2018-2019

EnergyWorks

Teacher Guide

Hands-on explorations coupled with background reading that uncover the things energy does—heat, light, motion, sound, growth, and powering technology.

Grade Levels:

- Elem Elementary
- Int Intermediate

Subject Areas:

- Science
- Math
- Language Arts
- Technology

NEED
National Energy Education Development Project

NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

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Teacher Advisory Board

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.

NEED
National Energy
Education Development

1.800.875.5029
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EnergyWorks
Teacher Guide

EnergyWorks Kit

- 2 1,000 mL Pitchers
- 2 500 mL Pitchers
- 12 Balloons
- 1 Clay
- 1 Clear tubing
- 4 Color filters (various colors)
- 1 Container of sand
- 1 Cork ball with hole
- 4 Digital thermometers
- 2 Dual calibration spring scales
- 3 Flashlights with batteries
- 2 Friction blocks
- 1 Magnifying glass
- 2 Mallets
- 4 Marbles (large and small)
- 3 Measuring tapes
- 3 Metal cans
- 5 Mirrors (small)
- 1 Prism
- 1 Protractor
- 1 Pull-back vehicle
- 1 Slinky spring (The WAVE)
- 1 Solar cell kit
- 2 Spectroscopes
- 1 Steel ball with hole
- 1 Stopwatch
- 15 Student thermometers
- 2 Tuning forks (1024 Hz)
- 2 Tuning forks (256 Hz)
- 1 Wallpaper pan
- 1 Wooden spool

Table of Contents

Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

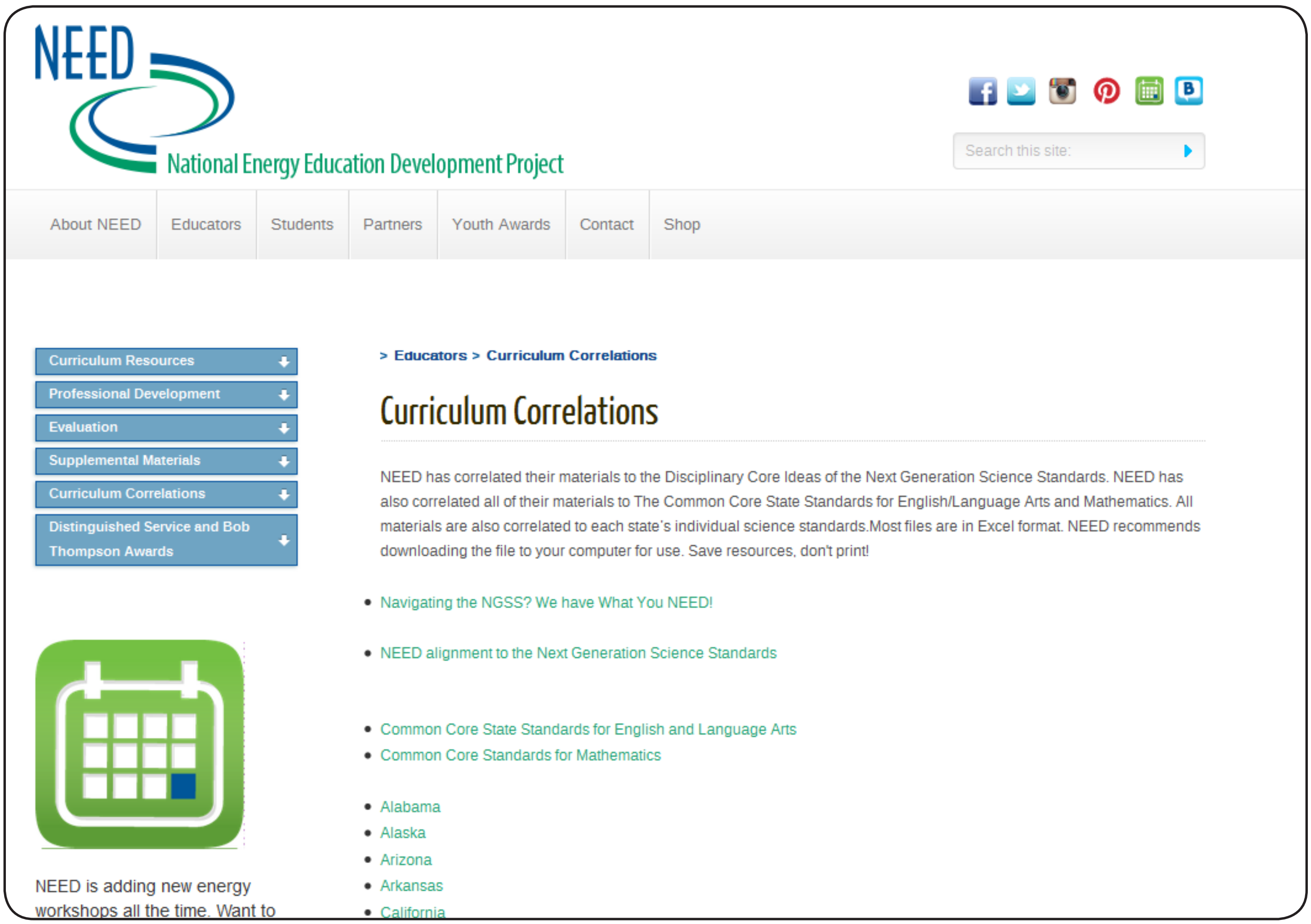
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



EnergyWorks Materials

	ACTIVITY	MATERIALS IN KIT	ADDITIONAL MATERIALS NEEDED
HEAT	*Exploring Heat Transfer 1*	▪1 – 1,000 mL Pitcher ▪2 – 500 mL Pitchers ▪1 Thermometer	▪Colored pencils ▪Cold water ▪Warm water
	Exploring Heat Transfer 2	▪2 – 1,000 mL Pitchers ▪1 – 500 mL Pitcher ▪1 Thermometer	▪Colored pencils ▪Cold water ▪Warm water
	Exploring Heat Transfer 3	▪1 Wallpaper pan ▪2 Thermometers ▪2 – 500 mL Pitchers	▪Cold water ▪Warm water ▪Room temperature water ▪Metric ruler
	Conductors and Insulators	▪4 Digital thermometers ▪Stopwatch	▪Plastic cup ▪Foam cup ▪Metal cup ▪Paper cup ▪Rubber bands ▪Plastic wrap ▪Ice water ▪Hot water ▪Graph paper (or Student Guide, page 17)
	Exploring Heat in Solids, Liquids, and Gases 1	▪4 Marbles	▪Clear plastic cups ▪Hot water ▪Ice water ▪Food coloring
	Exploring Heat in Solids, Liquids, and Gases 2	▪2 Thermometers ▪Sand	▪Clear plastic cups ▪Room temperature water ▪Sunny day or bright lamp
	Exploring Heat in Solids, Liquids, and Gases 3	▪4" Balloons ▪1 Measuring tape ▪1 Thermometer	▪Bowl of ice water ▪Bowl of hot water ▪Graph paper (or Student Guide, page 21)
LIGHT	*Exploring Light 1*	▪1 Wooden spool ▪1 Flashlight	▪White paper ▪Tape ▪Metric ruler
	Exploring Light 2	▪1 Spectroscope ▪1 Prism ▪1 Flashlight	▪1 Beaker full of water ▪White paper ▪Pencil ▪Colored pencils
	Exploring Light 3	▪1 Magnifying glass ▪1 Flashlight	▪Penny ▪White paper ▪Metric ruler
	Exploring Light 4	▪Protractor	▪Full length mirror ▪Colored pencils
	Exploring Light 5	▪5 Small mirrors ▪Flashlight (or laser pointer) ▪Protractor ▪Clay	▪Colored pencils
	Exploring Light 6	▪Flashlight ▪4 Filters (various colors) ▪Spectroscope	▪Colored pencils

	ACTIVITY	MATERIALS IN KIT	ADDITIONAL MATERIALS NEEDED
MOTION	*Exploring and Graphing Potential Energy 1*	▪1 Marble ▪1 Metal sphere ▪1 Measuring tape	▪5 Books (each about 1 cm thick) ▪Red and blue colored pencils ▪Graph paper (copy from Student Guide, page 21) ▪1 Grooved metric ruler
	Exploring and Graphing Potential Energy 2	▪1 Marble ▪1 Measuring tape	▪1 Book (about 1 cm thick) ▪4 Surfaces (wood, tile, carpet, concrete, etc.) ▪1 Grooved metric ruler
	Exploring Force and Motion	▪1 Spring scale ▪1 Friction block	▪2 Different surfaces
	Exploring Friction and Inertia	▪1 Spring scale ▪1 Friction block	▪3 Pencils – round barrel ▪3 Pencils – hexagon barrel ▪Notebook paper ▪Smooth surface
	Exploring Gravitational Force	▪2 Spheres of different masses with holes ▪Stopwatch ▪Measuring tape	▪Measuring stick ▪Masking tape ▪2 Pieces of string (60 cm long)
SOUND	*Exploring Sound 1*	▪1 Slinky	▪1 8' Long table
	Exploring Sound 2	▪1 Tuning fork, 256 Hz ▪1 Tuning fork, 1024 Hz ▪1 Mallet ▪1 Metal can	▪Tape ▪Wood object ▪Plastic object ▪Sweater or jacket
	Exploring Sound 3	▪1 Tuning fork, 256 Hz ▪1 Tuning fork, 1024 Hz ▪1 Mallet ▪2 Metal cans	▪Rubber band ▪Plastic wrap ▪Pepper
	Exploring Sound 4		▪5 Materials of your choosing, for example: ▪Paper ▪Textbook ▪Jacket
	Exploring Sound 5	▪2 Flexible tubing, 8' each ▪Clay	▪4 Quarters or plastic disks ▪Pencil ▪Water ▪1 8' Table ▪Heavy duty tape
GROWTH	*Exploring Growth 1*		▪Sandwich bags ▪Paper towels ▪2 Cups of water in a jar with a lid ▪Beans ▪Paper grocery bag ▪Marker ▪Stapler
	Exploring Growth 2		▪6 Small plants ▪2 Cups of water in a jar with a lid ▪Heavy-duty paper lunch bags ▪Tablespoon ▪Marker
	TECHNOLOGY		▪Appliances and machines

Teacher Guide

Background

EnergyWorks is a hands-on exploration unit that focuses on the different work energy does—heat, light, motion, sound, growth, and powering electronic technology. After completing the unit, students will be able to explain that everything energy does includes motion or the potential for motion—the motion of electrons, atoms, molecules, waves, substances, and objects.

Students will explore the subjects from an energy perspective, with a Student Guide that includes background information, vocabulary, scientific tools and measurements in both English and metric systems, charting and graphing, data analysis, and scientific process skills. The Student Guide is written on a fourth/fifth grade reading level, but many of the activities are suitable for younger and older students.

Teacher demonstration materials and masters are included in the Teacher Guide to introduce the subjects. The unit includes a list of concepts covered to help teachers meet academic objectives and is designed so that the activities are separated, allowing teachers to choose the activities suitable for their classrooms and objectives.

The *EnergyWorks* Kit contains most of the materials needed to conduct the explorations, including a class set of the Student Guides. The materials not included are easily available and inexpensive. All of the materials used in activities are listed in this guide as well as in the Student Guide. Please see pages 5-7 for detailed lists of materials included and needed for each activity and teacher demonstration. Teachers who do not wish to purchase the kit can obtain the materials they need for the unit without difficulty from science supply catalogs.

Preparation

- Read the Teacher and Student Guides thoroughly and decide how you are going to implement the unit in your classroom. Be prepared to address lab safety rules with students, using page 9.
- Obtain the additional materials needed for the hands-on activities.
- Parent or older student volunteers may be helpful to assist with explorations.
- Sample rubrics for grading are provided on page 8. The Student Guide/Science Notebook Rubric can be used while students are conducting explorations and while reviewing science notebooks. The Culminating Projects Rubric can be used for the student technology research presentations. Discuss or copy these rubrics for the class, if desired.
- Complete the unit evaluation on page 35 and return to NEED.

TEACHER DEMO	MATERIALS IN KIT	MATERIALS NEEDED
Heat	▪15 Fahrenheit/Celsius thermometers	▪Room temperature (~70°F) water ▪Several pieces scrap paper - 2-3 pieces per student ▪2 Buckets or boxes
Light	▪Magnifying glass ▪Solar cell kit ▪Protractor	▪Bright light source
Motion	▪Pull-back vehicle ▪Balloons	
Sound	▪Balloons ▪Wallpaper pan	▪Eraser ▪Rock
Technology		▪CFL bulb (or picture) ▪Incandescent bulb (or picture) ▪LED bulb (or picture)

Grade Levels

- Elementary, grades 4-5
- Intermediate, grades 6-8

Time

- Approximately 21 class periods

Additional Resources

Use shop.NEED.org to find additional materials to support and extend your energy unit:

- *Elementary Energy Infobook*
- *Intermediate Energy Infobook*
- *Elementary Science of Energy*
- *Intermediate Science of Energy*
- *Energy Flows*

Science Notebooks

Throughout this curriculum, science notebooks are referenced. If you currently use science notebooks or journals, you may have your students continue using them. A rubric to guide assessment of student notebooks can be found on page 8 in the Teacher Guide.

In addition to science notebooks, student worksheets have been included in the Student Guide. Depending on your students' level of independence and familiarity with the scientific process, you may choose to use these instead of science notebooks. Or, as appropriate, you may want to make copies of worksheets and have your students glue or tape the copies into their notebooks.

Lab Safety Rules

It is important to address lab safety protocols with students. For a list of suggested rules, see page 9.

Rubrics

Student Guide/Science Notebook Rubric

GRADE	SCIENTIFIC CONCEPTS	SCIENTIFIC INQUIRY	PRESENTATION
4	Student demonstrates thorough understanding of concepts through pictures, writing, and verbal communication.	Student is able to follow all steps of the scientific process: predicting, observing/recording data, and drawing a more complex conclusion related to his/her data. Student shows higher level thinking by asking his/her own questions.	Handwriting is legible. Pictures are realistic and include labels. All parts of the assignment are complete.
3	Student demonstrates understanding of concepts through pictures, writing, and/or verbal communication.	Student is able to predict, observe/record data, and draw a basic conclusion.	Handwriting is legible. Pictures are realistic and include most labels. All parts of the assignment are complete.
2	Student demonstrates a beginning understanding of concepts, may have a couple of lingering misconceptions.	Student is able to do two of the following: predict, observe/record data, draw conclusions.	Words and/or pictures may be hard to decipher at times. Pictures are present but are missing labels. The notebook has some missing components.
1	Student demonstrates confusion about concepts. Many misconceptions remain.	Student is able to do one or fewer of the following: predict, observe/record data, draw conclusions.	Words and/or pictures are hard to decipher. They may not be connected to the investigation. The notebook has many missing components.

Culminating Projects Rubric

GRADE	CONTENT	ORGANIZATION	ORIGINALITY	WORKLOAD
4	Project covers the topic in-depth with many details and examples. Subject knowledge is excellent.	Content is very well organized and presented in a logical sequence.	Project shows much original thought. Ideas are creative and inventive.	The workload is divided and shared equally by all members of the group.
3	Project includes essential information about the topic. Subject knowledge is good.	Content is logically organized.	Project shows some original thought. Work shows new ideas and insights.	The workload is divided and shared fairly equally by all group members, but workloads may vary.
2	Project includes essential information about the topic, but there are 1-2 factual errors.	Content is logically organized with a few confusing sections.	Project provides essential information, but there is little evidence of original thinking.	The workload is divided, but one person in the group is viewed as not doing his/her fair share of the work.
1	Project includes minimal information or there are several factual errors.	There is no clear organizational structure, just a compilation of facts.	Project provides some essential information, but no original thought.	The workload is not divided, or several members are not doing their fair share of the work.

Lab Safety Rules

Eye Safety

- Always wear safety glasses when performing experiments.

Fire Safety

- Do not heat any substance or piece of equipment unless specifically instructed to do so.
- Be careful of loose clothing. Do not reach across or over a flame.
- Keep long hair pulled back and secured.
- Do not heat any substance in a closed container.
- Always use tongs or protective gloves when handling hot objects. Do not touch hot objects with your hands.
- Keep all lab equipment, chemicals, papers, and personal effects away from the flame.
- Extinguish any flame as soon as you are finished with the experiment and move it away from the immediate work area.

Heat Safety

- Always use tongs or protective gloves when handling hot objects and substances.
- Keep hot objects away from the edge of the lab table, in a place where no one will accidentally come into contact with them.
- Remember that many objects will remain hot for a long time after the heat source is removed or turned off.

Glass Safety

- Never use a piece of glass equipment that appears cracked or broken.
- Handle glass equipment carefully. If a piece of glassware breaks, do not attempt to clean it up yourself. Inform your teacher.
- Glass equipment can become very hot. Use tongs if glassware has been heated.
- Clean glass equipment carefully before packing it away.

Chemical Safety

- Do not smell, touch, or taste chemicals unless instructed to do so.
- Keep chemical containers closed except when using them.
- Do not mix chemicals without specific instructions.
- Do not shake or heat chemicals without specific instructions.
- Dispose of used chemicals as instructed. Do not pour chemicals back into containers without specific instructions to do so from your teacher.
- If a chemical accidentally touches your skin, immediately wash the affected area with water and inform your teacher.

Thermometer Safety: Thermometers included in the *EnergyWorks* kit contain alcohol spirits and are safe for classroom use. They do not contain mercury.

Teacher Guide: Heat

✪Objectives

- Students will be able to describe how heat transfers through solids, liquids, and gases.
- Students will be able to identify examples of solids, liquids, and gases.

★Concepts

- Thermal energy, or heat, is everywhere and in everything. In strict scientific terms, thermal energy (heat) is defined as a transfer of energy due to a temperature difference, and temperature is defined as the average kinetic (motion) energy of all the molecules. These strict definitions are difficult for younger students to understand and are rarely used in elementary texts. Heat is a more general term to use with students. Text books usually define heat as thermal energy or the kinetic energy of molecules, and temperature as a measure of the hotness or coldness of a substance. These more general definitions are used in this unit.
- Molecules in solids, liquids, and gases are always vibrating and moving.
- The space between molecules increases as heat is added. Heat gives molecules more energy so they move faster, and bounce harder off each other, creating more space between them. Solids expand a little, liquids expand more, and gases expand a lot as heat is added.
- Heat seeks balance and can move to achieve it. Heat can move by conduction, convection, and radiation.
- The molecular structure of a substance determines how well the substance conducts energy. Substances that do not conduct energy well are called insulators. Substances that conduct energy well are called conductors.
- We can measure the temperature of substances using thermometers. There are different scales we can use to measure temperature.

Time

- 3–5 hours

Materials

- Collect the materials as listed on pages 5 and 7 of the Teacher Guide.

Preparation

- Project or copy the *Thermometer* and *Student Thermometer* masters on pages 13 and 14 of the Teacher Guide.
- Set up the teacher demonstration materials and workstations for the student explorations with the materials needed.

Key Words—Heat Answers *from Student Guide, page 11*

1. kinetic energy	2. convection	3. gas	4. boiling point	5. expand	6. temperature	7. radiation	8. solid
9. insulator	10. conduction	11. freezing point		12. molecules	13. contracts	14. conductor	15. liquid

Thermometer Answers *from Student Guide, page 12*

100–212, 37–98.6, 0–32

Activity 1: Introduction

Time

- 30-45 minutes

✔ Procedure

1. Introduce the heat module by discussing familiar things that heat does and the many ways we produce and use heat.
2. Have students read the informational text on pages 4-10 of their Student Guides. Students should take notes in their science notebooks about how heat transfers. Discuss the important ideas students learned in the reading.
3. Instruct students to complete the *Key Words—Heat* worksheet.

OPTIONAL: The *Key Words—Heat* worksheet may be completed at the end of the heat module to use as a review.

Activity 2: Teacher Demonstration - Thermometer

Time

- 30 minutes

✔ Procedure

1. Use the *Thermometer* master to explain how to read a thermometer and the Celsius and Fahrenheit scales. Use the *Student Thermometer* master to show students the range of the thermometer they will be using in the kit.
2. Have students complete the *Thermometer* worksheet on page 12 of the Student Guide, obtaining the actual temperature readings of the classroom, outdoors, and drinking water, if possible. Use the *Thermometer* master to explain how to convert temperature from Celsius to Fahrenheit and vice versa.

Activity 3: Teacher Demonstration - Modeling Thermal Energy Transfer

Time

- 1 class period

Preparation

- Choose a location in your classroom or the hallway that allows the activity to proceed without a lot of obstacles. Students will need to be able to move around somewhat and have a clear pathway to walk.
- Crumple the scrap paper into paper wads if you do not want your students to do this.

✔ Procedure

1. If your students need to expend some energy of their own, have them crumple the scrap paper into paper wads they can easily hold and pass along to each other.
2. To model conduction, have your students stand side-by-side in a line, with one bucket or box at each end of the line. Place all the paper wads in one box. Explain to the students that the paper represents thermal energy, and the box with all the paper is hotter because it has more thermal energy than the empty box. Tell students they, standing in a line, are a conductor from one box to another. Students should make sure they can easily pass paper wads between them, and if not they should adjust their positions. When you say begin, students begin passing paper wads along the "conductor" (the line of students) until all the "heat" (the paper wads) is distributed evenly between the two buckets and the students. It may be helpful to know how many pieces of paper you are using, or you can just visually estimate the distribution of the paper. Tell students that when they have the thermal energy evenly distributed, both buckets and the conductor between them are all the same temperature and energy is no longer being transferred.

3. Convection is modeled by having the students move in a long, narrow circle. Place the buckets on opposite sides of the room and indicate a circular pathway the students should move in. Place all the "heat" in one bucket. Explain to students that the full bucket is hotter than the empty bucket. To transfer the energy by convection, students will pick up some "heat" from the full bucket and carry it in the pathway you indicate to the empty bucket. Students will continue to do this until the "heat" is evenly distributed among the buckets and students. At that point everything is the same temperature and energy transfer stops.
4. Radiation is modeled in the most fun way of all! You will stand at the front of the room holding one bucket. You can have another student hold the other bucket if you wish, and you can each have a partner to help you "radiate" if you wish. Students will be given the "heat." They are hotter than you and the buckets, and they should radiate the energy toward you by throwing it to the buckets. You or your partner then radiate some of it back until the energy is evenly distributed. This models radiation in that it is the least efficient way to transfer energy to a specific object, and shows how other objects (the floor, for example) get heated as well.
5. Return the paper wads to the recycling bin.

Activity 4: Student Explorations

Time

- Two to three 45 minute class periods

✔ Procedure

PART 1

1. Divide the class into three groups and assign each group one module to work on. There will be one group working on Module 1 (*Exploring Heat Transfer 1, 2, 3*), one group working on Module 2 (*Conductors and Insulators*), and one group working on Module 3 (*Exploring Heat in Solids, Liquids, and Gases 1, 2, 3*). Students should read through their exploration worksheets and write a prediction or hypothesis for each activity in their science notebooks. Students then conduct the investigations, recording observations and data in their science notebooks.
2. After students have completed the investigations they should work together to make sure they understand what happened. All students should be able to demonstrate and explain their investigations to their peers.

PART 2

1. Divide each group in half. On the first day, half of the group will stay at the station to present while the other half will rotate through the other stations. The next day students will switch roles. Everyone will have a chance to present, and everyone will rotate through the other stations.

OPTIONAL: Have groups rotate through all stations so everyone conducts each investigation, rather than presenting to their peers.

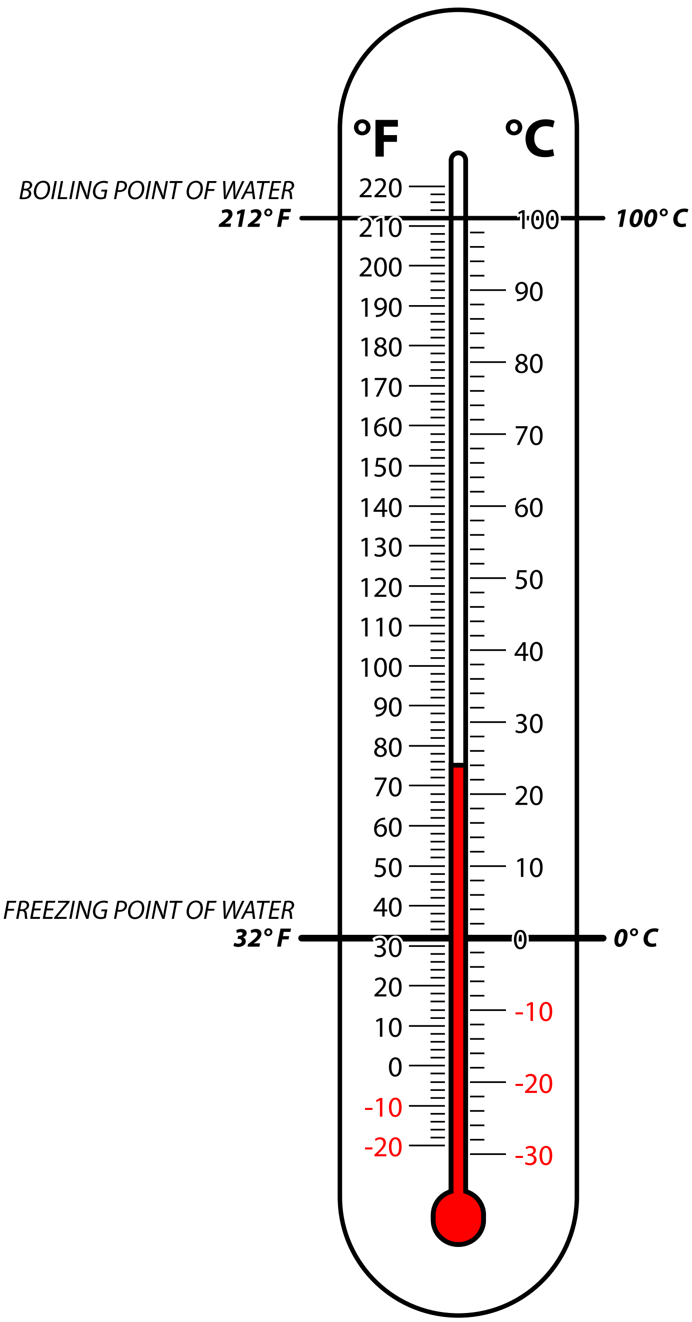
PART 3

1. Discuss the Conclusion questions on the worksheets after the completion of each of the explorations.
2. Evaluate the activities with the students.

Thermometer

A thermometer measures temperature.

A thermometer measures temperature. The temperature of a substance is a measure of the average amount of kinetic energy in the substance.
This thermometer is a long, glass tube filled with colored alcohol. Alcohol is used in many thermometers because it expands in direct proportion to the increase in kinetic energy or temperature.
Temperature can be measured using many different scales.
The scales we use most are:



▪ Celsius

The Celsius (C) scale uses the freezing point of water as 0°C and the boiling point of water as 100°C.

▪ Fahrenheit

The Fahrenheit (F) scale uses the freezing point of water as 32°F and the boiling point of water as 212°F.

In the United States, we usually use the Fahrenheit scale in our daily lives, and the Celsius scale for scientific work. People in most countries use the Celsius scale in their daily lives as well as for scientific work.

Notice the numerical difference between the freezing and boiling points of water are different on the two scales. The difference on the Celsius scale is 100, while the difference on the Fahrenheit scale is 180. There are more increments on the Fahrenheit scale because it shows less of an energy change with each degree.

▪ Celsius to Fahrenheit Conversion

To convert from Celsius to Fahrenheit, multiply the C number by $\frac{180}{100}$ or $\frac{9}{5}$, then add 32, as shown in the formula below.

$$F = (C \times \frac{9}{5}) + 32$$

If C = 5

$F = (5 \times \frac{9}{5}) + 32$

$F = 9 + 32$

$F = 41$

▪ Fahrenheit to Celsius Conversion

To convert from Fahrenheit to Celsius, subtract 32 from the F number, then multiply by $\frac{100}{180}$ or $\frac{5}{9}$ as shown in the formula below.

$$C = (F - 32) \times \frac{5}{9}$$

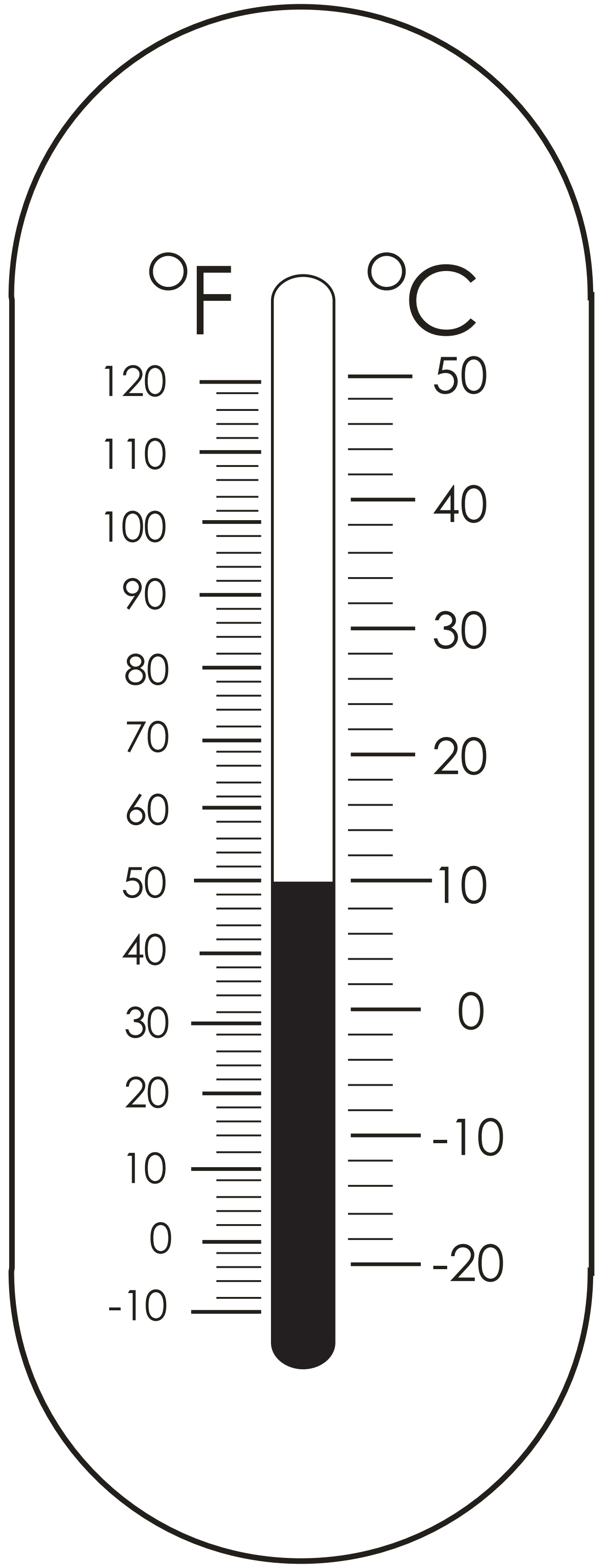
If F = 50

$C = (50 - 32) \times \frac{5}{9}$

$C = 18 \times \frac{5}{9}$

$C = 10$

Student Thermometer



Teacher Guide: Light

✪Objective

- Students will ge able to describe how light moves.

★Concepts

- We use light energy every day in many ways. It is essential for survival on Earth.
- Light is radiant energy that travels in waves.
- Light waves travel in straight lines, as evidenced by shadows and reflected light.
- Light waves can be refracted, reflected, and absorbed by substances.
- There is radiant energy we can see—visible light—as well as energy we can't see such as ultraviolet rays, infrared radiation, and x-rays.
- A wavelength is the distance from the crest of one wave to the crest of the next.
- Many wavelengths of radiation produce colors we can see. Substances absorb certain wavelengths and reflect others. The substances appear to our eyes as the colors that are reflected.
- Lenses can bend—or refract—light waves at predictable and measurable angles.
- We can predict and measure the refraction or reflection of light waves.

Time

- 2–4 hours

Materials

- Collect the materials as listed on pages 5 and 7 of the Teacher Guide.

Preparation

- Project or copy the *Photovoltaic Panel* and *Protractor* masters on pages 17 and 18 of the Teacher Guide.
- Set up the teacher demonstration materials and workstations for the student explorations with the materials needed.

Key Words—Light Answers *from Student Guide, page 28*

1. convex lens	2. protractor	3. prism	4. concave lens	5. wavelength	6. visible light	7. radiant energy
8. refracted light	9. reflected light	10. image	11. absorbed light	12. shadow	13. eclipse	14. degrees
15. angle						

Protractor Answers *from Student Guide, page 29*

Angle of Light Wave A: 30°	Angle of Reflected Wave A: 30°
Angle of Light Wave B: 55°	Angle of Reflected Wave B: 55°
Angle of Light Wave C: 70°	Angle of Reflected Wave C: 70°
Light Wave Angle: 40°	Reflected Wave Angle: 40°

Activity 1: Introduction

Time

- 30-45 minutes

✔ Procedure

1. Introduce the light module by discussing familiar ways that we use light and the many ways it is produced.
2. Have students read the informational text on pages 22-27 of their Student Guides. Students should take notes in their science notebooks about the properties of light. Discuss the important ideas students learned in the reading.
3. Instruct students to complete the *Key Words— Light* worksheet.

OPTIONAL: The *Key Words— Light* worksheet may be completed at the end of the light module to use as a review.

Activity 2: Teacher Demonstration

Time

- 30-45 minutes

✔ Procedure

1. Use the *Photovoltaic Panel* master and the solar cell kit to demonstrate how radiant energy is converted into electricity by the solar cell, then into motion by the motor. By covering sections of the solar cell, changing the light source, and changing the angle of incidence (the angle at which the light hits the solar cell), demonstrate how the amount of electricity produced is changed. Use the sun, an overhead projector, and perhaps a strong flashlight as light sources. Instructions for the solar cell kit are included with the kit packaging. For a detailed explanation of how a solar cell works, see the *Secondary Energy Infobook* or the *Intermediate Science of Energy* guide.
2. If the solar cell demonstrator doesn't work when you open the kit, you may need to jumpstart the motor by attaching it to a D battery.
3. Let the students examine the magnifying glass. Show them how the magnifying glass in the kit is a convex lens with a handle. Ask them what they think a concave lens would do in the light.
4. Use the *Protractor* master to explain how to measure angles. Have the students complete the *Protractor* worksheet on page 29 of the Student Guide.

Activity 3: Light Explorations

Time

- Two to three 45 minute class periods

✔ Procedure

PART 1

1. Divide the class into three groups and assign each group one module to work on. There will be one group working on Module 1 (*Exploring Light 1, 2)*, one group working on Module 2 (*Exploring Light 3, 4*), and one group working on Module 3 (*Exploring Light 5, 6*). Students should read through their exploration worksheets and write a prediction or hypothesis for each activity in their science notebooks. Students then conduct the investigations, recording observations and data in their science notebooks.
2. After students have completed the investigations they should work together to make sure they understand what happened. All students should be able to demonstrate and explain their investigations to their peers.

PART 2

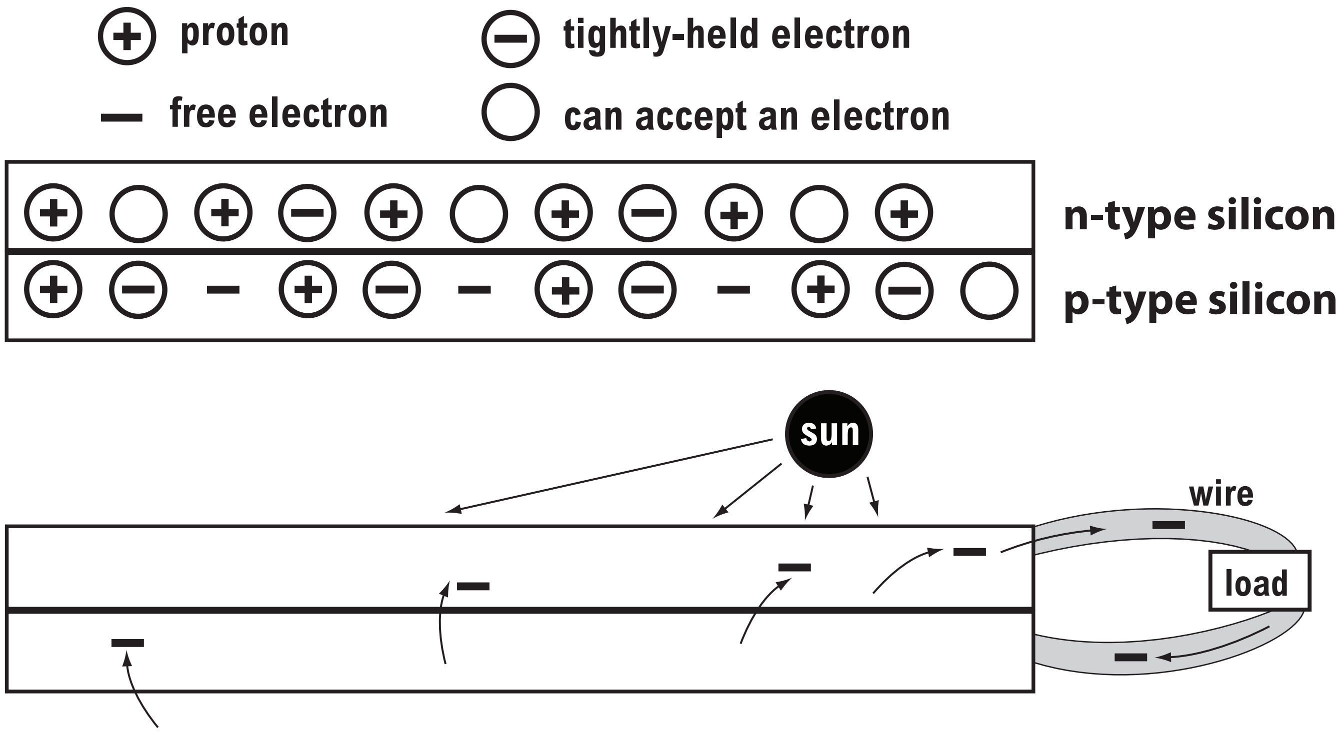
1. Divide each group in half. On the first day, half of the group will stay at the station to present while the other half will rotate through the other stations. The next day students will switch roles. Everyone will have a chance to present, and everyone will rotate through the other stations.

OPTIONAL: Have groups rotate through all stations so everyone conducts each investigation, rather than presenting to their peers.

PART 3

1. Discuss the Conclusion questions on the worksheets after the completion of each of the explorations.
2. Evaluate the activities with the students.

Photovoltaic Panel



Photovoltaic comes from the words *photo,* meaning light, and *volt*, a measurement of electricity. Photovoltaic cells are also called **PV cells** or **solar cells** for short. You are probably familiar with photovoltaic cells. Solar-powered toys, calculators, watches, lighting, and roadside telephone call boxes all use solar cells to convert sunlight into electricity.

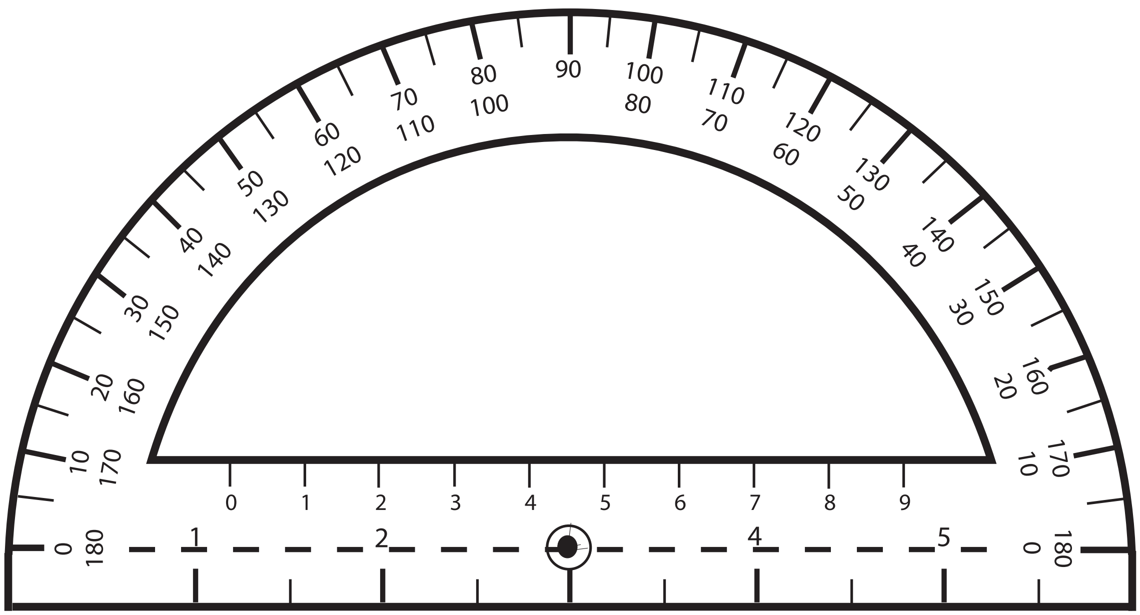
Solar cells are made of a thin piece (called a wafer) of silicon, the substance that makes up sand and the second most common substance on Earth. The top of the wafer has a very small amount of phosphorous added to it. This gives the top of the wafer an extra amount of free electrons. This is called n-type silicon because it has a habit of giving up electrons, a negative tendency. The bottom of the wafer has a small amount of boron added to it, and it has a habit of attracting electrons. It is called p-type silicon because of its positive tendency. When both of these chemicals have been added to the silicon wafer, some of the electrons from the n-type silicon flow to the p-type silicon and an electric field forms between the layers. The p-type now has a negative charge and the n-type has a positive charge.

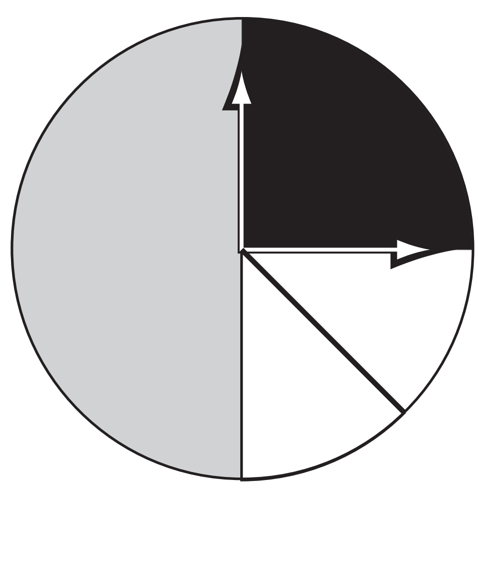
When the PV cell is placed in the sun, the radiant energy energizes the free electrons. If a circuit is made by connecting the top and bottom of the silicon wafer with wire, electrons flow from the n-type through the wire to the p-type. The PV cell is producing electricity—the flow of electrons. If a light bulb is placed along the wire, the electricity will do work as it flows, lighting the bulb. The transfer of sunlight into electricity takes place silently and instantly. There are no mechanical parts to wear out.

Compared to other ways of producing electricity, PV systems can sometimes be more expensive. It can cost 10-20 cents a kilowatt-hour for homes, schools, and small businesses to produce electricity from solar cells. On average, people pay about 13 (12.6) cents per kilowatt-hour for electricity for their homes. The electricity comes from a power company that uses fuels like coal, uranium, or hydropower. Today, PV systems are mainly used to generate electricity in areas that are a long way from electric power lines.

Protractor

A protractor is a tool that measures angles. It is shaped like a half-circle. Around the outside edge of the half-circle are numbers from 0 to 180 that measure angles in degrees. Degrees are written with a small circle after the number like this: 10°. On the outside flat edge of this protractor is a ruler in inches. Inches are written with two small lines after the number like this: 10″. On the inside flat edge is a ruler in centimeters. Centimeters are written with a small cm after the number like this: 10 cm.





A circle is divided into 360 equal parts called degrees.
It is divided by drawing straight lines through the center of the circle.

Look at the circle on the right. The gray part is half of the circle - it has 180° - the same as the protractor. (1/2 x 360 = 180)

The black part is one-fourth of the circle - it has 90°.
Look at the angle formed by the two straight lines. It is a 90° angle.
A 90° angle is called a right angle because the lines are perpendicular to each other. (1/4 x 360 = 90)

The two white parts are each one-eighth of the circle - they each have 45°. (1/8 x 360 = 45)

By placing the dotted line of the protractor on one of the flat sides of an angle, we can measure the angle.

Teacher Guide: Motion

✪Objective

- Students will be able to analyze and describe the relationship between force and motion.

★Concepts

- Every motion takes energy. The energy of motion is called kinetic energy.
- Potential energy is stored energy, the energy of position.
- Objects move in predictable and measurable ways. There are laws that govern the motion of objects.
- Newton's First Law of Motion states that an object at rest will stay at rest, and an object in motion will continue in motion in the same direction and at the same speed, until an unbalanced force acts upon it. This is called inertia.
- Newton's Second Law of Motion states that the motion of an object will change when a force is applied. The change in motion is dependent upon the direction and amount of the force that is applied.
- Newton's Third Law of Motion states that for every action there is an equal and opposite reaction; forces always act in pairs. If a force is applied to an object, the object will apply an equal and opposing force on that which applies the force.
- Gravity is the force of attraction between all objects—the greater the mass of the objects, the greater the force of gravity. The weight of an object is the amount of force acting on a body due to gravity.
- Friction is a force that slows the motion of two objects in contact with each other. Friction is always directed opposite to the motion.
- We can measure mass and force using balances and scales. Mass is measured in kilograms. Force is measured in pounds and newtons.
- The linear motion of force can be changed into a circular motion, such as with a pendulum.

Time

- 2–4 hours

Materials

- Collect the materials as listed on pages 6 and 7 of the Teacher Guide.

Preparation

- Project or copy the *Spring Scale* master on page 21 of the Teacher Guide.
- Set up the teacher demonstration materials and workstations for the student explorations with the materials needed.

Key Word— Motion Answers *from Student Guide, page 43*

1. gravity	2. mass	3. kilogram	4. newton	5. potential energy	6. friction
7. kinetic energy	8. weight	9. inertia	10. force	11. pendulum	12. vibration
13. centripetal force	14. amplitude	15. period			

Spring Scale Answers *from Student Guide, page 44, and Teacher Guide, page 21*

1. 2.0 N
2. 700 grams
3. 100 pounds

Activity 1: Introduction

Time

- 30-45 minutes

✔ Procedure

1. Introduce the activity by discussing motion and the many ways it is produced.
2. Have students read the informational text on pages 38-42 of their Student Guides. Students should take notes in their science notebooks about the properties of motion. Discuss the important ideas students learned in the reading.
3. Instruct students to complete the *Key Words—Motion* worksheet.

OPTIONAL: The *Key Words—Motion* worksheet may be given out at the end of the motion module to use as a review.

Activity 2: Teacher Demonstration

Time

- 30-45 minutes

✔ Procedure

1. Project the *Spring Scale* master to explain how to measure force. Have the students complete the *Spring Scale* worksheet on page 44 of the Student Guide.
2. Use the pull-back car to demonstrate potential and kinetic energy and friction. Use the balloon to demonstrate potential and kinetic energy, friction, and gravity.

Toy Car: The car has a spring in it. When you push down on the car, you transfer your kinetic energy by compressing the spring. Your kinetic energy is now stored in the form of elastic energy. When the car is released, the car starts to move. The elastic energy in the spring changes to motion. Why does the car eventually stop? The car stops because of friction. Friction changes some of the motion into heat and sound.

Balloon: When you blow up a balloon, you are using your kinetic energy to stretch the rubber, just like you used your energy to compress the spring in the car. Energy is stored in stretched rubber and compressed air instead of a compressed spring. Where did the energy go when you let go of the balloon? The elastic energy was converted into motion, heat, and sound.

Activity 3: Student Explorations

Time

- Two to three 45 minute class periods

✔ Procedure

PART 1

1. Divide the class into five groups and assign each group one module to work on. (Note: Module 4 should have at least five students in it.) Students should read through their exploration worksheets and write a prediction or hypothesis for each activity in their science notebooks. Students then conduct the investigations, recording observations and data in their science notebooks.
2. After students have completed the investigations they should work together to make sure they understand what happened. All students should be able to demonstrate and explain their investigations to their peers.

PART 2

1. Divide each group in half. On the first day, half of the group will stay at the station to present while the other half will rotate through the other stations. The next day students will switch. Everyone will have a chance to present and rotate through the other stations.

OPTIONAL: Have groups rotate through all stations so everyone conducts each investigation, rather than presenting to their peers.

PART 3

1. Discuss the Conclusion questions on the worksheets after the completion of each exploration.
2. Evaluate the activities with the students.

Spring Scale

A spring scale measures force. It can measure weight, which is the force of gravity on an object. It can measure the amount of force it takes to overcome the inertia of an object at rest. It can measure the amount of force it takes to move an object at a steady speed.

This spring scale has a handle that can be used to hang or pull the spring scale to measure force. It has a metal nut on the top to adjust the spring scale so that it reads exactly zero when no force is applied. You can turn the nut in either direction until the top of the bar is exactly on zero.

This spring scale measures force or weight in newtons (N). The scale measures from 0 N up to 2.5 N of force. It takes about 4.5 N to equal one pound of force or weight.

The other side of the scale measures mass in grams. The scale would only be accurate on Earth because it depends on the force of the Earth's gravity. Do you see the relationship between grams and newtons?

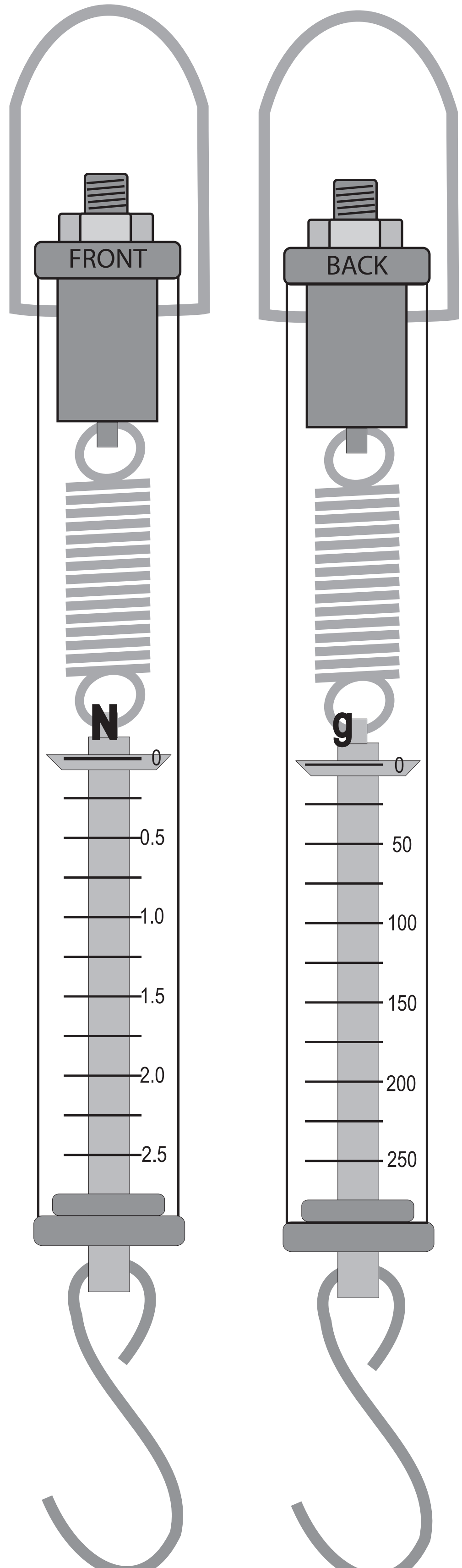
See if you can answer the questions below:

1. How many newtons of force would 200 grams apply?

2. What would be the mass of an object that weighs 7 N on Earth?

3. If an object weighs 450 N, how much does it weigh in pounds?

Practice using the spring scale. First, check the scale to make sure it reads zero. Adjust the screw if needed. Hang a pair of scissors on the hook and read both measurements. Hang another pair on and see if the measurements double. Try pulling a small book across a table to read the scale as it is moving.



Teacher Guide: Sound

✪Objective

- Students will be able to describe the properties of sound and how sound travels.

★Concepts

- Sound is caused by the compression of matter due to the vibrations of objects. Sound is energy moving through substances in longitudinal waves.
- In longitudinal waves, molecules vibrate back and forth in the same direction as the wave. The part of the wave in which the molecules are pushed together is the compression; the part in which the molecules are pulled apart is called the expansion or rarefaction. To rarefy means to make less dense.
- The loudness, or amplitude, of a sound wave is determined by the amount of energy it contains. Amplitude is measured on the Decibel Scale, which is a logarithmic scale.
- The pitch of a sound wave is determined by the frequency of the wave. Frequency is measured in Hertz—the number of vibrations per second.
- The ear transforms sound into electrical signals carried to the brain by the auditory nerve.
- Liquids and solids transfer sound better than gases because the molecules are denser.
- Sound waves, like light waves, can be reflected or absorbed.

Time

- 2–4 hours

Materials

- Collect the materials as listed on pages 6 and 7 of the Teacher Guide.

Preparation

- Project or copy the *Longitudinal Wave* and *Transverse Wave* masters on pages 24 and 25 of the Teacher Guide.
- *Exploring Sound 5* is an optional activity. If you choose to use this activity, prepare the following tubes:
    - Seal the ends of one tube with heavy duty tape so that it is filled with air. Label this Tube 1.
    - Seal one end of the second tube with heavy duty tape. Make sure there are no holes, the seal must be water tight. Label this Tube 2.
    - Fill Tube 2 with water. Seal the open end of the tube with heavy duty tape. Make sure there are no holes and that the seal is water tight.
    - Place a ring of hot glue around the face edge of a quarter. Attach the quarter to the end of Tube 1. Repeat three more times until the end of each tube has a quarter attached to it.
- Set up the teacher demonstration materials and five stations—one for each investigation.

Key Words—Sound Answers *from Student Guide, page 54*

1. trough	2. frequency	3. amplitude	4. sound wave	5. echo	6. auditory nerve	7. decibels
8. Hertz	9. pitch	10. eardrum	11. compression	12. crest	13. rarefaction	14. longitudinal
15. transverse						

Activity 1: Introduction

Time

- 30-45 minutes

✔ Procedure

1. Introduce the activity by discussing sound and how it is produced. Have the students feel their vocal cords as they change the pitch and amplitude of their voices.
2. Have students read the informational text on pages 50-53 of their Student Guides. Students should take notes in their science notebooks about the properties of sound. Discuss the important ideas students learned in the reading.
3. Instruct students to complete the *Key Words—Sound* worksheet.

OPTIONAL: The *Key Words—Sound* worksheet may be completed at the end of the sound module to use as a review.

Activity 2: Teacher Demonstration

Time

- 30-45 minutes

✔ Procedure

1. Use the *Longitudinal Wave* master to explain how sound travels in waves.
2. Use the *Transverse Wave* master and the wallpaper pan to show transverse waves. Place the eraser in the middle of the pan and drop a rock into the water at one end to create a wave. The eraser will bob up and down in the middle; the wave will move horizontally from one end of the pan to the other.
3. Blow up the balloon and demonstrate how you can change the pitch of the escaping air by changing the size and shape of the end.

Activity 3: Student Explorations

Time

- Two to three 45 minute class periods

✔ Procedure

PART 1

1. Divide the class into four groups and assign each group to one of the modules, 1-4. Students should read through their exploration worksheets and write a prediction or hypothesis for each activity in their science notebooks. Students then conduct the investigations, recording observations and data in their science notebooks.
2. After students have completed the investigations they should work together to make sure they understand what happened. All students should be able to demonstrate and explain their investigations to their peers.

PART 2

1. Divide each group in half. On the first day, half of the group will stay at the station to present while the other half will rotate through the other investigations. The next day students will switch roles. Everyone will have a chance to present, and everyone will rotate through the other stations.

OPTIONAL: Have groups rotate through all stations so everyone conducts each investigation, rather than presenting to their peers.

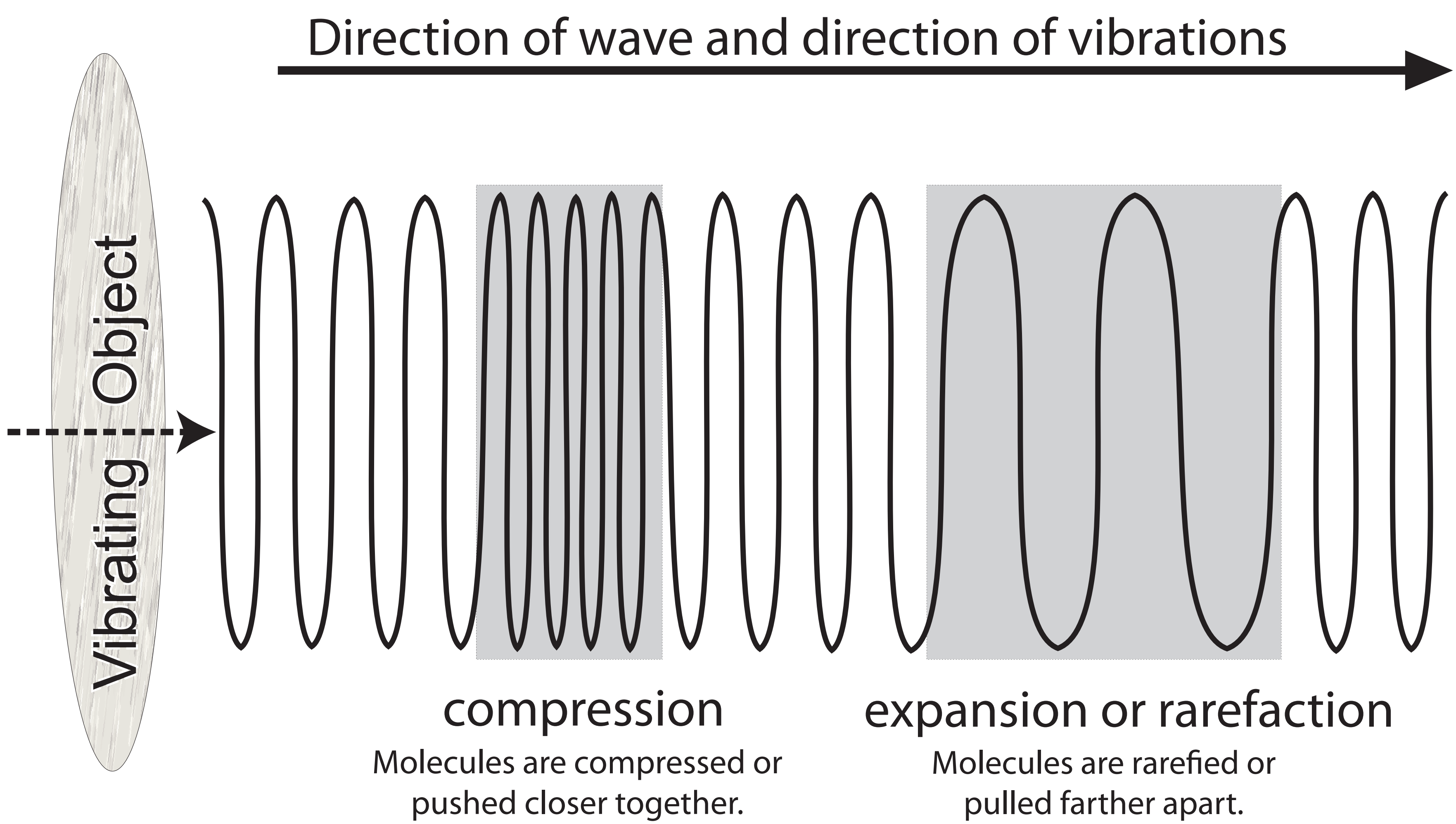
PART 3

1. Discuss the Conclusion questions on the worksheets after the completion of each of the explorations.
2. Evaluate the activities with the students.
3. Conduct *Exploring Sound 5* as an optional class activity.

Extension

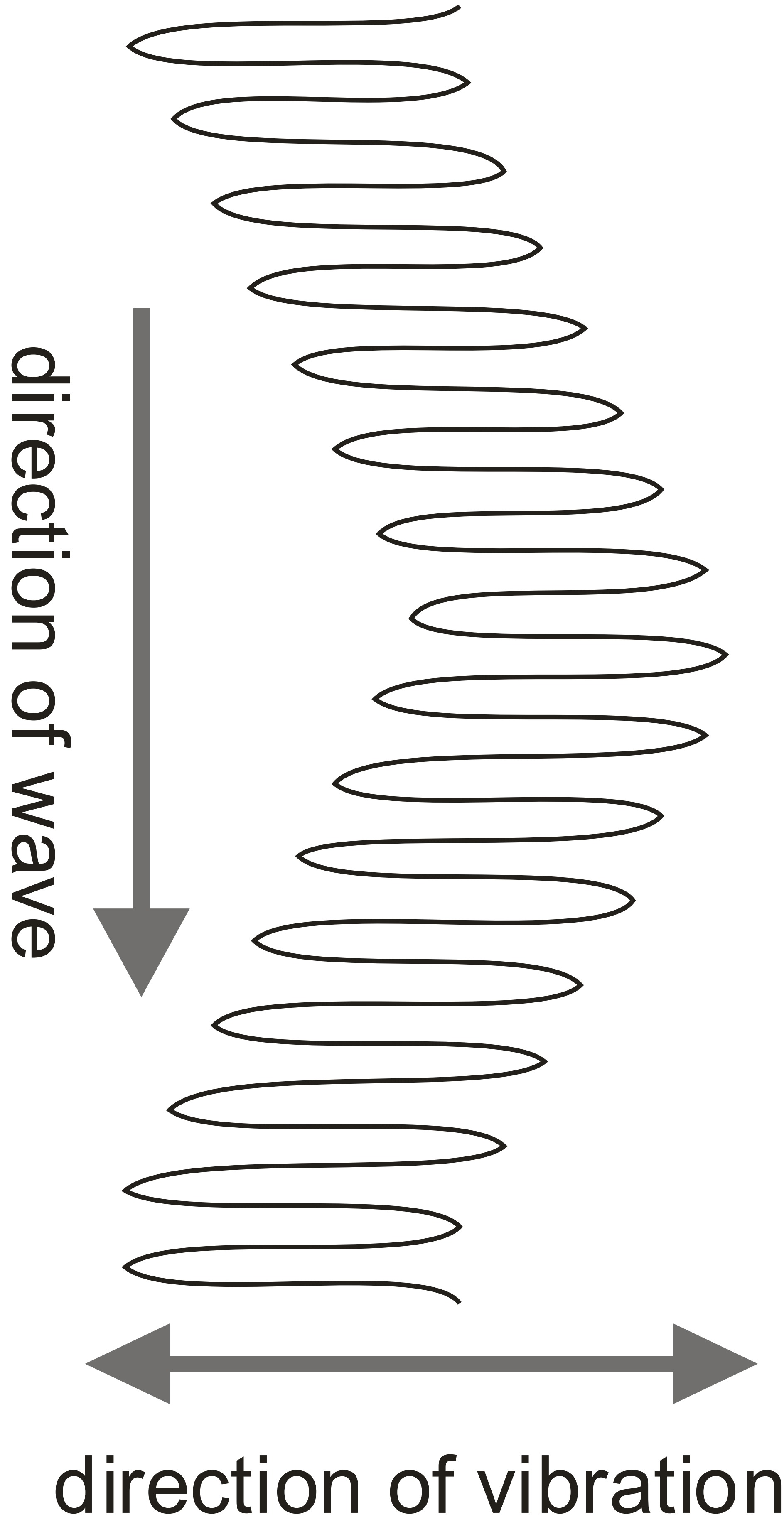
- If your school has sound recording equipment, have the students record their voices to see the sound waves created. Direct them to change the amplitude and frequency of the sound waves. Have them look at the sound waves produced by different musical instruments.

Longitudinal Wave



When the vibrating object moves to the right, it pushes the molecules together.
When the object moves to the left, it pulls the molecules apart.

Transverse Wave



Teacher Guide: Growth

✪Objectives

- Students will be able to describe how energy transformations are responsible for growth.
- Students will be able to explain photosynthesis and its flow through the food chain.

★Concepts

- Every living organism is constantly growing. They may not always be growing in size, but they are always growing new cells.
- It takes energy to grow. During the process of photosynthesis, plants use energy from the sun to convert water and carbon dioxide into oxygen and glucose—a simple sugar that is the basic food of all life.
- All animals get their energy from the glucose produced by plants through the food chain.
- This energy comes from the sun in the form of radiant energy.

Time

- A few minutes a day over the course of 10 days

Materials

- See the materials needed on page 6 of the Teacher Guide. No materials for the growth module are included in the kit.

Preparation

- Copy or project the *Photosynthesis* master on page 28 of the Teacher Guide.
- Set up a workstation for the explorations with all of the materials needed.

Key Words—Growth Answers *from Student Guide, page 62*

1. growth	2. glucose	3. food chain	4. carnivore	5. chemical energy	6. producer
7. herbivore	8. photosynthesis	9. consumer	10. omnivore	11. carbon dioxide, oxygen	

Energy Flow Answers *from Student Guide, page 65*

1. Sun
2. Lily Pad
3. Bug
4. Small Fish
5. Big Fish
6. Bear
7. Man

Activity 1: Introduction

Time

- 30-45 minutes

✔ Procedure

1. Introduce the activity by discussing growth in plants and animals.
2. Have students read the informational text on pages 60-61 of their Student Guides. Students should take notes in their science notebooks about the properties of growth. Discuss the important ideas students learned in the reading.
3. Use the *Photosynthesis* master to explain how plants convert radiant energy from the sun into chemical energy (food).
4. Instruct students to complete the *Key Words—Growth* worksheet.

OPTIONAL: The *Key Words—Growth* worksheet may be completed at the end of the growth module to use as a review.

Activity 2: Student Explorations

Time

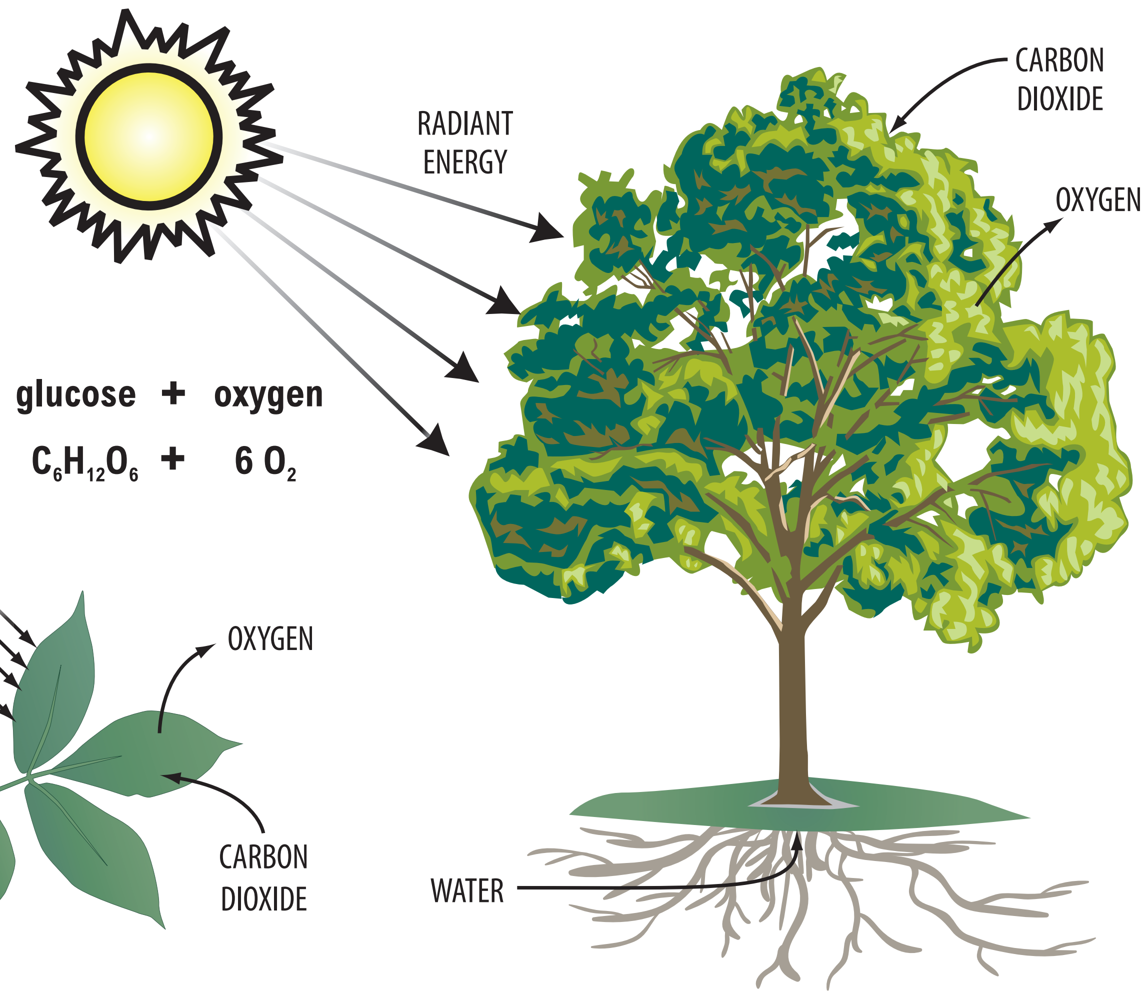
- variable, depending on depth of exploration over 10 days

✔ Procedure

1. Divide the class into two groups. Assign each group to conduct one of the growth explorations. Students should take detailed notes and record data in their science notebooks so they can present their findings to the class after ten days.
2. Let each group present their exploration, data, and conclusions to the class. This can be done in any format including a multimedia presentation.
3. For review, have all students complete the *Energy Flow* activity on page 65 of the Student Guide.
4. Evaluate the activities with the students.

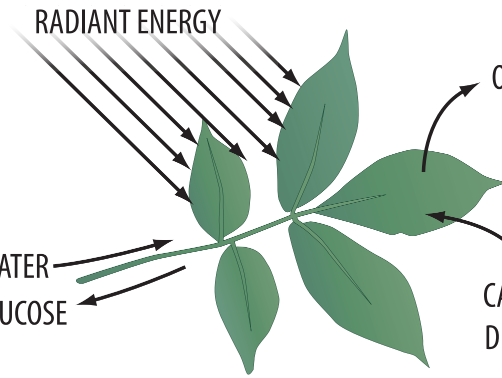
Photosynthesis

In the process of photosynthesis, plants convert radiant energy from the sun into chemical energy in the form of glucose (or sugar).



water + carbon dioxide + sunlight ⟶ glucose + oxygen

$$6\,H_2O + 6\,CO_2 + \text{radiant energy} \longrightarrow C_6H_{12}O_6 + 6\,O_2$$



Teacher Guide: Technology

✪Objective

- Students will be able to identify forms of technology they use and describe how electricty powers them.

★Concepts

- Technology is the science of making and using things.
- Much of our energy consumption goes toward generating electricity to run electronic technologies.
- Electronics is the ability to use electricity to control electrical devices and perform tasks.
- A transistor is a switch that controls electrons, changing their patterns. The invention of the transistor paved the way for modern technology.
- Microchips are devices with many tiny transistors that can perform complex tasks in modern machines such as computers.

Time

- 2-3 hours

Preparation

- Obtain permission from colleagues and/or school administration to have students look at nameplates on machines in use around the school.
- Gather the materials needed for the teacher demonstration as listed on page 7.

Key Words—Technology Answers *from Student Guide, page 67*

1. Electronics 2. transistor 3. technology 4. microchip 5. electricity

Activity 1: Introduction

Time

- 30-45 minutes

✔ Procedure

1. Introduce the activity by discussing ways we use modern technologies.
2. Have students read the informational text on page 66 in their Student Guides. Students should take notes in their science notebooks about the properties of technology. Discuss the important ideas students learned in the reading.
3. Instruct students to complete the *Key Words— Technology* worksheet.

OPTIONAL: The *Key Words— Technology* worksheet may be completed at the end of the technology activities to use as a review.

Activity 2: Teacher Demonstration

Time

- 30-45 minutes

✔ Procedure

1. Show students a CFL bulb, incandescent bulb, and LED bulb. (If you do not have bulbs, pictures will work). Ask students what they know about each type of bulb.
2. Read and complete *Facts of Light* and *The Facts of Light Activity* on pages 68-70 of the Student Guide or pages 31-32 of the Teacher Guide and graph the results, either as a class or individually.
3. Ask students why they would purchase an LED now or would they wait? Why or why not? Discuss how cost affects savings.

Activity 3: Student Explorations

Time

- 45-60 minutes

✔ Procedure

1. Explain to students what a nameplate is and how it can be read to analyze how much electricity a machine or appliance is configured to use. Use page 71 in the Student Guide and practice reading one or two appliances as a class, calculating their energy usage.
2. Have students work in pairs or small groups to find machines and appliances around the building and calculate their energy use.
3. Discuss what students found during their analysis. Are there ways that teachers and students could conserve energy by changing the ways these machines are used?

OPTIONAL: After students have analyzed 5-10 items, have them return to class and complete the *Cost of Using Machines Investigation* worksheet (on page 72 of the Student Guide).

Extension: Student Research

Time

- Time will vary

✔ Procedure

1. Assign students individually or in small groups to research one technological device of their choosing. Some suggestions are cell phones, televisions, automobiles, computers, etc.
2. Using the graphic organizer on page 33 of the Teacher Guide, students should use school resources and the internet to research the history of the product and determine three important milestones in the product's development, from its first innovation to its current use today. Students should also think about the future of this product and predict what changes might occur to make the product more efficient or better for consumers.
3. Students will create a presentation about the product they chose and present their findings to the class.

Facts of Light

Facts of Light

Ten years ago, we used a lot of energy in the form of electricity to make light to be able to see. Thirty percent of the electricity schools used was for lighting, and homes used about 14 percent of their electricity consumption for lighting. That's because homes, schools, and other commercial buildings used a lot of **incandescent** lighting. These inefficient bulbs were perfected by Thomas Edison in 1879 and didn't change much for the next 125 or more years! These bulbs were surprisingly inefficient, converting up to 90 percent of the electricity they consumed into heat.

The Energy Independence and Security Act of 2007 changed the standards for the efficiency of light bulbs used most often. As of 2014, most general use bulbs must be 30 percent more efficient than traditional, inefficient incandescent bulbs. What do the new standards mean for consumers? The purpose of the new efficiency standards is to give people the same amount of light using less energy. Most incandescent light bulbs have since been phased out and are no longer available for sale. This has resulted in significant energy savings for homes and schools. Newer, efficient lighting now accounts for only 17 percent of the electricity used in schools, and 17.52 percent used in homes.

There are several lighting choices on the market that meet the new efficiency standards. Energy-saving incandescent, or **halogen**, bulbs are different than traditional, inefficient incandescent bulbs because they have a capsule around the **filament** (the wire inside the bulb) filled with halogen gas. This allows the bulbs to last three times longer and use 25 percent less energy.

Compact fluorescent light bulbs (CFLs) provide the same amount of light as incandescent bulbs, but use up to 75 percent less energy and last ten times longer. CFLs produce very little heat. Using CFLs can help cut lighting costs and reduce environmental impacts. Today's CFL bulbs fit almost any socket, produce a warm glow and, unlike earlier models, no longer flicker and dim. CFLs have a small amount of mercury inside and should always be recycled rather than thrown away. Many retailers recycle CFLs for free.

Light emitting diodes, better known as LEDs, are gaining in popularity. Once used mainly for exit signs and power on/off indicators, improved technology and lower prices are enabling LEDs to be used in place of incandescents and CFLs. LEDs are one of the most energy-efficient lighting choices available today. LEDs use 75 percent less energy than traditional incandescents, and have an average lifespan of at least 25,000 hours. The cost of LEDs has dropped in the last five years and may continue to drop. They use even less energy than CFLs, save more electricity, and produce fewer carbon dioxide emissions. The U.S. Department of Energy estimates that widespread adoption of LED lighting by 2027 would reduce lighting electricity demand by 33 percent. This would avoid construction of 40 new power plants.

Cost of 25,000 Hours of Light

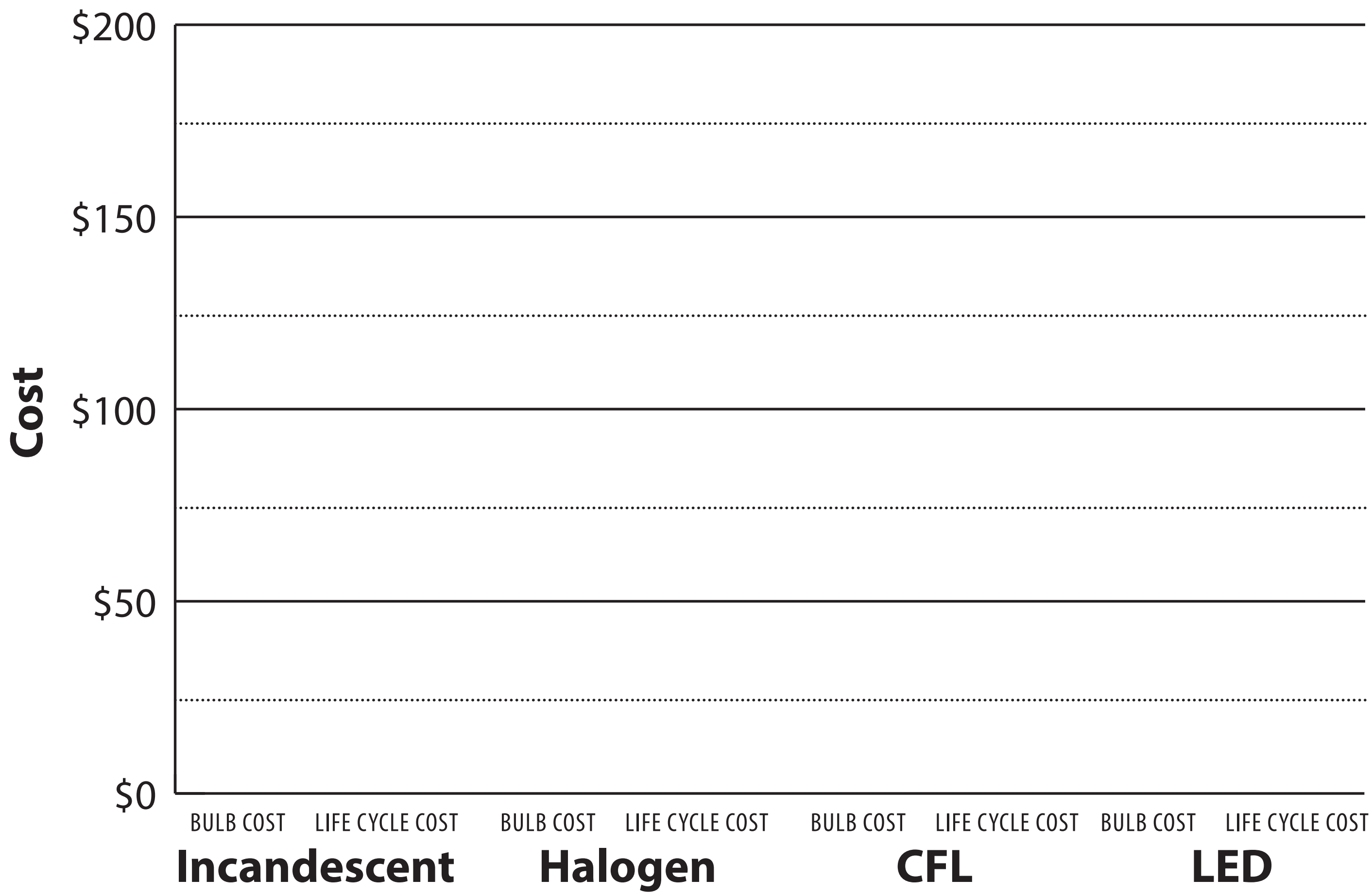


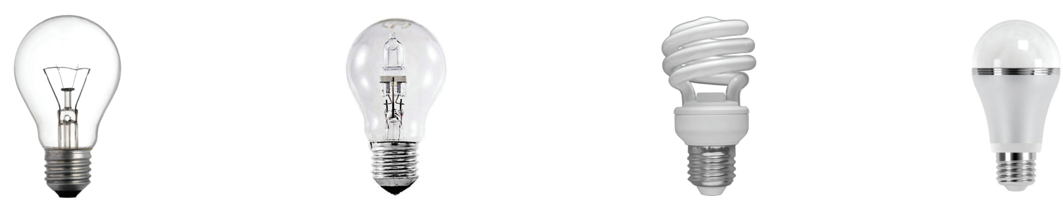

All bulbs provide about 850 lumens of light.

	COST OF BULB	INCANDESCENT BULB	HALOGEN	COMPACT FLUORESCENT (CFL)	LIGHT EMITTING DIODE (LED)
	Life of bulb (how long it will light)	1,000 hours	3,000 hours	10,000 hours	25,000 hours
	Number of bulbs to get 25,000 hours	25 bulbs	8.3 bulbs	2.5 bulbs	1 bulb
x	Price per bulb	$0.50	$1.50	$1.50	$1.33
=	**Cost of bulbs for 25,000 hours of light**	**$12.50**	**$12.45**	**$3.75**	**$1.33**
	COST OF ELECTRICITY	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total Hours	25,000 hours	25,000 hours	25,000 hours	25,000 hours
x	Wattage	60 watts = 0.060 kW	43 watts = 0.043 kW	13 watts = 0.013 kW	12 watts = 0.012 kW
=	Total kWh consumption	1,500 kWh	1,075 kWh	325 kWh	300 kWh
x	Price of electricity per kWh	$0.126	$0.126	$0.126	$0.126
=	**Cost of Electricity**	**$188.25**	**$134.91**	**$40.79**	**$37.65**
	LIFE CYCLE COST	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Cost of bulbs	$12.50	$12.45	$3.75	$1.33
+	Cost of electricity	$188.25	$134.91	$40.79	$37.65
=	**Life cycle cost**	**$200.75**	**$147.36**	**$44.54**	**$38.98**
	ENVIRONMENTAL IMPACT	**INCANDESCENT BULB**	**HALOGEN**	**COMPACT FLUORESCENT (CFL)**	**LIGHT EMITTING DIODE (LED)**
	Total kWh consumption	1,500 kWh	1,075 kWh	325 kWh	300 kWh
x	Pounds (lbs) of carbon dioxide per kWh	1.6 lb/kWh	1.6 lb/kWh	1.6 lb/kWh	1.6 lb/kWh
=	**Pounds of carbon dioxide produced**	**2,400.0 lbs carbon dioxide**	**1,720.0 lbs carbon dioxide**	**520.0 lbs carbon dioxide**	**480.0 lbs carbon dioxide**

The Facts of Light Activity

Comparing Light Bulbs





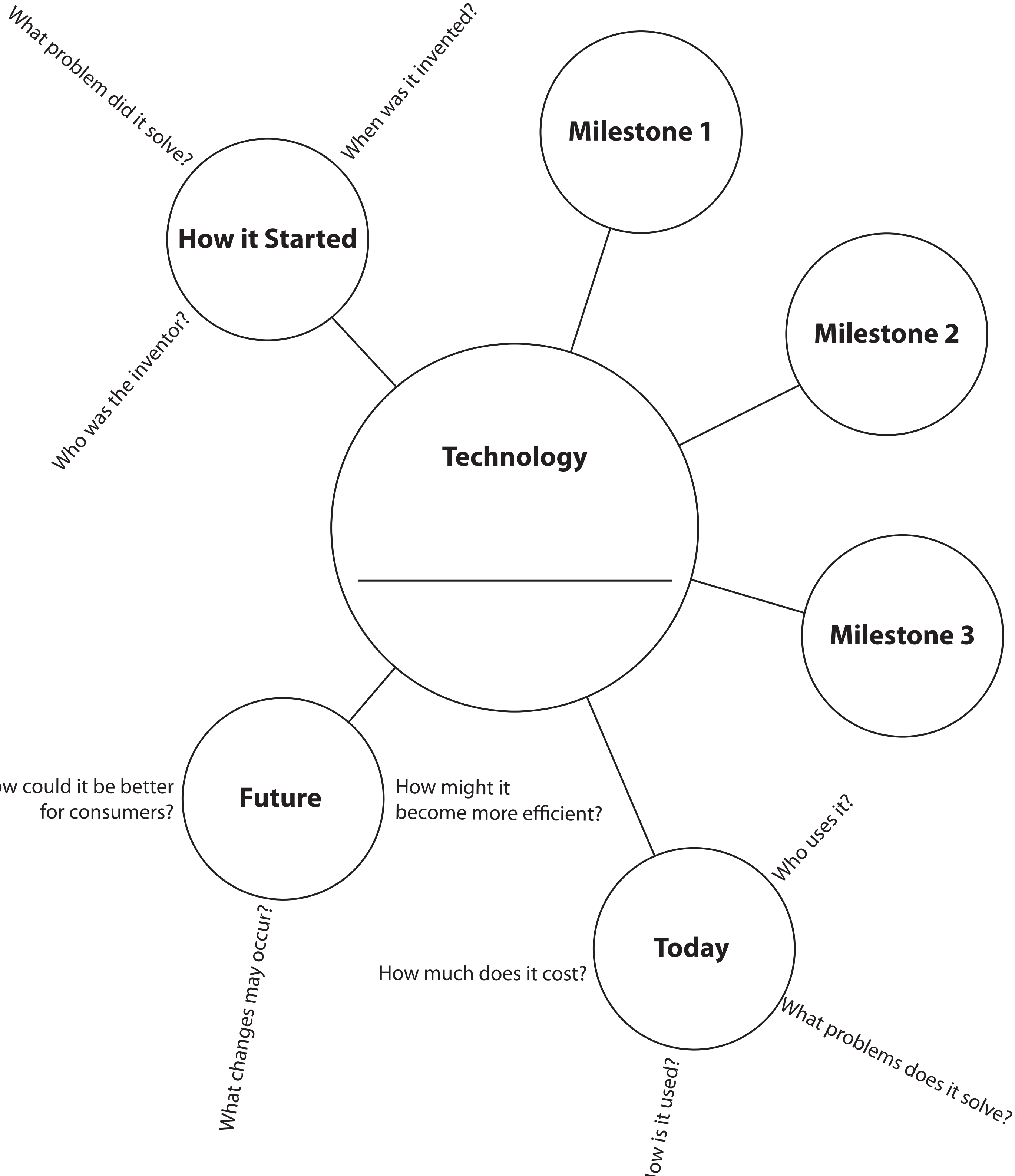
	Incandescent	Halogen Incandescent	CFL	LED
Bulb Cost	$12.50	$12.45	$3.75	$1.33
Electricity Cost	$188.25	$134.91	$40.79	$37.65
Life Cycle Cost	$200.75	$147.36	$44.54	$38.98

Note: Bulb cost reflects the number of bulbs needed to produce 25,000 hours of light, which is the lifespan of one LED bulb. To produce the same amount of light, it would take 25 incandescent bulbs and 2.5 CFL bulbs.

Answer the following questions in your science notebook.

1. Draw the Comparing Light Bulbs graph in your science notebook. Use the data provided to create a bar graph.
2. Looking at the graph and the data table, what conclusions can you draw about the cost of each type of bulb?
3. If you were going to change all of the light bulbs in your home, which bulbs would you use and why?

Research Activity



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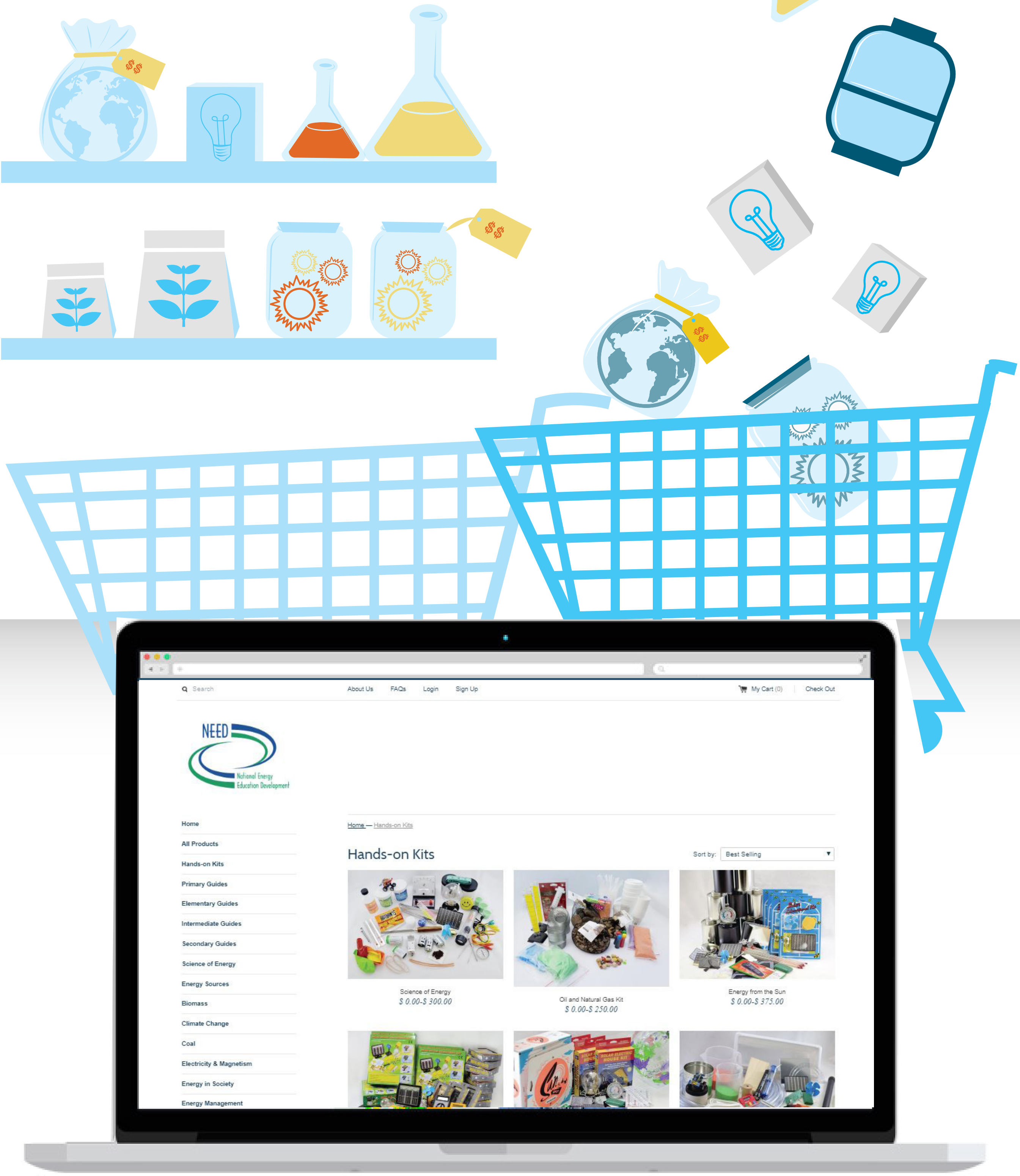

EnergyWorks Evaluation Form

State: ____________ **Grade Level:** ____________ **Number of Students:** ___________

1. **Did you conduct the entire unit?**	❑ Yes	❑ No
2. **Were the instructions clear and easy to follow?**	❑ Yes	❑ No
3. **Did the activities meet your academic objectives?**	❑ Yes	❑ No
4. **Were the activities age appropriate?**	❑ Yes	❑ No
5. **Were the allotted times sufficient to conduct the activities?**	❑ Yes	❑ No
6. **Were the activities easy to use?**	❑ Yes	❑ No
7. **Was the preparation required acceptable for the activities?**	❑ Yes	❑ No
8. **Were the students interested and motivated?**	❑ Yes	❑ No
9. **Was the energy knowledge content age appropriate?**	❑ Yes	❑ No
10. **Would you teach this unit again?**	❑ Yes	❑ No

Please explain any 'no' statement below.

How would you rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor
How would your students rate the unit overall?	❑ excellent	❑ good	❑ fair	❑ poor

What would make the unit more useful to you?

Other Comments:

Please fax or mail to: **The NEED Project**
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820

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