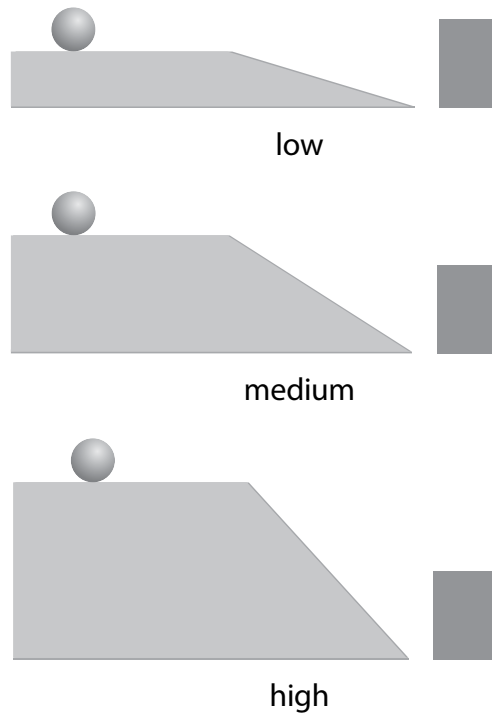
3. Draw a model of energy causing a change. Your drawing may show a before-and-after transformation, or you can use your imagination. Identify the type of energy causing the change. Write a sentence describing the change.



Type of energy: _____

Describe the change: _____

4. You are setting up an investigation to show the relationship between the speed of a moving object and its energy. You have a ball and a block. You also have three different types of ramps: a low-height ramp, a medium-height ramp, and a high-height ramp.



Which ramp will result in the greatest amount of change? Explain your thinking using words from your Core Vocabulary deck.

5. Which ramp will result in the least amount of change? Explain why using words from your Core Vocabulary deck.

6. What is the relationship between the speed of an object and its energy of motion? Use evidence and examples you have learned during this unit to support your explanation.

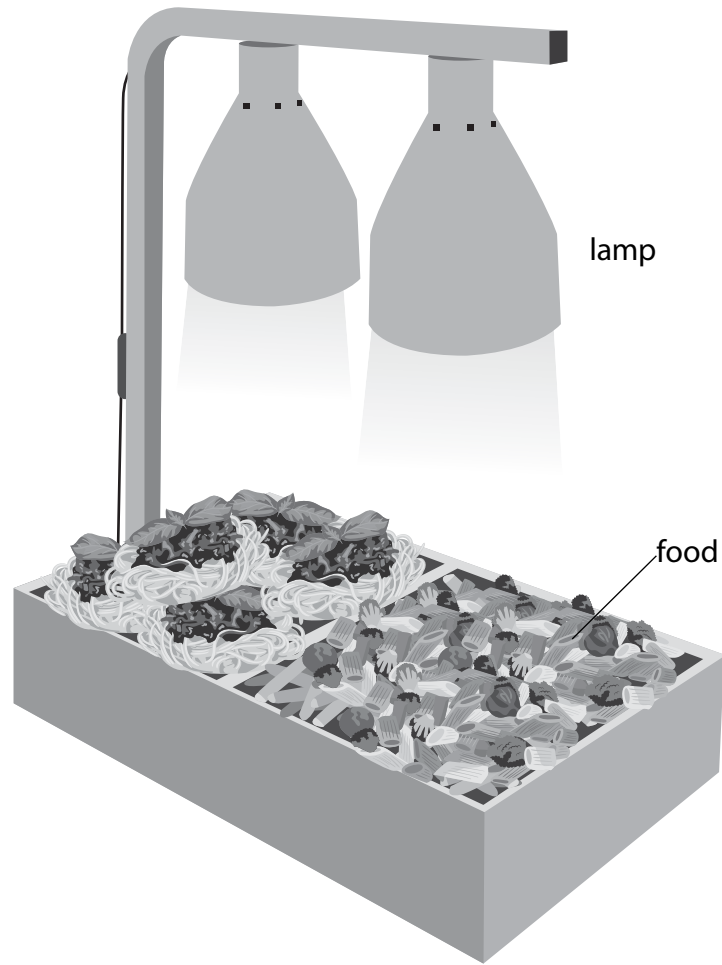
7. Maria has been studying sound energy at school. She has written an explanation of sound using an example from her experience.

Maria says, "Sound energy only travels over long distances. When I am on the playground, I can hear the bell that rings from across the field that lets me know recess is over."

Do you agree with Maria? Use your own evidence to support your answer.

8. Which statements are evidence that energy has been transferred from object to object or place to place? Circle the letter for each correct answer.

- a) Your friend kicks a goal while playing soccer.
- b) Gravity pulls on an apple, but it doesn't fall out of a tree.
- c) You push on the school door, but it stays closed.
- d) You hear a bell ringing from far away.
- e) You flip a light switch, and the room lights up.
- f) A person pulls a wagon down a street.
- g) The backpack you left in the car gets hot on a sunny day.



The school cafeteria keeps cooked food under lamps until students pick it up to eat. The top of each portion of food stays warmest.

9. What two kinds of energy are the lamps transferring to the food?

10. What evidence would support your claims about the types of energy used in the cafeteria example above? Use terms from your Core Vocabulary deck in your answer.

11. You roll a toy car down a ramp into a stack of four blocks. The top block falls off the stack.

You add some weight to the toy car and repeat the test, changing **ONLY** the weight of the car. This time, the top two blocks fall off the stack.

Based on this pattern, explain the result in terms of energy change.

What can you predict if even more weight is added to the toy car for the next test? Use terms from your Core Vocabulary deck in your answer.

12. Your teacher holds a ball up and drops it. She asks what happened to the energy of the ball. Here are the answers from four students.

Student A: The stored energy of the ball becomes motion energy.

Student B: The chemical energy of the ball becomes motion energy.

Student C: Heat transforms into motion energy.

Student D: Gravity is transferred into heat energy.

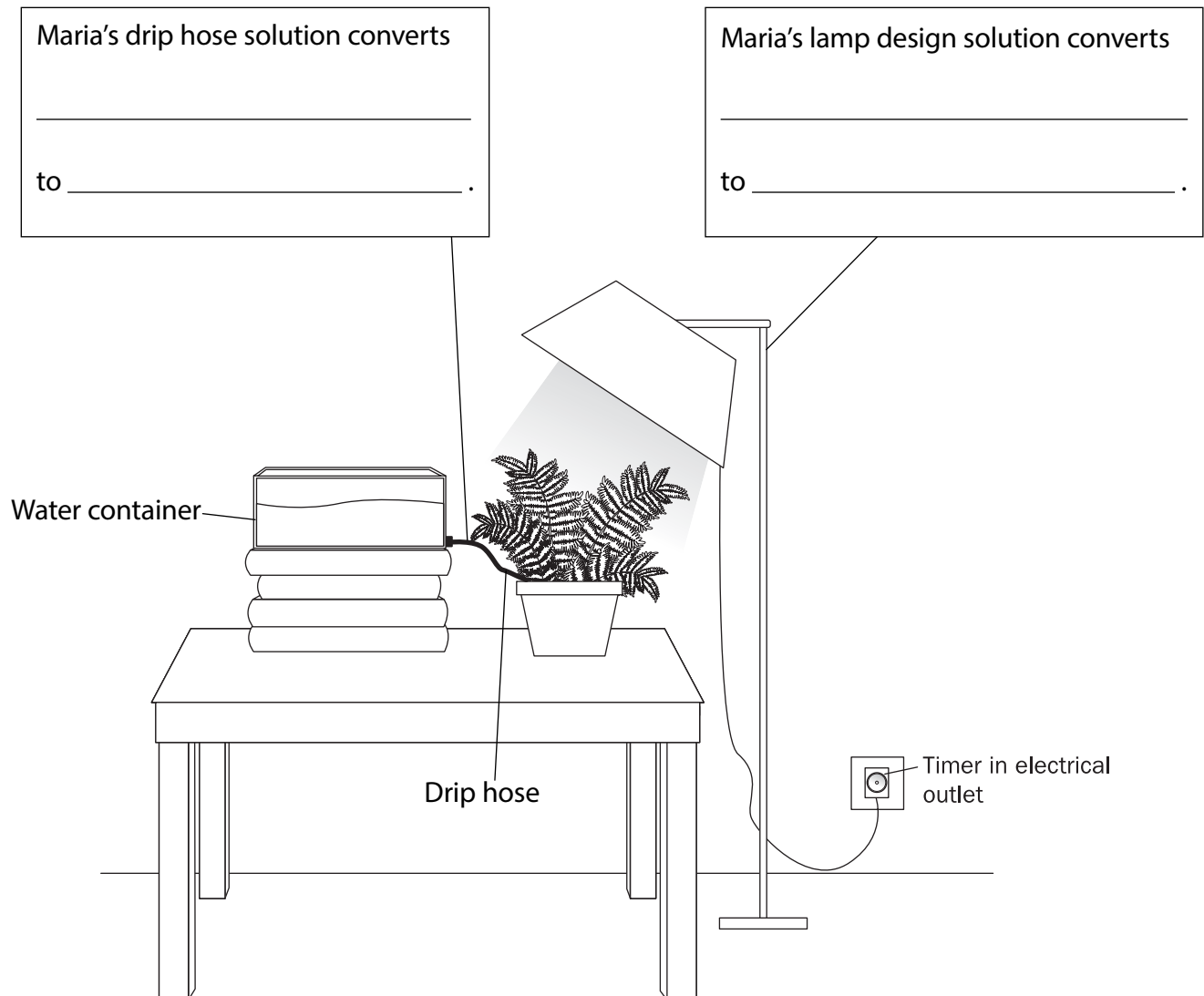
Which student is correct? Explain your reasoning using vocabulary, such as *position*, and examples that you have learned during this unit.

13. Your teacher is leaving over the weekend, but the house plants in his classroom can't be left without water or light. Describe a device that could solve this problem. The solution would need to automatically provide water **and** light to a plant when people are away.

14. If you were to build your device for your teacher, how would you test it to see if it works, and how might you improve your design based on your test results?

15. A student named Maria made a sketch of her solution to the same problem. Maria's solution includes plugging a lamp into a timer that works in a wall socket. At the same times each day, the timer switches the lamp on and off. Her solution also includes a container of water that allows water to drip slowly through a hose down into the planter. The container of water sits on a stack of books so it is positioned higher than the planter.

Complete the labels on Maria's diagram to identify the types of energy that are converted in her design.



Activity Pages Answer Key: Energy Transfer and Transformation

This answer key offers guidance to help you assess your students' learning progress. Here, you will find descriptions of the expectations and correct answers for each of the Activity Pages of this unit.

Energy Scavenger Hunt (AP 1.1) (page 101)

- Students should include examples of three changes and a brief explanation of how each change occurs.
- Accept any reasonable student questions that are based on the examples the students wrote.

Surprise! (AP 2.1) (page 102)

1. Light energy transfers (moves) into the room.
2. Electrical energy transforms into light energy as the light is turned on.
3. Sound energy is made by the people talking and the noisemakers.
4. Light and heat energy are released by the candle.

Energy Causes Change (AP 2.2) (page 103)

- Students should correctly identify a change caused by the energy they circled in the word box, such as stored energy changing to motion energy when a person walks across the room.
- Before and after drawings should be correct and include the form of energy causing the change, such as drawing the candle without a flame and then a lit candle.
- Students should identify both the cause and the effect. For example, a match can be struck to light the candle, and the effect is light and heat.

On the Move (AP 3.1) (page 104)

- Students should identify an object that moves.
- Before and after drawings should be correct and show the change.
- Students' descriptions should include correct before and after descriptions based on their drawings.

Ramp It Up! (Day 1) (AP 4.1) (page 105)

Step 5 Students should complete the table for each trial. The first trial should show a lower starting height, less speed, less cup movement, and less energy. The second trial should show a higher starting height, greater speed, more cup movement, and more energy.

Step 6 Students should use their results to note the relationship between energy and speed, citing evidence to support their explanation. A steeper ramp makes the ball roll faster. The greater speed has more energy when it hits the cup, so it moves farther.

Drop It (Day 2) (AP 4.2) (page 106)

Step 6 Students should complete the table for each trial. The first trial should show a lower starting height, less speed, less impact, and less motion energy. The second trial should show a higher starting height, more speed, greater impact, and more motion energy.

Step 7 Students should use their results to describe the relationship between energy and speed, citing evidence to support their explanation. A drop from a greater height makes the ball drop faster. The greater speed has more energy when it hits, so the impact makes a bigger crater.

Lesson 6 Check (AP 6.1) (page 107)

Students should note that the pencil transfers energy of motion to the bottom of the cup and that the sound of the tapping is evidence of energy transfer. Students should also note that sound from the tapping comes out of the top of the cup and that the movement of the paper is evidence of energy transfer.

Lesson 7 Check (AP 7.1) **(page 108)**

1. b, c, d
2. Student drawing should show a clearly captioned and explained energy transfer by heat or electricity. The term *evidence* is used in the caption.

Investigating Energy Transfer – Station 1: Light Transfers Energy (AP 8.1) **(page 109)**

Step 4 Students should note that light energy is transferring from the flashlight to the wall.

1. Students should note that the flashlight batteries transfer chemical energy to light.
2. Students should note that they cannot see the beam of light without the chalk dust.
3. Students should note the chalk dust gives the light energy something to bounce off.
4. Students should note the evidence of energy transfer is the light shining on the chalk dust and wall.

Investigating Energy Transfer – Station 2: Heat Transfers Energy (AP 8.1) **(page 110)**

Step 3 Students should note that electrical energy is transferring to the hot plate. Then the heat energy is transferring from the hot plate to the beaker and then to the ice cubes.

1. Students should note that less heat energy would flow from the hot plate to the beaker, causing the ice cubes to melt slower.
2. Students should note that more ice cubes would take longer to melt because more heat energy would be needed.
3. Students should note the melting of the ice cubes is evidence that energy is being transferred from place to place.

Investigating Energy Transfer – Station 3: Electricity Transfers Energy (AP 8.1) **(page 111)**

Step 3 Students should note the electrical energy is transferring from the outlet to the surge protector and then to the device.

Station 3, continued

1. Students should note that the electrical energy flowing from the surge protector to the device causes a change.
2. Students should note that when the surge protector is off, no electrical energy flows and that when it is on, electrical energy flows.
3. Students should note that the electrical energy would not flow if there were no wire.
4. Students should note the device is signaling when electrical energy is flowing into the device.

Examples of Energy Transfer (AP 9.1) **(page 112)**

Students should include examples from all four types of energy listed and should include an accurate description of the transfer.

Claims, Evidence, and Reasoning About Energy Transfer (AP 9.2) **(pages 113–114)**

Part 1

1. **Claim:** A claim is a statement that declares a fact or presents an argument that has not been proven. People make claims as a key step to making a scientific examination.
2. **Evidence:** Evidence is proof that supports or refutes a claim. An example of evidence would be the results from a science investigation.
3. **Reasoning:** Student examples of reasoning should show a clear and logical progression. People use reasoning in science because they seek to reach testable truths.

Part 2

1. Student examples should indicate a clear transfer of energy, such as hot soup being poured into a bowl and subsequent temperature changes.
2. Student evidence should refer back to their learning or investigation, such as noting that the bowl that the hot soup is poured into gets hot, indicating the transfer of heat energy.
3. Student responses should be properly supported and in the form of “I know . . . because . . .,” such as, “I know the heat energy in the soup transferred to the bowl because the bowl is now hot.”

Lesson 10 Check (AP 10.1) **(page 115)**

1. The soccer player's foot and the soccer ball are about to collide.
2. The form of energy before the collision is energy of motion.
3. There would be energy of motion, which you could see as the ball moves. There would be sound energy that you could hear. There would be a tiny amount of heat energy from the collision.
4. The drumsticks and drum are about to collide.
5. The form of energy before the collision is energy of motion.
6. There would be energy of motion as the drumsticks bounce back up. There would be sound energy, which you could hear. There would be a tiny amount of heat energy from the collision.

Investigating Collisions (Day 1): **Predictions (AP 11.1)** **(page 116)**

Sample responses:

1. We want to find out how energy causes changes during a collision and if the amount of energy changes with speed.
2. We will use a ramp and send a toy car down the ramp. It will collide with a can, and we can see how far the can moves.
3. The toy car will collide with the can.
4. I predict the toy car will push the can back.
5. We will roll the car down the ramp to observe it. We will measure the distance the can moves by using car lengths.

Investigating Collisions (Day 2): Testing and Observation (AP 11.2) **(pages 117–118)**

3. Student observations should show that the object travelling down the ramp collided with and moved the object at the bottom of the ramp.
4. Students should identify one independent variable to change, such as the height of the ramp or the weight of an object.
5. If the toy car has more weight, it will move the can farther back when they collide.

(Day 2), continued

9.
 - Energy of motion was transferred from the toy car to the can.
 - Student observations between the two tests should be consistent with the change in variables, e.g., adding more weight to the car or height to the ramp caused a collision with more energy, resulting in the effect of the can moving farther.
 - The more energy added before the collision, the more energy we saw during the collision.
 - If more energy is added to a collision (cause), then we will see more movement (effect) after the collision.
10. We predicted adding more weight to the car would result in more energy in the collision. The prediction was accurate as the can moved farther after the collision in the second test.

Lesson 12 Check (AP 12.1) **(page 119)**

1. How do energy transformations help people?
2. an oven or stove
3. Electrical energy is converted to energy of motion and sound energy.
4. A kitchen timer provides the solution of what to do when you need to cook something a specific length of time so it does not overcook or undercook.
5. The stored energy of the spring inside the timer changes to energy of motion. When the bell rings, energy of motion changes to sound energy.
6. Accept all reasonable responses, such as, "The lights in the classroom allow the change of electrical energy into light energy so students can read their books."

Device Design Proposal (Day 1) (AP 13.1) **(pages 120–121)**

- The student problem to be solved should be their assigned problem.
- Students should identify the initial and final forms of energy their device will transform.
- Student descriptions of their device should include how the device solves the problem and some reference to how the energy will be transformed.
- Accept all plausible criteria and constraints.

(Day 1), continued

- Students should circle or list any materials they will use in their device.
- Student drawings of their device should include clear incorporation of their materials.

Device Test Results (Day 2) (AP 13.2) **(page 122)**

- Student results and observations may vary, but there should be improvements or fixes to their devices based on the test results.
- Claims should indicate that testing their device was an important step in improving the device.

Device Presentation Plan (Day 3) (AP 13.3) **(page 123)**

- Students should identify the problem, criteria, and energy transformation from Device Design Proposal (AP 13.1).
- Students should provide a clear description of how they built their device.
- Students should refer to Device Test Results (AP 13.2) for initial information about their test results, which they can then expand on.
- Students should refer to Device Test Results (AP 13.2) for initial information about their refinements to their device, which they can then expand on.

Device Presentation Scoring Guide **(Day 4) (AP 13.4)** **(page 124)**

Students should complete the scoring guide for the device. Students should also identify what they liked in the other group's device, as well as other questions they may have had about the device.

Energy Vocabulary Crossword Puzzle (AP 13.5) **(pages 125–126)**

ACROSS:

2. energy transfer

4. heat

8. forms of energy

11. energy of motion

DOWN:

1. position

3. motion

5. light

6. energy

(AP 13.5), continued

12. convert

13. electricity

14. speed

15. evidence

16. change

7. sound

9. stored energy

10. distance

Energy Vocabulary Review (AP 13.6) **(page 127)**

1. heat **2.** energy of motion, position **3.** sound
4. transfer **5.** energy transformation **6.** change
7. forms of energy **8.** stored energy **9.** electricity
10. speed, distance **11.** energy transformation

Energy's Big Questions (AP UR.1) **(page 128)**

Students should circle their assigned question. Student responses should reflect the content and experiences from the lesson(s) from which the Big Question originates. Vocabulary terms from their Core Vocabulary decks should be incorporated in their written responses and underlined.

Consider student responses as follows:

Above Average—Written responses clearly identify examples and ideas that help answer the Big Question. Examples are clearly linked to the Disciplinary Core Ideas learned, and Core Vocabulary is incorporated into the response and underlined.

Average—Written responses may include examples of learning about the Big Question but do not clearly link to the DCIs learned during the lessons. Core Vocabulary is incorporated into the response.

Adequate—The Big Question is answered, but not using examples from the lessons or Student Reader chapters. Core Vocabulary may be listed but is not used in a complete sentence, and/or a minor misunderstanding about the Disciplinary Core Ideas is present.

Inadequate—Responses do not relate to the Big Question, or responses include a clear misunderstanding of the Big Question or DCI.

Unit Assessment: Teacher Evaluation Guide

Teacher Directions: The Unit Assessment on pages 129–136 is designed as a fifty-point test. Through this assessment, students demonstrate their overall learning of the unit’s Learning Objectives. CKSci Unit Assessments typically range from ten to fifteen questions in the upper elementary grades, which can be answered in a longer, single classroom session or administered in two sittings.

Items with simpler answers that assess knowledge but not the deeper understandings of the content, such as multiple choice or short answers, are weighted differently and are worth fewer points. Assessment items that require more complex thinking and a deeper understanding of the content, such as writing explanations or identifying multiple relationships, are worth more points. Items that require synthesis of content and other student knowledge are weighted with more points as well. Some test items encourage students to use their Core Vocabulary decks as a reference source for terminology and concepts related to the test item.

Expected Answers and Model Responses

1.

a, b, c, d

(2 points)
2.

a) light and heat

b) light, sound (Heat and motion also should be considered correct.)

c) motion, sound

d) motion, sound (Heat should also be considered correct.)

e) motion, sound (Electrical energy should also be considered correct.)

f) electrical energy, light (Heat should also be regarded as correct.)

(6 points)
3.

(4 points)

Above Average	Student response includes labels and/or clear descriptions of what is happening in the illustration. The type of energy causing the change is identified, and student clearly describes the change.
Average	Student response includes an accurate drawing with labels. The type of energy causing the change is identified, and student describes the change.
Adequate	Student response includes a drawing. The type of energy causing the change is identified, and/or student describes the change.
Inadequate	Student response includes an inaccurate or no drawing. The type of energy causing the change is not identified or is incorrect. Student does not describe the change.

4. Student response should note that the highest ramp will result in the greatest energy of motion when the ball contacts the block. When the energy is transferred to the block, it will move it the farthest. (3 points)
5. Student response should note that the lowest ramp will result in the least energy of motion when the ball contacts the block. When the energy is transferred to the block, it will move it the least distance. (3 points)
6. Student response should note that as the speed of an object increases, the amount of its energy of motion increases. (3 points)
7. Student response should include evidence that sound energy can travel over long or short distances. (3 points)
8. a, d, e, f, g (3 points)
9. The food lamps transfer light and heat energy to the food. (2 points)
10. Accept all plausible responses. Student responses providing evidence that the lamps transfer light and heat could include: the food stays hot on the counter, you can feel the heat coming from the lamp, and you can see the light with your eyes. (3 points)
11. Student response should note that the more weight in the car, the more stored energy it probably must have that is converted to motion energy. Based on this pattern, the car with more weight will knock more blocks over than a car with less weight. (3 points)
12. Student response should note that Student A is correct because the ball has stored energy while it is positioned in the teacher's hand. This stored energy transforms into motion energy when she drops the ball. (3 points)
13. Accept all plausible student descriptions of a device that automatically provides water and light to a plant. (4 points)
14. It could be tested by making sure the plant is healthy and the soil is moist. It might be improved by adjusting it to get more light or water. (4 points)
15. Maria's drip hose solution converts energy of position to energy of motion (as water runs down from the container to the planter). Maria's lamp solution converts electrical energy to light energy. (4 points)

Glossary

Blue words and phrases are Core Vocabulary terms for the unit, and Student Reader page numbers are listed in parentheses. **Bold-faced words and phrases** are additional vocabulary terms related to the unit that you should model for students during instruction and that are often used within the Student Reader, and these latter terms do not have specific page numbers listed. Vocabulary words are not intended for use in isolated drill or memorization.

C

cause and effect, n. is a relationship in which one thing makes another thing happen

change, v. to become different (1)

claim, n. a statement that answers a question or poses a solution to a problem

collide, v. to come together with impact (25)

collision, n. an instance of colliding (25)

contact, n. to be physically touching

conversion, n. the process of being converted or changing form (32)

convert, v. to change form (32)

D

design problem, n. a problem for which a design solution should be applied

design solution, n. the method someone develops to solve a design problem

distance, n. amount of space between two objects

E

electrical energy, n. the flow of electrons from one location to another

electricity, n. a form of energy caused by the movement of electrons

energy, n. the ability to cause change (1)

energy change, n. the conversion of one form of energy into one or more other forms of energy

energy of motion, n. the energy an object possesses while it is moving (9)

energy transfer, n. movement of energy from one object to another or from one place to another (17)

energy transformation, n. the change of one form of energy to another form of energy (32)

engineering design, n. a process used to develop a solution to a problem (36)

evidence, n. anything that helps prove or disprove an idea

F

forms of energy, n. the different forms energy can be found in, such as light or heat

H

heat, n. a form of energy caused by the movement of atoms or molecules

L

light, n. a form of energy caused by the movement of photons, which are little packets of energy

M

model, n. a helpful tool for representing an idea or explaining a process or relationship

motion, n. the process of an object changing position (7)

O

observation, n. the act of noting or viewing something

P

position, n. the place an object occupies

prediction, n. a statement about what might or will happen

R

reasoning, n. a scientific mindset that connects claims and evidence

rotate, v. to spin

S

solution, n. a method for solving a problem

sound, n. a form of energy that comes from a vibrating object (28)

speed, n. a measurement of the distance an object travels over an amount of time (13)

stored energy, n. energy that has the ability to cause change at a later time (4)

T

transfer, v. to move from one place to another

transform, v. to change the appearance or form of something; see also **energy transformation**

V

variable, n. something that is changed or is not consistent

Classroom Safety for Activities and Demonstrations

In the Core Knowledge Science program (CKSci), activities and demonstrations are a vital part of the curriculum and provide students with active engagement related to the lesson content. The activities and demonstrations in this unit have been selected and designed to engage students in a safe manner. The activities and demonstrations make use of materials and equipment that are typically deemed classroom safe and readily available.

Safety should be a priority when engaged in science activities. With that in mind, observe the following safety procedures when the class is engaged in activities and demonstrations:

- Report and treat any injuries immediately.
- Check equipment prior to usage, and make sure everything is clean and ready for use.
- Clean up spills or broken equipment immediately using the appropriate tools.
- Monitor student behavior to ensure they are following proper classroom and activity procedures.
- Do not touch your eyes, ears, face, or mouth while engaging in an activity or demonstration.
- Review each step of the lesson to determine if there are any safety measures or materials necessary in advance.
- Wear personal protective equipment (e.g., safety goggles, aprons, etc.) as appropriate.
- Check for allergies to latex and other materials that students may have, and take appropriate measures.
- Secure loose clothing, hair, or jewelry.
- Establish storage and disposal procedures for chemicals as per their Safety Data Sheet (SDS), including household substances, such as vinegar and baking soda.

Copy and distribute the Student Safety Contract, found on the next page, for students to read and agree to prior to the start of the first unit so students are aware of the expectations when engaged in science activities.

Online Resources



For additional support for safety in the science classroom, follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Student Safety Contract

When doing science activities, I will do the following:

- Report spills, breakages, or injuries to the teacher right away.
- Listen to the teacher for special instructions and safety directions. If I have questions, I will ask the teacher.
- Avoid eating or drinking anything during the activity unless told to by my teacher.
- Review the steps of the activity before I begin. If I have questions, I will ask the teacher.
- Wear safety goggles when working with liquids or things that can fly into my eyes.
- Be careful around electric appliances, and unplug them, just by pulling on the plug, when a teacher is supervising.
- Keep my hands dry when using tools and devices that use electricity.
- Be careful to use safety equipment like gloves or tongs when handling materials that may be hot.
- Know when a hot plate is on or off and let it cool before touching it.
- Roll or push up long sleeves, keep my hair tied back, and secure any jewelry I am wearing.
- Return unused materials to the teacher.
- Clean up my area after the activity and wash my hands.
- Treat all living things and the environment with respect.

I have read and agree to the safety rules in this contract.

_____ / ____ / ____ /

Student signature and date

Print name

Dear Parent or Guardian,

During science class, we want to create and maintain a safe classroom. With this in mind, we are making sure students are aware of the expectations for their behavior while engaged in science activities. We are asking you to review the safety rules with your daughter or son and sign this contract. If you have any questions, please feel free to contact me.

_____ / ____ / ____ /

Parent or guardian signature and date

Strategies for Acquiring Materials

The materials used in the Core Knowledge Science program (CKSci) are readily available and can be acquired through both retail and online stores. Some of the materials will be reusable and are meant to be used repeatedly. This includes equipment such as scales, beakers, and safety goggles, but also items such as plastic cups that can be safely used again. Often these materials can be cleaned and will last for more than one activity, or even one school year. Other materials are classified as consumable and are not able to be used more than once, such as glue, baking soda, and aluminum foil.

Online Resources



The Material Supply List for this unit's activities can be found online. Follow the links in the Online Resources Guide for this unit:

www.coreknowledge.org/cksci-online-resources

Ways to Engage with Your Community

The total cost of materials can add up for an entire unit, even when the materials required for activities and demonstrations have been selected to be individually affordable. And the time needed to acquire the materials adds up too. Reaching out to your community to help support STEM education is a great way to engage parents, guardians, and others with the teaching of science, as well as to reduce the cost and time of collecting the materials. With that in mind, the materials list can be distributed or used as a reference for the materials teachers will need to acquire to teach the unit.

Consider some of the following as methods for acquiring the science materials:

- **School Supply Drive**—If your school has a supply drive at any point in the year, consider distributing materials lists as wish lists for the science department.
- **Open Houses**—Have materials lists available during open houses. Consider having teams of volunteers perform an activity to show attendees how the materials will be used throughout the year.
- **Parent Teacher Organizations**—Reach out to the local PTO for assistance with acquiring materials.
- **Science Fair Drive**—Consider adding a table to your science fair as part of a science materials drive for future units.
- **College or University Service Project**—Ask service organizations affiliated with your local higher education institutions to sponsor your program by providing materials.
- **Local Businesses**—Some businesses have discounts for teachers to purchase school supplies. Others may want to advertise as sponsors for your school/programs. Usually you will be asked for verifiable proof that you are a teacher and/or examples of how their sponsorship will benefit students.

Remember: if your school is public it will be tax exempt, so make sure to have a Tax Identification Number (TIN) when purchasing materials. If your school is private, you may need proof of 501(c)(3) status to gain tax exemption. Check with your school for any required documentation.

Advance Preparation for Activities and Demonstrations

Being properly prepared for classroom activities and demonstrations is the first step to having a successful and enriching science program. Advance preparation is critical to effectively support student learning and understanding of the content in a lesson.

Before doing demonstrations and activities with the class

- Familiarize yourself with the activity by performing the activity yourself or with a team, and identify any issues or talking points that could be brought up.
- Gather the necessary materials for class usage. Consider if students will gather their materials at stations or if you will preassemble the materials to be distributed to the students and/or groups.
- Identify safety issues that could occur during an activity or demonstration, and plan and prepare how to address them.
- Review the Teacher's Guide before teaching, and identify opportunities for instructional support during activities and demonstrations. Consider other Support and/or Challenge opportunities that may arise as you work to keep students engaged with the content.
- Prepare a plan for postactivity collection and disposal of materials/equipment.

While engaged in the activity or demonstration

- Address any emergencies immediately.
- Check that students are observing proper science safety practices as well as wearing any necessary safety gear, such as goggles, aprons, or gloves.
- When possible, circulate around the room, and provide support for the activity. Return to the Teacher Guide as students work, to utilize any Support and Challenge opportunities that will make the learning experience most meaningful for your students.

After the activity or demonstration

- Use your plan for students to set aside or dispose of their materials as necessary.
- Have students wash their hands after any activity in which they could come in contact with any potentially harmful substances.

When engaging students in activities and demonstrations, model good science practices, such as wearing proper safety equipment, never eating during an investigation, etc. Good science practices at a young age will lead to students observing good science practices themselves and being better prepared as they move into upper-level science classes.

What to Do When Activities Don't Give Expected Results

Science activities and experiments do not always go according to plan. Microwave ovens, super glue, and X-rays are just some of the discoveries made when people were practicing science and something did NOT go according to plan. In your classroom, however, you should be prepared for what to do when activities don't give the expected results or when an activity doesn't work.

When going over an activity with an unexpected result, consider these points in discussion with your students:

- Was there an error in following the steps in order? You or the student may have skipped a step. To help control for this, have students review the steps to an investigation in advance and make a check mark next to each step as they complete it.
- Did students design their own investigation? Perhaps their steps are out of sequence, or they missed a step when performing the activity. Review and provide feedback on students' investigation plans to ensure the work is done in proper sequence and that it supports the lesson's Big Question.
- When measurements were taken, were they done correctly? It is possible a number was written down incorrectly, a measurement was made in error, such as wrong unit of measure or quantity, or the starting or ending point of a measurement was not accurate.
- Did the equipment or materials contribute to the situation? For example, chemicals that have lost their potency or a scale that is not measuring accurately can contribute to the success or failure of an activity.

One of the greatest gifts a student can learn when engaged in science is to develop a curiosity for *why something happened*. Students may find it challenging or frustrating to work through a problem during an activity, but guiding them through the problem and figuring out *why* something happened will help them to develop a better sense of how to do science.



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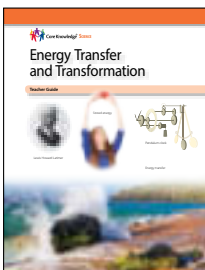
Energy Transfer and Transformation

Core Knowledge Science 4



What is the Core Knowledge Sequence?

The *Core Knowledge Sequence* is a detailed guide to specific content and skills to be taught in Grades K–8 in language arts, history, geography, mathematics, science, and the fine arts. In the domains of science, including earth and space, physical, and the life sciences, the *Core Knowledge Sequence* outlines topics that build systematically grade by grade to support student learning progressions coherently and comprehensively over time.



For which grade levels is this book intended?

In general, the content and presentation are appropriate for readers from the middle to upper elementary grades. For teachers and schools following the *Core Knowledge Sequence*, this book is intended for Grade 4 and is part of a series of **Core Knowledge SCIENCE** units of study.

For a complete listing of resources in the
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