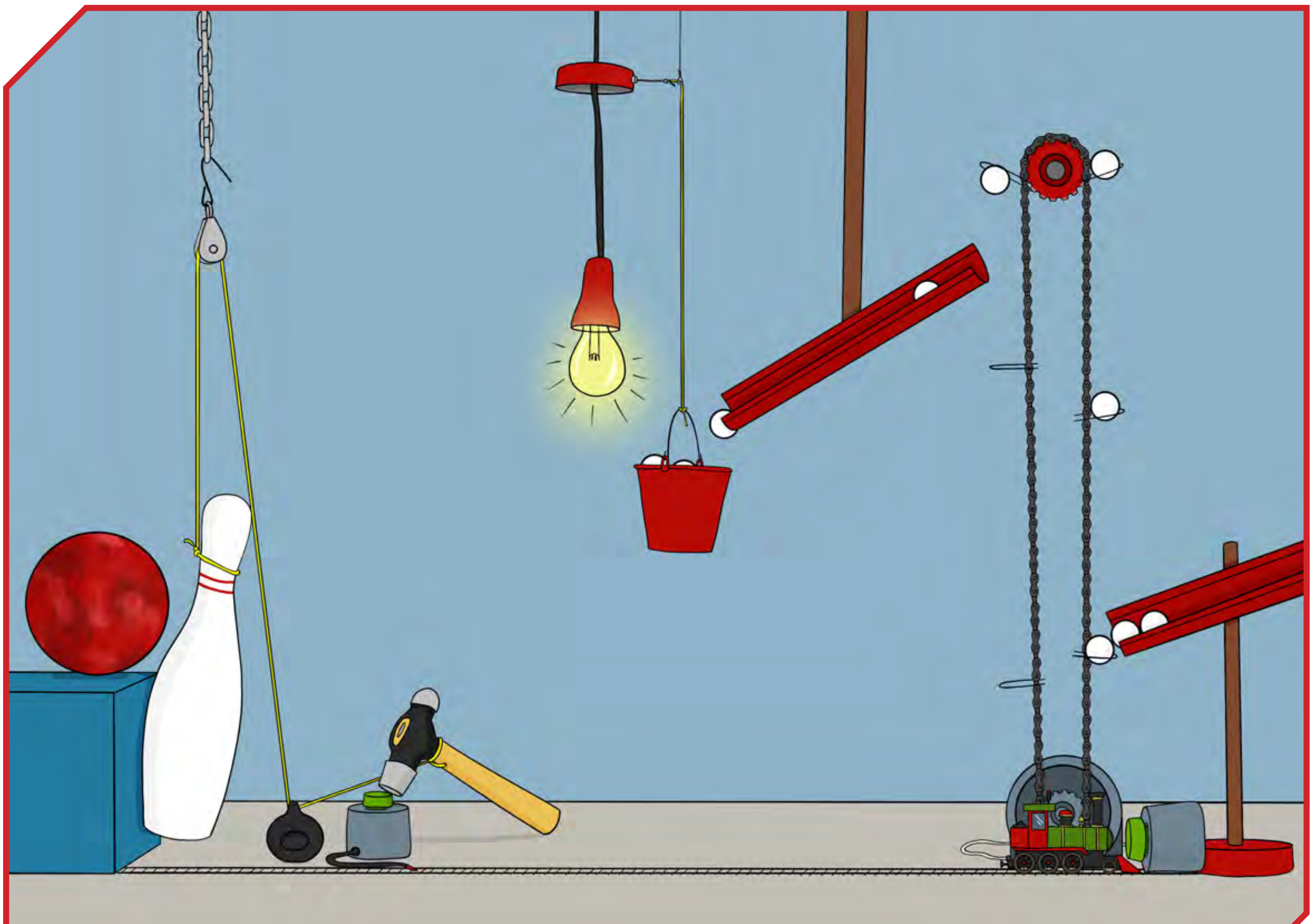
Cereal City Science by BCAMSC

Teacher Guide and Student Journal
Sample Activity and Planning Pages

Energy and Waves
4PNG



SECOND EDITION

A fourth grade unit supporting Next Generation Science Standards and Michigan Science Standards

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Energy and Waves
4PNG

A fourth-grade unit supporting **Next Generation Science Standards** and the **Michigan Science Standards** developed and written by the Battle Creek Area Mathematics and Science Center for

CEREAL CITY SCIENCE™
by BCAMSC

Energy and Waves

Pre-activity Informational Pages

Activities

Appendix

NEXT GENERATION SCIENCE STANDARDS

Disciplinary Core Ideas	Activity
PS3.A: Definitions of Energy • The faster a given object is moving, the more energy it possesses. • Energy can be moved from place to place by moving objects or through sound, light, or electric currents.	1,2,3,4,5,7
4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object.	1,2,4
4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.	1,3,4,5,6,7,8
4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.	1,2,4
PS3.B: Conservation of Energy and Energy Transfer • Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing their motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. • Light also transfers energy from place to place. • Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with by transforming the energy of motion into electrical energy.	1,2,3,4,5,6,7,8
4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.	1,3,4,5,6,7,8
4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.	1,2,4
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	3,4,5,6,7
PS3.C: Relationship Between Energy and Forces • When objects collide, the contact forces transfer energy so as to change the objects' motions.	1,2,8
4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.	1,2,4

NEXT GENERATION SCIENCE STANDARDS

PS3.D: Energy in Chemical Processes and Everyday Life • The expression "produce energy" typically refers to the conversion of stored energy into a desired form for practical use.	1,4,7,8
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	3,4,5,6,7
PS4.A: Wave Properties • Waves, which are regular patterns of motion, can be made in water by disturbing the surface. When waves move across the surface of deep water, the water goes up and down in place; it does not move in the direction of the wave except when the water meets the beach. • Waves of the same type can differ in amplitude (height of the wave) and wavelength (spacing between wave peaks).	6,8
4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.	3
PS4.C: Information Technologies and Instrumentation • Digitized information can be transmitted over long distances without significant degradation. High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa.	8
4-PS4-3: Generate and compare multiple solutions that use patterns to transfer information.	2,3,4
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 one meets the specified criteria for success or how well each takes the constraints into account.	5,8
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	3,4,5,6,7
ETS1.C: Optimizing the Design Solution • Different solutions need to be tested in order to determine which of them best solves the problem, given criteria and the constraints.	5,8
4-PS4-3: Generate and compare multiple solutions that use patterns to transfer information.	2,3,4

NEXT GENERATION SCIENCE STANDARDS

Science and Engineering Practices	Activity
Asking Questions and Defining Problems Asking questions and defining problems in grades 3-5 builds on grades K-2 experiences and progresses to specifying qualitative relationships. • Ask questions that can be investigated based on patterns such as cause-and-effect relationships.	2,3,4,8
4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.	1,4
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Make observations to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. (4-PS3-2)	2,3,4
4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.	1,3,4,5,6,7,8
Constructing Explanation and Designing Solutions Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems. • Use evidence (e.g., measurements, observations, patterns) to construct an explanation. (4-PS3-1) • Apply scientific ideas to solve design problems. (4-PS3-4)	1,2,3,4,5,6
4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object.	1,2,4
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	3,4,5,6,7
4-PS4-3: Generate and compare multiple solutions that use patterns to transfer information	2,3,4

NEXT GENERATION SCIENCE STANDARDS

Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 3–5 builds on K–2 experiences and progresses to evaluate the merit and accuracy of ideas and methods. • Obtain and combine information from books and other reliable media to explain phenomena.	1,5,6,7,8
4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.	1,3,4,5,6,7,8
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. Develop a model using an analogy, example, or abstract representation to describe a scientific principle.	3,5,6,8
4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.	3

NEXT GENERATION SCIENCE STANDARDS

Crosscutting Concepts	Activity
Cause and Effect • Cause-and-effect relationships are routinely identified and used to explain change.	1,2,4,5
4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object.	1,2,4
4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.	1,2,4
4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.	3
Energy and Matter • Energy can be transferred in various ways and between objects.	1,2,3,4,5
4-PS3-1: Use evidence to construct an explanation relating the speed of an object to the energy of that object.	1,2,4
4-PS3-2: Make observations to provide evidence that energy can be transferred from place to place by sound, light, heat, and electric currents.	1,3,4,5,6,7,8
4-PS3-3: Ask questions and predict outcomes about the changes in energy that occur when objects collide.	1,2,4
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	3,4,5,6,7
Patterns • Similarities and differences in patterns can be used to sort and classify natural phenomena. • Similarities and differences in patterns can be used to sort and classify designed products.	1,2,3,4,5
4-PS4-1: Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move.	3
4-PS4-3: Generate and compare multiple solutions that use patterns to transfer information.	3,4

NEXT GENERATION SCIENCE STANDARDS

Connections to Engineering, Technology, and Applications of Science	
Interdependence of Science, Engineering, and Technology • Knowledge of relevant scientific concepts and research findings is important in engineering.	5,7
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	3,4,5,6,7
Influence of Engineering, Technology, and Science on Society and the Natural World • Engineers improve existing technologies or develop new ones • Over time, people's needs and wants change, as do their demands for new and improved technologies	8
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	3,4,5,6,7
Connections to Nature of Science	
Science is a Human Endeavor • Most scientists and engineers work in teams. • Science affects everyday life.	1,2,3,4,5,6,7,8
4-PS3-4: Apply scientific ideas to design, test, and refine a device that converts energy from one form to another.	3,4,5,6,7

UNIT AT A GLANCE

Activity	Time to Complete	Lesson Level Learning Goal	Phenomenon/ Engineering Challenge	Summary: Students will...
1 What is Energy?	Preparation: 20 min. Activity: 2 classes Lesson 1A: 45–50 min. 2 class periods Lesson 1B: 45–50 min. Lesson 1C: 45–50 min.	Gather information to develop a model of a Rube Goldberg action that explains how energy moves from place to place.	Observe video of a Rube Goldberg device. Introduce engineering challenge to build a Rube Goldberg device.	• Introduce performance task: Rube Goldberg device. • Brainstorm ideas about energy. • Explore Energy Stations. • Compare initial ideas about energy as related to energy moving from place to place.
2 The Energy of Motion	Preparation: 15 min. Activity: 8 classes Lesson 2A: 45–50 min. Lesson 2B: 45–50 min. 2 class periods Lesson 2C: 45–50 min. Lesson 2D: 45–50 min 2 class periods Lesson 2E: 45–50 min. 2 class periods	Gather evidence to demonstrate that energy is present in moving objects. Determine that energy can transfer from place to place by moving objects and through collisions.	Basketball and tennis ball collisions. Bubble Soccer collisions	• Investigate energy related to motion. • Make measurements and collect data to determine the relationship between speed and amount of energy. • Investigate energy transfer as it is related to bounce. • Investigate energy and energy transfer as related to collisions of objects.
3 The Energy of Sound	Preparation: 20 min. Activity: 7 classes Lesson 3A: 45–50 min 2 class periods Lesson 3B: 45–50 min. Lesson 3C: 45–50 min. Lesson 3D: 45–50 min. 2 class periods Lesson 3E: 45–50 min. 2 class periods	Relate sound to the concept of energy. Provide evidence that energy can be transferred from place to place by sound. Observe how sound is made through vibrations and travels in waves.	Bass track vibrations shaking windows.	• Investigate vibrations and how sounds are made. • Build a model instrument to demonstrate vibrations and sound waves. • Demonstrate how energy can move from one place to another by sound. • Compare different instruments to determine how vibrations of different materials create different pitches.

UNIT AT A GLANCE

Students Figure Out How To:	Practices and Crosscutting Concepts	PE at Lesson Level and Assessment
• Develop a model to explain energy moving from place to place. • Construct explanations of the concept of energy through definitions, characteristics, and examples. • Determine when energy is present and how it transfers from place to place.	Developing and Using Models Asking Questions and Defining Problems Constructing Explanations and Designing Solutions Cause and Effect Energy and Matter Patterns	**Formative Assessment** Activity Page group models Science Talk class charts (What We Think and Freyer Model) revisions to models
• Gather evidence to demonstrate that energy is present in moving objects. • Make observations to determine that energy can be transferred from place to place by moving objects and collisions. • Recognize the cause-and-effect relationships between motion and collisions and energy transfer from place to place.	Developing and Using Models Constructing Explanations and Designing Solutions Planning and Carrying Out Investigations Asking Questions and Defining Problems Analyzing and Interpreting Data Cause and Effect Patterns	**Formative Assessment** What We Think chart Activity Page Science Talk Scientific Explanation: Claim, Evidence, Reasoning (CER) Science Talk **Summative Assessment** Journal Entries (CER) student investigations and data charts Activity Page
• Develop a model that explains how the music from a bass track causes windows to shake. • Construct explanations of sound energy and how vibrations produce sound. • Compare different sounds in terms of amplitude and frequency. • Construct explanations of how energy can move from place to place by sound. • Make a model of a wave that demonstrates amplitude and wavelength.	Developing and Using Models Asking Questions and Defining Problems Obtaining, Evaluating, and Communicating Information Constructing Explanations and Designing Solutions Cause and Effect Patterns	**Formative Assessment** Science Talk Journal Entry **Summative Assessment** Science Talk Journal Entries Respond to Text Instruments and Presentations

UNIT AT A GLANCE

Activity	Time to Complete	Lesson Level Learning Goal	Phenomenon/ Engineering Challenge	Summary: Students will...
4 Rube Goldberg	Preparation: Activity 4: Set the time frame for building the Rube Goldberg devices as one of the limitations that is appropriate for your class.	Design, test, and refine a device that transfers energy by motion, sound, light, heat, or electricity and ends with the production of sound.	Rube Goldberg design challenge	• Design and build a device that solves a problem and demonstrates how energy can move from one place to another. • Complete the task within constraints and limitations.
5 What About Thermal Energy?	Preparation: 10 min. Activity: 5 classes Lesson 5A: 45–50 min. Lesson 5B: 45–50 min. 2 class periods Lesson 5C: 45–50 min. 2 class periods	Provide evidence that energy can be transferred from place to place by heat. Investigate how heat transfers from warm objects to cooler objects.	Cake Server, melting butter action	• Investigate temperature change due to rubbing. • Collect data to determine how heat energy moves from warm objects to cold objects. • Investigate temperature change using a candle.
6 Energy Related to Light	Preparation: 15 min. Activity: 4 classes Lesson 6A: 45–50 min. 2 class periods Lesson 6B: 45–50 min. 2-3 class periods	Observe changes associated with the transfer of light energy to thermal energy.	Engineering challenge: How can we melt the butter in the cake server device without using a candle or other heating device?	• Gather evidence to demonstrate how light energy transforms to heat energy. • Design and conduct an investigation into the transformation of light energy to heat energy in a variety of materials.

UNIT AT A GLANCE

Students Figure Out How To:	Practices and Crosscutting Concepts	PE at Lesson Level and Assessment
• Design, test, and refine a device that converts energy from one form to another that ends with the production of a sound or signal.	Developing and Using Models Constructing Explanations and Designing Solutions Cause and Effect	**Summative Assessment** Rube Goldberg device Rube Goldberg presentation
• Provide evidence that energy can be transferred from place to place by heat. • Determine how heat transfers from warm objects to cooler objects.	Asking Questions and Defining Problems Constructing Explanations and Designing Solutions Planning and Carrying Out Investigations Analyzing and Interpreting Data Developing and Using Models Cause and Effect	**Formative Assessment** Investigations and Journal Entries Science Talk Activity Page
• Provide evidence that energy can be transferred from place to place by light. • Determine how light energy from the sun transfers to heat energy and warms Earth.	Planning and Carrying Out Investigations Analyzing and Interpreting Data Constructing Explanations and Designing Solutions Developing and Using Models Cause and Effect Energy and Matter	**Summative Assessment** Journal Entries Models Science Talk

UNIT AT A GLANCE

Activity	Time to Complete	Lesson Level Learning Goal	Phenomenon/ Engineering Challenge	Summary: Students will...
7 Electricity	Preparation: 15 min. Activity: 7 classes Lesson 7A: 45–50 min. 2 class periods Lesson 7B: 45–50 min. 2 class periods Lesson 7C: 45–50 min. 2 class periods Lesson 7D: 45–50 min.	Provide evidence that energy can be transferred from place to place by electric current.	Turn classroom lights and/or electronic devices on and off.	• Experiment with a battery, bulb, and wire to make a complete circuit. • Gather evidence to demonstrate how electrical energy can transform to different types of energy.
8 Energy All Around	Preparation: 10 min. Activity: 3 classes Lesson 8A: 45–50 min. Lesson 8B: 45–50 min. Lesson 8C: 45–50 min.	Find patterns and commonalities among the different ways we find evidence of energy moving from place to place. Make connections among information gained through investigations and information in written text and video.		• Use and compare resources to gather information about energy. • Analyze and compare their previous ideas about energy with their new knowledge. • Read and analyze text from two different books.

UNIT AT A GLANCE

Students Figure Out How To:	Practices and Crosscutting Concepts	PE at Lesson Level and Assessment
• Design and build an electrical circuit to demonstrate how energy is transferred from place to place by electricity. • Use their knowledge about a complete circuit to design a switch. • Determine that electrical energy transforms to heat, light, and sound.	Developing and Using Models Constructing Explanations and Designing Solutions Obtaining, Evaluating, and Communicating Information Matter and Energy Science as a Human Endeavor Cause and Effect	**Summative Assessment** Science Talk Journal Entries Activity Pages Respond to Text
• Recognize patterns and commonalities among the different forms of energy. • Make connections among information gained through their investigations and information in written text and video.	Obtaining, Evaluating, and Communicating Information	**Summative Assessment** Respond to Text Journal Entries Freyer Model Science Talk Energy Stations Data Chart discussion group presentations

WHAT IS ENERGY?

Teacher Background Information
The unit begins by spending considerable time brainstorming and exploring students' initial ideas about Rube Goldberg devices, energy, engineering, and technology and serves as a formative assessment to help drive instruction throughout the remainder of their study of energy. Students begin to share their initial ideas about energy and make initial models of the transfer of energy in a Rube Goldberg device.

Considerations for Students with Special Needs
The lessons in Activity 1 ask students to write responses to explain their thinking. Students with special needs may benefit from dictating their answers or discussing their ideas and/or using a word processor. Students are also asked to make observations of a video and look for evidence. Students may be more successful if they are provided questions to look for prior to viewing the video.

Engage the Learner
The initial phase of learning activates students' prior knowledge and preconceptions regarding energy. Students begin to make connections between what they have experienced and made sense of regarding the term *energy*. Before exploring the basic concepts of energy, the class is introduced to an engineering challenge through the use of a Rube Goldberg device. Students brainstorm their ideas about energy and raise questions about what information they need to know to complete the challenge. Students are encouraged to think about the necessary information they need to build a device and explain how energy moves through the system.

LESSON 1A: LOOKING FOR EVIDENCE OF ENERGY

Advance Preparation
Duplicate copies of the unit Parent Letter and Activities To Do at Home to be sent home.

Make copies of the *Rube Goldberg Device* and *Product Descriptor* for each student.

Google search the Lemonade Machine Rube Goldberg:

https://thekidshouldseethis.com/post/the-lemonade-machine-an-epic-rube-goldberg-collaboration

Google search the Cake Server Rube Goldberg:

https://www.youtube.com/watch?v=auIlGqEyTm8

ESTIMATED TIME
Lesson 1A: 45–50 minutes
2 class periods

Lesson 1B: 45–50 minutes

Lesson 1C: 45-50 minutes

LESSON LEVEL LEARNING GOALS
Gather information to develop a model of a Rube Goldberg action that explains how energy moves from place to place.

TEACHING TIP
Throughout the activities in the Teacher Guide you will notice that specific student instructions from the Student Journal pages are italicized.

The summative assessment located in the Assessment Section of the Teacher Guide is divided into sections. Instructions for administering the assessment are given at the end of the appropriate lesson. This assessment is not intended to be a Pre/Post Assessment but to assess the student understanding along the way.

PS3.A: DEFINITIONS OF ENERGY
- ~~The faster a given object is moving, the more energy it possesses.~~
- **Energy can be moved from place to place by moving objects or through sound, light, or electric currents.**

MATERIALS NEEDED
For each student:
student pages
For each group:
chart paper
markers
Internet access
Post-it notes
Teacher provides:
chart paper
markers
Internet access
Post-it notes

TEACHING TIP
Throughout the activities in the Teacher Guide, you will notice that specific student instructions from the Student Journal pages are given first and italicized. Additional information for the teacher follows the italicized instructions in plain print.

Specific student questions from the Student Journal are also italicized in the Teacher Guide.

DEVELOPING AND USING MODELS
Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- ~~Develop a model using an analogy, example, or abstract representation to describe a scientific principle.~~
- **Develop and/or use models to describe and/or predict phenomena.**

TEACHING TIP
If your class is equipped with sufficient number of electronic notebooks or iPads, have the students observe the video in pairs, stop the video when they observe energy, engineering, and/or technology and collaborate to make the entry in the Student Journal.

View possible sites of Rube Goldberg projects by fourth- and fifth-grade students:

https://www.youtube.com/watch?v=EjOFeC-Dm7U
https://www.youtube.com/watch?v=XPtMMciARYE
https://www.youtube.com/watch?v=ZYkNJoCKM18
https://www.youtube.com/watch?v=VunNpfdw68g
https://www.youtube.com/watch?v=b-IDAgxl9Dk
https://www.youtube.com/watch?v=zTBTRzzJ1MM

Make a What We Think chart

What We Think	Questions We Have	What We Did (Practices)	What We Figured Out (DCIs)	How Does That Help Us to Figure Out the Phenomenon?

Procedure
Engage the learner.
To engage the students in actively thinking about motion, energy, and the transfer of energy and to introduce them to the engineering design challenge, show one of the following videos:

https://www.youtube.com/watch?v=auIlGqEyTm8
https://thekidshouldseethis.com/post/the-lemonade-machine-an-epic-rube-goldberg-collaboration

Ask students to observe the video and write down some of their observations using the chart in the Student Journal.

1. *Use the chart below to record at least three of your observations of energy, engineering, and technology. First make a list of the actions.*

Looking for Evidence of Energy

Action	*Energy*	*Engineering*	*Technology*

2. *After observing the video, write why you think it is evidence of energy, engineering, and/or technology.*
3. *Choose one of the actions you observed and develop a model to explain what is happening right before the action, during the action, and after the action.*

Action ______________________

Before	During	After

Allow sufficient time for students to observe the video and complete the chart and model in the Student Journal.

After students have had the opportunity to enter their ideas in the Student Journal, divide the class into groups of four and have them share in a group setting. After the groups have shared their charts and models, have each group choose one action from the video and develop a group model to share with the class.

Facilitate the small group sharing and brainstorming by circulating among the students and listening to their ideas about energy, motion, technology and engineering. Carry a clipboard and pencil to record student ideas that will be critical to revisit and discuss as a class. Listen for students that use the term Rube Goldberg device to call on them when introducing the engineering challenge at the end of the lesson. Make note of the different actions the students chose to develop their model.

To help students elaborate on their initial ideas and thinking, ask:

- _____________, I see that you have__________ added to the energy column of your chart, can you say more about that?
- Can you give an example?
- Can someone add to that idea?
- Do the rest of you agree? Why or why not?
- So let me see if I understand what you are saying. Are you saying...?
- Who can rephrase what __________ just said or put it in your own words?
- Does that make sense? Why or why not?

After the groups have had the opportunity to discuss their ideas and develop a model of one of the actions from the video, distribute markers, Post-It Notes, and chart paper to each group. Have them draw a group model on chart paper and display their models around the room. Ask one or two students in each group to record questions on the Post-It Notes as the discussion continues.

Science Talk
Ask the students to bring their models to the circle and display their models in the middle of the circle. Ask each group to discuss their model and as a class, look for common ideas and unique ideas. Facilitate the Science Talk by asking:

- What common components do you recognize in many or all of the models?

TEACHING TIP
Make note if any team(s) decide to develop a model for the action of the candle and melting butter or candle burning through string from the Cake Server device. Thermal energy is addressed in Activity 5.

Some students may struggle to combine the observation and writing task. Accommodate the students by allowing them to view the entire video first, then view it once again with the purpose of stopping the video and writing in the Student Journal.

TEACHING TIP
If this is the students' first experience in developing models of their thinking, you will need to discuss and model how scientists and engineers use models to explain their ideas and make the invisible, visible.

Be sure to save their initial ideas to use as a reference and revisit throughout and at the end of the unit.

TEACHING TIP
Science Talk is a make-meaning and pre-writing strategy used throughout the unit. An effective Science Talk is all students engaged in listening and talking to one another. The teacher serves only as the role of a facilitator and record keeper. Have your students face each other (in a circle). As they discuss their ideas, they should address one another and not discuss ideas through the teacher. Good, effective Science Talk should develop as students become more comfortable with collaboration.

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships.

Identify scientific (testable) and non-scientific (non-testable) questions.

- **Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.**
- Ask questions about what would happen if a variable were changed.
- **Define a simple problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.**

PS3.A: DEFINITIONS OF ENERGY

- ~~The faster a given object is moving, the more energy it possesses.~~
- **Energy can be moved from place to place by moving objects or through sound, light, or electric currents.**

PS3.C: RELATIONSHIP BETWEEN ENERGY AND FORCES

- **When objects collide, the contact forces transfer energy so as to change the objects' motions.**

- Why do you think that component is important?
- Does anyone else what to respond to that idea?
- Can anyone take that idea and push it a little further?
- Tell me more about…
- What do you mean when you say…?
- Do the rest of you agree? Why or why not?
- Some of the models include the use of arrows. Can someone explain what the arrows represent?
- Why is that important in understanding energy in the device we observed in the video?

Ask the class if the development and presentation of the models gave them more ideas and questions about the video and the energy, engineering, and technology associated with a device like the one in the video.

Display the What We Think chart and record some of the initial ideas about the Rube Goldberg device they observed on the video. Use your notes from their small group and Science Talk discussions to start the recording of initial ideas. Assist the students in turning their wonderings into questions. Listen for initial ideas about energy and that energy is present whenever there is motion or change, sound, light, and heat and that energy is transferred from place to place.

Record all questions from their small group discussions and model development on the Questions We Have column of the What We Think chart. Ask students to share their questions. Develop the question column by asking a group to share one question and then have others share similar or like questions. Categorize questions as they are presented by the students. Categories may include:

- Energy
- Motion
- Materials used
- Building
- Forces
- Gravity
- Friction
- Questions about how the action worked

(See sample Questions We Have column at the end of this lesson.)

Introduce the Rube Goldberg challenge to the class. As a class, read the article about Rube Goldberg in the Student Journal.

Read the performance task to the class (See Student Journal page 51):

You have been asked to build a device that will make a signal when something is going to happen. It may be a signal of your choosing. Your device must demonstrate at least three energy transfers by light, sound, heat, motion, and/or electricity. Choose one of the Performance Tasks and work with a team to solve the problem. Use the Engineering Design Plan to complete the challenge.

Performance Task 1: You have an important homework assignment due. You want to make sure your family does not interrupt you. Design a Rube Goldberg device that will signal your family when you are busy working and again when you have completed the assignment.

Performance Task 2: You and your friend are going on an early morning fishing trip. You are famous for sleeping through the alarm clock. Design a Rube Goldberg alarm that will be sure to wake you up and get you out of bed.

Performance Task 3: You were listening to a news program on the radio. You heard the newscaster say, "The world is running out of energy." Design a Rube Goldberg device to demonstrate how energy is not used up, but transfers from place to place and can transform from one type to another. Write or create a video of how you would explain how energy does not "run out," but we may "run out" of fossil fuels or natural resources.

Performance Task 4: Write a performance task of your choosing. Describe the purpose of the device.

Discuss the challenge and how the devices in the videos served a purpose (dispensed lemonade, served cake) and the science and engineering information the class needs to find out before completing the challenge. Discuss other ideas about a purpose for the Rube Goldberg device. Review the Rube Goldberg product descriptor and focus the attention on the requirement *#5 A model that explains how energy moves from place to place for least three energy transfers within the device.* Discuss student ideas of the meaning of energy and energy transfers and what further information the class needs to find out before completing the task. Record additional ideas to the What We Think column of the class chart. Do not attempt to revise or inform their thinking at this time.

PS3.B CONSERVATION OF ENERGY AND ENERGY TRANSFER

- **Energy is present whenever there are moving objects, sound, light, or heat. When objects collide, energy can be transferred from one object to another, thereby changing the motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced. (4-PS3-3)**

FORMATIVE ASSESSMENT

Use the student responses to the Energy Stations to assess initial ideas about energy. Check for patterns in student thinking that may demonstrate common naive ideas among the students.

TEACHING TIP

Make note if any groups developed a model for the action of the candle and melting butter or candle burning through string from the Cake Server device. Thermal energy is addressed in Activity 5.

Be sure to save their initial ideas to use as a reference and revisit throughout and at the end of the unit.

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships.

Identify scientific (testable) and non-scientific (non-testable) questions.

- **Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.**
- Ask questions about what would happen if a variable were changed.
- **Define a simple problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.**

Assessment: Formative

Use the Activity Page, group models, and Science Talk to assess the students initial thinking about the Rube Goldberg device, energy, engineering, and technology.

Cake Server Example Question chart:

Questions We Have

Motion

- How did they determine how fast the ball should move?
- What force was used to move the butter?
- What collision or motion did the moving peas cause?
- What caused the phone to move?
- What caused the wheel to move?

Building

- How did they determine the timing and distance of the ball?
- How long did it take to build?
- How did he know the open part of the wheel would go over his head?

Action

- How did the butter move?
- How did the flame from the candle make things move?
- How did the candle chandelier stop swinging?
- How did he know the timing of the wheel would work?

Materials

- What materials are available for the device?
- What was the purpose of the candle?
- Did the computer break when it fell?

Energy

- What is energy?
- Where is there energy in the Rube Goldberg system?

LESSON 1B: EXPLORING ENERGY

Teacher Background Information
In Lesson 1B students visit "Energy Stations." They select assessment probes reflecting their initial ideas about energy within the system at each station. In Lesson 1C they compare their responses to the probes and collectively analyze each other's ideas and attempt to describe and define energy.

Advance Preparation
Set up Energy Activity Stations:

- A row or circle of Dominoes to be knocked over in a chain
- Tennis ball and ramp
- Rubber bands
- Flashlight with batteries
- Marble magnets
- Energy pictures

Prepare an Energy Stations Data Chart for the class.

Energy Station Data Chart

	Responses			
Stations	1	2	3	4
Dominos				
Ball and Ramp				
Rubber Bands				
Flashlight				
Magnet Marbles				
Pictures				

Plan to assign each group one of the energy stations to develop and share an initial model that explains how energy within the system moves from place to place.

Procedure
Explore the concept.
Review the What We Think chart from the previous lesson. Discuss the Rube Goldberg engineering challenge and what the students need to know to design a Rube Goldberg and explain the movement of energy within the system. Review students initial ideas about energy and what further information the class needs to find out before completing the task. Make additions to the chart if necessary.

MATERIALS NEEDED
For each student:
student pages
For the class:
dominoes
ramp
tennis ball
rubber bands
flashlight with batteries
marble magnets
Energy Pictures card set (*wind, carpenter, children, jet, boy/dog*)
Teacher provides:
chart paper
markers
Internet access
Post-it notes

PS3.A: DEFINITIONS OF ENERGY

- The faster a given object is moving, the more energy it possesses.
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

FORMATIVE ASSESSMENT
Student responses to the Energy Stations serve as a Formative Assessment in their understanding of the concept of energy and how energy is conserved and moves from place to place.

TEACHING TIP

Encourage lively discussion and debate. There are no right or wrong answers at this stage of their learning. Validate all ideas by recording them on the What We Think chart.

Be sure to save their initial ideas to use as a reference and revisit at the end of the unit.

PS3.B CONSERVATION OF ENERGY AND ENERGY TRANSFER

- **Energy is present whenever there are moving objects,** sound, **light,** or heat. **When objects collide, energy can be transferred from one object to another, thereby changing the motion. In such collisions, some energy is typically also transferred to the surrounding air; as a result, the air gets heated and sound is produced.** (4-PS3-3)

CAUSE AND EFFECT

- Cause-and-effect relationships are routinely identified and used to explain change.

ENERGY AND MATTER

- Energy can be transferred in various ways and between objects.

Introduce the Energy Stations to the class. Divide the class into six different groups. Inform the students that they are going to be given the opportunity to visit six different activity centers with the focus on energy. Within each station or center, students will discuss the material and activity and record their ideas of how energy is related to the activity. Review the prompts for each station in the Student Journal. Explain that each group will be assigned one station to also develop a model that explains the movement of energy within the system to share with the class. Assign each group their station to model.

Set a time limit for each station. Encourage the students to read and discuss the information in the Student Journal about each station to guide their explorations. Give the students sufficient time to visit each station and record their observations in the Student Journal.

Domino station: *Push the first domino in the row over and observe what happens. Place an X next to all the statements that you think are true about the falling Dominoes.*

___ 1. A force was needed to transfer energy to the row of Dominoes.

___ 2. The energy was used up when the last Domino fell.

___ 3. The energy of motion moved from one Domino to the next.

___ 4. Dominos do not have energy.

Develop a model to explain what you think is happening to the energy within the system of the falling Dominos before the action, during the action, and after the action.

Write questions about energy related to the motion of the Dominos.

Tennis ball and ramp: *Roll the ball down the ramp and make observations of energy related to the motion of the ball. Next, change the angle of the ramp and repeat your observations of the ball rolling down the ramp at a different angle. Put an X next to all the statements that you think are true about the motion of the ball and ramp.*

___1. The faster the ball travels, the greater the energy.

___2. The amount of energy of the ball increases as the ball is released from a higher position above the floor.

___3. The energy of the ball decreases and goes away as the ball stops.

____4. *Changing the angle of the ramp does not change the amount of energy when the ball rolls down the ramp.*

Develop a model to explain what you think about the energy related to the ball before rolling down the ramp, during the roll down the ramp, and after rolling down the ramp.

Write questions about energy related to the motion of the ball on the ramp.

Rubber bands: *Hold an unstretched rubber band in the palm of your hand. Stretch the rubber band and then release it. Put an X next to all the statements that you think are true about the stretched and unstretched rubber band.*

____ 1. *The unstretched rubber band does not have energy.*

____ 2. *The stretched rubber band has energy when it is released.*

____ 3. *The motion energy of the rubber band naturally decreases and disappears when it stops.*

____ 4. *Rubber bands have more energy when they are stretched the tightest or biggest.*

Develop a model to explain what you think about the energy related to the rubber band before it is stretch, while the rubber band is being stretched, and when the rubber band is fully stretched.

Write questions about energy related to the rubber band, (unstretched, stretched, and released).

Flashlight with batteries: *Observe the flashlight with the switch turned off. Turn the switch on and observe the flashlight. Put an X next to all the statements that you think are true about the energy related to the flashlight.*

____ 1. *Turning the flashlight on creates light energy.*

____ 2. *When the flashlight is turned off all the energy goes away.*

____ 3. *Energy moves from one form to another when the flashlight is turned on and off.*

____ 4. *Light energy transfers energy from place to place.*

Develop a model to explain what you think about the energy related to the flashlight when it is turned on and when it is off.

Write questions about energy related to the flashlight.

TEACHING TIP

Circulate among the groups and record observations and key emerging ideas you hear during their discussions. Use the student remarks during the Science Talk at the end of the lesson.

ASKING QUESTIONS AND DEFINING PROBLEMS

Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships.

Identify scientific (testable) and non-scientific (non-testable) questions.

- Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause-and-effect relationships.
- Ask questions about what would happen if a variable were changed.
- Define a simple problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost.

CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation ~~or design a solution to a problem~~.
- **Identify the evidence that supports particular points in an explanation**
- ~~Apply scientific ideas to solve design problems.~~

Energy and Matter

- Energy can be transferred in various ways and between objects.

Marble magnets: *Make observations of what happens when the marble magnets are placed close to one another. Pull the marble magnets apart and observe what happens. Put an X next to all the statements that you think are true about the energy related to marble magnets.*

___ 1. Energy of magnetism can transform into energy of motion.

___ 2. When the marbles move toward one another the energy increases.

___ 3. When the marbles are together the energy disappears.

___ 4. When the marbles move, energy is transferred from place to place.

Develop a model to explain what you think about the energy related to the magnetic marbles before they start moving, when they are moving and after they have stopped moving.

Write questions about energy related to the magnets and the magnetic marbles.

Energy pictures: *Look at the pictures and discuss with your group if there is evidence of energy in any of the pictures.*

Picture 1: Is there evidence of energy in the picture? How do you know?

Picture 2: Is there evidence of energy in the picture? How do you know?

Picture 3: Is there evidence of energy in the picture? How do you know?

Picture 4: Is there evidence of energy in the picture? How do you know?

Picture 5: Is there evidence of energy in the picture? How do you know?

Facilitate the group activity by circulating among the stations and listening to students' ideas. Record interesting, insightful, and different ideas to discuss as a whole group in the following lesson. To check student progress and help students elaborate on their ideas, ask:

- Can someone explain what you have observed so far?
- How do you think your observation is related to energy? Why do you think that?
- What do you mean when you say…?

- How does changing ___________ affect your thinking?
- What questions have the stations generated?

Allow time for each group to develop the assigned station model on chart paper or white board to share with the class.

Science Talk
Have the groups gather in a circle with their Student Journals and their models. Ask the students if their experiences at the stations gave them any further ideas about energy and how they might explain the cause and effect relationship between energy and the changes or actions observed in the Rube Goldberg devise. To help the students listen to one another and deepen their reasoning, ask:

- Did anyone find any similarities and/or differences in their observations at the energy stations?
- Can you say more about that?
- Is there energy before the action? If so, where is the energy before the action at each station?
- What do people think about what ________ said?
- Who can repeat what ________ said or put it into their own words?
- Is there energy during the action? If so, where is the energy during the action at each station?
- Do the rest of you agree? Why or why not?
- Is there energy after the action? If so, where is the energy after the action at each station?
- Who can say more about that? Do the rest of you agree? Why or why not?

Ask each group to share their model of the assigned station. Ask students to look for similarities and differences in each model.

- What is the common component in each model?
- What does that tell you about energy within any system?
- Did the energy move? What makes you think that?

Revisit their What We Think chart and discuss how the term energy is used and how they have heard the term in the past. Refer to any emerging ideas that you observed during the facilitation of the activity stations. Add any questions to the Questions We Have column in the chart.

TEACHING TIP
Science Talk is a make-meaning and pre-writing strategy used throughout the unit. An effective Science Talk is all students engaged in listening and talking to one another. The teacher serves only as the role of a facilitator and record keeper. Have your students face each other (in a circle). As they discuss their ideas, they should address one another and not discuss ideas through the teacher. Good, effective Science Talk should develop as students become more comfortable with collaboration.

Make room for the students to conduct the Science Talk in a circle so all students are facing one another and engaged in the conversation.

Systems and System Models

- A system can be described in terms of its components and their interactions.

TEACHING TIP
Teaching and learning about energy and energy transfer through the development of models presents an opportunity to include the Crosscutting Concept, Systems and System Models. Ask students to describe the components of the systems and the interaction among components.

TEACHING TIP
Save the group models of the energy stations as they will be revisited and a final model developed at the end of the unit.

Inform the class that in the next several activities they will be given the opportunity to explore energy in a variety of settings and begin to determine the characteristics and properties that may help them in their understanding of the concept of energy and its role in the Rube Goldberg devise.

Assessment: Formative
Use the Science Talk, and Activity Pages to assess the students' initial ideas for describing (defining) energy and energy transfer. (PS3.A, PS3.B)

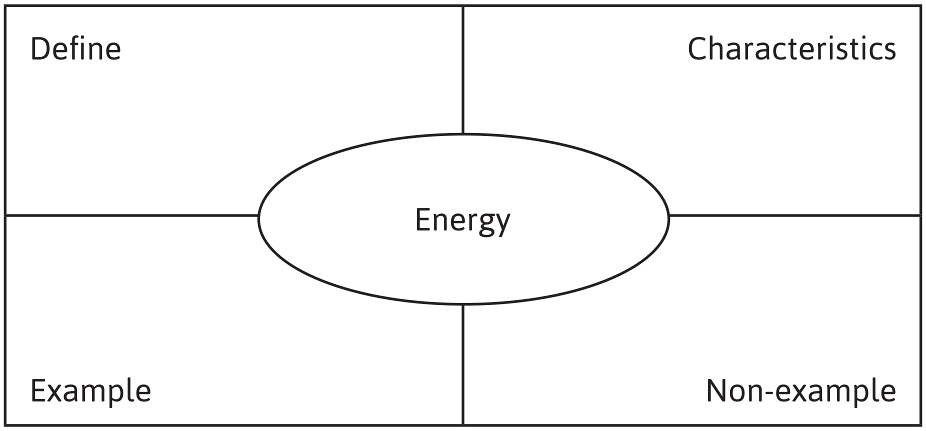
LESSON 1C: DEFINING ENERGY

Advance Preparation

Set up the Energy Stations from Lesson 1B. Display the Energy Stations Data Chart from Lesson 1B.

Make a Freyer Model chart to reflect the students' initial thinking about energy.

Freyer Model Energy Chart



Display the Energy Stations Data Chart to record the collective student observations of the Energy Stations.

Save the Freyer Model chart and Energy Stations Data Chart to refer to and revise throughout the unit.

Procedure

Explain the concept and define the terms.

Conduct a whole-class sharing of their experiences at the Energy Stations in Lesson 1B. Compile the student responses from the different activity centers into a data chart. Ask students to discuss their ideas and choices of true or not-true statements. Have them explain their reasoning for their choices. Place tally marks in the responses that students selected as true statements. Discuss their selections and have students justify their thinking. Do not try to change their ideas at this time. Tell the students that they will revisit the chart throughout and at the end of the unit to check for changes in their ideas about energy.

To help students collectively make sense of each others' ideas and patterns in their thinking, ask:

- What do you think about what _________said?
- Do the rest of you agree? Why or why not?
- Does anyone have the same answer but a different way to explain it? What answers keep coming up?
- Can you explain why your answer makes sense?

MATERIALS NEEDED

For each student:
- student pages

For the class:
- Energy Station materials (from lesson 1B)

Teacher provides:
- chart paper
- markers
- Internet access
- Post-it notes

ENERGY STATIONS DATA CHART

	Responses			
Stations	1	2	3	4
Dominoes				
Ball and Ramp				
Rubber Bands				
Flashlight				
Magnet Marbles				
Pictures				

TEACHING TIP

The Freyer Model Energy Chart is an extension of the What We Think chart and serves as a tool to help students develop their ideas.

Check for initial ideas that reflect an understanding that the faster an object travels, the greater the energy. (Ball and Ramp Station)

PATTERNS

- Similarities and differences in patterns can be used to sort and classify natural phenomena.

ENERGY AND MATTER

- Energy can be transferred in various ways and between objects.

FORMATIVE ASSESSMENT

Use the Freyer Model chart as an ongoing assessment of student understanding and conceptual shifts. Refer to their initial ideas and emerging ideas as a result of observations, evidence, and information gathering.

PS3.A: DEFINITIONS OF ENERGY

- **The faster a given object is moving, the more energy it possesses.**
- Energy can be moved from place to place by moving objects or through sound, light, or electric currents.

CONSTRUCTING EXPLANATIONS AND DESIGNING SOLUTIONS

Constructing explanations and designing solutions in 3–5 builds on K–2 experiences and progresses to the use of evidence in constructing explanations that specify variables that describe and predict phenomena and in designing multiple solutions to design problems.

- Use evidence (e.g., measurements, observations, patterns) to construct or support an explanation or design a solution to a problem.
- Identify the evidence that supports particular points in an explanation
- Apply scientific ideas to solve design problems.

- How can we use all our observations and explanations and develop a definition or description of energy?
- Are there any patterns in our observations that can help us understand energy?

Elaborate on the concept.
Show the class the chart with the Freyer Model diagram. Inform the class that they will be working in small groups and using their ideas from the Energy Stations to develop responses to complete the different sections of the diagram.

Each group is to discuss the sections and collectively decide on:

1. A definition of energy,
2. Characteristics or properties of energy,
3. Examples of energy, and finally,
4. Non-examples of energy.

They write their ideas on a Post-it Note and then place the notes on the class chart. Ask students to write one idea per Post-it Note.

Divide the class into groups of four students. Distribute Post-it Notes and a marker to each group. Give the students sufficient time to discuss each category and write their ideas. Facilitate the group activity by circulating among the students, listening to their ideas and taking notes on some of the key ideas expressed by the students. To help students make connections among their ideas of energy and their observations at the stations, ask:

- How does your definition relate to…?
- Can someone give me an example?
- Can you think of a counterexample?
- Why do you think that?
- How would you prove or explain that to someone?
- Do the rest of you agree? Why or why not?

Science Talk
After the groups have had sufficient time to discuss, write, and post their understandings about energy, review their ideas. Validate all ideas at this time. Invite student volunteers to share their posts on the chart and explain their choices. Allow sufficient time for students to express their ideas and make adjustments based on the reasoning of others.

Tell the class that in the following activities they are going to explore different ways energy moves and changes things and gather more information. At the end of the unit, the class will revisit the chart and make adjustments based on new learning and understanding.

Explain that in the following science activities, students will learn more about energy, different forms of energy, and how to recognize energy. Later in the unit, students will be given the opportunity to demonstrate their understanding of energy by designing and creating a device that solves a problem. The device will need to demonstrate different energy transfers to complete a task.

Review the video of a Rube Goldberg device from Lesson 1A. Discuss evidence of energy in the different actions the groups chose to model. To help the students elaborate on their ideas and learn to reason scientifically, ask:

- What evidence do you have that energy was present in that action?
- Why do you think that?
- What do you mean when you say…?
- Tell me more about the components that interacted to cause the transfer of energy.
- Can someone add on to what __________ just said?
- Can you give me another example of how the components interact?
- How would you prove that?
- What did the inventors of the device need to know to build and explain the energy involved in each action as the chain of events occur within the system?

Evaluate students' understanding of the concept.
Listen for student ideas that relate to energy involved in motion, sound, heat, and light. Validate all ideas at this time. Review the initial ideas on the Freyer chart regarding energy and ask students if they would like to make any adjustments at this time. Ask students if the Energy Stations gave them any ideas for the Rube Goldberg devices to be developed later the unit.

Add new ideas that relate to energy on the What We Think chart. Ask students what more they need to know about energy to complete the Rube Goldberg task. Record new questions on the Questions We Have column of the chart. Review the questions for any that may have been answered during the energy stations activity.

PS3.D: ENERGY IN CHEMICAL PROCESSES IN EVERYDAY LIFE

- The expression "produce energy" typically refers to the conversion of stored energy into a desired form of practical use.

DEVELOPING AND USING MODELS

Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions.

- Develop a model using an analogy, example, or abstract representation to describe a scientific principle.
- Develop and/or use models to describe and/or predict phenomena.

TEACHING TIP

During the Science Talk, listen for ideas that energy is produced or that energy goes away or disappears. Make a note of the student initial ideas to revisit as the unit progresses and their understanding of energy changes.

Systems and System Models

- A system can be described in terms of its components and their interactions.

WRITING
TEXT AND TYPE PURPOSES
W.4.2: Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

a. Introduce a topic clearly and group related information in paragraphs and sections; include formatting (e.g., headings), illustrations, and multimedia when useful to aiding comprehension.
c. Link ideas within categories of information using words and phrases (e.g., another, for example, also, because).
d. Use precise language and domain-specific vocabulary to inform about or explain the topic.
e. Provide a concluding statement or section related to the information or explanation presented.

Read the Journal Entry to the class. Tell the students that what they write today will be revisited and revised often throughout the unit.

Pre-Writing Strategy: Science Talk
Give the students sufficient time to discuss their ideas of energy that makes the most sense to them prior to revising their models. Encourage students to write one or two key ideas that came from the discussion to put into the models.

Journal Entry
Revisit your individual and group model of the action in the Rube Goldberg device. Make changes to your model based on what you have learned from the Energy Stations and discussion with your group.

Describe the changes and new information your group added to your initial model.

Assessment: Formative
Use the class charts, revisions to models, Science Talk, and Journal Entry to assess the students' initial ideas about definitions of energy (PS3.A), conversion of energy, and energy transfer (PS3.B).

ENGINEERING DESIGN PROCESS

The Engineering Design Process provides students with a series of steps to guide them as they solve problems and design and test products, models, and solutions. The process is cyclical, yet not necessarily in an order. Students are encouraged to evaluate as they progress through the process, revisit the mission often, and revise thinking and their plan multiple times as the process unfolds.

Engineers do not always follow the Engineering Design Process steps in order, one after another. It is very common to design something, test it, find a problem, and then go back to an earlier step to make a modification or change the design. Engineers must always keep in mind the mission or problem they are trying to solve and the limitations (cost, time, material, etc.) that are part of the solution to the problem. Two key elements in working as an engineer are teamwork and design-test-and-redesign.

Mission

- Defines the problem and what the engineers are trying to design or build.
- Describes the limitations within which the engineers must solve the problem.

Brainstorm Ideas

- Imagine, discuss, and sketch possible solutions.
- Conduct research into what has already been done.
- Discover what materials are available, time frame, and other limitations.

Plan and Design

- Draw and write a plan.
- Design your solution through drawing and manipulating materials.
- Develop a plan or steps and a schedule.

Build

- Construct your engineering device or project.
- Follow your plan.
- Adjust and test along the way.

Test and Adjust

- Test your device to see if it solves the problem within the mission and limitations.
- Make your project better based on tests: Test → Revise → Test.
- Improve based on feedback of others.

Present Your Solution

- Demonstrate how your solution solves the problem.
- Define problems and limitations.
- Describe the challenges and limitations in solving the problem.
- Describe additional revisions that could improve the device or project.

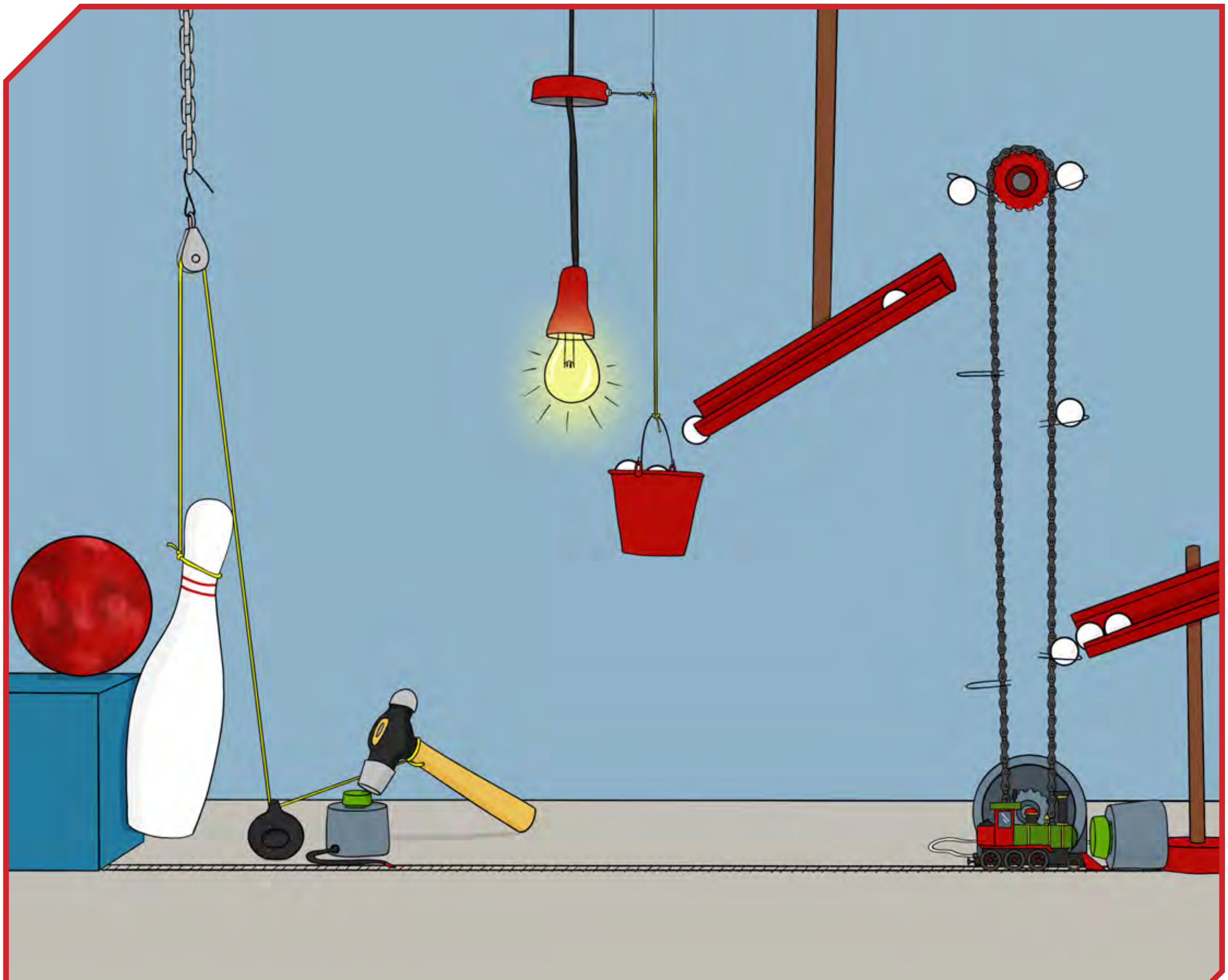
ENGINEERING DESIGN PROCESS

by Battle Creek Area Mathematics and Science Center
Cereal City Science
Adopted from the Carnegie Mellon Robotics Academy

CEREAL CITY SCIENCE by BCAMSC

Student Journal
4.PS.NGSS

Energy and Waves
4PNG



SECOND EDITION

A fourth grade unit supporting Next Generation Science Standards
and Michigan Science Standards

Name:____

Name: ______________________________

Date: ______________________________

ACTIVITY **1A**

What Is Energy?

1. Use the chart below to record at least three of your observations of energy, engineering, and technology. First make a list of the actions.

Looking for Evidence of Energy

Action	Energy	Engineering	Technology

2. After observing the video, write why you think there is evidence of energy, engineering, and/or technology.

1A ACTIVITY
What Is Energy

Name: ______________________

Date: ______________________

3. Choose one of the actions you observed and develop a model to explain what is happening right before the action, during the action, and after the action.

Action: ________________

Before	During	After

Name: ______________________________

Date: ______________________________

Domino station: Push the first Domino in the row over and observe what happens. Place an X next to all the statements that you think are true about the falling Dominos.

____ 1. A force was needed to transfer energy to the row of Dominos.
____ 2. The energy was used up when the last Domino fell.
____ 3. The energy of motion moved from one Domino to the next.
____ 4. Dominos do not have energy.

Develop a model to explain what you think is happening to the energy within the system of the falling Dominos before the action, during the action, and after the action.

Before	During	After

Write questions about energy related to the motion of the Dominos.

____

____

____

____

1B ACTIVITY
Exploring Energy

Name: ____________________

Date: ____________________

Tennis ball and ramp: Roll the ball down the ramp and make observations of energy related to the motion of the ball. Next, change the angle of the ramp and repeat your observations of the ball rolling down the ramp at a different angle. Put an X next to all the statements that you think are true about the motion of the ball on the ramp.

____ 1. The faster the ball travels, the greater the energy.
____ 2. The amount of energy of the ball increases as the ball is released from a higher position above the floor.
____ 3. The energy of the ball decreases and goes away as the ball stops.
____ 4. Changing the angle of the ramp does not change the amount of energy when the ball rolls down the ramp.

Develop a model to explain what you think about the energy related to the ball before rolling down the ramp, during the roll down the ramp, and after rolling down the ramp.

Before	During	After

Write questions about energy related to the motion of the ball on the ramp.

____

____

____

____

Name: ____________________

Date: ____________________

Rubber bands: Hold an unstretched rubber band in the palm of your hand. Stretch the rubber band and then release it. Put an X next to all the statements that you think are true about the stretched and unstretched rubber band.

____ 1. The unstretched rubber band does not have energy.
____ 2. The stretched rubber band has energy when it is released.
____ 3. The motion energy of the rubber band naturally decreases and disappears when it stops.
____ 4. Rubber bands have more energy when they are stretched the tightest or biggest.

Develop a model to explain what you think about the energy related to the rubber band before it is stretch, while the rubber band is being stretched, and when the rubber band is fully stretched.

Before	During	After

Write what questions about energy related to the rubber band, (unstretched, stretched, and released).

____

____

____

____

1B ACTIVITY

Exploring Energy

Name: ______________________

Date: ______________________

Flashlight with batteries: Observe the flashlight with the switch turned off. Turn the switch on and observe the flashlight. Put an X next to all the statements that you think are true about the energy related to the flashlight.

____ 1. Turning the flashlight on creates light energy.
____ 2. When the flashlight is turned off all the energy goes away.
____ 3. Energy moves from to another when the flashlight is turned on.
____ 4. Light energy transfers energy from place to place.

Develop a model to explain what you think about the energy related to the flashlight when it is turned on and when it is off.

On	Off

Write questions about the energy related to the flashlight.

____

____

____

____

Name: ______________________________

Date: ______________________________

Marble magnets: Make observations of what happens when the marble magnets are placed close to one another. Pull the marble magnets apart and observe what happens. Put an X next to all the statements that you think are true about the energy related to marble magnets.

____ 1. Energy of magnetism can transform to energy of motion.
____ 2. When marbles move toward one another the energy increases.
____ 3. When the marbles are together the energy disappears.
____ 4. When marbles move, energy is transferred from place to place.

Develop a model to explain what you think about the energy related to the magnetic marbles before they start moving, when they are moving and after they have stopped moving.

Before	During	After

Write questions about energy related to the magnets and magnetic marbles.

____

____

____

____

____

1B ACTIVITY
Exploring Energy

Name: ______________________

Date: ______________________

Energy pictures: Look at the pictures and discuss with your group if there is evidence of energy in any of the pictures.

Picture #1: Is there evidence of energy in the picture? How do you know?

Picture #2: Is there evidence of energy in the picture? How do you know?

Picture #3: Is there evidence of energy in the picture? How do you know?

Picture #4: Is there evidence of energy in the picture? How do you know?

Picture #5: Is there evidence of energy in the picture? How do you know?

Name: ______________________________

Date: ______________________________

Revisit your individual and group model of the action in the Rube Goldberg device. Make changes to your model based on what you have learned from the Energy Stations and discussion with your group.

Describe the changes and new information your group added to your initial model.