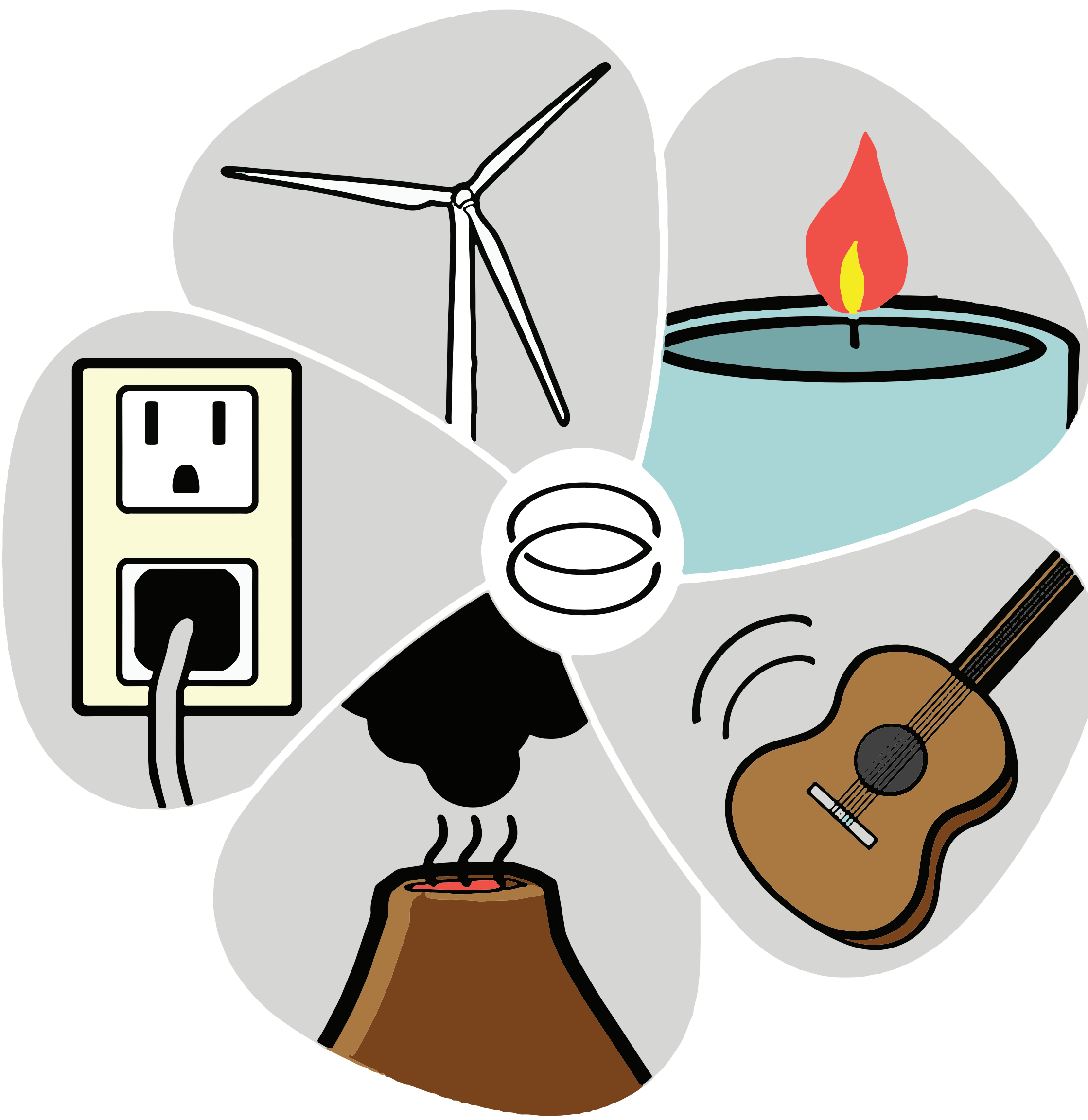
mosaic

an integrated approach to
mathematics, science, technology, & language

Grade 4

Differentiating Among Light, Thermal, Mechanical, Sound, and Electrical Energy



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MOSAIC: An Integrated Approach to Mathematics, Science, Technology, and Language represents a significant revision and update of *Integrating Mathematics, Science, and Language: An Instructional Program* (Paso Partners), produced in 1993 by Betty J. Mace-Matluck and Norma G. Hernandez, and developed by a partnership of three public schools, an institution of higher education, and SEDL specialists.

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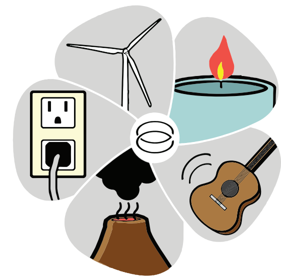


Differentiating Among Light, Thermal, Mechanical, Sound, and Electrical Energy

Introduction

This lesson on energy is one part of a K–5 instructional cross-curriculum program that integrates science, mathematics, and technology applications. The concepts in the lesson support the implementation of the 2010–2011 Texas Essential Knowledge and Skills (TEKS) as well as the Texas English Language Proficiency Standards (ELPS). The ELPS provide guidance for teachers working with English learners in the core content areas.

The cross-curricular integration in this lesson includes inquiry-based activities to engage students with content while teaching higher-order thinking skills and facilitating understanding of the connections among math, science, and technology. *The National Science Education Standards* (National Research Council, 1996) describes inquiry-based instruction as "the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world" (p. 23). Inquiry-based instruction must be carefully structured to ensure that students engage in investigations that deepen and expand their scientific knowledge as well as develop their scientific habits of mind. In *A Framework for K–12 Science Education* (2012), the National Research Council has redefined "inquiry" as "scientific and engineering practices." To promote such practices, teachers should provide learning experiences that engage students with fundamental questions and guide them in how to find the answers.

In addition to the integration of math, science, and technology, this module provides a list of related reading resources that may be used during reading or storytelling time. The books could also be used as an additional resource during the investigations and group activities. You may want to consult with the school librarian or a local community library to reserve as many of these books as possible for use during this module.

Language Objectives for English Learners

Effective instruction in second language acquisition involves giving ELs opportunities to listen, speak, read, and write at their current levels of English development while gradually increasing the linguistic complexity of the English they read and hear and are expected to speak and write. The ELPS and Texas English Language Proficiency Assessment System (TELPAS) define four English language proficiency levels: beginning, intermediate, advanced, and advanced high. These levels are not grade-specific, although there is a grade band for grades K–1 and a second for grades 2–12. ELs also may exhibit different proficiency levels within the language domains of listening, speaking, reading, and writing. The proficiency level descriptors outlined in the chart below show the progression of second language acquisition from one proficiency level to the next for each language domain. These descriptors serve as a road map to help content-area teachers instruct ELs in ways that are commensurate with students' linguistic needs.

ELPS-TELPAS Proficiency Descriptors

	Beginning	Intermediate	Advanced	Advanced High
Listening	Beginning English learners (ELs) have little or no ability to understand spoken English used in academic and social settings.	Intermediate ELs have the ability to understand simple, high-frequency spoken English used in routine academic and social settings.	Advanced ELs have the ability to understand, with second language acquisition support, grade-appropriate spoken English used in academic and social settings.	Advanced high ELs have the ability to understand, with minimal second language acquisition support, grade-appropriate spoken English used in academic and social settings.
Speaking	Beginning English learners (ELs) have little or no ability to speak English in academic and social settings.	Intermediate ELs have the ability to speak in a simple manner using English commonly heard in routine academic and social settings.	Advanced ELs have the ability to speak using grade-appropriate English, with second language acquisition support, in academic and social settings.	Advanced high ELs have the ability to speak using grade-appropriate English, with minimal second language acquisition support, in academic and social settings.
Reading	Beginning English learners (ELs) have little or no ability to use the English language to build foundational reading skills.	Intermediate ELs have a limited ability to use the English language to build foundational reading skills.	Advanced ELs have the ability to use the English language, with second language acquisition support, to build foundational reading skills.	Advanced high ELs have the ability to use the English language, with minimal second language acquisition support, to build foundational reading skills.
Writing	Beginning English learners (ELs) have little or no ability to use the English language to build foundational writing skills.	Intermediate ELs have a limited ability to use the English language to build foundational writing skills.	Advanced ELs have the ability to use the English language, with second language acquisition support, to build foundational writing skills.	Advanced high ELs have the ability to use the English language, with minimal second language acquisition support, to build foundational writing skills.

From: *Educator Guide to TELPAS: Grades K–12* (pp. 15, 22, 30, 40, 78, 84) by Texas Education Agency (TEA), Student Assessment Division, 2011, Austin, TX: TEA. Copyright 2011 by TEA. Available from **http://www.tea.state.tx.us/student.assessment/ell/telpas**. Adapted by SEDL with permission.

The 5E Lesson Cycle

The 5E lesson cycle provides a structure for implementing learning activities that elicit and build on students' existing knowledge to expand and deepen their understanding of that knowledge. Each of the 5Es describes a phase of learning: Engage, Explore, Explain, Elaborate, and Evaluate. The lesson cycle should be implemented in its entirety, and educators should avoid pulling selected activities and using them in a piecemeal fashion. The 5Es are designed to introduce and develop deeper conceptual understanding in a carefully constructed sequence.

The ELPS are embedded into the 5E lesson cycle to provide strategies and techniques for teachers to use as they shelter science and mathematics content and academic English.

1 ENGAGE

The introduction to the lesson should capture the students' attention and make connections between students' prior knowledge and the new concept they will be learning.

In this module: Students observe and draw a model of a demonstration of sound moving through air as the teacher hits the bottom of a milk jug with a wooden spoon, causing a candle flame to extinguish. Students then work in cooperative groups to investigate whether sound vibrations moving through air can make various lightweight materials move.

English learners: English learners (ELs) at the beginning level will require significant facilitation to access prior knowledge, such as materials in their first language and gestures and pictures. ELs at the intermediate level will require opportunities to make associations between the knowledge learned in the two languages, such as working in mixed-language groups with plenty of opportunities to discuss the content in both languages as well as additional time or opportunities to express their understanding orally or in writing. ELs at the advanced levels will require practice with the appropriate expression of the content's mastery (oral or written).

2 EXPLORE

Students receive opportunities to interact socially as they acquire a common set of experiences by actively exploring the new concept through investigations or activities. Students should have common experiences before they are asked to explain their understanding of a new concept. After the initial use of the activities, you may find it helpful to leave the Explore materials out in the classroom to allow students to revisit the centers for further reinforcement of the introduced concept.

In this module: Students rotate through centers to experience light, heat/thermal, sound, mechanical, and electrical energy. More than one type of energy may be involved in each center activity. Students also explore how to use standard units of measurement to determine the circumference of a shape.

English learners: Because they must process both content and academic language, ELs usually need more time to explore at the centers than English-proficient speakers. Grouping ELs with students who speak their first language and have higher levels of English proficiency will help ELs understand content concepts in their native language while learning English. As ELs explore through hands-on experiences at the centers, the teacher should monitor conversations to check for understanding of concepts and engagement.

3 EXPLAIN

Students share information about their observations at the Explore centers and engage in meaningful discussions with one another and the teacher to clarify any misconceptions and deepen their understanding of the concept they are studying. After students have had a direct experience with the concept and the chance to communicate their operational definitions, the teacher uses targeted questioning strategies to connect student experiences and observations with the concept being taught and to introduce correct terminology.

In this module: Students explain their observations of the activities at the Explore centers and participate in teacher-led discussions as a formative assessment of student understanding.

English learners: Beginning and intermediate ELs may have difficulty explaining or sharing their understanding from the Explore activities without prior practice or preparation. To help them prepare, allow ELs to practice sharing out in pairs before sharing with the whole class. One strategy might be to pair students who have different language proficiency levels. Then have the pairs discuss their personal understanding and use language frames (e.g., "Today I learned . . .") to prepare a response in English to share with the class.

4 ELABORATE

Students have the opportunity to apply the concept in a new context through additional activities, such as reading to learn, or investigations. Providing additional active learning experiences allows students to strengthen and expand their understanding of the concept.

In this module: Students apply and extend their knowledge of energy, with a focus on deepening their understanding of insulators and conductors of heat energy.

English learners: The goal during the Elaborate phase is to minimize the language demands and optimize content understanding. While building content knowledge through activities such as sharing examples of insulators and conductors, explicitly share illustrations and vocabulary for ELs. When possible, allow ELs to practice additional investigations and present their findings with an English-proficient partner to help them learn the concepts and demonstrate their understanding.

5 EVALUATE

Students demonstrate their mastery of the concept and process skills, allowing both the teacher and the students to monitor and reflect on the progress made as an outcome of instruction.

In this module: Students work in small groups to develop a digital story about the different forms of energy and how they cause changes. Teachers may also elect to have each student complete a multiple-choice assessment to help prepare for the state assessment.

English learners: Evaluations for ELs should use a variety of formats that reflect each students' level of English language proficiency. For example, assessments may include teacher observations and students' alternative expressions of knowledge. For ELs at beginning levels, responses in their first language (when possible), acting out a response, or drawing a response is appropriate. ELs at intermediate levels should be allowed to use oral and written responses using language frames (e.g., "Today I learned that ____ happened because ____."). Advanced and advanced high ELs may be assessed in the same way as their English-speaking peers, but assessment may require linguistic support with academic English terms, such as *define, provide evidence for,* and *give an example of.*

Background Knowledge

The study of energy is abstract for elementary students. To increase their understanding of energy, provide concrete experiences that enable students to connect different forms of energy to their everyday lives. As students experience increasingly complex interactions between energy and matter, they will begin to understand that many of the changes they observe occur in predictable patterns for each form of energy. The study of energy also fosters a student's ability to observe, describe, and predict patterns in a qualitative and quantitative manner.

Energy

Because energy is an abstract concept, Grade 4 students need multiple opportunities to experience different forms of energy. The U.S. Department of Energy defines energy as the ability to do work or the ability to move an object. By the end of this unit, fourth grade students should be able to differentiate among the forms of energy, including light, heat or thermal, electrical, mechanical, and sound. Students also should be able to identify everyday applications of these forms of energy and describe the use of energy insulators and conductors.

Light

Many sources of light exist, but the initial energy for all light sources comes from the sun. All light travels away from its source in straight lines as waves of energy. Patterns in the behavior of light are very predictable because light moves in waves through space until it comes in contact with an object or material that changes its direction. Light can pass through, bounce off (reflect), or be blocked by different materials as it moves in a straight line from its source.

Light rays can reflect or bounce off a surface or an object in much the same way that a ball bounces off a wall. The texture of the surface determines how much light will be reflected or absorbed. Mirrors have smooth, shiny surfaces that absorb very little light, so they reflect light in almost exactly the same pattern as it hits the mirror, which allows us to see a complete reflected image of objects.

Heat or Thermal Energy

Thermal energy is the amount of kinetic energy contained in the particles of a substance or material. The hot particles in warm substances move faster than the particles in cool substances. When the hotter particles bump into the cooler particles, some of the thermal energy is transferred. This action is why thermal energy flows from warmer to cooler substances. Insulators, such as foam cups, contain large air spaces where air particles are very far apart. Heat flows very slowly through foam cups because it bumps into fewer particles in the air spaces. Heat flows much faster through materials with tightly packed particles, such as metal and glass, which can serve as energy conductors.

Mechanical Energy

Mechanical energy is the sum of potential energy and kinetic energy. An object that has the ability to work or change its position has mechanical energy. The movements of a car or the rolling of a ball are types of mechanical energy. For more information, the Physics Classroom (**www.physicsclassroom.com/class/energy/u5l1d.cfm**) provides a nice overview for teachers.

Sound

Sound is a type of energy caused by tiny back-and-forth movements called vibrations. We can hear a sound when sound waves travel through the air to our ears and cause a vibration on the eardrums. Sound can also travel through other substances or mediums, such as liquids or solids, through which it moves more quickly than through gases.

Electrical Energy

Electrical energy is carried by tiny particles called electrons as they move from one place to another in wires, light bulbs, or motors. The source of electrical energy may be a battery or an electrical wall outlet that is connected to an electrical power plant.

A series circuit is one where all the components are attached along one direct path in a series. Any break in the circuit causes the flow of electrical energy to stop. Many holiday and party lights are examples of series circuits. One bad bulb causes all the bulbs to go out.

Perimeter and Circumference

Students should have used standard units to find a perimeter in third grade; and by fourth grade, they should be able to use measurement tools to estimate and determine perimeters. A review of the concept of perimeter might be necessary to ensure that all students understand it prior to the heat energy center. The ability to measure circumference (a task in the heat energy center) is not in the Texas Essential Knowledge and Skills (TEKS) until Grade 6. However, the foundation of circumference can be developed in Grade 4. In essence, the circumference of a circle is its "perimeter," and the idea of "the distance around" is the same in this application.

Technology

Students should receive multiple opportunities to use technology to access, interpret, and share information. Technology enables students to document and present data in ways that are visually interesting and easy to understand. Technology also affords students the opportunity to explore and experiment with science that might otherwise be costly, difficult, or dangerous, such as through the use of simulations. And technology is useful to reteach a concept or to instruct students who were absent during the hands-on learning time. If a student misses a lab experience, many examples of similar labs can often be found on websites such as TeacherTube. This module provides opportunities for students to use technology to experiment with simulations, document and report findings, and create a digital story about different forms of energy.

Whenever possible, technology activities should be used to enhance concept development, not replace hands-on experiences. In addition, technology should not be limited to the Internet and computers. Some other forms of technology to integrate into instruction include calculators, digital cameras, and recording devices.

Lesson Overview

This module has been developed so that teachers can adapt it to their schedule and classroom structure. The amount of time required to teach the module and the individual activities will vary depending on how often you teach science and math and for how long. General guidelines for structuring the lessons are provided, but teachers may find that different schedules or structures are more suitable for their classrooms. However, the sequence and order of the individual activities should be followed to achieve the educational goals.

Big Ideas

- There are many types of energy. Some materials conduct energy, and other materials slow the transfer of energy.
- A perimeter is the distance around a multi-sided shape or area.

Concepts

By the end of this lesson, Grade 4 students should understand the following concepts:

- Energy exists in many forms, including light, heat/thermal, sound, mechanical, and electrical energy.
- Energy can move from one object or material to another object or material.
- Light travels in straight lines until it comes in contact with matter.
- Thermal or heat energy is produced by the energy of moving particles in matter.
- Adding heat energy causes materials to expand; removing heat energy causes materials to contract.
- Metals are good conductors of heat/thermal energy; cloth and plastics are good insulators.
- Sounds are vibrations that can travel through gases, liquids, and solids.
- Mechanical energy is movement or motion, and is the sum of potential energy and kinetic energy.
- Electrical energy is the movement of tiny particles through a circuit to produce light and heat.
- A perimeter is the distance around a multi-sided shape and can be measured.
- Investigations should be planned and implemented safely.
- Investigations involve asking well-defined questions, making observations, and using appropriate equipment to collect measureable data so as to make inferences and explanations.
- After an investigation, we should use appropriate technology to communicate orally and in written form the data and results to other audiences.

Language Support for English Learners

Embedded throughout this lesson are strategies for academic English language support. The following strategies or supports should be used consistently during the instructional process:

- Consider the language demands of instruction. Find ways to contextualize abstract concepts. For example, to explain the concept of energy, show pictures or video clips of machines or people using energy, or use graphic organizers with content-specific vocabulary.
- For beginning ELs, create picture word banks for vocabulary.
- Pair beginning and intermediate ELs with more advanced ELs.
- Encourage more advanced ELs to provide linguistic support in their native language to assist beginning-level students.

- Model demonstrations and procedures explicitly. For example, use body gestures while explaining concepts or provide realia (real examples, such as a flashlight or mirror), illustrations, pictures, and so on.
- Provide opportunities for students to engage actively in academic conversations and hands-on learning. (ELs may disengage or sit passively if they do not understand or cannot communicate their ideas. They need opportunities to practice academic English).
- In general, be cognizant of the amount of wait time you give ELs to allow them enough time to process their thinking.
- Beginning and intermediate ELs may not have the academic English necessary to comprehend assessments. Differentiate assessments by limiting the number of questions and allowing students to show their knowledge by creating drawings and demonstrating experiments.
- The following is a list of high-frequency vocabulary in this lesson that teachers may find helpful for supporting beginning ELs. The list addresses English-Spanish translations; teachers may need additional word-to-word translations for other languages. Visuals for selected terms are also provided in the Resources section of this unit for use on a word wall or during instruction.

English Vocabulary	Spanish Vocabulary
battery	pila
circle	circulo
circuit	circuito
circumference	circunferencia
compare	compare
conductor	conductor
different	diferente
electrical energy	energía eléctrica
energy	energía
flashlight	linterna
gas	gas
heat	calor
heat energy	energía térmica
hot water	agua caliente
ice cube	cubo de hielo
insulator	aislante
kinetic energy	energía cinética
length	largo
light	luz
light bulb	bombilla
liquid	líquido
measurement	medida

English Vocabulary	Spanish Vocabulary
mechanical energy	energía mecánica
melt	derretir
metals	metales
mirror	espejo
motion	movimiento
observe	observe
perimeter	perímetro
polygon	polígono
potential energy	energía potencial
solid	sólido
sound	sonido
temperature	temperatura
thermal energy	energía térmica
thermometer	termómetro
thunderstorm	tormenta eléctrica
unit	unidad
vibrate	vibrar
vibrations	vibraciones
volume	volumen
water	agua
What happens when…	Que sucede cuando…
wire	alambre

Lesson Procedures

ENGAGE

Power of Sound

Time: Approximately 15 minutes

1. Prior to the activity, set up the materials for the class on a central demonstration table. Place the candle in a holder or a ball of clay to keep it safely upright when lit.
2. Put on safety goggles to model good safety habits. Explain that safety goggles must be worn during investigations involving heat, flame, chemicals, or flying particles.
3. Distribute a Power of Sound Data Sheet to each student. Tell students to observe closely as you perform a demonstration.

PREPARE IN ADVANCE
Practice steps 4–5 to ensure success

4. Hold the empty milk jug in one hand and place the mouth of the jug 15–20 cm away from the candle flame.
5. Hold the wooden spoon in your other hand and hit the bottom of the milk jug hard with the bowl of the spoon. The action should cause the candle flame to blow out.
6. Ask students to explain on their data sheets how they think hitting the milk jug with the spoon made the candle flame go out. Students should draw a labeled model and write an explanation.

Materials

For the class

- ☐ Tall candle and holder
- ☐ Matches
- ☐ Safety goggles
- ☐ Plastic milk jug (empty, no lid)
- ☐ Wooden spoon
- ☐ Chart paper
- ☐ Markers

For each group

- ☐ Plastic milk jug (empty, no lid)
- ☐ Wooden spoon
- ☐ Paper plate with puffed rice cereal or confetti
- ☐ Ping-Pong ball
- ☐ Small plastic container of water

For each student

- ☐ Power of Sound Data Sheet (see Resources section)

7. Organize students into groups of four. Assign each group member a cooperative learning role. Discuss the responsibilities of each role or job:
   - Principal Investigator–leads the investigation
   - Materials Manager–gathers and returns materials
   - Safety Technician–ensures safety rules are followed
   - Reader/Recorder–reads directions and records group information
8. Instruct the Materials Managers to pick up the following group items: a milk jug, a wooden spoon, a paper plate of lightweight material, a Ping-Pong ball, and a small container of water.
9. Give the groups 5–10 minutes to test how hitting the milk jug near the plate of lightweight material, the Ping-Pong ball, and the container of water affects each in turn. Students should mimic the process used in the demonstration, but they may want to hold the mouth of the milk jug closer to the objects to get better results. The Principal Investigator should perform the tests, and the Reader/Recorder should record the results. Each group member should then complete his or her data sheet.
10. When the groups are done, ask the Materials Managers to return the items to a designated area.
    - Which materials were easiest to move? *Most students will say the lightweight materials on the plate.*
    - Was any group able to move the Ping-Pong ball? *Yes, we held the mouth of the jug fairly close to the Ping-Pong ball when hitting the bottom of the jug.*
    - What happened when you hit the jug near the surface of the water in the container? *It caused ripples across the surface of the water.*
    - What might be the source of energy? *our hands, vibrations*
    - What moves inside the jug when the bottom is hit with a spoon? *air*
    - What causes the air to move? *Hitting the spoon on the milk jug makes the air move or vibrate, which causes the air next to it to move or vibrate.*
    - Can vibrations only move through air? *No, they moved across the water in the container and through the plastic jug.*
11. Lead students to discuss how they could feel the plastic jug vibrate when they hit it.

English Language Support

- Model instructions explicitly to ensure that ELs understand how the experiment is performed.
- Provide beginning and intermediate ELs with Spanish translations of key terms.
- Ensure that ELs in each group are engaged. Perhaps assign beginning and intermediate ELs the Materials Manager role.
- Consistently check for understanding as each group is performing the experiments.
- ELs at the beginning and intermediate levels may not be able to respond to questions in English. During discussion, allow them to respond in their native language or to draw or demonstrate their responses.

General Instructions for Explore Centers

Time: Approximately 1.5 hours, including about 15 minutes per center (monitor center activity to see if students finish sooner)

This activity consists of five centers. Organize students into groups of two to three members and assign a portion of the groups to work at each center. Then rotate. A class of 25 students will need approximately two centers each for light, heat, sound, mechanical, and electrical.

1. Prior to class, set up the center materials in areas of the classroom that allow space for students to work together in small groups of two to three. Refer to the Materials List and Details in the Resources section for more information about setting up each center.
2. Instruct students that their job involves making careful observations about the activity at each of the centers they visit with their group. Emphasize to students the importance of recording detailed information on their data sheets or in their journals.
3. Carefully review the instructions for each center and demonstrate the activities. Ask if students have any questions.
4. While students are at each center, move about the room to monitor their activities. After about 15 minutes, have groups rotate centers.
5. You may want to leave the Explore centers set up for several days, if possible, to allow students to return to the activities and complete them more than once.

Light Energy Center

Students observe that light must be present to see an object and that light follows certain patterns of behavior, such as travelling in a straight line, bouncing off shiny surfaces, and passing through clear liquids.

Materials

For each center

- ☐ Light Energy Center Instructions (see Resources section)
- ☐ Eye diagram (on the center instructions)
- ☐ Flashlight
- ☐ 1 m string
- ☐ Tape

For each student

- ☐ Light Energy Center Data Sheet (see Resources section)

Heat Energy Center

Safety goggles required

Students measure and record the circumference of an inflated balloon. They repeat the process after placing the balloon under a heating pad and in a cooler of ice, respectively. Students then determine the change in circumference of the balloon for each case.

Before the center, demonstrate for students how to use a string and ruler to measure the circumference of a round object. Wrap a length of string around an inflated balloon. With a red marker, mark the place where the string meets. Then straighten out the string on a table and use a ruler to measure the distance of the string that went around the balloon. Alternatively, have students use a tape measure.

Materials

For each center

- ☐ Heat Energy Center Instructions (see Resources section)
- ☐ Medium round balloon (inflated; per group)
- ☐ 1 m string (per group)
- ☐ Metric ruler
- ☐ Red marker
- ☐ Thermometer
- ☐ Foil pie pan
- ☐ Heating pad
- ☐ Cooler with ice (big enough to hold inflated balloon and pan)
- ☐ Timer
- ☐ Safety goggles (per group member)

For each student

- ☐ Heat Energy Center Data Sheet (see Resources section)

Sound Energy Center

Students observe the effects of a tapped tuning fork coming in contact with a gas, a liquid, and a solid.

Materials

For each center

- ☐ Sound Energy Center Instructions (see Resources section)
- ☐ Tuning fork
- ☐ Plastic bowl
- ☐ Water

For each student

- ☐ Sound Energy Center Data Sheet (see Resources section)

Mechanical Energy Center

Students observe how long a toy top spins after pushing the spin knob a different number of times. The students then investigate potential and kinetic energy (which equals mechanical energy) at the computer by manipulating a skateboard park simulation.

PREPARE IN ADVANCE
Download and install the PhET Energy Skate Park simulation

Materials

For each center

- ☐ Mechanical Energy Center Instructions (see Resources section)
- ☐ Toy spinning top (with push knob)
- ☐ Stopwatch
- ☐ Computer with PhET Energy Skate Park simulation installed: **http://phet.colorado.edu/en/simulation/energy-skate-park**

For each student

- ☐ Mechanical Energy Center Data Sheet (see Resources section)

Electrical Energy Center

Students explore how to use a D cell battery and electrical tape to light up a partial strand of holiday lights. The students then draw a diagram of the simple circuit they created. After the students have had a real experience making an electrical circuit, they build circuits in two virtual labs on the computer.

PREPARE IN ADVANCE
Holiday Light Strand

PREPARE IN ADVANCE
Download and install the PhET Signal Circuit and Circuit Construction Kit virtual labs

Materials

For each center

- ☐ Electrical Energy Center Instructions (see Resources section)
- ☐ Prepared holiday light strand (see Materials List and Details in Resources section)
- ☐ D cell battery
- ☐ Electrical tape strips
- ☐ Computer with following installed:
  - PhET Signal Circuit: **http://phet.colorado.edu/en/simulation/signal-circuit**
  - PhET Circuit Construction Kit: **http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab**

For each student

- ☐ Electrical Energy Center Data Sheet (see Resources section)

English Language Support

- The activities in this section are highly engaging and provide excellent opportunities for ELs to learn abstract concepts, such as mechanical and electrical energy.
- For beginning and intermediate ELs, provide visual support of the materials at each center by pointing to each item and stating its English name (e.g., "This is a thermometer.") and/or by providing cards with illustrated and labeled terms. (Illustrated English-Spanish vocabulary cards for selected terms are available in the Resources section.)
- Explicitly model each center procedure and monitor your pacing to ensure that ELs have enough time to process the information. Make intentional efforts to ask ELs questions to check for understanding.
- As ELs engage in each center activity, make intentional efforts to ask them questions. Ask ELs to demonstrate what they are learning as a formative assessment.
- Use language frames to encourage ELs to use academic language related to what they are learning (e.g., "We are measuring the ____________ of the balloon.").

General Instructions

Time: Will vary with the level of discussion

Students explain their observations from the Explore centers and participate in a teacher-led discussion as a formative assessment of student understanding. The teacher provides additional activities to give students more experiences related to energy and to introduce new vocabulary.

Light Energy

Ask students the following questions about their observations at the light energy center:

- What was the source of light energy? *the flashlight*
- How was the light energy produced? *the battery in the flashlight*
- Where did the light travel? *straight along the string toward the picture of the eye on the wall*
- How did you know the line was straight? *The string was taut and straight, and the light from the flashlight followed the string exactly.*
- Why did we use the string? *It acted as a model of a straight ray of light, because it is hard to see how light travels.*
- What happened when the light hit the picture? *Some of the light bounced off the picture toward us, enabling our eyes to see the picture.*
- How does light energy travel? *Light travels in straight lines, like the string. These lines are waves of energy.*

Heat Energy

1. Ask students the following questions about their observations at the heat energy center:
   - What was the room temperature? *Answers will vary.*
   - What was the temperature of the cooler of ice? *Answers will vary, but should be between 3 and 6 degrees Celsius.*
   - What was the temperature of the heating pad? *Answers will vary based on the heating pad, but likely will be more than 30 degrees Celsius.*
   - What happened to the balloon when the heating pad was placed on it? *The balloon expanded.*
   - How do you know? *We measured the circumference of the largest part of the balloon before and after we put the balloon under the heating pad, and the circumference changed.*

Materials

For the class

- ☐ Computer with Internet access
- ☐ Data projector and screen
- ☐ Math Is Fun! polygon simulation: **http://www.mathsisfun.com/definitions/regular-polygon.html**

- What happened to the balloon in the cold ice chest? *The balloon shrank.*
- How do you know? *We measured the circumference of the largest part of the balloon before and after we put the balloon in the ice chest, and the circumference changed.*
- What caused the change in the size of the balloon? *adding or removing heat energy*

2. At this point, make the connection between circumference and perimeter. Review the concept of a perimeter by having students find the perimeter of polygon-shaped areas in the room, such as floor tiles. Ensure that students understand that perimeter is the distance around a multi-sided shape or area.
3. Next, using a computer that has Internet access and is attached to a projector, access and display the Math Is Fun! polygon simulation: **http://www.mathsisfun.com/definitions/regular-polygon.html**.
4. Start with 4 sides (a square) and have students determine the perimeter.
5. Have students repeat the activity as you increase the number of sides to 6, 8, and then 10.
6. Ask students what the polygons are beginning to look like. *Students should notice that the shapes are starting to look more and more like circles.*
7. Skip to larger numbers, such as 20 or 30 sides. Use the activity to help students make the connection that a circle also has a type of perimeter; the difference is that a circle does not have sides, so it cannot be measured in the same way.
8. Remind students how they used a string and ruler to find the distance around the balloon. Explain that instead of the term *perimeter,* which is the distance around a polygon (multi-sided shape), we use the term *circumference* for the distance around a circle, as students learned in the heat energy center.

Sound Energy

Ask students the following questions about their observations at the sound energy center:

- What did you hear through the air when you tapped the tuning fork gently on your shoe? *The tuning fork made a faint humming noise.*
- What did you hear through the air when you tapped the tuning fork harder on your shoe? *The tuning fork made a louder humming noise.*
- What happened when you tapped the tuning fork gently on your shoe and then touched the top of the water with the edge of the fork? *The back-and-forth movements of the tuning fork caused the water to spray and splash.*
- What happened when you tapped the tuning fork gently on your shoe and then touched the top of the table with the edge of the tuning fork? *The back-and-forth movements of the tuning fork on the table caused a loud buzzing noise.*
- Can vibrations pass through gases, liquids, and solids? *yes*
- Which material created the loudest sound? *the table*

- Why do you think that happened? *Lead students to understand that the particles of a solid, such as the table, are packed closely together, so sound vibrations move through the particles without getting spread out, which makes the sound louder.*
- Which material created the softest sound? *the tuning fork vibrating in air*
- Why do think that happened? *Lead students to understand that the particles of a gas, such as air, are spread out, so sound vibrations get spread out as they move through the air, which makes the sound softer.*

Mechanical Energy

Materials

For the class

- ☐ Computer with PhET Energy Skate Park simulation installed: **http://phet.colorado.edu/en/simulation/energy-skate-park**
- ☐ Data projector and screen

1. Ask students the following questions about their observations at the mechanical energy center:
   - What did you do to "wind up" the toy top? *pushed on the spinning knob*
   - What happened when you released the top? *It started to spin or move.*
   - What happened when you pushed the knob more times before releasing the top? *The top spun or moved for longer before stopping.*
   - What do we call this type of energy? *mechanical energy*
   - What does the top need to start moving? *potential (stored up) energy built up by pushing the knob*
2. Have students explore potential and kinetic energy further. Using a computer attached to a projector, display the PhET Energy Skate Park simulation (installed previously): **http://phet.colorado.edu/en/simulation/energy-skate-park.**
3. After you open the simulation, look at the panel on the right. Under Energy Graphs, check the "Show Pie Chart" option.
4. When the skateboarder is at the top of the path, press pause (located at the bottom of the window). Point to the circle above the skateboarder and ask students what it indicates. *The skateboarder has a lot of potential energy.*
5. Press play to resume the skateboarder's motion. When the skateboarder is at the bottom of the path, press pause again. Point to the circle above the skateboarder and ask students what it indicates now. *The skateboarder now has more kinetic energy than potential energy (some potential energy has changed to kinetic energy).*
6. Resume play. As students watch the moving skateboarder, ask:
   - When is there a lot of potential energy? *when he is at the top of the path*
   - When is there a lot of kinetic energy? *when he is at the bottom of the path*
   - What do you think potential energy is? *stored energy*
   - What do you think kinetic energy is? *energy in motion*
   - What do we call the sum of potential and kinetic energy? *mechanical energy*

Electrical Energy

Materials

For the class

- ☐ Computer with following installed:
  - PhET Signal Circuit: **http://phet.colorado.edu/en/simulation/signal-circuit**
  - PhET Circuit Construction Kit: **http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab**
- ☐ Data projector and screen

1. Ask students the following questions about their observations at the electrical energy center:
   - What method did you use to light the holiday bulb? *Each end of the holiday light strand has an exposed wire. Taping each wire to an opposite end of the battery made the bulb light up.*
   - Did you notice anything else when the bulb was lit? *The bulb, wires, and battery felt warm.*
   - What happened when a wire was removed from one of the metal ends of the battery? *The bulb went out.*
   - What could be traveling along the wires? *electrical energy*
   - Can electrical energy jump a gap? *No, the bulb went out when the metal ends of the wires were not touching the metal ends of the battery.*
2. Using a computer attached to a projector, display the PhET Signal Circuit virtual lab (installed previously): **http://phet.colorado.edu/en/simulation/signal-circuit**.
3. This virtual lab shows the electrical circuit from a light switch to a chandelier. Click the light switch to start the flow of electricity through the circuit.
   - What do the blue dots represent? *electricity (electrons)*
4. Check "Paint Electron" at the bottom of the window.
   - What does the red *X* represent? *Students will learn the parts of the atom in a later grade. For now, tell them the* X *represents one tiny part of the electricity (one electron or part of an atom).*
   - What do we call the electrical path shown? *a circuit*
5. Close the virtual lab and open the PhET Circuit Construction Kit (installed previously): **http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab**.
6. Ask for one or two volunteers to come up to the computer and use the virtual kit to build a circuit that will turn on the light bulb. To use the kit:
   a. Drag and drop components from the panel on the right to the blue workspace.
   b. Drag components together to link them and create a closed circuit.
   c. To disconnect two items, right-click on a junction point and select the option to split the junction. Right-click on other components, such as the light bulb or resistor, to see other options.
7. After the students light the bulb, have them right-click on a junction to split the circuit.
   - What happens when the circuit has an opening? *The electricity stops moving because it cannot jump the gap, and the light bulb goes out.*
8. Have another student place the switch into the circuit (if it is not already there).
   - What happens when we raise (turn off) the switch? *The switch stops the electricity from moving along the wire, and the light bulb goes out.*

9. Quickly create a circuit that includes the resistor. Right-click on the resistor and select the change resistance. On the scale that appears, slide the marker slowly toward 100.0.
    - What is changing? *the speed of the electricity (electrons) in the circuit is slowing and the brightness of the light bulb is dimming*
10. Slide the marker slowly back to 0.0.
    - When is the bulb the brightest? *when the slider is on 0.0*
    - When is the bulb the dimmest? *when the slider is on 100.0*
    - Have you seen something like this slider before? *Lead students to recall a dimmer switch, like some students may have at home. Describe this type of switch for students who have never seen one or locate an image of one on the Internet to show students.*
11. Explain that when resistance is low, it is a good conductor. For example, if we hold a metal spoon in hot water, the spoon will quickly get hot because metal is a good conductor, or carrier, of heat. That is why we use metal pots and pans to cook.
12. Then explain that when resistance is high, it is a good insulator. Not much electricity travels through the wires. Rubber and plastic are also good insulators, which is why wires to lamps and other electrical devices are often covered with those materials. These insulating materials stop us from getting electrocuted when we touch an electrical cord.
    - What is a good insulator for heat? What do we use to pick up hot pans? *cloth pot holders*
    - What does a conductor do? *carries energy from one place to another*
    - What does an insulator do? *stops energy from moving from one place to another*

English Language Support

The language demands of this part of the lesson are very high. To make the learning more contextualized (concrete), the teacher should consider the following:

- During the series of questions and demonstrations, explicitly model content by using objects, body gestures, and visuals. For example, model the actions as you ask a question such as, "What did you hear through the air when you tapped the tuning fork gently on your shoe?"
- Watch your pacing (use a slower rate of delivery) as you ask questions and guide the discussion.
- Provide wait time after questions to give ELs enough time to process the information.
- Provide ELs with opportunities to speak and engage by asking them recall questions and by using language frames (e.g., "The top ____________ when I let it go.").
- Intermediate ELs may need the same support as beginners as both groups are learning new concepts.
- During question and discussion sessions, pair ELs at different English proficiency levels and have the pairs engage in think-pair-share activities (e.g., "Tell your partner what you saw when. . .").

ELABORATE

Conduction and Insulation of Heat Energy

Time: Approximately 30 minutes

The Elaborate phase allows students to apply their new knowledge of heat energy, with a focus on conductors and insulators of heat (or thermal) energy. In this activity, students observe how spoons of different materials transfer different amounts of heat to melt butter holding a pea. The directions are for a class demonstration, but the activity may also be done as a group activity or center.

Materials

For the class

- ☐ 1000 mL beaker
- ☐ Warm water
- ☐ Metal spoon
- ☐ Wooden spoon
- ☐ Butter
- ☐ Dried split peas

For each group

- ☐ Thermometer
- ☐ Stopwatch

For each student

- ☐ Journal
- ☐ Safety goggles

Safety goggles required

1. Ensure that everyone is wearing safety goggles. Remind students that safety goggles must be worn during investigations involving heat, flame, chemicals, or flying particles.
2. Organize students into small groups of two to three and give each group a thermometer and a stopwatch.
3. Demonstrate how to place a small pat of butter in the bowl of each spoon and then how to stick a pea on top of each pat of butter.
4. Discuss with students that to conduct a fair test, each pat of butter should be the same size and placed in the same location on each type of spoon.

Water should not be warmer than 54°C for safety.

5. Pour warm water into a beaker for safety. Again, caution the students to be very careful near hot substances.
6. Place the butter-and-pea-laden bowls of the two spoons on the surface of the water at the same time. Have the groups start timing with their stopwatches. Demonstrate how to hold the bowl of each spoon on the surface of the water without getting the butter wet.
7. Before, during, and after the investigation, students should work in their groups to make diagrams and record data, such as the temperature of the water and the time it takes to observe changes in each spoon. Allow for variation of design as long as students record data before, during, and after the investigation.
8. During the investigation, direct students to observe the butter on the spoons for changes. The students should note changes such as how long it takes each pat of butter to melt and what happens to the peas as the butter melts.

9. After both pats of butter have melted, provide students with time to complete their documentation. Then ask:
   - Which spoon melted the butter first? *the metal spoon*
   - How long did it take for the butter to melt on the metal spoon? *Answers will vary.*
   - What happened to the pea when the butter in the metal spoon began to melt? *The pea slid down the spoon.*
   - What happens when you place a metal spoon in very warm water or in hot food that is cooking on the stove? *The metal spoon becomes warm very quickly, and the heat moves or conducts quickly from the hot liquid or food to the spoon.*
   - How long did it take for the butter to melt on the wooden spoon? *Answers will vary.*
   - What happens when you place a wooden spoon in very warm water or in hot food that is cooking on the stove? *The handle of the spoon stays the same temperature and does not move or conduct the heat from the hot liquid or food.*
   - Which spoon would you choose to use when stirring a hot dish on the stove? *The wooden spoon because it would not burn my hands.*
   - Which spoon is a good conductor of heat? *the metal spoon*
   - Which spoon is a good insulator of heat? *the wooden spoon*

English Language Support

The language demands of this part of the lesson are very high. To make the learning more contextualized (concrete), the teacher should consider the following:

- During the activity, explicitly model procedures, questions, and discussions by using realia (real objects), body gestures, and visuals.
- Give ELs the opportunity to engage in the demonstration.
- Provide a word bank with examples for key vocabulary.
- Provide ELs with opportunities to speak by asking them recall questions and by using language frames.
- Provide wait time to give ELs more time to process information.
- Intermediate ELs may need the same support as beginners as both groups are learning new concepts.
- During question and discussion sessions, pair ELs at different English proficiency levels and have the pairs engage in think-pair-share activities (e.g., "Tell your partner what you saw when. . .").
- Consistently check for understanding and clarify any misconceptions or misinterpretations.
- Summarize the key points before wrapping up this part of the lesson.

EVALUATE

A group project for assessing student understanding is provided below. Teachers may also elect to have each student complete the provided multiple-choice assessment to help prepare for the state assessment.

Group Project

Time: Approximately 1.5 hours (1 hour to develop; 30 minutes to present)

Materials

For each group

- ☐ Group Project Rubric (see Resources section)
- ☐ Computer with Internet access
- ☐ Storytelling website such as **http://www.storybird.com**

1. Organize students into small groups of two to three.
2. Have the groups use a storytelling website such as **http://www.storybird.com** to create a digital story about energy. After registering on the site, students can choose images and enter text to tell their story. You may want to preselect images on the site for students.
3. Ask each group to include the following forms of energy—light, heat (thermal), sound, mechanical, and electrical—in the story.
4. Explain to students that they are going to create either a fiction or nonfiction story that includes a minimum of at least one change caused by each form of energy and how that change can be measured.
5. In class, model the process for students by going to the website, selecting story art, and adding your own text. You may also want to create a story in advance that meets all the requirements of the project to provide as a model for students.
6. Provide each group with a copy of the rubric on the next page (also provided in the Resources section), which will be used to grade the digital stories. Read the rubric aloud to students row by row. After you read each row, check that students understand what is expected.
7. Monitor the groups while they work to check their progress, provide feedback, review expectations, and offer assistance or guidance.
8. Have each group present its digital story to the class.

	1-Needs Improvement	2-Satisfactory	3-Excellent
Energy	The five forms of energy are not included.	The five forms of energy are included, but an example of how each one causes change is not.	The five forms of energy are included as well as at least one example of how each one causes change.
Measurement	No measurements are included, or an explanation is not given as to why no measurements are included.	One or more of the forms of measurement included is inappropriate (e.g., time for length).	The units of measurement included are used correctly, or a reason is given as to why a measurement is not relevant.
Technology	Technology is not used successfully.	Technology is limited to word processing.	Students created and shared their digital book online.

Individual Assessment

Time: 30 minutes

Have each student complete the Energy Assessment, which is similar to STAAR™. See the Resources section for the assessment, instructions, and answer key.

Materials

For each student

- ☐ Energy Assessment (see Resources section)
- ☐ 2 pencils

Assessment Support for English Learners

While developing assessments for English learners, take into consideration each student's English language proficiency level (from TELPAS and teacher observation). Differentiate evaluations by levels of English proficiency. Methods of assessing ELs might include the following:

Beginning and Intermediate:

- Physical demonstrations (repeating the experiment while a teacher checks for understanding)
- Pictorial products (drawings related to what students learned in the centers)

Advanced:

- Oral presentations of what students learned while a teacher provides linguistic support
- English-Spanish word bank with content-specific vocabulary for ELs to use during assessments
- Linguistic support provided by monitoring ELs while they are taking the assessment
- Clarification of test questions if needed to ensure understanding of what is being asked (e.g., arrange the pictures in order from coldest to hottest)

Advanced High:

- Limited linguistic support with comprehension of test questions as needed
- Consistent monitoring of ELs while they are engaged in the assessment and clarification of concepts as needed

Materials List and Details

ENGAGE

Power of Sound

Teacher Preparation: In advance, practice using the milk jug and spoon to extinguish a candle to ensure that you achieve the desired results. Prior to class, make a copy of the Power of Sound Data Sheet for each student and set up the materials on a central demonstration table.

For the class

- ☐ Tall candle and holder
- ☐ Matches
- ☐ Safety goggles
- ☐ Plastic milk jug (empty, no lid)
- ☐ Wooden spoon
- ☐ Chart paper
- ☐ Markers

For each group

- ☐ Plastic milk jug (empty, no lid)
- ☐ Wooden spoon
- ☐ Paper plate containing puffed rice cereal or confetti
- ☐ Ping-Pong ball
- ☐ Small plastic container of water

For each student

- ☐ Power of Sound Data Sheet

EXPLORE

Light Energy Center

Teacher Preparation: Copy the eye diagram on the Light Energy Center Instructions, cut the diagram out, and laminate it. Attach the diagram to the wall next to (but not above) a table. The diagram should be about shoulder height for the average fourth grader. Make sure that the area in front of the eye diagram is clear; students will need to stand there. Measure 1 meter of string. Tape one end of the string to a flashlight lens and the other end to the pupil in the eye diagram. Place the flashlight on the table. Prior to class, make a copy of the Light Energy Center Data Sheet for each student.

For each center

- ☐ Light Energy Center Instructions (for teacher)
- ☐ Eye diagram (on the center instructions; laminate for repeated use)
- ☐ Flashlight
- ☐ 1 m string
- ☐ Tape

For each student

- ☐ Light Energy Center Data Sheet

Heat Energy Center

Teacher Preparation: Copy and laminate the Heat Energy Center Instructions and make a copy of the Heat Energy Center Data Sheet for each student. Blow up the balloons. Cut pieces of string that are long enough to encircle the widest part of each balloon with a few inches left. You will need one balloon and string per group. Just before class, plug in the heating pad and set it on medium heat.

For each center

- ☐ Heat Energy Center Instructions (laminate for repeated use)
- ☐ Medium round balloon (inflated; per group)
- ☐ 1 m string (per group)
- ☐ Metric ruler
- ☐ Red marker
- ☐ Thermometer
- ☐ Foil pie pan
- ☐ Heating pad
- ☐ Cooler with ice (big enough to hold inflated balloon and pan)
- ☐ Timer
- ☐ Safety goggles (per group member)

Safety goggles required

For each student

- ☐ Heat Energy Center Data Sheet

Sound Energy Center

Teacher Preparation: Copy and laminate the Sound Energy Center Instructions and make a copy of the Sound Energy Center Data Sheet for each student.

For each center

- ☐ Sound Energy Center Instructions (laminate for repeated use)
- ☐ Tuning fork (available for purchase online)
- ☐ Plastic bowl
- ☐ Water

For each student

- ☐ Sound Energy Center Data Sheet

Mechanical Energy Center

Teacher Preparation: Copy and laminate the Mechanical Energy Center Instructions and make a copy of the Mechanical Energy Center Data Sheet for each student. In advance, download and install the PhET Energy Skate Park simulation on a computer to go at the center. Familiarize yourself with the simulation so you can assist students (see the Explain: Mechanical Energy activity for guidance), but encourage students to explore the simulation on their own. Prior to class, start the simulation, check "Show Pie Chart" in the panel on the right, and then pause the simulation.

For each center

- ☐ Mechanical Energy Center Instructions
- ☐ Toy spinning top with push knob (can modify activity to use a wind-up toy if a top with a knob cannot be found)
- ☐ Stopwatch
- ☐ Computer with PhET Energy Skate Park simulation installed: **http://phet.colorado.edu/en/simulation/energy-skate-park**

PREPARE IN ADVANCE

Download and install the PhET Energy Skate Park simulation: http://phet.colorado.edu/en/simulation/energy-skate-park

For each student

- ☐ Mechanical Energy Center Data Sheet (see Resources section)

Electrical Energy Center

Teacher Preparation: Copy and laminate the Electrical Energy Center Instructions and make a copy of the Electrical Energy Center Data Sheet for each student. In advance, prepare the holiday light strand (see instructions below). Then download and install the PhET Signal Circuit and Circuit Construction Kit virtual labs on a computer to go at the center. Familiarize yourself with the labs so you can assist students (see the Explain: Electrical Energy activity for guidance), but encourage students to explore the labs on their own. Prior to class, start the virtual labs. In the Signal Circuit lab, check "Show Electrons" and "Paint Electron."

For each center

- ☐ Electrical Energy Center Instructions
- ☐ Prepared holiday light strand (see instructions below)
- ☐ D cell battery
- ☐ Electrical tape strips

- ☐ Computer with following installed:
  - ☐ PhET Signal Circuit virtual lab: http://phet.colorado.edu/en/simulation/signal-circuit
  - ☐ PhET Circuit Construction Kit (DC Only) virtual lab: http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab

For each student

- ☐ Electrical Energy Center Data Sheet

Holiday light strand preparation

Use wire cutters to clip off a section of holiday lights that includes one bulb and the cord on each side of it. Use wire strippers or a small sharp knife to peel back the plastic coating on each end of the section. You need about 2.5 cm (1 in.) of exposed wire on each end. Test the bulb by using electrical tape to attach one exposed wire to one end of a D cell battery and the other exposed wire to the other end of the battery. The bulb should light.

- ☐ String of holiday lights
- ☐ Wire cutters
- ☐ Wire strippers or small sharp knife

PREPARE IN ADVANCE
Download and install the PhET Signal Circuit and Circuit Construction Kit (DC Only) virtual labs: http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab

PREPARE IN ADVANCE
Holiday Light Strand

Never allow both ends of the wire to touch the ends of the battery for longer than 8–10 seconds because the wire can become very hot.

EXPLAIN

Heat Energy

Teacher Preparation: Prior to class, familiarize yourself with the Math Is Fun! polygon simulation and ensure that you can project it from your computer onto a screen for the class to see.

For the class

- ☐ Computer with Internet access
- ☐ Math Is Fun! polygon simulation: http://www.mathsisfun.com/definitions/regular-polygon.html
- ☐ Data projector and screen

Mechanical Energy

Teacher Preparation: If needed, download and install the PhET Energy Skate Park simulation. Familiarize yourself with it (see the activity procedures for guidance) and ensure that you can project it from your computer onto a screen for the class to see.

For the class

- ☐ Computer with PhET Energy Skate Park simulation installed: http://phet.colorado.edu/en/simulation/energy-skate-park
- ☐ Data projector and screen

Electrical Energy

Teacher Preparation: If needed, download and install the PhET Signal Circuit and Circuit Construction Kit virtual labs. Familiarize yourself with them (see the activity procedures for guidance) and ensure that you can project them from your computer onto a screen for the class to see.

For the class

- ☐ Computer with following installed:
  - ☐ PhET Signal Circuit: **http://phet.colorado.edu/en/simulation/signal-circuit**
  - ☐ PhET Circuit Construction Kit: **http://phet.colorado.edu/en/simulation/circuit-construction-kit-dc-virtual-lab**
- ☐ Data projector and screen

ELABORATE

Conduction and Insulation of Heat Energy

For the class

- ☐ 1000 mL beaker
- ☐ Warm water
- ☐ Metal spoon
- ☐ Wooden spoon
- ☐ Butter
- ☐ Dried split peas

Water should not be warmer than 54°C for safety.

For each group

- ☐ Thermometer
- ☐ Stopwatch

For each student

- ☐ Journal
- ☐ Safety goggles

Safety goggles required

EVALUATE

Group Project

For each group

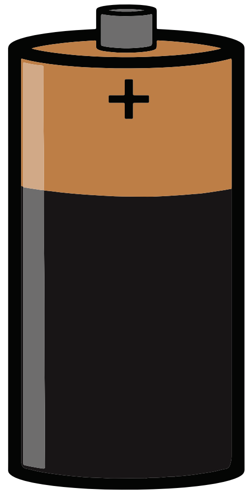
- ☐ Group Project Rubric
- ☐ Computer with Internet access
- ☐ Collaborative storytelling website such as **http://www.storybird.com**

Individual Assessment

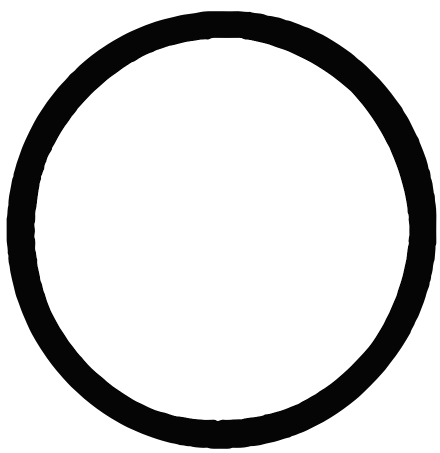
For each student

- ☐ Energy Assessment
- ☐ 2 pencils

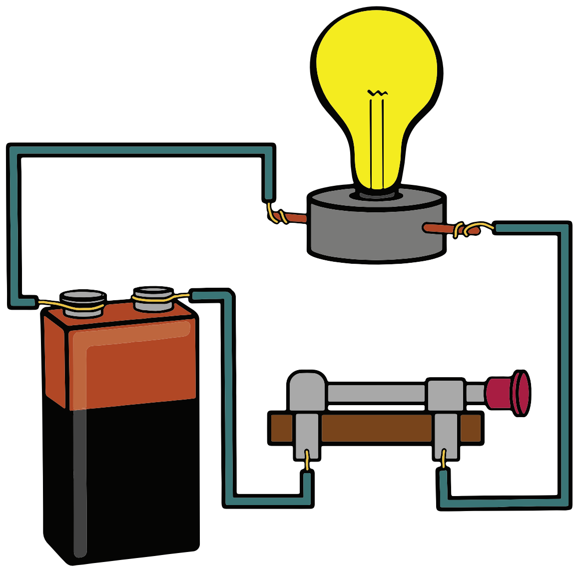
Frequent English/Spanish Vocabulary Words



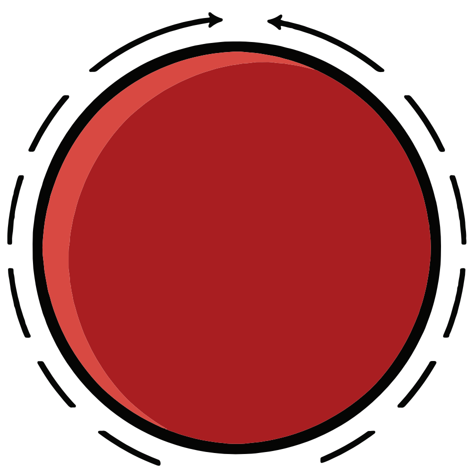
battery / pila



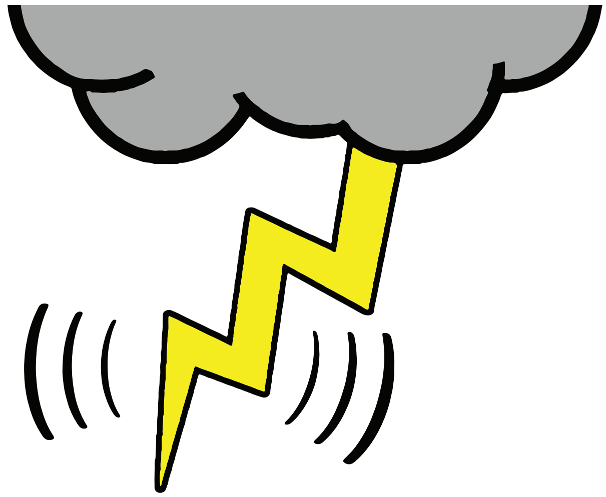
circle / circulo



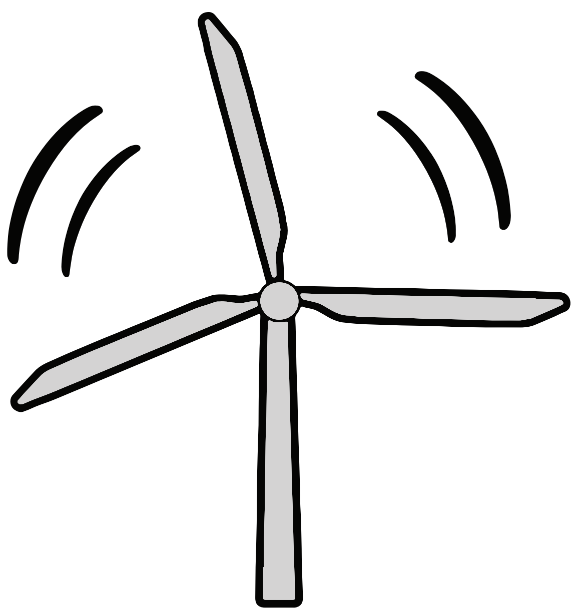
circuit / circuito



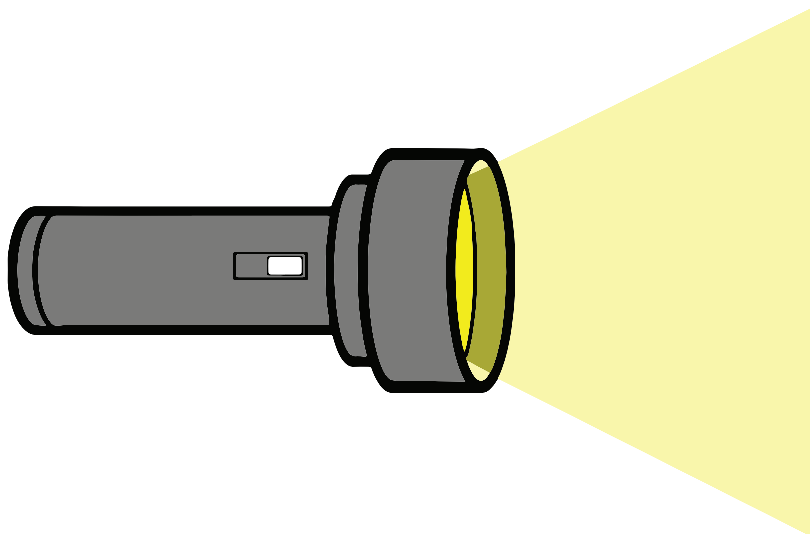
circumference / circunferencia



electrical energy / energía eléctrica

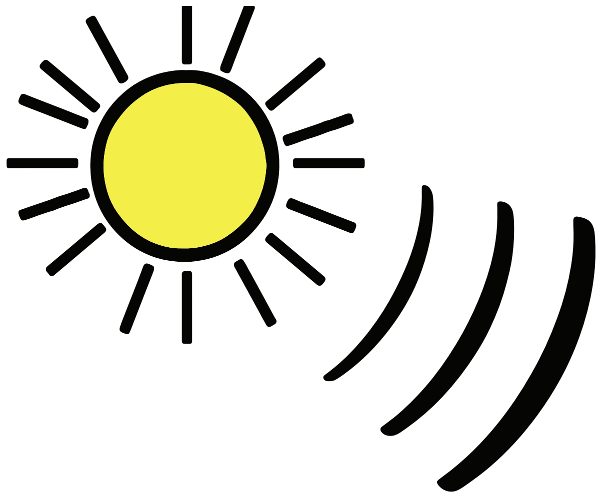


energy / energía

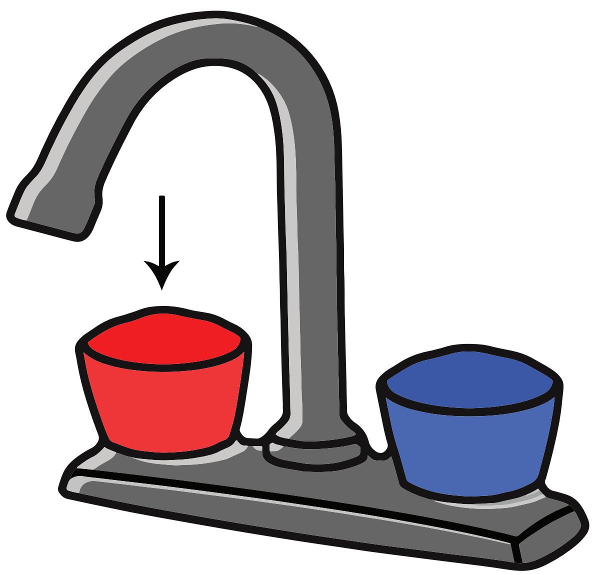


flashlight / linterna

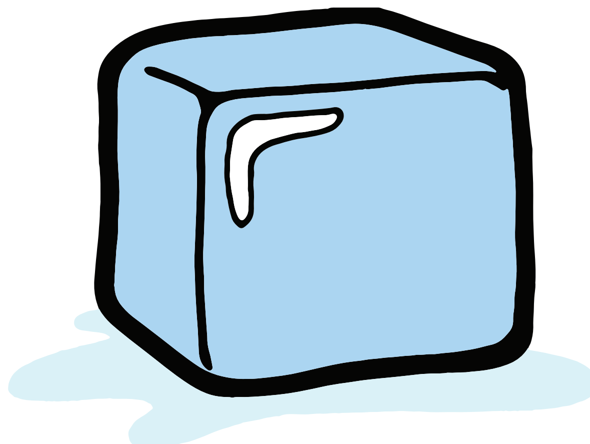
heat / calor



heat energy / energía térmica

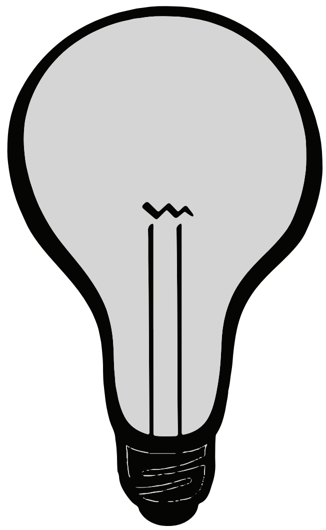


hot water / agua caliente

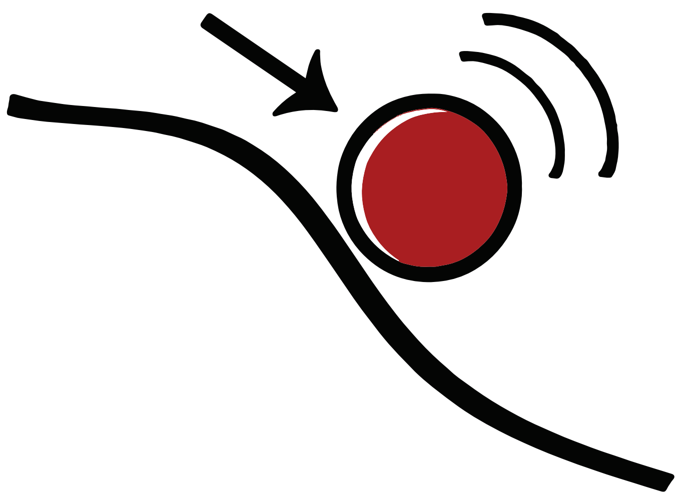


ice cube / cubo de hielo

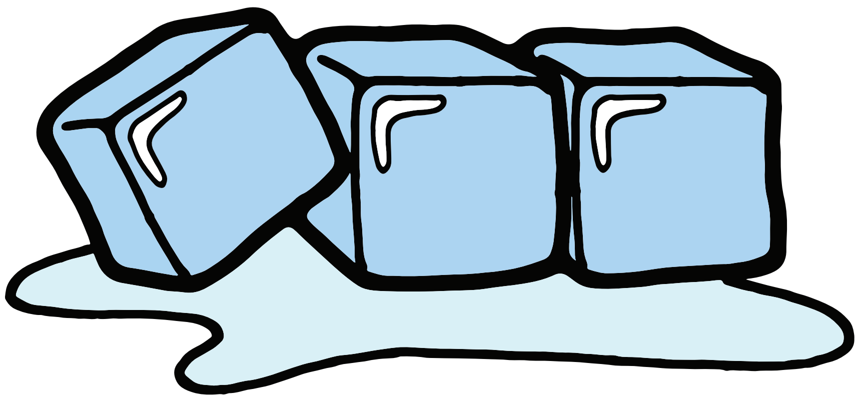
light / luz



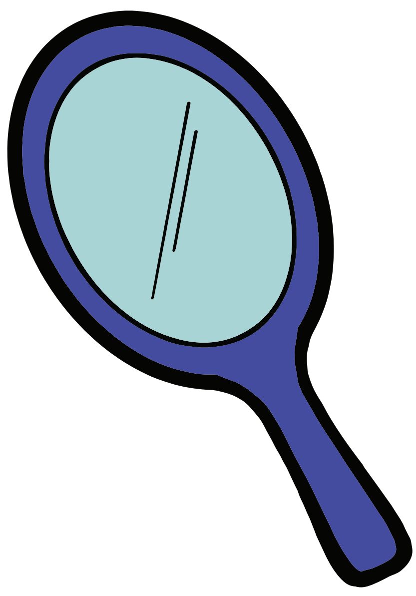
light bulb / bombilla



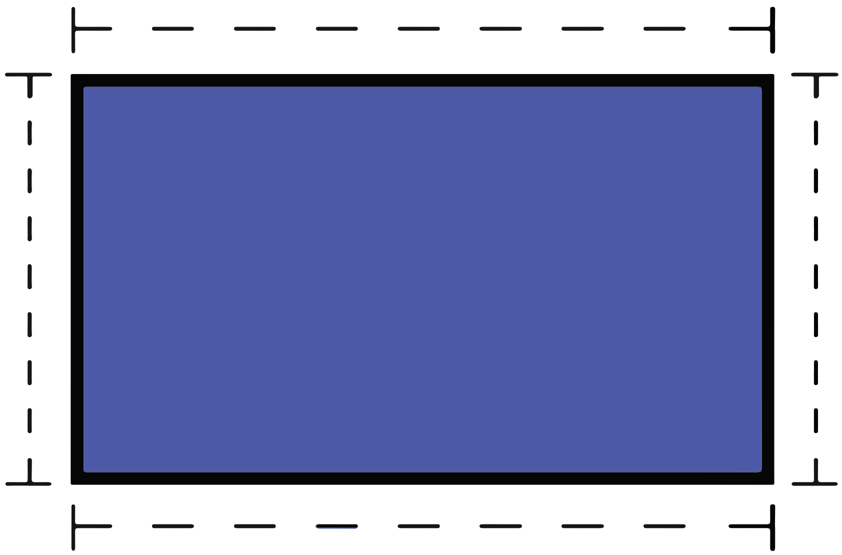
mechanical energy / energía mecaníca



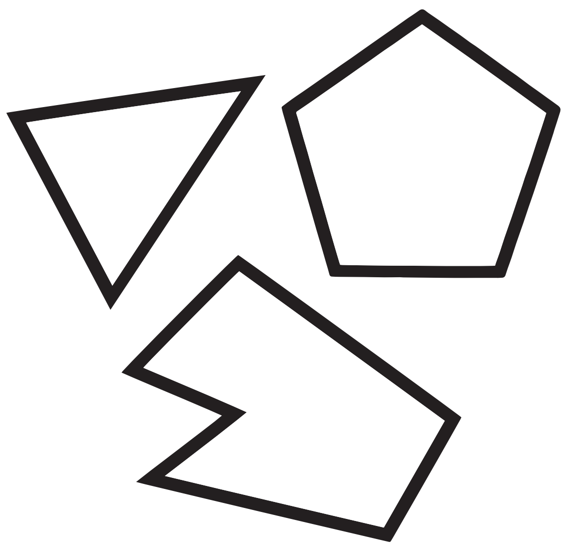
melt / derretir



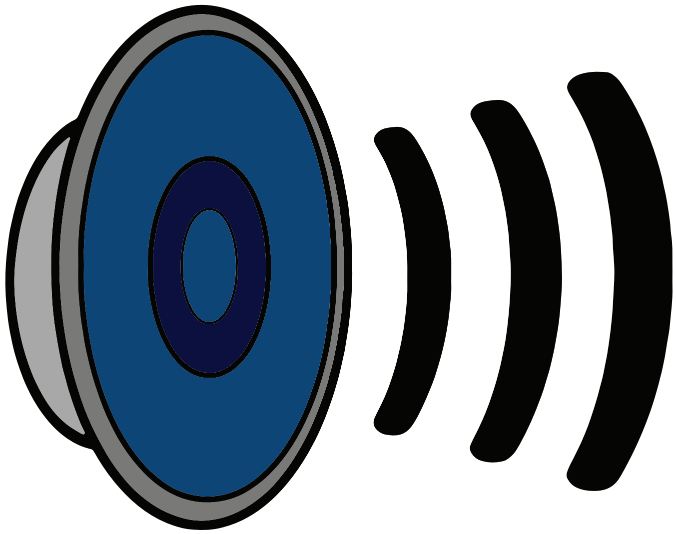
mirror / espejo



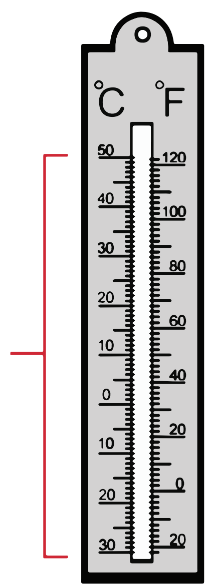
perimeter / perímetro



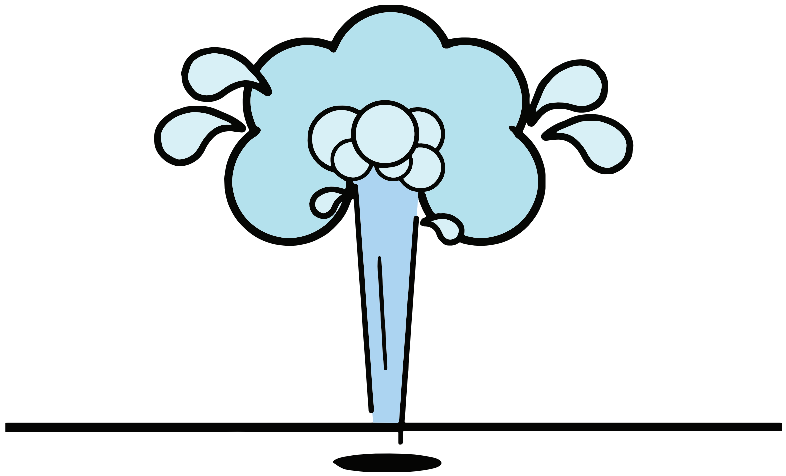
polygon / polígono



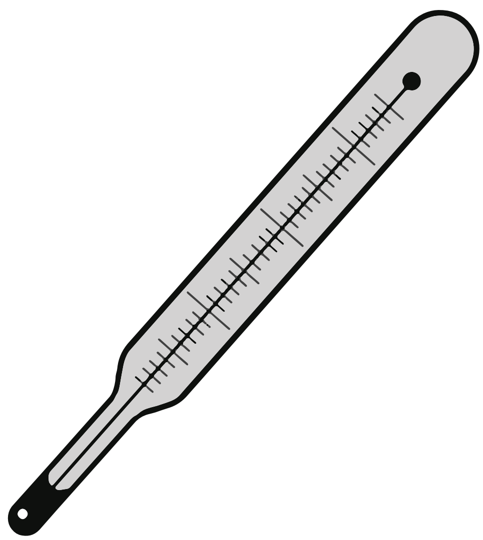
sound / sonido



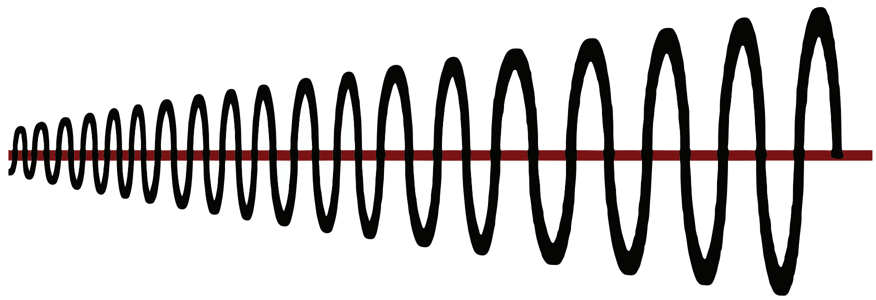
temperature / temperatura



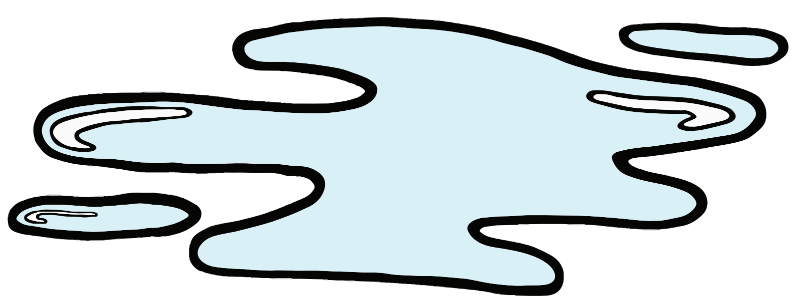
thermal energy / energía térmica



thermometer / termómetro



vibrations / vibraciones



water / agua

Power of Sound Data Sheet

Demonstration

Carefully observe the demonstration of the milk jug and the candle flame.

Draw a labeled model or **diagram** in the box below that shows how you think the candle flame was blown out. Then explain in writing how you think it happened.

Diagram	Explanation

Group Investigation

1. Test the milk jug and spoon with each item listed below.
2. Hold the mouth of the milk jug near the first item. Then hit the bottom of the milk jug hard with the spoon. Observe and record the results.
3. Repeat Step 2 for the other two items.

Plate of Lightweight Material:

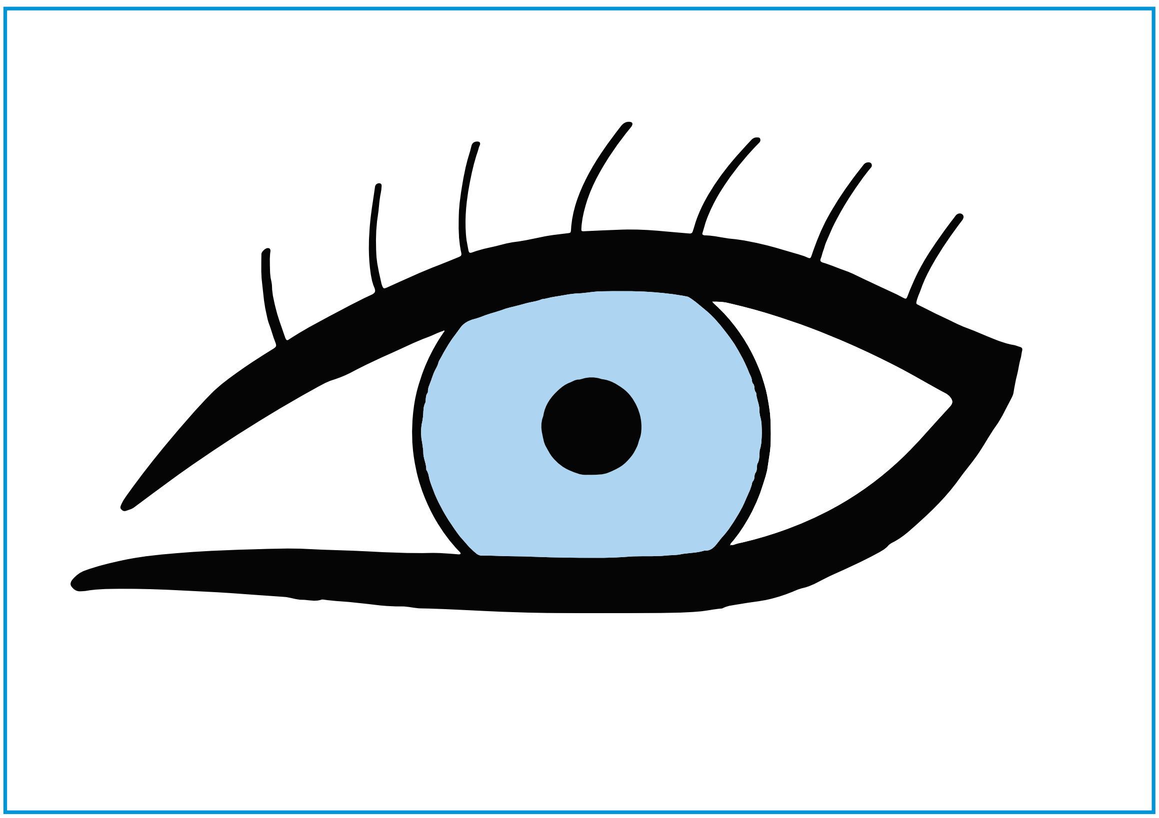
Ping-Pong Ball:

Container of Water:

Light Energy Center Instructions

For the Teacher

1. Copy and laminate the eye diagram below.
2. Tape the eye diagram to the wall next to (but not above) a table. The diagram should be about shoulder height for the average fourth grader. Make sure that the area in front of the eye diagram is clear; students will need to stand there.
3. Measure and cut 1 meter of string.
4. Tape one end of the string to a flashlight lens and the other end to the pupil in the eye diagram. Place the flashlight on the table.



Light Energy Center Data Sheet

Name ______________________________ **Date**____________________

Read all the steps before you begin the investigation.

1. Turn on the flashlight.
2. Hold the flashlight at shoulder height. Move until the string is stretched as tightly as possible without pulling off the tape at either end.
3. Observe the path of the light.
4. In the box below, draw a labeled diagram of the path of light from the flashlight lens to the eye diagram. The dark area in the center of the eye is called a **pupil.**

Diagram

Heat Energy Center Instructions

Read all the steps before you begin the investigation. Record your observations on the Heat Energy Center Data Sheet.

1. Use the string to measure the distance around the largest part of the balloon. This distance is called the **circumference.** Mark the measurement on the string with a red marker.
2. Lay the string on a table in a straight line. Use a ruler to measure the length of string that went around the balloon. Record the result on the data sheet.
3. Put on the safety goggles. Each member of the group must wear goggles.
4. Note the temperature in degrees Celsius on the thermometer. This is the temperature of the room. Record this temperature on the data sheet.
5. Measure the temperature of the heating pad by placing the thermometer bulb under it for 20 seconds. Record the temperature in degrees Celsius on the data sheet.
6. Measure and record the temperature of the ice in the cooler.
7. Place the balloon in the foil pie pan. Gently place the warm heating pad over the balloon and the pan. Set the timer for 3 minutes.
8. Draw a labeled diagram of the heating pad over the balloon and the pan on your data sheet while you wait.
9. Remove the balloon after 3 minutes. Measure and record the distance around the largest part of the balloon.
10. Place the balloon on the foil pie pan again. Then place the pan and the balloon in the cooler and close the lid. Set the timer for 3 minutes.
11. Draw a labeled diagram of the balloon and pan in the cooler on your data sheet while you wait.
12. Remove the balloon after 3 minutes. Measure and record the circumference of the largest part of the balloon.

Heat Energy Center Data Sheet

Name ____ **Date**______________________

Follow the instructions at the heat energy center.

Measurements

Distance around the largest part of the balloon: ____________ cm

Temperature of room: ____________ cm

Temperature of heating pad: ____________ cm

Temperature of cooler: ____________ cm

Circumference of balloon under heating pad: ____________ cm

Circumference of balloon in cooler: ____________ cm

How would you find the change in circumference of the balloon for each case?

Change in the circumference of balloon under heating pad = ____________ cm

The circumference is **larger** **smaller**

(circle correct one)

Change in the circumference of balloon in cooler = ____________ cm

The circumference is **larger** **smaller**

(circle correct one)

Heat Energy Center Data Sheet, continued

Diagrams

Draw labeled diagrams of the balloon to show how it changes when heat is added or removed.

Original Balloon

Balloon Under Heating Pad

Balloon in Cooler

Sound Energy Center Instructions

Read all the steps before you begin the investigation. Record your observations on the Sound Energy Center Data Sheet.

1. Tap the tuning fork on your shoe. Observe its vibrations and the sound they make as they travel through air, which is a **gas.**
2. Record your observation in a complete sentence on your data sheet.
3. Tap the tuning fork on your shoe again. Place just the ends of the tuning fork on the surface of the water. Observe the vibrations and the sound they make as they travel through water, which is a **liquid.**
4. Record your observation in a complete sentence on your data sheet.
5. Tap the tuning fork on your shoe again. Place just the ends of the tuning fork on the top of the table. Observe the vibrations and the sound they make as they travel through the material of the table, which is a **solid.**
6. Record your observation in a complete sentence on your data sheet.

Sound Energy Center Data Sheet

Name ______________________________ **Date** ____________________

Follow the instructions at the sound energy center.

Describe what happens when the vibrating tuning fork touches each of the following:

Gas: ______________________________

____

____

____

____

Liquid: ______________________________

____

____

____

____

Solid: ______________________________

____

____

____

____

Mechanical Energy Center Instructions

Read all the steps before you begin the investigation. Record your observations on the Mechanical Energy Center Data Sheet.

Spinning Top

1. Observe the toy top. Does it move on its own?
2. Push down on the knob of the top 1 time.
3. Use the stopwatch to time how long the top spins. Record the time on the data sheet.
4. Push down on the knob of the top 3 times.
5. Use the stopwatch to time how long the top spins. Record the time.
6. Push down on the knob of the top 5 times.
7. Use the stopwatch to time how long the top spins. Record the time.

Energy Skate Park

1. At the computer, locate the Energy Skate Park **simulation.** You will see a skateboarder above a curved path.
2. Click the **Play** button at the bottom of the window.
3. Observe the skateboarder as he moves and the circle above him.
4. Discuss the questions on your data sheet.

Mechanical Energy Center Data Sheet

Name ______________________________ **Date**____________________

Follow the instructions at the mechanical energy center.

Spinning Top

Record the length of time the top spins after one, three, and five pushes.

Pushes	Spin Time
1	
3	
5	

Energy Skate Park

Discuss the questions with your group.

1. How does the circle above the skateboarder change as he moves along the path?
2. When is there a lot of potential energy?
3. When is there a lot of kinetic energy?
4. What are potential and kinetic energy called?

Electrical Energy Center Instructions

Read all the steps before you begin the investigation. Record your observations on the Electrical Energy Center Data Sheet.

Never allow both ends of the wire to touch the ends of the battery for longer than 8–10 seconds because the wire can become very hot.

Holiday Light

1. Observe the plastic cord with the bulb and the two wire ends. Look carefully at the wires.
2. Observe the sides and ends of the battery. Then observe the strips of silver tape. This tape is used to attach items to metal.
3. Work with your group to find a way to arrange the materials that causes the bulb to light.
4. Draw a diagram of the method in the first box on the data sheet.
5. Work with your group to find two ways to arrange the materials that do not cause the bulb to light.
6. Draw a diagram of each method in the second box on the data sheet.

Circuits

1. At the computer, locate the Signal Circuit window. You will see a rectangle with a light switch, a battery, and a chandelier.
2. Click the light switch. Observe what happens. Explore the other options and see how they affect the electrical **circuit**.
3. Locate the Circuit Construction Kit window. You will see a blue workspace with a panel of items on the right. Drag and drop a light bulb, a battery, and wire pieces onto the blue area to build a circuit. Try to make the bulb light up. Then explore adding a resistor and a switch.
4. Discuss the questions on your data sheet.

Electrical Energy Center Data Sheet

Name ______________________________ **Date**____________________

Follow the instructions at the electrical energy center.

Holiday Light

Draw and label a diagram showing one way to arrange the plastic cord with bulb, the battery, and the strips of tape to make the bulb light.

Then draw and label diagrams showing two ways to arrange the materials that do not make the bulb light.

Bulb Lights	Bulb Does Not Light

Electrical Energy Center Data Sheet , continued

Circuits

Discuss the questions with your group.

1. In the Signal Circuit window, what do the blue dots represent?

2. What does the red “X” represent?

3. In the Circuit Construction Kit, what powers the light?

4. Can electrical energy flow through a circuit that has an opening?

Group Project Rubric

	1-Needs Improvement	2-Satisfactory	3-Excellent
Energy	The five forms of energy are not included.	The five forms of energy are included, but an example of how each one causes change is not.	The five forms of energy are included as well as at least one example of how each one causes change.
Measurement	No measurements are included, or an explanation is not given as to why no measurements are included.	One or more of the forms of measurement included is inappropriate (e.g., time for length).	The units of measurement included are used correctly, or a reason is given as to why a measurement is not relevant.
Technology	Technology is not used successfully.	Technology is limited to word processing.	Students created and shared their digital book online.

Energy Assessment Teacher Instructions

1. Duplicate the assessment and distribute to each student.

2. Read the following instructions aloud to the class:

> **"Carefully read each question and the possible answers. Then circle the letter next to the best answer to the question."**

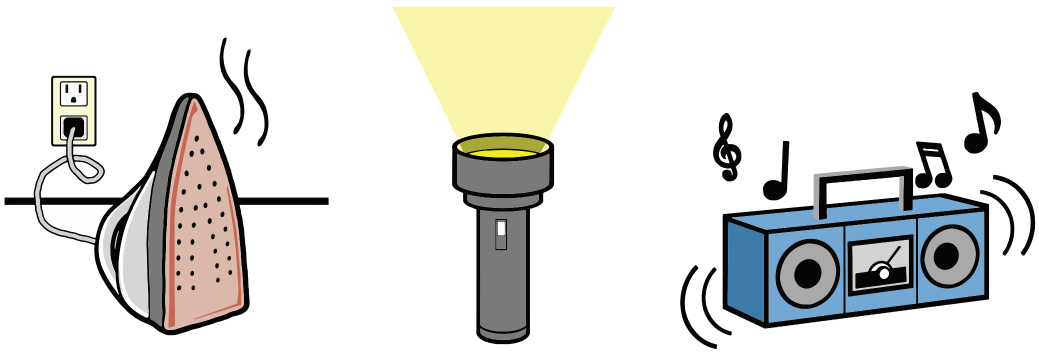
Answer Key

1. **B**
2. **C**
3. **B**
4. **D**
5. **C**
6. **B**
7. **B**

Name ______________________________ Date ________________

Energy Assessment

Observe the objects below to answer questions 1–3.



A B C

1. Object B is a source of energy that __________ .

A vibrates in three states of matter

B travels in straight lines

C is measured with a thermometer

D is measured with a balance

2. Object A changes electrical energy into __________ .

A light energy

B mechanical energy

C thermal energy

D sound energy

3. If Object C is turned to its loudest volume, a person standing next to it may __________ .

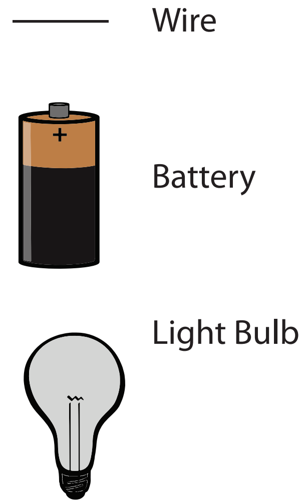
A see light energy

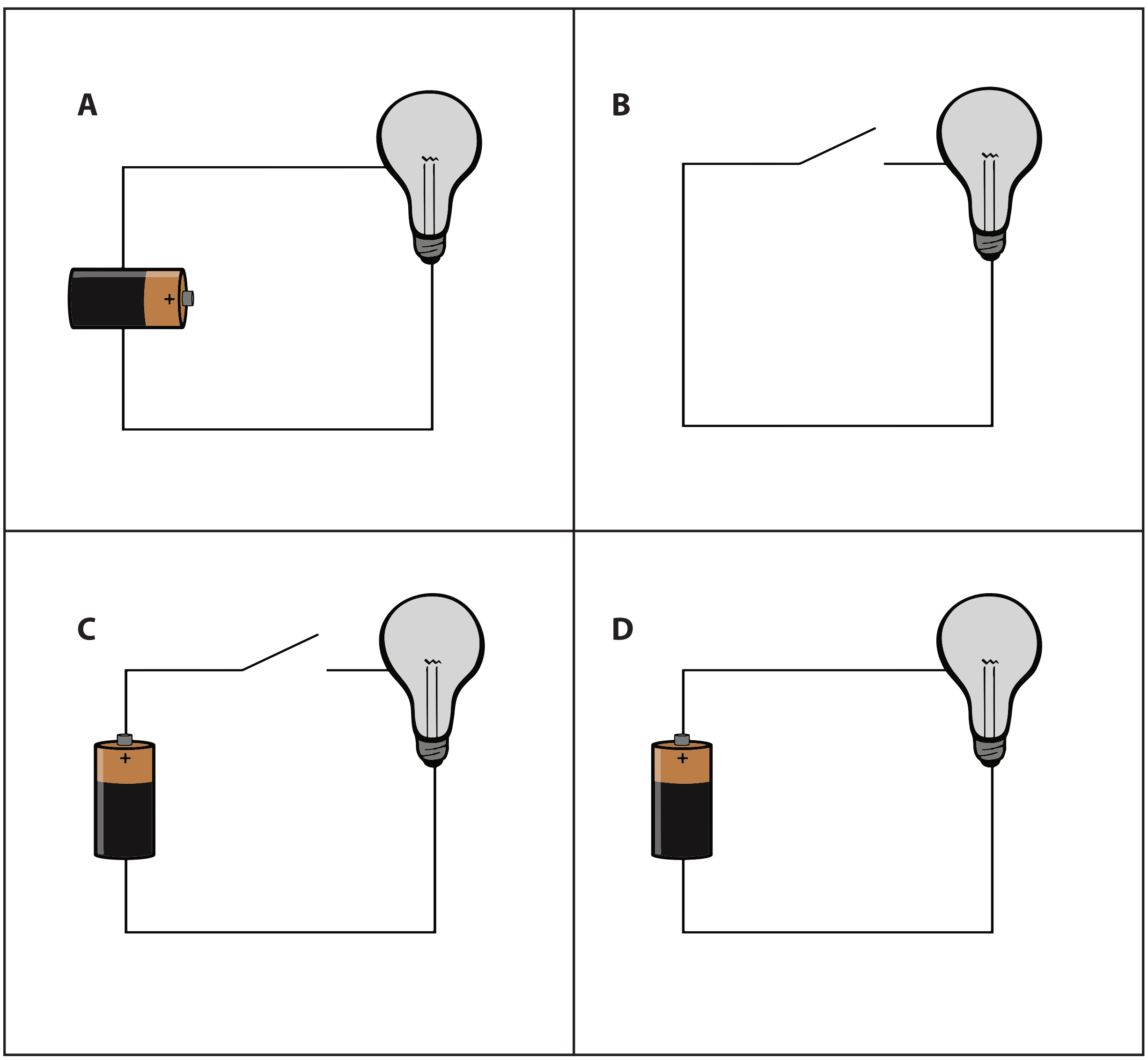
B feel vibrations

C feel thermal energy

D feel magnetism

4. Which circuit will light the bulb?





5. The diagram above demonstrates that __________ .

A light must travel in a closed circuit

B light is a source of loud vibrations

C light travels in straight lines from its source

D light moves from cooler to warmer materials

6. The physical properties of metals make them __________ .

A good insulators of thermal energy

B good conductors of thermal energy

C poor conductors of thermal energy

D full of large air spaces

7. The circumference of a circle is like __________ .

A the area of a polygon

B the perimeter of a polygon

C the volume of a cube

D the length of a side of a polygon

Reading Connections

The following books are recommended as literary resources to enhance the study of light, heat, and sound energy for Grade 4 students.

Light

Branley, F. M. (1998). *Day light, night light: Where light comes from.* (Let's-Read-and-Find-Out Science 2). New York, NY: HarperCollins Publishers.

Branley, F. M. (2005). *What makes day and night* (Let's-Read-and-Find-Out Science 2). New York, NY: HarperCollins Publishers.

Heat

Greathouse, L. (2010). *Melting and freezing.* (Science Readers: A Closer Look). Huntington Beach, CA: Teacher Created Materials. (Available in English and Spanish)

Manolis, K. (2008). *Temperature.* (Blastoff! Readers: First Science). Minneapolis, MN: Bellwether Media.

Sound

Branley, F. M. (2005). *Flash, crash, rumble and roll.* (Let's-Read-and-Find-Out Science 2). New York, NY: Harper Collins Publishers.

Manolis, K. (2008). *Sound* (Blastoff! Readers: First Science). Minneapolis, MN: Bellwether Media.

Pfeffer, W. (1999). *Sounds all around.* (Let's-Read-and-Find-Out Science 1). New York, NY: HarperCollins Publishers.

Wright, L. (2000). *The science of noise.* (Science World). Austin, TX: Raintree Steck-Vaughn Company.

Texas Essential Knowledge and Skills (TEKS) Focus

§112.15. Science, Grade 4, Beginning with School Year 2010–2011.

(b) Knowledge and skills.

(1) Scientific investigation and reasoning. The student conducts classroom and outdoor investigations following home and school safety procedures and environmentally appropriate and ethical practices. The student is expected to:

(A) demonstrate safe practices and the use of safety equipment as described in the Texas Safety Standards during classroom and outdoor investigations.

(2) Scientific investigation and reasoning. The student uses scientific methods during laboratory and outdoor investigations. The student is expected to:

(A) Plan and implement simple descriptive investigations, including asking well-defined questions, making inferences, and selecting and using appropriate equipment and technology to answer his/her questions;

(B) collect and record data by observing and measuring, using the metric system, and using descriptive words and numerals such as labeled drawings, writing, and concept maps;

(C) construct appropriate simple graphs, tables, maps, and charts using tools and current technology, including computers, to organize, examine, and evaluate data;

(D) analyze data and interpret patterns to construct reasonable explanations from data that can be observed and measured;

(E) perform repeated investigations to increase the reliability of results;

(F) communicate valid oral and written results supported by data.

(3) Scientific investigation and reasoning. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to:

(A) in all fields of science, analyze, evaluate, and critique scientific explanations by using empirical evidence, logical reasoning, and experimental and observational testing, including examining all sides of scientific evidence of those scientific explanations, so as to encourage critical thinking by the student.

(4) Scientific investigation and reasoning. The student knows how to use a variety of tools, materials, equipment, and models to conduct science inquiry. The student is expected to:

(A) collect, record, and analyze information using tools, including calculators, microscopes, cameras, computers, hand lenses, metric rulers, Celsius thermometers, mirrors, spring scales, pan balances, triple beam balances, graduated cylinders, beakers, hot plates, meter sticks, compasses, magnets, collecting nets, and notebooks; timing devices, including clocks and stopwatches; and materials to support observation of habitats of organisms such as terrariums and aquariums; and

(B) use safety equipment as appropriate, including safety goggles and gloves.

(5) Matter and energy. The student knows that matter has measurable physical properties and those properties determine how matter is classified, changed, and used. The student is expected to:

(A) measure, compare, and contrast physical properties of matter, including size, mass, volume, states (solid, liquid, gas), temperature, magnetism, and the ability to sink or float;

(B) predict the changes caused by heating and cooling such as ice becoming liquid water and condensation forming on the outside of a glass of ice water.

(6) Force, motion, and energy. The student knows that energy exists in many forms and can be observed in cycles, patterns, and systems. The student is expected to:

(A) differentiate among forms of energy, including mechanical, sound, electrical, light, and heat/thermal;

(B) differentiate between conductors and insulators.

§111.16. Mathematics, Grade 4.

(b) Knowledge and skills.

(11) Measurement. The student applies measurement concepts. The student is expected to estimate and measure to solve problems involving length (including perimeter) and area. The student uses measurement tools to measure capacity/volume and weight/mass. The student is expected to:

(A) estimate and use measurement tools to determine length (including perimeter), area, capacity and weight/mass using standard units SI (metric) and customary.

(16) Underlying processes and mathematical tools. The student uses logical reasoning. The student is expected to:

(A) make generalizations from patterns or sets of examples and non-examples; and

(B) justify why an answer is reasonable and explain the solution process.

§126.3. Technology Applications, Grades 3–5.

(b) Knowledge and skills.

(2) Foundations. The student uses data input skills appropriate to the task. The student is expected to:

(A) use a variety of input devices such as mouse, keyboard, disk drive, modem, voice/sound recorder, scanner, digital video, CD-ROM, or touch screen;

(B) use proper keyboarding techniques such as correct hand and body positions and smooth and rhythmic keystroke patterns.

(3) Foundations. The student complies with the laws and examines the issues regarding the use of technology in society. The student is expected to:

(A) follow acceptable use policies when using computers; and

(B) model respect of intellectual property by not illegally copying software or another individual's electronic work.

(5) Information acquisition. The student acquires electronic information in a variety of formats, with appropriate supervision. The student is expected to:

(A) acquire information including text, audio, video, and graphics; and

(B) use on-line help and documentation.

(7) Solving problems. The student uses appropriate computer-based productivity tools to create and modify solutions to problems. The student is expected to:

(A) use software programs with audio, video, and graphics to enhance learning experiences;

(B) use appropriate software to express ideas and solve problems including the use of word processing, graphics, databases, spreadsheets, simulations, and multimedia; and

(C) use a variety of data types including text, graphics, digital audio, and video.

(11) Communication. The student delivers the product electronically in a variety of media, with appropriate supervision. The student is expected to:

(A) publish information in a variety of media including, but not limited to, printed copy, monitor display, Internet documents, and video; and

(B) use presentation software to communicate with specific audiences.

(12) Communication. The student uses technology applications to facilitate evaluation of communication, both process and product. The student is expected to:

(A) select representative products to be collected and stored in an electronic evaluation tool.

§74.4. English Language Proficiency Standards.

(a) Introduction.

(1) The English language proficiency standards in this section outline English language proficiency level descriptors and student expectations for English language learners (ELLs). School districts shall implement this section as an integral part of each subject in the required curriculum. The English language proficiency standards are to be published along with the Texas Essential Knowledge and Skills (TEKS) for each subject in the required curriculum.

(2) In order for ELLs to be successful, they must acquire both social and academic language proficiency in English. Social language proficiency in English consists of the English needed for daily social interactions. Academic language proficiency consists of the English needed to think critically, understand and learn new concepts, process complex academic material, and interact and communicate in English academic settings.

(3) Classroom instruction that effectively integrates second language acquisition with quality content area instruction ensures that ELLs acquire social and academic language proficiency in English, learn the knowledge and skills in the TEKS, and reach their full academic potential.

(4) Effective instruction in second language acquisition involves giving ELLs opportunities to listen, speak, read, and write at their current levels of English development while gradually increasing the linguistic complexity of the English they read and hear, and are expected to speak and write.

(5) The cross-curricular second language acquisition skills in subsection (c) of this section apply to ELLs in Kindergarten-Grade 12.

(6) The English language proficiency levels of beginning, intermediate, advanced, and advanced high are not grade-specific. ELLs may exhibit different proficiency levels within the language domains of listening, speaking, reading, and writing. The proficiency level descriptors outlined in subsection (d) of this section show the progression of second language acquisition from one proficiency level to the next and serve as a road map to help content area teachers instruct ELLs commensurate with students' linguistic needs.

(b) School district responsibilities. In fulfilling the requirements of this section, school districts shall:

(1) identify the student's English language proficiency levels in the domains of listening, speaking, reading, and writing in accordance with the proficiency level descriptors for the beginning, intermediate, advanced, and advanced high levels delineated in subsection (d) of this section;

(2) provide instruction in the knowledge and skills of the foundation and enrichment curriculum in a manner that is linguistically accommodated (communicated, sequenced, and scaffolded) commensurate with the student's levels of English language proficiency to ensure that the student learns the knowledge and skills in the required curriculum;

(3) provide content-based instruction including the cross-curricular second language acquisition essential knowledge and skills in subsection (c) of this section in a manner that is linguistically accommodated to help the student acquire English language proficiency; and

(4) provide intensive and ongoing foundational second language acquisition instruction to ELLs in Grade 3 or higher who are at the beginning or intermediate level of English language proficiency in listening, speaking, reading, and/or writing as determined by the state's English language proficiency assessment system. These ELLs require focused, targeted, and systematic second language acquisition instruction to provide them with the foundation of English language vocabulary, grammar, syntax, and English mechanics necessary to support content-based instruction and accelerated learning of English.

(c) Cross-curricular second language acquisition essential knowledge and skills.

(1) Cross-curricular second language acquisition/learning strategies. The ELL uses language learning strategies to develop an awareness of his or her own learning processes in all content areas. In order for the ELL to meet grade-level learning expectations across the foundation and enrichment curriculum, all instruction delivered in English must be linguistically accommodated (communicated, sequenced, and scaffolded) commensurate with the student's level of English language proficiency. The student is expected to:

(A) use prior knowledge and experiences to understand meanings in English;

(B) monitor oral and written language production and employ self-corrective techniques or other resources;

(C) use strategic learning techniques such as concept mapping, drawing, memorizing, comparing, contrasting, and reviewing to acquire basic and grade-level vocabulary;

(D) speak using learning strategies such as requesting assistance, employing non-verbal cues, and using synonyms and circumlocution (conveying ideas by defining or describing when exact English words are not known);

(E) internalize new basic and academic language by using and reusing it in meaningful ways in speaking and writing activities that build concept and language attainment;

(F) use accessible language and learn new and essential language in the process;

(G) demonstrate an increasing ability to distinguish between formal and informal English and an increasing knowledge of when to use each one commensurate with grade-level learning expectations; and

(H) develop and expand repertoire of learning strategies such as reasoning inductively or deductively, looking for patterns in language, and analyzing sayings and expressions commensurate with grade-level learning expectations.

References

National Research Council: Committee on Conceptual Framework for the New K–12 Science Education Standards. (2011). *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas*. Washington, DC: National Academies Press. Available from **http://www.nap.edu/catalog.php?record_id=13165**

National Research Council: National Committee on Science Education Standards and Assessment. (1996). *The national science education standards* (p. 23). Washington, DC: National Academies Press. Available from **http://books.nap.edu/catalog.php?record_id=4962**

Texas Education Agency, Student Assessment Division. (2011). *Educator Guide to TELPAS: Grades K–12* (pp. 15, 22, 30, 40, 78, 84). Austin, TX: Author. Available from **http://www.tea.state.tx.us/student.assessment/ell/telpas**

Texas Essential Knowledge and Skills, 19 Tex. Admin. Code § 74.4, 111, 112, 126 (2010). Available from **http://www.tea.state.tx.us/index2.aspx?id=6148**

